1993

1993 South Dakota Beef Report

Department of Animal and Range Sciences, South Dakota State University

Agricultural Experiment Station, South Dakota State University

Cooperative Extension Service, South Dakota State University

Department of Animal and Range Sciences

1993 SOUTH DAKOTA BEEF REPORT

Agricultural Experiment Station

Cooperative Extension Service

South Dakota State University, Brookings

The following companies and individuals generously provided livestock, commercial products, equipment, grant funds or their time in support of beef cattle research, extension, and teaching programs at South Dakota State University:

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Syntex Animal Health, Des Moines, IA
Tri County State Bank, Kimball, SD
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Published in accordance with an act passed in 1881 by the 14th Legislative Assembly, Dakota Territory, establishing the Dakota Agricultural College and with the act of re-organization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University. Educational programs and material offered without regard to age, race, color, religion, sex, handicap, or national origin. An Equal Opportunity Employer. 500 printed by the Department of Animal and Range Sciences at a cost of $4.56 each. AS001--September 1993.

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September 1993

Dear Beef Producer,

This is the 1993 version of the South Dakota Beef Report. We hope the research information reported here is of benefit to you.

Our beef cattle research is carried out at five locations in the state. The main campus experiment station in Brookings includes our purebred Angus and Simmental cows used for research and teaching, the individually fed cows from the beef breeding project, and a 550-head capacity feedlot. At the Southeast South Dakota Experiment Farm at Beresford, we have a research feedlot with a 350-head capacity. West River our 200-head beef cattle breeding herd is located at the Antelope Range Livestock Station near Buffalo, and we have a 140-head crossbred cow herd that winters at the Cottonwood Range and Livestock Station near Philip and summers on pastures at Fort Meade outside Sturgis. In addition, we purchase feeder calves annually for summer grazing studies at the Cottonwood Station. Our research locations are situated to mimic the diversity in the State of South Dakota and to give us research opportunities in conditions similar to those you experience.

We hope you will share your ideas with us for research in beef cattle and range management that needs to be carried out. We want to know what you feel are problem areas that need answers. We also hope that you can visit the experiment stations and see in person the research conducted there.

Sincerely,

Jim Males

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

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SDSU

COOPERATIVE EXTENSION SERVICE

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September 1993

Dear Beef Cattle Industry Friends:

Thank you for examining the 1993 South Dakota Beef Report. The articles published in this report summarize many of the beef cattle research activities conducted at South Dakota State University during the past year.

The articles in this report have many levels of application. Some information has immediate application for your farm, ranch, or agribusiness. Other articles will lead to more studies in the future. Application of some of this information is perhaps a few years in the future.

Please feel free to contact the Department of Animal and Range Sciences with concerns and questions that you may have. The Extension, Research, and Teaching staff appreciate your continued support of programs at South Dakota State University.

Sincerely,

John J. Wagner
Extension Ruminant Nutrition Specialist

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INTERPRETING EXPERIMENTAL RESULTS

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

CATTLE 93-1

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

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

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

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

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

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

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

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

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[1]Associate Professor.

SDSU BEEF TEACHING HERD

R. J. Pruitt[1]
Department of Animal and Range Sciences

CATTLE 93-2

Summary

A herd of Angus, Simmental and Simmental-Angus crossbreds are maintained at the Cow-Calf Teaching and Research Unit near the SDSU campus. Cattle from this herd are used for teaching, research, and extension activities. In addition to use in the classroom, cattle are used for the annual SDSU Little International, field days, and numerous 4-H, FFA, and other educational events. Research projects include reproductive physiology, creep feeding, and cow nutrition studies.

For teaching purposes, cattle within each breed that vary in calving ease, growth rate, mature size, and maternal value are maintained. Although it is not feasible to maintain all of the breeds that are useful to the commercial beef cattle industry in this region, two breeds that are distinctly different are used. The goal for our breeding program is to produce bulls that are useful to the commercial beef industry that fit into the following four categories:

1. Low birth weight Angus bulls to breed to yearling heifers.
2. Higher growth Angus bulls to breed to cows.
3. Simmental bulls to breed to cows in a rotational crossbreeding system.
4. Simmental-Angus crossbred (or composite) bulls to use in a simplified crossbreeding system to maintain the percentage Simmental at 50% or less.

The specific objective goals for the bulls produced are presented in Tables 1 and 2. The average EPDs of the cow herd and the AI sires used in 1993 to get closer to those goals are shown in Tables 3 and 4.

In the past the bulls produced have been used in other SDSU crossbred research herds with other bulls offered for sale privately. In April of 1993 the first SDSU Limited Auction Bull Sale was held at the Cow-Calf Teaching and Research Unit. The Block and Bridle Club contacted potential buyers, distributed advertising, washed and clipped the bulls, clerked the sale, and prepared lunch. If you would like to receive information on the bulls to be sold in April of 1994, contact Kevin VanderWal (unit manager) or Dick Pruitt of the Animal and Range Sciences Department.

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[1]Associate Professor.

Table 1. Goals for the majority of Angus bulls produced

	Low birth weight bulls	Higher growth bulls
Birth weight EPD	< +2	< +6
Weaning weight EPD	> +25	> +30
Milk EPD	> +10	> +10
Yearling weight EPD	> +40	> +50
Frame score	5 to 6	6 to 7
Yearling scrotal circumference	> 34 cm	> 34 cm

Table 2. Goals for the majority of Simmental bulls produced

Calving ease EPD, heifers	> -2
Birth weight EPD	< 0
Weaning weight EPD	> +5
Yearling weight EPD	> +10
Maternal calving ease EPD, heifers	> -1
Milk EPD	> -2
Frame score	6 to 7
Yearling scrotal circumference	> 34 cm

Table 3. Average EPDs of Angus AI sires and cows[a]

	AI sires used to produce low birth wt bulls	AI sires used to produce higher growth bulls	Low birth wt cows	Higher growth cows
Birth weight	-.5	+4.1	+1.5	+4.9
Weaning weight	+32	+37	+24	+30
Milk	+21	+14	+11	+11
Combined maternal index	+37	+32	+23	+26
Yearling weight	+57	+65	+41	+50

[a]EPD's from Fall 1993 Angus Evaluation.

Table 4. Average EPDs of Simmental AI sires and cows[a]

	AI sires	Cows
Calving ease, heifers	+3.9	+1.6
Birth weight	-1.2	+.1
Weaning weight	+11.4	+10.3
Yearling weight	+22.2	+16.6
Maternal calving ease, heifers	+2.2	+1.8
Milk	+1.2	+3.8
Maternal weaning weight	+6.9	+9.0

[a]EPD's from Spring 1993 Simmental Evaluation.

LEVEL OF AVAILABLE FORAGE AND SUPPLEMENTAL PROTEIN AND ENERGY FOR COWS GRAZING WINTER RANGE

R. J. Pruitt[1], M. C. Namminga[2], R. H. Haigh[3], and D. B. Young[4]
Department of Animal and Range Sciences

CATTLE 93-3

Summary

A winter grazing trial at the SDSU Range and Livestock Research Station near Cottonwood was conducted to determine if the response to feeding a high starch supplement is dependent on the amount of protein fed and the amount of forage available. During December and January 126 Simmental-Angus crossbred cows grazing two pastures with differing amounts of available forage were fed four supplemental treatments that provided the following amounts of crude protein (lb) and metabolizable energy (Mcal) per cow daily: 1) .72 and 3.92, 2) .72 and 10.64, 3) 1.44 and 7.78, and 4) 1.44 and 10.91. Cows grazing the high available forage pasture gained 41 lb more than those grazing the low forage pasture. Increasing the amount of supplemental protein from .72 to 1.44 lb per cow daily increased cow gains. Increasing the amount of supplemental energy did not improve cow weight gains when the level of supplemental protein was .72 lb per cow daily. When the amount of protein was doubled, increasing the amount of supplemental energy increased gains by 21 lb. There was a tendency for a greater response to the higher protein, higher energy supplement for cows grazing the pasture with less forage available.

Key Words: Beef Cows, Winter Range, Supplement, Energy, Protein, Available Forage

Introduction

A commonly asked question is "Should I feed a small amount of more expensive high protein supplement or a larger amount of a less expensive low protein supplement to cows grazing winter range?" Numerous research studies indicate that the first consideration should be protein. Providing supplemental protein in the form of alfalfa hay or a high protein concentrate supplement will increase the digestibility of the forage and allow greater forage consumption resulting in more favorable cow winter weight change. Several studies show that providing grain as supplemental energy usually decreases digestibility of the forage and the amount of forage consumed. As a result, there may be no advantage in weight gain or even greater weight loss when the supplemental energy is in the form of a high starch, low protein supplement like corn. It has been assumed by some that if forage is limited, grain may be more beneficial.

Results from two previous cow winter grazing trials at the SDSU Range and Livestock Research Station near Cottonwood seem to conflict. In the first study higher levels of a soybean meal-corn supplement were detrimental to cow gains. This detrimental effect was greater for cow grazing the low forage available pasture. In the following winter trial, weight gain was the highest for cows receiving the most supplement. In an attempt to determine the factors that affect the response to level of supplementation, this trial was conducted

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[1]Associate Professor.
[2]Graduate Assistant.
[3]Superintendent, Range and Livestock Research Station.
[4]Ag Research Technician, Range and Livestock Research Station.

to determine the effect of level of protein on the response to a high starch supplement for cows grazing pastures of differing available forage.

Materials and Methods

A winter grazing trial was conducted with 126 pregnant Simmental-Angus crossbred cows grazing native winter range at the SDSU Range and Livestock Research Station near Cottonwood, SD. Cows were allotted by age and weight to four soybean meal-corn supplement treatments (Tables 1 and 2) and grazed on a pasture of either high or low available forage during December and January. The low level of protein (.72 lb per cow daily) was calculated to provide NRC (1984) requirements for crude protein not provided by grazed forage as estimated by forage intake and forage protein analysis from previous studies. The high level of protein was calculated to supply twice the amount of supplemental crude protein as the low level. The level of high energy low protein supplement was calculated as the maximum amount of supplement possible using corn that would supply .72 lb crude protein. The high protein, high energy supplement was designed to supply a similar amount of energy but at the higher level of protein. Supplements were fed in pelleted form (3/8 in. diameter) and were balanced to exceed NRC (1984) requirements for phosphorous and potassium (Table 2).

Table 1. Supplemental treatments[a]

	Low protein		High protein	
Item	Low energy	High energy	Low energy	High energy
Soybean meal	82.18	--	96.28	23.89
Corn grain	--	95.04	--	72.39
Molasses	2.50	2.50	2.50	2.50
Dicalcium phosphate	7.92	.84	2.76	.40
Potassium chloride	7.40	1.61	2.06	.80

[a]Percentage on a dry matter basis.

Table 2. Composition of daily supplemental intake per cow[a]

	Low protein		High protein	
Item	Low energy	High energy	Low energy	High energy
Dry matter, lb	1.74	7.41	3.07	7.56
Metabolizable energy, Mcal	3.92	10.64	7.78	10.91
Crude protein, lb	.72	.72	1.44	1.44
Phosphorus, lb	.03	.03	.03	.03
Potassium, lb	.09	.09	.10	.10

[a]ME values are calculated from NRC feed tables. Other values are based on chemical analysis.

The two pastures used in the study were dominated by western wheatgrass. The low available forage pasture (270 acres) was grazed for 3,684 animal unit days during November just prior to the start of the trial to create differences in forage available. The high forage pasture (351 acres) had not been grazed since the previous April.

From December 5 to February 4, cows were gathered every morning, sorted into treatment groups and bunk fed their respective diets. At the beginning and end of the trial, cows were weighed in the morning on two consecutive days after overnight removal from feed and water. Initial and final cow weights were the average of the two consecutive weights. Condition scores (1 to 9, 1 = extremely thin, 9 = obese) were assigned by two people at the beginning and end of the trial.

Data were analyzed as a 2 x 4 factorial with two pastures and four treatments as main effects using the GLM procedure of SAS and treatment means separated by the PDIFF option.

Results and Discussion

Cows grazing the high forage pasture gained 41 lb more ($P<.01$) and had a greater condition score increase ($P<.01$) than cows grazing the low forage pasture (Table 3). Cows receiving the higher level of protein (1.44 lb) gained more than those receiving .72 lb crude protein per day to meet their NRC (1984) requirements. The two high energy treatments are the only direct comparison of two levels of protein at a similar energy content. In this comparison, gains were 67 lb greater for cows receiving the higher protein supplement ($P<.01$). For cows supplemented with the lower level of protein increasing the level of energy from 3.92 to 10.64 Mcal ME per cow daily (or 1.74 to 7.41 lb of supplement dry matter) did not increase weight gains. When cows received the higher level of protein, increasing the supplemental energy from 7.78 to 10.91 Mcal ME per cow daily (or 3.07 to 7.56 lb of supplement dry matter) increased weight gains by 21 lb ($P<.01$). There was a tendency for the response to the high protein, high energy supplement to be greater for cows grazing the low forage available pasture.

This and previous trials show that amount of forage available has a major effect on cow gains that may be even larger than the amount of supplement fed. When forage is abundant, cows are able to select a diet that is higher in protein and more digestible. In an earlier trial at the Cottonwood Station providing .7 lb of supplemental protein improved cow weight gains for a 60 day winter grazing trial by 76 lb. Additional results from subsequent trials show that the primary concern for a winter supplementation program should be protein. The weight change advantage of supplying additional energy in the form of a high starch supplement like corn has been mixed. In one trial increasing the amount of corn improved performance and in another trial cows receiving more supplement actually gained less weight than cows than cows fed less supplement. This trial would indicate that if higher gains are desirable, the amount of protein per day should be increased for higher levels of supplement to be effective. This situation would be most likely when cows are thin at the beginning of the winter, grazable forage is limited and hay is expensive relative to grain. Under most situations supplemental protein in the form of alfalfa hay or an all natural high protein supplement will provide the greatest benefit in minimizing winter weight loss and body condition.

After the 1994 calving season, reproductive performance of the cows in this trial will be analyzed. Future winter supplementation studies will be conducted to evaluate the response to low starch supplements fed to cows grazing pastures of varying available forage.

Table 3. Effect of available forage and supplement treatment on cow performance

	Forage available			Low protein		High protein		
Item	High	Low	SE	Low energy	High energy	Low energy	High energy	SE
No. of cows	63	63		30	32	32	32	
Initial wt, lb	1125	1122	11	1126	1124	1120	1124	15
Gain, lb	96[a]	55[b]	4	48[a]	47[a]	93[b]	114[c]	5
Initial condition score	5.7	5.7	.1	5.6	5.7	5.7	5.7	.1
Condition score change	.5[a]	.2[b]	.1	.1[d]	.3[de]	.4[de]	.5[e]	.1

[a,b,c]Means within main effect with uncommon superscripts differ (P<.01).
[d,e]Means wihtin main effect with uncommon superscripts differ (P<.05).

EFFECTS OF LEVEL OF CONCENTRATE ON UTILIZATION OF MATURE PRAIRIE HAY BY STEERS

M. C. Namminga[1], R. J. Pruitt[2], and R. H. Pritchard[2]
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CATTLE 93-4

Summary

A trial involving total tract digestibility and ruminal in situ disappearance was conducted to determine effects of level of concentrate supplement on utilization of mature prairie hay by beef steers. Supplemental treatments included CONTROL (no supplement) and combinations of corn and soybean meal to provide .66 lb of ruminally degradable protein from increasing amounts of concentrate supplement (LOW = 2.16 lb/day, MEDIUM = 6.28 lb/day, and HIGH = 10.38 lb/day). Steers receiving higher levels of concentrate supplements (MEDIUM and HIGH) exhibited decreased intake ($P<.01$) and digestibility ($P<.01$) of mature prairie hay. Supplementation with the low level of high crude protein supplement (LOW) resulted in improved dry matter intake ($P<.01$) and digestibility ($P<.02$) of mature prairie hay. Apparent dry matter digestibility of the total diet increased ($P<.05$) as level of concentrate supplement increased. Supplementation with the high level of concentrate supplement (HIGH) decreased disappearance of dry matter ($P<.05$) and neutral detergent fiber ($P<.05$) from the rumen and depressed ruminal pH ($P<.01$) at 4, 8, and 12 hours post-supplementation. Results of this trial confirm the benefits of low levels of high crude protein, all natural supplements on utilization of mature forages and indicate that high levels of high starch supplements will depress utilization of mature prairie hay.

Key Words: Beef Cattle, Intake, Digestibility, Supplement, Mature Forage

Introduction

Protein is considered the most limiting nutrient in mature, low quality forages. Protein supplementation has been found to improve performance of cows by enhancing utilization through improved intake and digestibility. Research examining effects of high starch energy supplements such as corn on performance of beef cows consuming low quality forages has shown little benefit and in some cases, detrimental effects. Lack of improved performance or decreased performance from supplementation with high starch energy supplements such as corn has been shown to decrease utilization of forage as a result of decreased forage intake and fiber digestion. The objective of this study was to determine the effect of level of concentrate supplement on intake, digestibility, nutrient disappearance from the rumen, and ruminal pH of steers consuming mature prairie hay similar to native pastures used in grazing studies at the SDSU Range and Livestock Research Station near Cottonwood.

Materials and Methods

Four ruminally fistulated Angus steers (1257 lb) were used in a 4 x 4 Latin square design to examine effects of level of supplementation on intake, total tract digestibility, nutrient disappearance from the rumen and ruminal pH when fed mature prairie hay. The trial consisted of four 20-day periods. Each period included a 7-day adjustment phase, a 7-day intake measurement phase, and a

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6-day phase in which total fecal collections were made and ruminal nutrient disappearance and pH were measured. Steers were housed indoors in a continuously lighted, controlled temperature room (68^{o} F) with slatted floors (6 x 8 foot pens) and had continuous access to water and prairie hay. Iodized trace mineral salt was top dressed each time hay was offered to meet NRC recommendations for sodium in the diet.

Supplements fed in this trial were used in a previous winter grazing trial conducted at the SDSU Range and Livestock Research Station near Cottonwood (Table 1). The supplements were formulated to provide .51 lb of ruminally degradable protein to cows grazing dormant winter range. Supplements were pelleted (3/8 in. diameter) and balanced so that the total diet would exceed NRC requirements for calcium, phosphorus, and potassium. Steers were fed supplements at proportional amounts on a metabolic body weight basis ($BW^{.75}$) to what cows received in the winter grazing trial (Table 2). Supplements were fed daily at 0700 and were consumed within 30 minutes. Mature prairie hay (Table 3), harvested in late August near Midland, SD, was ground through a tub grinder (2 in. screen) and offered twice daily during intake, and total collection phases at 130% of each steer's hay intake during the adjustment phase.

During the intake and total collection phases, individual orts were weighed and refed in the mornings and collected each night with 10% aliquots kept for later analysis. Hay and supplement samples were taken each night. Feed and ort samples were dried in a forced air oven at 140^{o} F for 48 hours, weighed, composited by steer, ground through a Wiley mill (1 mm screen), subsampled, and stored in air tight containers. Hay, ort, and supplement samples were analyzed for ash content, acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein content. Hay samples were also analyzed for acid detergent lignin.

Table 1. Supplemental treatments[a]

Item	LOW	MEDIUM	HIGH
Soybean meal	81.35	21.28	8.44
Corn		71.18	86.40
Dicalcium phosphate	6.23	1.17	.09
Potassium chloride	9.91	3.86	2.56
Molasses	2.51	2.51	2.51

[a]Percentage on a dry matter basis.

Ruminal nutrient disappearance of mature prairie hay was estimated by an in situ technique. A representative sample of the mature prairie hay was ground through a Wiley mill (2 mm screen), oven dried (212^{o} F for 48 hours), and stored in an air tight container. Approximately 5 grams of the representative sample were placed in dacron bags (approximately 10 x 20 cm) and sealed with #8 rubber stoppers and rubber bands. On day 15 of each period, duplicate hay samples in

Table 2. Composition of average daily supplemental intake per steer

Item	LOW	MEDIUM	HIGH
Dry matter, lb	2.16	6.28	10.38
Crude protein, lb	.89	1.20	1.43
Ruminally degraded protein, lb[a]	.66	.65	.67
Metabolizable energy, Mcal[b]	2.50	8.52	14.80
Calcium, lb	.035	.024	.009
Phosphorus, lb	.039	.038	.038
Potassium, lb	.142	.178	.218

[a]Calculated values (NRC,1985).
[b]Calculated values (NRC,1984).

Table 3. Chemical composition of mature prairie hay[a]

Item	Composition
Dry matter, %	94.2
Crude protein, %	5.6
Ash, %	7.6
Calcium, %	.41
Phosphorus, %	.10
Potassium, %	.93
Neutral detergent fiber, %	68.2
Acid detergent fiber, %	40.2
Acid detergent lignin, %	5.3

[a]Dry matter basis.

dacron bags along with duplicate empty bags were hydrated in warm water (102° F) for 15 minutes and placed in unanchored lingerie bags (43 x 53 cm) inside of the rumen. Sample incubation times used were 0, 4, 8, 12, 24, 48, and 72 hours. Bags to be incubated in the rumen for 72 hours were placed in first followed by the remaining samples in reverse order. Zero hour bags were only allowed to hydrate in warm water for 15 minutes. Following incubation, all samples were removed from the rumen at the same time and hand rinsed in water filled buckets until rinse water was clear. Samples were then oven dried (140° F) for 12 hours, allowed to air equilibrate for 3 hours to room temperature, weighed, and analyzed for NDF content. Apparent dry matter and NDF disappearance from the rumen was then calculated from residues remaining after incubation. Blank bags were used to adjust for influx of particles into dacron bags.

Steers were fitted with harnesses and fecal bags on day 16 to determine total tract digestibility. Fecal collection lasted 5 days. Individual fecal bags were emptied twice daily and contents were weighed, thoroughly mixed, subsampled (10% aliquot), and frozen (-13° F). Fecal samples were later thawed, composited by steer, and subsamples were taken for dry matter analysis. Samples were oven dried (140° F) for 72 hours or until they reached a constant weight and were stored in air tight containers. Fecal samples were analyzed for total nitrogen, ash, NDF, and ADF.

Ruminal fluid samples were obtained from the steers at 0, 4, 8, 12, 16, and 24 hours postsupplementation on day 19. Approximately 300 ml of ruminal fluid were taken from each steer at respective sampling times. Ruminal fluid pH was immediately analyzed with a combination electrode.

Dry matter digestibility of mature prairie hay was calculated by difference assuming TDN values from NRC were equal to dry matter digestibility and were 90% and 86%, respectively, for corn and soybean meal. Apparent dry matter, nitrogen, ADF, and NDF digestibility coefficients were calculated by subtracting amount recovered in feces from the intake amount and dividing by the intake amount. Digestible dry matter intake was calculated by multiplying the digestion coefficient for each steer by its dry matter intake. Digestibility and intake data were analyzed by the GLM procedure of SAS appropriate for a 4 x 4 Latin square design. Orthogonal contrasts were used to test for linear, quadratic, and cubic treatment effects. Nonorthogonal contrasts were used to test CONTROL vs (LOW + MEDIUM + HIGH)/3, CONTROL vs LOW, and CONTROL vs HIGH.

Effects of concentrate supplements on in situ disappearance of dry matter and NDF were analyzed in a Latin square split plot design using the GLM procedure of SAS. Main effects in the whole plot included steer, period, and treatment with steer x period used as the error term. Incubation time, steer x incubation time, period x incubation time, and treatment x incubation time were included in the split plot with residual error used as the error term. Where significant treatment by hour interactions existed, data were analyzed within time. Orthogonal contrasts were used to test for linear, quadratic, and cubic treatment differences. Nonorthogonal contrasts were used to compare CONTROL vs (LOW + MEDIUM + HIGH)/3, CONTROL vs LOW, and CONTROL vs HIGH.

Results and Discussion

Dry matter intake of hay decreased (P<.01) in a cubic manner as level of supplement increased in the diet (Table 4). Supplementation with LOW increased (P<.01) dry matter intake while supplementation with HIGH decreased (P<.01) dry matter intake. Hay digestible dry matter intake paralleled hay dry matter intake. In contrast, total digestible dry matter intake increased (P<.01) quadratically as level of supplement increased in the diet.

Apparent diet dry matter digestibility increased (P<.05) quadratically as level of supplement increased in the diet (Table 5). This result would be expected since corn and soybean meal are much more digestible than hay. Apparent ADF and NDF digestibilities responded in a quadratic manner (P<.05 and P<.01, respectively) by decreasing as level of supplement increased in the diet. Apparent NDF digestibility was increased (P<.01) with LOW supplementation and decreased (P<.05) with HIGH supplementation. Apparent ADF digestibility was not affected by HIGH supplementation but was increased (P<.02) by LOW supplementation. Supplementation improved (P<.01) apparent nitrogen digestibility. Hay dry matter digestibility, which was calculated by difference assuming constant digestibilities of soybean meal and corn, decreased in a quadratic manner (P<.01) as level of concentrate supplement increased. Dry matter digestibility of hay was increased (P<.02) with LOW supplementation and decreased (P<.01) with HIGH supplementation.

Table 4. Daily intake of mature prairie hay and total diet of steers receiving different levels of concentrate supplement

	Treatments						Contrasts[d]		
Item	Control	Low	Med	High	SE[a]	P	1	2	3
DM intake/day									
Hay, lb	21.6	25.9	22.0	17.6	.71	.0009[b]	NS	.01	.01
Hay, % BW	1.5	1.9	1.6	1.3	.05	.0010[b]	NS	.01	.03
Total diet, lb	21.6	27.8	27.8	27.3	.68	.0024[b]	.01	.01	.01
Digestible DM intake									
Hay, lb	8.4	11.2	8.6	5.7	.33	.0179[c]	NS	.01	.01
Total diet, lb	8.4	13.0	14.1	14.6	.44	.0026[b]	.01	.01	.01

[a]Standard error of the mean.
[b]Probability of a quadratic response.
[c]Probability of a cubic response.
[d]Contrast 1 = Control vs (Low + Medium + High) / 3; Contrast 2 = Control vs Low; Contrast 3 = Control vs High; NS = nonsignificance (P>.10).

Table 5. Digestibility coefficients of diets containing mature prairie hay and different levels of concentrate fed to steers

	Treatments						Contrasts[d]		
Digestibility, %	Control	Low	Med	High	SE[a]	P	1	2	3
Apparent NDF	43.4	48.3	45.9	40.3	.86	.0009[b]	NS	.01	.05
Apparent ADF	39.9	46.1	41.2	39.3	1.35	.0238[b]	NS	.02	NS
Apparent nitrogen	26.0	49.8	44.5	46.5	1.53	.0019[c]	.01	.01	.01
Apparent dry matter	39.0	46.9	50.6	53.8	.71	.0157[b]	.01	.01	.01
Hay dry matter[e]	39.0	43.4	39.6	33.2	.92	.0011[b]	NS	.02	.01

[a]Standard error of the mean.
[b]Probability of a quadratic response.
[c]Probability of a cubic response.
[d]Contrast 1 = Control vs (Low + Medium + High) / 3; Contrast 2 = Control vs Low; Contrast 3 = Control vs High; NS = nonsignificance (P>.10).
[e]Based on constant digestibility of supplement using TDN values (NRC, 1984).

Supplementation with the high level of corn which was high in starch (HIGH) caused a depression in ruminal pH at 4, 8, and 12 hours following supplementation (Figure 1). Ruminal pH fell below 6.1 at 4 hours postsupplementation. Ruminal pH levels below 6.2 may inhibit growth of cellulolytic microorganisms which are responsible for fiber digestion in the rumen. The HIGH supplement depressed dry matter disappearance from the rumen (Figure 2). The LOW supplement did not improve dry matter disappearance from the rumen. NDF disappearance from the rumen was decreased at 4, 8, and 24 hour incubation times by HIGH supplementation (Figure 3). The LOW supplement did not improve ruminal NDF disappearance.

Crude protein levels in the diet less than 6.25% have been found to limit voluntary intake. The mature prairie hay used in this trial was analyzed at 5.6% crude protein so we would expect relatively low dry matter intake due to insufficient crude protein. Many researchers have observed benefits from providing low levels of high crude protein, all natural supplements to cattle consuming mature, low protein forage. This trial demonstrates that a small amount of supplemental protein enhances utilization of mature prairie hay through increased dry matter intake, digestible dry matter intake, and dry matter digestibility of hay.

Recent energy supplementation research has shown high levels of supplemental corn may be detrimental to the performance of cows consuming mature forages, even when protein requirements are met. Hay intake, digestibility, and ruminal disappearance of dry matter and NDF were decreased with additions of supplemental corn to the diet. Decreases in ruminal pH caused by high levels of starch in corn may have contributed in part to these depressions. Results of this trial illustrate the negative effects of high starch supplements such as corn on utilization of mature forages.

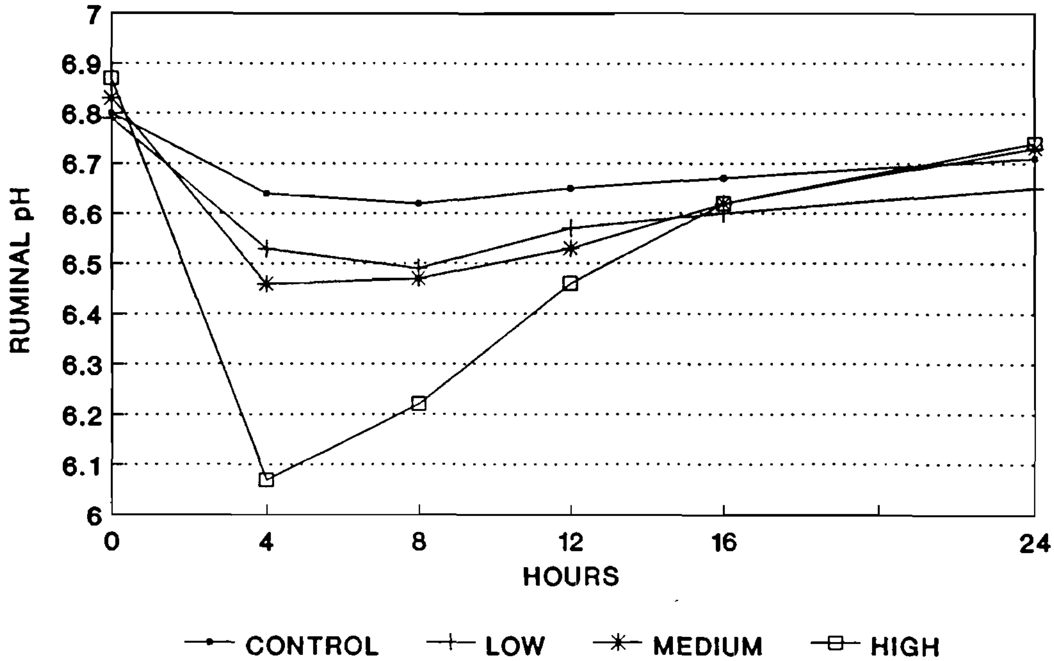

Figure 1. Ruminal pH measurements of steers consuming mature prairie hay and different levels of concentrate supplement over time. (The HIGH supplement differs ($P \leq .01$) from CONTROL at 4, 8, and 12 hours postsupplementation.)

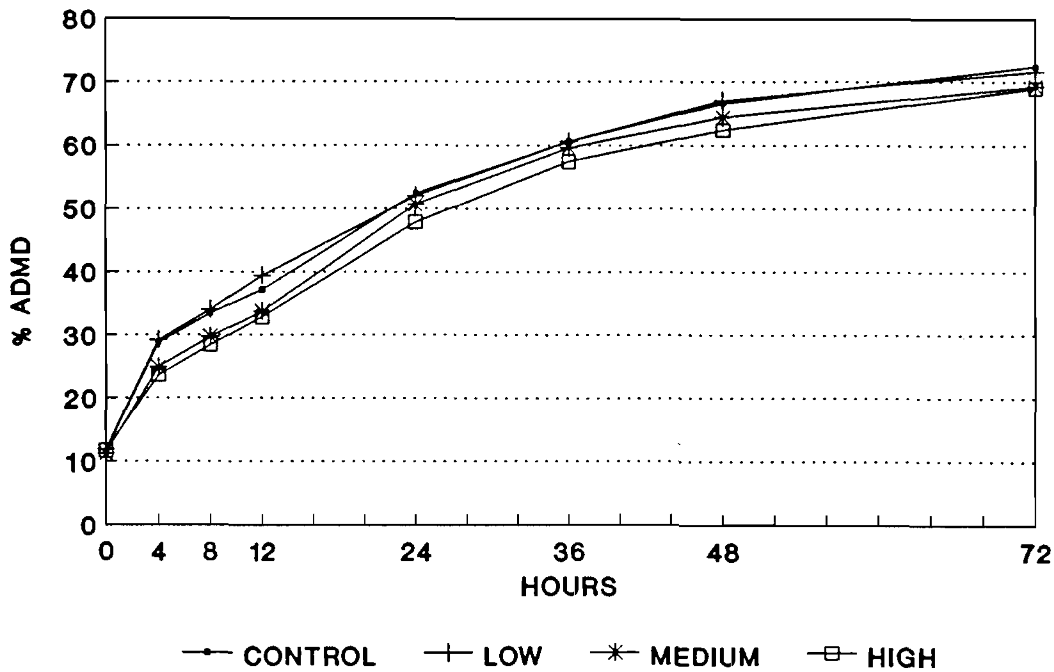

Figure 2. Apparent in situ disappearance of dry matter from dacron bags suspended in the rumen over time. (The HIGH supplement differs ($P \leq .05$) from CONTROL at 4, 8, 12, 24, 36, and 72 hour incubation times.)

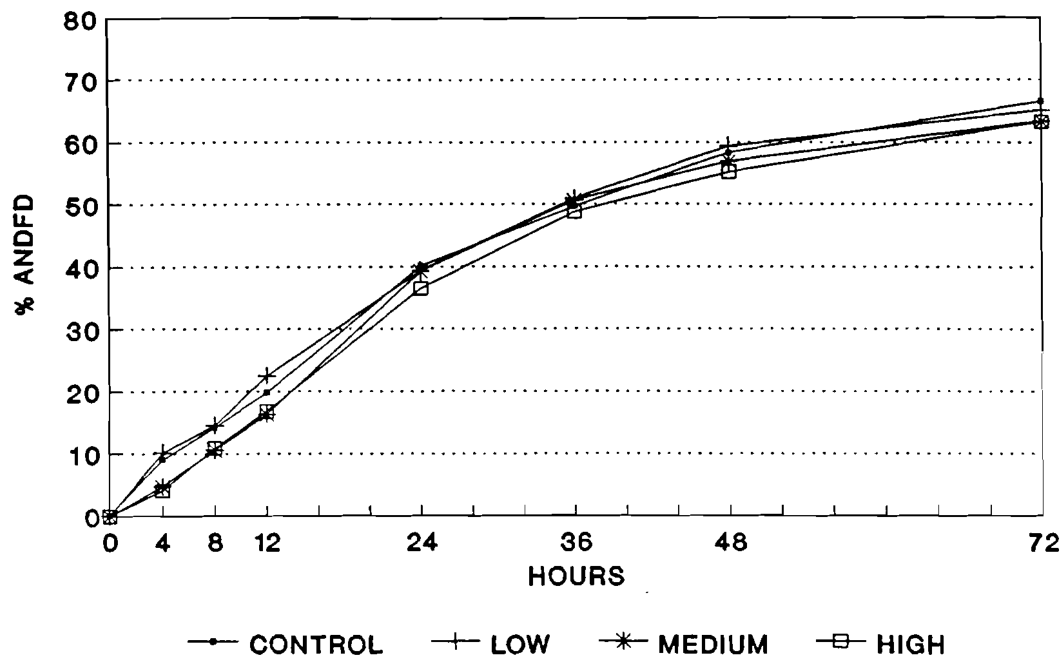

Figure 3. Apparent in situ disappearance of neutral detergent fiber from dacron bags suspended in the rumen over time. (The HIGH supplement differs ($P \leq .05$) from CONTROL at 4, 8, and 24 hour incubation times.)

AMMONIATED OAT HULLS FOR GROWING CALVES

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CATTLE 93-5

Summary

Eighty-one steer calves were fed growing diets that contained 50% of either 1) ground brome hay (BROME), 2) unground oat hulls (OH), or 3) unground oat hulls treated with 3% ammonia and enough water to raise the moisture content to 20% (NH_3-OH). Treated oat hulls were allowed to react for 63 days prior to feeding. Daily gains of NH_3-OH fed steers were 18 and 13% greater than those of OH and BROME fed steers, respectively, during the 88-day study (P<.01). Dry matter intakes were not affected by diet (P>.10). However, feed efficiency was 13% better for NH_3-OH fed steers than steers fed OH and 9% better than those fed the BROME diet (P<.05). Calculated NE_m and NE_g estimates for the brome hay, untreated and treated oat hulls used in this study were 53.9 and 31.9, 51.0 and 29.2, and 64.7 and 40.8 Mcal/cwt DM, respectively. Oat hulls respond well to ammonia treatment and may contain as much as 23% more net energy than brome hay in calf growing diets.

Key Words: Oat Hulls, Ammoniation, Growing Diets

Introduction

Oats have been an important crop in South Dakota for many years. In recent years, production has ranged from 46 to 87 million bushels. A portion of this crop is milled in or near the border of South Dakota, resulting in localized supplies of oat hulls. Oat hull use in cattle diets is limited because of its poor digestibility.

Techniques for chemical treatment of poor quality crop residues have been available for many years and have been demonstrated to increase digestibility and dry matter intake of residues such as wheat straw and corn stalks. Ammonia (NH_3) has become the most popular chemical for treatment mainly due to the readily available supply, ease of application, and contribution of N to the residue. Residues high in hemicellulose tend to respond best to NH_3 treatment, and moisture additions usually enhance the response. Oat hulls are high in hemicellulose and recent South Dakota work demonstrated substantial improvement in digestibility in vitro due to NH_3 treatment.

The objective of this study was to determine the effect of ammoniated oat hull based growing diets on weaned calf performance.

Materials and Methods

Treatment of oat hulls. Approximately 18 ton of cleaned, unground oat hulls were mixed in a mixer wagon with sufficient water to bring their moisture content up to 20% and then piled on bare ground. A length of plastic tubing had previously been laid on the ground such that the end was positioned in the middle of the pile and extended upward about 1½ feet into the oat hulls. The pile was then covered with a 6-mil black plastic sheet and sealed by burying the edges in an 8-inch deep trench. Two rows of tires were

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also placed around the edges of the plastic to help keep it in place. Anhydrous NH_3 was injected into the pile at a level equal to 3% of the oat hull dry weight. Based on previous work, the moisture and NH_3 addition levels were considered the minimum necessary for maximum response. The oat hulls were allowed to react with the NH_3 and water for 63 days before feeding.

Feeding trial. A group of 95 Charolais steer calves with an average weight of 590 lb were vaccinated (IBR, BVD, BRSV, Lepto and 7-way clostridium), dewormed (Ivermectin[3]), implanted (Synovex-S[4]), and ear tagged upon arrival at the feedlot. From these, 81 steers were randomly allotted to one of nine pens and fed growing diets containing 50% of either 1) ground brome hay (BROME), 2) untreated oat hulls (OH), or 3) NH_3-treated oat hulls (NH_3-OH). The balance of the diets consisted of rolled corn and supplement. Diet composition is presented in Table 1.

Initial and final weights were taken after overnight removal of feed and water. The steers were fed for 88 days.

Table 1. Test diet compositions (dry matter basis)

	Diet		
Item	BROME	OH	NH_3OH
Ingredient		Percent	
Rolled corn	41.27	32.23	32.65
Brome hay	50.00		
Oat hulls		50.00	
NH_3-oat hulls			50.00
Molasses	4.00	4.00	4.00
Soybean meal	2.73	11.35	11.35
Limestone	1.00	1.00	1.00
Dicalcium phosphate		.35	.35
Urea	.42	.42	
Trace mineral salt	.50	.50	.50
Premix[a]	.08	.15	.15
Analysis			
Dry matter	80.2	79.3	75.7
Crude protein	10.5	11.0	13.1
Natural	9.3	9.8	9.4
NPN	1.2	1.2	3.7

[a]Provided 180 mg Rumensin and 45,000 IU vitamin A per day.

[3]IVOMEC, MSD AGVET, Rahway, NJ, 90965.
[4]Syntex Animal Health, Des Moines, IA, 50303.

Daily weight gains (ADG) were analyzed appropriately for a completely random design to test for diet effects using the individual animal as the experimental unit with initial weight included in the model as a covariate. Feed dry matter intake (DMI) and feed efficiency (F:G) were analyzed using the pen as the experimental unit.

Results and Discussion

It was apparent during the study that the extent of ammoniation varied throughout the pile of oat hulls. Although the entire pile was obviously treated, the most intense NH_3 concentrations were present in the middle one third. There was only one point of NH_3 injection and this was in the middle of a pile that measured approximately 40 ft x 15 ft x 8 ft (LxWxH). The addition of water and the fact that NH_3 is water soluble may have reduced the migration of NH_3 throughout the pile and additional injection points would probably be necessary to treat larger quantities.

Overall, treatment of the oat hulls resulted in a decrease in NDF and an increase in crude protein content (75.65 vs 84.66% of DM and 9.87 vs 2.51% of DM, respectively). ADF content was not affected. These changes are typical of ammonia treatment. Dry matter content of the treated oat hulls fed during the study was 4.4 percentage points lower than calculated from original oat hull analysis and added water. This may have been due to the relatively slow rate at which oat hulls absorbed the water, allowing it to migrate downward in the pile where the majority of the oat hulls were removed for feeding. The remainder of the treated oat hulls not fed may have been drier than expected. Formulations were maintained on a dry matter basis.

Although formulated to contain at least 12% total crude protein, diets were lower due to the light test weight, low protein corn which was prevalent in this region at that time (Table 1). However, crude protein intakes for all treatments were above expected requirements, with 7% or less of the requirement covered by nonprotein N. Additionally, DMI for diets was slightly greater than expected based on energy content. Treatment differences likely reflect differences primarily in energy availability.

Performance data are presented in Table 2. Ammoniation of oat hulls resulted in an increase of 18% in ADG compared to steers fed untreated oat hulls ($P<.01$). ADG of NH_3-OH steers was also 13% greater than those of BROME fed steers ($P<.01$). ADG was greater in spite of the fact that DMI did not differ among treatments ($P<.10$). Intake is usually increased as a result of ammoniation due to increased rate of particle size reduction and digestion. Lack of intake response in this case may be due to the small initial particle size of the oat hulls. As a result of increased ADG but similar DMI, F:G of NH_3-OH fed steers was 13 and 9% better ($P<.05$) than that of OH and BROME fed steers, respectively.

The oat hulls used in this study were cleaned and not ground. Much of the oat hulls currently available are ground to increase bulk density and decrease transportation costs. It seems likely that similar responses would be seen with ground oat hulls since oat hulls are of small particle size already and further reduction would probably have limited effect. However, levels lower than those used in the test diets may be necessary to keep diets from becoming too dense which may reduce intake.

Additionally, it should be noted that, on occasion, ammoniation of feeds has apparently resulted in the occurrence of "crazy cow" syndrome. The fact that its occurrence is mainly associated with ammoniation of good quality forages (i.e., grass hay) instead of crop residues (i.e., wheat straw) is apparently due to the lack of soluble sugars in the latter. Oat hulls are similar to crop residues in this respect and not likely to be a problem. However, oat processing by-products often contain not only oat hulls but also considerable amounts of broken groats and it is not known if their presence could contribute to the formation of the compound thought to be responsible for the syndrome. In this case, caution may be advisable until more information is available.

Table 2. Performance data for steers fed growing diets containing brome hay (BROME), untreated oat hulls (OH), or oat hulls treated with ammonia (NH_3OH)

	Diet			
Item	BROME	OH	NH_3OH	SE
No. of steers	27	27	27	
Initial wt, lb	591	588	592	7.2
Final wt, lb	801[a]	794[a]	830[b]	6.7
Weight gain, lb/day	2.40[a]	2.31[a]	2.72[b]	.076
Dry matter intake, lb/day	17.6	17.8	18.1	.40
Feed:gain	7.35[c]	7.68[c]	6.67[d]	.206

[a,b]Means with different superscripts differ (P<.01).
[c,d]Means with different superscripts differ (P<.05).

Based on cattle performance and published values, NE_m and NE_g estimates for the brome hay, untreated oat hulls, and ammoniated oat hulls used in this study were 53.9 and 31.9, 51.0 and 29.2, and 64.7 and 40.8 Mcal/cwt DM, respectively.

In conclusion, these data suggest that oat hulls respond well to ammoniation and that, after treatment, they may contain as much as 23% more net energy than brome hay in calf growing diets. Ammoniated oat hulls are an effective substitute for conventional roughages in feedlot growing diets.

NET ENERGY OF SOYBEAN MILL RUN FOR GROWING CATTLE

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CATTLE 93-6

Summary

The objective of the experiment was to estimate the net energies for maintenance (NE_m) and gain (NE_g) of soybean mill run (SMR), a by-product typically containing about 90% soyhulls. Six steers with an average weight of 288 kg were alternately fed pelleted test diets at intakes varying from 3.6 to 9.4 kg per day in an energy balance experiment arranged in a crossover design. The test diets contained either 96.6% alfalfa (ALF) or 46.6% alfalfa and 50.0% soybean mill run (ALFSMR). Energy intake from feed and losses in feces and urine were determined from total collections. Energy lost as methane and heat were determined by indirect respiration calorimetry while the steers were fed and also while fasted. Dry matter (DM), neutral detergent fiber and acid detergent fiber digestibilities were greater ($P<.05$) for the ALF diet than the ALFSMR diet (66.7 vs 58.1%, 63.3 vs 52.5%, and 59.7 vs 45.6%, respectively). Diet protein digestibilities did not differ ($P>.20$). Fecal energy loss was greater for the ALF diet than the ALFSMR diet (41.8 and 34.9% of gross energy intake, $P<.01$), while urine and methane energy losses did not differ (2.6 vs 2.3% and 5.1 vs 4.8% of gross energy intake, respectively, $P>.20$). Diet digestible and metabolizable energy estimates (Mcal/kg of DM) were 2.56 and 2.21 for ALF and 2.83 and 2.51 for ALFSMR, respectively. Partial efficiencies of ME use for maintenance (k_m) and gain (k_g) did not differ between diets ($P>.20$). Using pooled k_m and k_g values, diet NE_m and NE_g estimates (Mcal/kg of DM) were 1.61 and .83 for ALF and 1.81 and .93 for ALFSMR, respectively. These data suggest that soyhulls, the major component of SMR, had NE_m and NE_g values of 1.98 and .99 Mcal per kg of DM, respectively.

Key Words: Soybean Mill Run, Soyhulls, Net Energy, Cattle

Introduction

Energy supplements are frequently used to support greater levels of production in cattle fed forage diets. The use of grain as an energy source in these situations can result in two problems. First, acidosis resulting from grain consumption that is too great or too rapid for the rumen to handle can reduce animal performance and health. Second, the drop in rumen pH reduces digestion of fiber provided by the forage.

The use of soyhulls instead of grain offers an alternative for energy supplementation that avoids these problems because soyhulls are highly digestible yet high in fiber and more slowly digested than grain. Net energy values for soyhulls and products containing soyhulls have been inferred from a variety of measures such as chemical analysis and animal performance but have not been directly determined.

Soybean mill run (SMR) is a widely available by-product of soybean processing that typically contains about 90% soyhulls. The objective of this study was to determine the net energies for maintenance (NE_m) and gain (NE_g) of SMR for growing cattle.

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[2]Former Graduate Assistant.

Materials and Methods

Six crossbred steers averaging 288 kg were tamed to lead and adapted to the metabolism facilities and collection procedures prior to the first collection period. The steers were paired by weight and allotted within pair to two groups which were alternately fed complete pelleted test diets containing either 96.6% sun-cured alfalfa (ALF) or 46.6% sun-cured alfalfa and 50.0% SMR (ALFSMR, Table 1). Alfalfa pellets were reground prior to mixing with other ingredients. SMR appeared to have been coarsely ground and was used as received. Based on chemical analysis, SMR was estimated to contain 90.9% soyhulls and 9.1% split soybeans. Test diets were fed at 90% of ad libitum for 7 days immediately prior to and 6 days during collection periods 1 and 3. Intakes were restricted to what was estimated to be 1.1 times the maintenance requirement for 7 days prior to and 6 days during collection periods 2 and 4. Groups were switched between test diets after collection period 2. Intakes ranged from 4.0 to 8.6 kg and 3.2 to 8.1 kg of dry matter (DM) for ALF and ALFSMR diets, respectively.

Table 1. Test diet compositions (dry matter basis)

	Diets	
Item	ALF	ALFSMR
Ingredient	—— Percent ——	
Alfalfa	96.6	46.6
Soybean mill run		50.0
Molasses	2.0	2.0
Trace mineral salt	.7	.7
Dicalcium phosphate	.7	.7
Analysis		
Gross energy, kcal/g	4.39	4.31
Crude protein, %	16.4	15.2
Neutral detergent fiber, %	51.0	52.4
Acid detergent fiber, %	33.0	34.3
Acid detergent lignin, %	8.2	3.6
Ash, %	9.0	7.7

Weights of feed offerings and refusals, feces, and urine were recorded during each collection period. With the exception of urine, samples were analyzed for DM, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and ash. All samples were analyzed for gross energy (GE) by complete combustion and crude protein (CP).

During each collection period, every steer spent two 23-hour periods in one of four indirect, respiration calorimeters for determination of oxygen consumption and carbon dioxide and methane production from which heat production was calculated. The calorimeters were designed to enclose only the animal's head but still allow free access to water and prescribed amounts of feed. Air flow through each calorimeter was measured by a dry gas meter and continuous samples of air were taken prior to entering and immediately after leaving the calorimeter. After collection period 4, the steers were fed the ALF diet at 1.65 times the estimated maintenance requirement for 2 weeks and then fasted for 5 days. Additional calorimetry measurements were taken on days 4 and 5 of the fast.

Digestible energy was calculated as feed GE minus energy lost in the feces (FE). Metabolizable energy (ME) was calculated as GE minus FE, urinary energy (UE), and energy in the form of methane (CH_4E). The partial efficiencies with which ME was used for maintenance (k_m) or gain (k_g) represent the change in energy retained in the body per unit change in ME consumed and were derived from a semilog regression of heat production on ME intake. Net energies for maintenance and gain were the product of ME and the respective partial efficiencies. The ME requirement for maintenance (ME_m) was the ME intake necessary to result in no gain or loss of energy by the animal.

The data were statistically analyzed for the discrete effects of diet and steer, with intake level included as a continuous variable. Least squares means adjusted for steer and intake are reported by diet.

Results and Discussion

Digestibility data are presented in Table 2. Dry matter, NDF, and ADF digestibilities were 14.8, 20.6, and 30.1% greater for the ALFSMR diet than the ALF diet ($P<.05$). In contrast, diet CP digestibilities were not different ($P>.20$). Differences in DM and fiber digestibilities are likely due to a large extent to less lignification of soyhull fiber as indicated by the acid detergent lignin (ADL) content of the ALFSMR diet compared to ALF (Table 1). The data suggest that SMR is considerably more digestible than forages, although not as digestible as corn grain. In general, level of intake did not affect digestibilities ($P>.20$). This may have been due to the fact that the diet components were of relatively small particle size prior to pelleting and would have had high rates of passage even at low intakes.

The partitioning of feed GE differed between diets only with respect to FE losses (Table 3). Fecal energy accounted for 34.9% of ALFSMR diet GE compared to 41.8% for the ALF diet ($P<.01$). Losses of UE and CH_4E did not differ between diets ($P>.20$) and were 2.6 and 5.1% of GE for ALF and 2.3 and 4.8% for ALFSMR diets, respectively. The DE and ME estimates for ALF were 2.56 and 2.21 Mcal per kg of DM and for ALFSMR were 2.83 and 2.51 Mcal per kg of DM, respectively.

Neither k_m nor k_g were affected by diet ($P>.20$). It is generally accepted that diet composition has little effect on k_m and test diet values were similar to those predicted by published equations. However, k_g usually increases with increasing metabolizability of the diet. As such, ALFSMR would be expected to have a k_g .06 units greater than ALF. Previous work suggests that pelleting eliminates metabolizability differences in k_g between forages. Additionally, because of their high fiber content, soyhulls result in a rumen volatile fatty acid profile more closely resembling that of forages than mixed diets with comparable ME content. Because partial efficiencies are typically estimated from metabolizability, either of these two factors, if not considered, could result in overprediction of k_g and ultimately NE_g.

Due to the absence of a diet effect on k_m and k_g, pooled estimates ($k_m = .73$, $k_g = .37$) were used in the calculation of NE_m and NE_g values. The ALFSMR diet contained 12% more NE_m and NE_g per kg DM than the ALF diet ($NE_m = 1.81$ vs 1.61, $NE_g = .93$ vs .83). Estimates of SMR NE_m and NE_g, calculated by difference, were 2.00 and 1.03 Mcal per kg DM. Assuming published NE_m and NE_g values for dehulled soybeans of 2.27 and 1.57 Mcal per kg DM, cleaned soyhulls would contain 1.98 and .99 Mcal NE_m and NE_g per kg DM, respectively. Previously reported estimates have ranged from 1.44 to 1.86 per Mcal NE_m and .86 to 1.22 Mcal NE_g per kg DM.

In summary, greater NE content of SMR compared to alfalfa was due solely to less FE loss. No differences in UE, CH_4E, or heat increment relative to GE content were observed.

Table 2. Test diet component digestibilities[a]

Component	Diet[b] ALF	Diet[b] ALFSMR	RSD[c]
	Percent		
Dry matter[d]	58.1	66.7	3.1
Crude protein	69.0	69.3	2.7
Neutral detergent fiber[d]	52.5	63.3	5.3
Acid detergent fiber[d]	45.6	59.7	6.3

[a]Covariately adjusted for intake level when significant.
[b]ALF = alfalfa diet, ALFSMR = alfalfa-soybean mill run diet.
[c]Residual standard deviation.
[d]Diet effect significant ($P<.05$).

Table 3. Energy partitioning[a]

Component	Diet[b] ALF	Diet[b] ALFSMR	RSD[c]
Fecal energy, $kcal\cdot BW^{-.75}\cdot d^{-1}$ [def]	129.7	108.4	15.9
Urinary energy, $kcal\cdot BW^{-.75}\cdot d^{-1}$ [e]	8.1	7.1	2.2
Methane energy, $kcal\cdot BW^{-.75}\cdot d^{-1}$ [e]	15.9	15.3	1.6
Energy digestibility, %	58.2	65.7	14.4
Energy metabolizability, %	50.4	58.1	4.5
ME_m, $kcal\cdot BW^{-.75}\cdot d^{-1}$ [g]	98.8	100.3	
k_m [h]	.73	.72	
k_g [i]	.40	.36	
Digestible energy, Mcal/kg DM	2.56	2.83	
Metabolizable energy, Mcal/kg DM	2.21	2.51	
Net energy for maintenance, Mcal/kg DM	1.61	1.81	
Net energy for gain, Mcal/kg DM	.83	.93	

[a]Covariately adjusted to gross energy intake of 310.4 $kcal\cdot BW^{-.75}\cdot d^{-1}$.
[b]ALF = alfalfa diet, ALFSMR = alfalfa-soybean mill run diet.
[c]Residual standard deviation.
[d]Diet effect significant ($P<.01$).
[e]Gross energy intake significant ($P<.01$).
[f]Diet x GE intake significant ($P<.05$).
[g]Metabolizable energy required for maintenance.
[h]Partial efficiency of ME used for maintenance.
[i]Partial efficiency of ME used for gain.

MATERNAL PERFORMANCE OF FIRST-CALF CROSSBRED BEEF COWS IN RELATION TO SIRE EXPECTED PROGENY DIFFERENCES (EPDs)

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CATTLE 93-7

Summary

Cumulative milk production of crossbred daughters of sires of several breeds was estimated using weigh-suckle-weigh procedures. Pooled-across-breed analyses were conducted to determine, in retrospect, relationships of sire expected progeny difference (EPD) values for milk and total maternal value to daughter milk yield and daughter's offspring weaning weight. The pooled coefficient for regression of daughter 214-day milk yield sire milk EPD was 13.4 lb/lb (residual correlation was .14). The overall mean estimated milk yield was 2,782 lb, suggesting that a difference in sire milk EPD of 1 lb corresponded to a difference of approximately .5% in cumulative daughter milk yield. The pooled coefficient for regression of daughter's offspring 214-day weight on sire total maternal EPD was 1.18 lb/lb (residual correlation was .17). Breeders who use sire milk and total maternal EPD values as selection tools should expect such selection to be effective, on average, but should also expect that a substantial proportion of individuals or small groups may not rank as predicted.

Key Words: Cattle, Expected Progeny Difference, Maternal, Milk

Introduction

Factors affecting observed differences in beef calf weaning weights include calf genetic potential for growth and dam milking ability. The increased availability of expected progeny difference (EPD) values for "milk" and(or) maternal value has given beef producers another tool for within-breed selection. A bull's total maternal weaning weight EPD refers to expected weaning weight differences in his daughters' offspring due to the cumulative effects of genes that he passes on to his daughters for maternal effect on weaning weight (presumably due primarily to milk production) and the genes passed on to his grandprogeny for preweaning growth. A bull's "milk" EPD refers to expected weaning weight differences in his daughters' offspring due only to differences in daughter maternal effect on weaning weight, separate and apart from differences in grandprogeny genetic potential for preweaning growth. Milk and total maternal EPD values are available not only for sires used extensively through artificial insemination but also frequently available for young, unproven bulls, such as those typically purchased by commercial cow-calf producers. It is important to test the validity of such information under typical commercial production conditions. The objective of this study was to examine the relationships of sire EPD values for milk and total maternal weaning weight (defined as milk EPD plus 1/2 direct weaning weight EPD) to the cumulative milk production of their crossbred daughters and to the weaning weights of the daughters' offspring.

Materials and Methods

Milk-yield estimates were measured on a different set of 2-year-old beef females each year from 1984 through 1990. These females were

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born at the Antelope Range Livestock Station in western South Dakota and then transferred to a drylot facility near Brookings as part of a production-efficiency experiment.

Milk production was estimated by the weigh-suckle-weigh method. Calves were separated from their dams in the evening. The following morning calves were weighed, allowed to nurse for approximately 15 minutes, and then reweighed. Milk yield was evaluated at various points throughout lactation, with a total of four measurements in 1984 and 1985, five measurements in 1986, and six measurements in each of the remaining years. Cumulative milk yields were estimated from lactation curves fitted for each cow. The lactation curve of each cow was fitted to the overall average length of lactation, 214 days. Calf weaning weights were linearly adjusted to 214 days of age. Calves were allowed access to a low energy creep feed.

Cows whose milk production was evaluated in this study were produced in four two-breed rotations: Simmental x Hereford, Angus x Hereford, Salers x Hereford, and Tarentaise x Hereford. Sires of the cows were Simmental, Angus, Salers, Tarentaise, or Polled Hereford bulls. Note that Polled Hereford bulls sired daughters of four breed types, whereas bulls of the other four breeds sired daughters of one breed type each.

The only records retained for analysis were for cows whose sires' 1992 EPD values were available from the respective breed associations. Records of 32 sires and 313 daughters remained after editing. Semen of 21 of these sires was obtained through commercial outlets, while the remaining 11 sires were purchased for use as natural service "cleanup" sires. A summary characterizing sire EPD and accuracy values is presented in Table 1. No data from this herd were reported to breed associations. Therefore, the data used in these analyses were independent of those used in the calculation of sire EPD values.

Relatively few sires were available within each sire breed for this study, so individual regressions (i.e., within breeding group) would have been subject to large sampling errors. Therefore, pooled-across-breed analyses were conducted to compute the regression of daughters' milk yield or daughters' offspring weaning weight on sire EPD. Statistical analyses accounted for the effects of breeding group, year, calf sex, and calf birth weight.

Results and Discussion

The overall average for 214-day milk yield was 2,782 lb. A 1-lb change in sire milk EPD corresponded to a change in daughter 214-day milk yield of 13.4 lb (Table 2). Direct interpretation of this coefficient is difficult because sire milk EPD is expressed in units of grandprogeny weaning weight rather than daughter milk yield. The regression of calf weaning weight on 214-day milk yield was .049 lb/lb, which equates to an additional 1 lb of calf weaning weight per additional 20.4 lb of cumulative milk. Assuming that the maternal effect on weaning weight is due completely to milk production, then the theoretical expectation for regression of daughter cumulative milk yield on sire milk EPD would be 20.4 lb/lb. Therefore, differences among daughters in milk yield were positively related to differences in sire milk EPD, although the magnitude of the relationship was somewhat less than expected (i.e., 13.4 vs 20.4 lb/lb) based on genetic evaluation theory.

A 1-lb change in sire total maternal weaning weight EPD corresponded to a change of 1.18 lb for daughter's calf weaning weight (Table 2). This regression value is very close to its theoretical expectation of one.

The value for pooled regression of daughter milk yield on sire milk EPD was approximately .5% of the overall mean milk yield. This suggests that a 1-lb change in sire milk EPD corresponded to a difference of approximately .5%, on average, in cumulative daughter milk yield.

Table 1. Numbers of sires and daughters, range and mean values for expected progeny difference (EPD), and mean accuracy values

Item	No. of sires	No. of daughters	Sire milk EPD, lb		Mean milk EPD accuracy	Sire total maternal weaning wt EPD, lb	
			Range	Mean[a]		Range	Mean
Polled Hereford	12	156	-21.8 to 16.1	2.03	.68	-19.6 to 22.7	11.6
Simmental	6	55	-3.3 to 11.5	4.06	.61	5.5 to 14.1	9.24
Angus	5	47	4.0 to 14.1	6.22	.64	14.1 to 26.9	21.1
Salers	5	26	-3.7 to 4.4	1.19	.45	-10.6 to -.2	-.99
Tarentaise	4	29	-1.3 to 3.1	.20	.92	-7.9 to 6.4	.84
Overall	32	313			.67		

[a]Each sire's EPD and accuracy values were weighted by the number of daughters.

Table 2. Pooled regressions of daughter production traits on sire expected progeny difference (EPD) values

Daughter production	Sire EPD	Regression coefficient[a] ± SE
214-day milk yield, lb	Milk EPD, lb	13.4 ± 5.29*
214-day calf wt, lb	Total maternal weaning wt EPD, lb	1.18 ± .40**

[a]The average change in daughter production per 1-lb change in sire EPD.
*P<.05.
**P<.01.

Results from the residual correlation analysis are presented in Table 3. Rather low, positive correlations were observed for daughter milk yield with both sire EPD values. Correlations of weaning weight with both sire EPD values were also relatively low and positive.

To examine the effect of including data from daughters of low accuracy sires on the results of this study, additional correlation analyses were conducted in which records from daughters of low accuracy sires (i.e., cleanup sires) were deleted. Data remaining after editing included 21 sires and 217 daughters. The mean accuracy value for sire milk EPD of remaining records was .86. Results of these analyses were very similar to those obtained from using the full data set. Correlations of sire milk EPD with daughter milk yield and daughter's offspring weaning weight were .15 and .21, respectively. Correlations of sire total maternal EPD with daughter milk yield and daughter's offspring weaning weight were .11 and .18, respectively. These results suggest that average relationships between sire EPD and actual daughter maternal production were not appreciably different for high-accuracy sires compared to low-accuracy sires. Genetic prediction theory indicates that the accuracy value for a mean EPD associated with a group of animals is greater than the accuracy associated with the EPD of an individual from the group.

Table 3. Residual correlation coefficients among sire expected progeny difference (EPD) values and daughter production traits

Item	Daughter 214-day calf wt	Sire milk EPD	Sire total maternal weaning wt EPD
Daughter 214-day milk yield	.52**	.14*	.14*
Daughter 214-day calf wt		.18**	.17**
Sire milk EPD			.84**

*P<.05.
**P<.01.

In interpreting the results of this study, it is important to consider some of the assumptions made and potential shortcomings of experimental methods. The procedures used to estimate cumulative milk yield may be less than perfect. Only 2-year-old cows, presumedly not yet at peak milk-producing potential, were included. Theoretical expectations for EPDs assume that bulls' EPDs were estimated with a high degree of accuracy, on average, and that the various bulls were mated to cows of similar average genetic potential for the traits evaluated. It is uncertain if or how heterosis for milk production and(or) calf growth would affect the prediction of crossbred daughter and grandprogeny performance from purebred sire EPDs compared to prediction of purebred descendant performance.

In summary, the results of this study suggest that differences among sires in milk and total maternal expected progeny difference values, on average, were positively related to actual crossbred daughter milk production and daughter's offspring weaning weight. While the magnitudes of such relationships were relatively modest in terms of selection response, they were reasonably consistent with theoretical expectations. Industry breeders who use sire milk and total maternal expected progeny difference values as selection tools should expect such selection to be effective, on average, but should also expect that a substantial proportion of individuals or small groups will not rank as predicted.

GENETIC PARAMETERS FOR CARCASS TRAITS IN BEEF CATTLE

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CATTLE 93-8

Summary

The recent scientific literature was reviewed to summarize genetic parameters for carcass traits in beef cattle. Heritability estimates were generally moderate to large, in agreement with previous literature estimates. This suggests good potential for making change through genetic selection for a given individual carcass characteristic. However, genetic improvement through multiple-trait selection would be slowed by several important genetic antagonisms between traits, suggesting the use of terminal breeding systems with complementary sire and dam genetic types. Individual and maternal heterosis estimates from age-constant analyses were numerically positive and quite large for fat thickness and tended to be numerically positive and small to modest in magnitude for most other carcass traits. Hence, potential contributions to improved carcass composition from crossbreeding would primarily result from genetic complementarity rather than heterosis. As the U.S. beef industry presumedly moves toward a more value-based marketing system, genetic concerns include 1) an apparent antagonistic genetic relationship between marbling and cutability in some populations, 2) the effect of increased leanness on maternal productivity, and 3) the extent to which terminal breeding systems can be used.

Key Words: Cattle, Body Composition, Breed Differences, Carcass, Genetic Parameters

Introduction

Beef cattle genetic improvement programs have traditionally focused primarily on growth traits. However, as consumers become more concerned with diet-health issues and as the beef industry focuses more on value-based marketing, then emphasis on body composition traits is expected to become increasingly important in the design of breeding programs. In order to compete with other sources of food protein, the beef industry must produce specified meat products in a predictable and cost-efficient manner. Beef breeders are faced with the challenge of utilizing diverse resources to produce cattle that are profitable to all segments of the industry and meat products that are in demand by consumers. To accomplish these goals, breeders need information on estimates of genetic parameters for a wide spectrum of traits in order to develop effective breeding schemes. The objective of this paper is to present a review of the scientific literature on genetic parameters for beef cattle carcass traits and relationships of carcass traits with growth traits.

Discussion

Heritability measures the extent to which observed (phenotypic) differences among individuals may be passed on from one generation to the next for a particular trait. Heritability varies from trait to trait and from population to population. Heritability estimates from the recent scientific literature were generally moderate to large for carcass traits in age-constant analyses (Table 1). Arnold et al. (1991) reported weight-constant heritabilities of .24, .46,

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Table 1. Heritability estimates for carcass traits (age-constant basis)

	Source[a]										
Trait	1	2	3	4	5	6	7	8	9	10	Avg
Carcass wt	.68	.43	.48	.44	.31		.33				.45
Longissimus muscle area	.28	.56	.40		.28		.01		.60		.36
Fat depth	.68	.41	.52		.24	.52					.47
Marbling score	.34	.40	.47		.33				.45	.23	.37
Est. cutability		.63[b]	.49		.23					.18	.38
Retail product wt	.38	.58		.45				.47			.47
Est. retail cuts per day of age										.30	.30
Fat trim wt	.94	.47		.50							.64
Fat trim percentage		.57									.57
Bone wt	.94	.57									.76
Bone percentage		.53									.53
Warner-Bratzler shear force		.31						.71	.09		.37
Sensory panel tenderness									.10		.10
Calpastatin activity								.70			.70

[a]Source	No. offspring	No. sires	Population
1. Koch et al. (1978)	377	64	Hereford
2. Koch et al. (1982)	2,453	370	Crossbreds
3. Benyshek et al. (1981)	8,474	1,524	Hereford field data
4. MacNeil et al. (1984)	5/sire	187	Crossbreds
5. Lamb et al. (1990)	824	95	Hereford
6. MacNeil et al. (1991)	4.25/sire	124	Several breeds
7. Reynolds et al. (1991)	139	30	Hereford
8. Shackelford et al. (1992)	555		Crossbreds
9. Van Vleck et al. (1992)	682	111	Crossbreds
10. Woodward et al. (1992)	8,265	420	Simmental field data

[b]Actual percentage retail cuts.

.49, and .35 for carcass weight, longissimus muscle area, fat depth, and marbling, respectively, in a study of 2,411 Hereford steers from 137 sires. These values support the common presumption that selection on individual carcass traits should generally be relatively effective in many beef cattle populations.

Both phenotypic and genetic correlations are presented in this paper. A phenotypic correlation expresses the observable or measurable association between two traits which can be influenced by both genetic and environmental factors, whereas a genetic correlation expresses the association between traits due only to genetic factors. From a genetic improvement standpoint, genetic correlations are of primary interest. A genetic correlation between two traits exists when genetic factors affecting one trait are not independent of the genetic factors affecting the second trait, the practical consequence being that selection for change in one trait will simultaneously cause change in the second trait whether intended or not. A correlation near zero indicates that the two traits are more or less independent of one another, whereas a correlation near -1 or 1 indicates a relatively strong association between the two traits. A favorable genetic correlation means that selection for improvement in one trait will also improve the correlated trait. An unfavorable or antagonistic genetic correlation means that selection for improvement in one trait might impede improvement in the correlated trait. An antagonistic genetic correlation does not necessarily mean improvement can't be made in both traits simultaneously, although improvement in one or both traits may be slowed as compared to selection for only one of the two traits.

Some readers might question why genetic parameters sometimes vary quite radically across different studies. Keep in mind that the values presented are only estimates of the true population parameters. The possible error associated with the estimation procedure can be quite large. Secondly, genetic parameters can vary across different populations and over time within a population. Another point which should be made is that some estimation procedures can result in estimated values that are outside the theoretical range of possible values. For example, correlations can range only from -1 to +1. However, estimates of correlations may sometimes lie outside that range.

Genetic and phenotypic correlations of carcass traits with preweaning and postweaning growth rate from age-constant analyses are presented in Table 2. Positive genetic and phenotypic correlations were found for preweaning and postweaning growth rate with carcass weight, longissimus muscle area, and retail product weight. Genetic correlations with carcass fat thickness were positive for preweaning growth (averaged .37) and quite variable for postweaning growth (ranged from -.20 to .62, averaging .13). Genetic correlations with preweaning and postweaning growth, respectively, averaged .36 and .52 for fat trim weight and .08 and .12 for fat trim as a percentage of carcass weight. Relatively weak negative correlations were observed between growth rate and cutability or retail product percentage. These values suggest selection for reduced carcass fatness could be somewhat antagonistic to increased growth rate, particularly for growth prior to weaning. From weight-constant analyses, Arnold et al. (1991) reported that fat thickness was negatively genetically associated with weaning weight (r_g = -.28) but positively associated with postweaning gain (r_g = .17).

The average genetic correlation between preweaning growth and marbling score was .39 (Table 2), indicating a moderate, favorable relationship between selection for increased weaning weight and increased marbling. The average genetic correlation between postweaning gain and marbling was .05, indicating near independence between the two traits, although the variation in estimates across studies (r_g ranged from -.62 to .48) indicates that the relationship may be quite different across different populations. Arnold et al. (1991) reported that marbling was uncorrelated with weaning weight (r_g = -.01) and positively correlated with postweaning gain (r_g = .54) on a weight-constant basis.

Age-constant genetic correlations among carcass traits (Table 3) suggest that selection for reduced carcass fat thickness would be compatible with selection for larger longissimus muscle area and improved cutability. A selection antagonism is indicated between decreased fatness and increased marbling. Arnold et al. (1991) also reported that reduced fat thickness was associated with larger longissimus muscle area (r_g = -.37) and reduced marbling (r_g = .19) in weight-constant analyses.

It is interesting to compare genetic correlation estimates involving marbling to those involving Warner-Bratzler shear force. Marbling is currently the primary factor used by the beef industry to evaluate carcass quality of young cattle. Marbling may be related to flavor, juiciness, and tenderness, although its relative

Table 2. Genetic and phenotypic correlations of carcass traits with growth traits[a]

	Phenotypic correlations		Genetic correlations	
	Weaning wt or preweaning gain	Postweaning gain	Weaning wt or preweaning gain	Postweaning gain
Carcass wt	.59 (1)	.74 (1)	.48 (1)	.78 (1)
	.61 (2)	.72 (2)	.73 (2)	.89 (2)
		.64 (5)	.94 (7)	.93 (5)
Longissimus muscle area	.23 (1)	.27 (1)	.16 (1)	-.07 (1)
	.25 (2)	.32 (2)	.49 (2)	.34 (2)
	.38 (5)	.34 (5)	.43 (3)	.48 (5)
Fat depth	.12 (1)	.32 (1)	.59 (1)	.62 (1)
	.31 (2)	.17 (2)	.04 (2)	.05 (2)
	.20 (5)	.29 (5)	.49 (5)	.05 (5)
		.24 (6)		-.20 (6)
Marbling score	-.05 (1)	.20 (1)	-.02 (1)	-.62 (1)
	.10 (2)	.07 (2)	.31 (2)	.15 (2)
	.15 (5)	.24 (5)	.71 (5)	.48 (3)
	.02 (10)		.16 (10)	
Cutability or retail product, %	-.29 (2)	-.15 (2)	-.03 (2)	-.13 (2)
	-.10 (10)		-.20 (10)	
Retail product wt	.59 (1)	.62 (1)	.37 (1)	.73 (1)
	.47 (2)	.66 (2)	.62 (2)	.73 (2)
		.74 (8)		.92 (8)
Fat trim wt	.35 (1)	.62 (1)	.40 (1)	.64 (1)
	.46 (2)	.37 (2)	.32 (2)	.40 (2)
Fat trim percentage	.31 (2)	.15 (2)	.08 (2)	.12 (2)
Warner-Bratzler shear force	.00 (2)	.02 (2)	-.05 (2)	.06 (2)
		-.12 (8)		-.44 (8)
Calpastatin activity		-.18 (8)		-.48 (8)

[a]Number in parenthesis is for the source of the estimate (see Table 1).

Table 3. Genetic (below diagonal) and phenotypic (above diagonal) correlations among carcass traits[a]

	Carcass wt	LMA	Fat depth	Marbling score	Est. cutability or retail product, %	Retail product wt	Fat trim wt	Fat trim %	Warner-Bratzler shear force	Sensory panel tenderness	Calpastatin activity
Carcass wt		.37 (1) .43 (2) .58 (5) .58 (11)	.42 (1) .36 (2) .38 (5)	.18 (1) .13 (2) .28 (5) .28 (11)	-.31 (1)	.84 (1) .84 (2)	.82 (1) .62 (2)	.34 (1)	.00 (2)		
Longissimus muscle area (LMA)	.02 (1) .44 (2) .65 (5) .80 (11)		-.08 (1) -.15 (2) .04 (5)	-.03 (1) .03 (2) .19 (5) .00 (9) .16 (11)	.27 (2)	.55 (1) .60 (2)	.07 (1) -.03 (2)	-.20 (2)	-.02 (2) -.05 (9)	.00 (9)	
Fat depth	.95 (1) .08 (2) .14 (5)	.03 (1) -.44 (2) -.04 (5)		.25 (1) .24 (2) .38 (5)	-.74 (2)	.07 (1) -.05 (2)	.65 (1) .77 (2)	.77 (2)	-.01 (2)		
Marbling score	-.33 (1) .25 (2) .64 (5) .38 (11)	-1.34 (1) -.14 (2) .57 (5) -.40 (9) .51 (11)	.73 (1) .16 (2) .73 (5)		-.37 (2) -.21 (5) -.15 (10)	-.04 (1) -.07 (2)	.35 (1) .36 (2)	.38 (2)	-.12 (1) -.18 (9)	.19 (9)	
Cutability or retail product %	-.11 (1)	.53 (2)	-.74 (2)	-.37 (2) -.36 (5) -.12 (10)		.23 (2)	-.91 (2)	-.98 (2)	.03 (2)		
Retial product wt	.80 (1) .81 (2)	-.02 (1) .72 (2)	.65 (1) -.34 (2)	-1.10 (1) -.02 (2)	.46 (2)		.38 (1) .13 (2)	-.19 (2)	-.07 (2) -.11 (8)		-.15
Fat trim wt	.90 (1) .45 (2)	.10 (1) -.28 (2)	.95 (1) .74 (2)	.33 (1) .42 (2)	-.91 (2)	.46 (1) -.12 (2)		.94 (2)	-.04 (2)		
Fat trim %	.13 (2)	-.48 (2)	.78 (2)	.34 (2)	-.98 (2)	-.44 (2)	.94 (2)		-.04 (2)		
Warner-Bratzler shear force	.00 (2)	-.28 (2) -.14 (9)	-.01 (2)	-.25 (1) -.53 (9)	-.16 (2)	.02 (2) -.08 (8)	.14 (2)	.16 (2)		-.70 (9)	.30 (8)
Tenderness		-.04 (9)		.74 (9)					-.96 (9)		
Calpastatin activity						-.20 (8)			.58 (8)		

[a]Number in parentheses is for the source of the estimate (see Table 1).

importance continues to be a topic of much debate. Shear force has been used primarily in research studies as a mechanical measurement of carcass tenderness. Unfortunately, genetic correlations (Table 3) indicate that selection for increased marbling would be expected to be antagonistic to selection for increased muscling, reduced carcass fatness, and increased retail product weight. On the other hand, genetic correlations of shear force with other carcass traits are either favorable or close to zero, suggesting that selection for improved shear force would be compatible with selection for improvement in most other carcass traits.

Another concern regarding possible antagonisms between traits are the effects of selection for leanness and muscling on cow maternal performance (e.g., fertility, mothering ability, etc.). There is little experimental evidence on genetic relationships between carcass traits of calves and maternal performance of their female relatives. Studies have indicated that a cow's own body condition can affect her rebreeding ability.

Heterosis estimates, expressed as percentages of straightbred means, were averaged across specific crosses within a study and then averaged across studies for a particular trait. Therefore, the values presented represent mean heterosis levels across many different breed crosses. The estimates included in Table 4 were from studies in which days fed or calf age was as a slaughter endpoint or statistical covariate. Individual heterosis estimates for carcass weight were consistently positive, as might be expected for a trait related to growth rate. Individual heterosis estimates for fat thickness were numerically positive and quite large (averaged 10.1%), indicating that crossbred cattle would tend to have fatter carcasses than their straightbred counterparts at a similar age or time on feed. Estimates of individual heterosis tended to be numerically positive and small to modest in magnitude for most other carcass traits. Maternal heterosis effects appear to be of minor importance for most carcass traits, although estimates for fatness were generally positive and quite large in some studies.

In general, it would appear that carcass composition tends not to be appreciably improved from heterosis. However, crossbreeding could potentially provide some benefit in carcass value through complementary blending of breeds. More importantly, so-called terminal-cross matings allow the use of dams that excel in maternal traits and sires that excel in growth and carcass traits, thus avoiding some of the problems associated with genetic antagonisms between traits which may occur in some straightbred breeding systems. The primary drawback to terminal breeding systems is that replacement females must be produced outside the terminal system, which may present a problem in some management situations such as relatively small herds.

In summary, as the U.S. beef industry presumably moves toward a more value-based marketing system, genetic concerns include 1) an apparent antagonistic genetic relationship between marbling and cutability (in some populations, at least), 2) the effect of selection for increased calf carcass leanness on maternal performance of females relatives, and 3) the extent to which terminal breeding systems can be used.

Table 4. Individual and maternal heterosis estimates (% of straightbred mean) for carcass traits averaged across breed crosses and studies

Trait	No. studies[a]	h_i, %	h_m, %
Carcass wt	12 (4)	6.5	3.6
Quality grade	6 (2)	1.6	.6
Marbling	7 (2)	3.8	-1.1
Fat depth	11 (4)	10.1	8.9
Kidney fat	6 (1)	4.9	7.6
Longissimus muscle area	9 (3)	4.1	3.3
Estimated retial product wt	2 (1)	6.6	2.2
Estimated cutability or retail product %	7 (1)	-.6	-2.5
Yield grade	1	5.4	
Estimated fat trim wt	1	3.8	
Fat trim %	1 (1)	6.3	12.7
Shear force	2 (1)	-6.7	.0
Dressing percentage	3	-.2	

[a]First number is the number of studies on which the value given for individual heterosis (h_i) is based. Number in parentheses is for maternal heterosis (h_m). References: Gregory et al. (1978); Drewry et al. (1979); Peacock et al. (1979, 1982); Bailey et al. (1982); Bertrand et al. (1983); Koch et al. (1983, 1985); Neville et al. (1984); Comerford et al. (1988); Arthur et al. (189); DeRouen et al. (1992).

CONVENTIONAL VERSUS HIGH ENERGY RECEIVING AND STEP-UP DIETS FOR FEEDLOT CATTLE

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CATTLE 93-9

Summary

Two hundred sixty-four yearling steers with an initial average weight of 730 lb were randomly allotted to 24 pens and fed ad libitum either conventional (CONV) receiving or step-up diets (hay content decreased from 50% to 40, 30, 20, and 10% of diet dry matter) or high energy (HE) diets (hay content was maintained throughout at 10% but wet corn distillers grain (WDG) decreased from 43% to 30, 20, 10, and 0%). The feeding of WDG in place of hay was designed to maximize energy intake while not overloading the rumen with starch during the grain adaptation period. Long grass hay was fed on day 1. Diets 1 through 4 were fed 7, 5, 6, and 4 days, respectively. Diet 5 (finishing diet) composition was the same for both treatments and was fed for 5 days. Average daily gain (CONV = 4.39 and HE = 4.41 lb per day) during the 28-day receiving/step-up trial was not affected by diet composition (P>.10). However, dry matter intake was 22% less (P<.001) for cattle fed the HE diets (16.0 vs 20.5 lb per day), resulting in a 23% improvement (P<.001) in feed efficiency (feed:gain 3.68 vs 4.76). Although HE diets also contained more protein than CONV diets, equal gains suggest protein was not limiting. The inclusion of low starch, high energy feeds such as WDG in receiving and step-up diets may improve efficiency but not rate of gain.

Key Words: Distillers Grains, Receiving, Step-up, Cattle

Introduction

Nutritional management of cattle during the first several weeks after arrival at the feedlot has a sizable impact on overall feedlot performance. Moving cattle quickly to a high energy finishing diet decreases cost of gain because purchase weight is recovered sooner and days on feed are reduced. However, increasing energy intake from high starch grain too rapidly can cause acidosis, founder, and liver abscesses which reduce rate and efficiency of weight gain. Ad libitum feeding of high energy diets throughout the receiving/step-up phase may be possible if roughage is replaced by a high energy, by-product feed containing little starch.

The objective of this study was to determine the effects of replacing most of the roughage in receiving and step-up diets with wet corn distillers grains (WDG), a high energy, low starch by-product feed, on yearling cattle performance during the first 28 days on feed.

Materials and Methods

A group of 298 crossbred yearling steers were vaccinated (IBR, BVD, BRSV and Lepto), ear tagged, and weighed upon arrival at the feedlot after being transported 1035 miles. From these, 264 steers were randomly allotted the same day to 24 pens and fed either a conventional receiving and step-up series of diets (CONV) in which hay was sequentially decreased from 50% to 40, 30, 20, and 10% or high energy diets (HE) initially containing WDG at 43% but sequentially

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reduced to 30, 20, 10, and 0% in which hay was held constant at only 10%. The balance of the diets consisted primarily of rolled corn. Hay was ground to pass a 3-inch screen. Long grass hay was fed in decreasing amounts on days 1 through 5. Diet 1 was topdressed beginning on day 2. Diets 1 through 4 were fed for 7, 5, 6, and 4 days, respectively. A common finishing diet containing 10% roughage and no WDG was fed for 5 days prior to weighing on day 28 of the study. All diets were offered in amounts necessary to permit ad libitum intake but minimize carryover. Bunks were weighed back as necessary. Diet compositions are presented in Table 1. The CONV diets were formulated to meet or exceed crude protein requirements. However, because of the high crude protein content of WDG, the HE diets contained considerable excess crude protein. Calculated NE_g values were 47.8, 51.6, 55.1, 59.6, and 64.1 Mcal per cwt dry matter for CONV diets 1 through 4 and the finishing diet (5), respectively. All of the HE diets were estimated to contain 63 to 64 Mcal per cwt, assuming WDG energy content equal to corn.

The steers were given BRSV booster and 7-way clostridial vaccines, dewormed (Ivermectin[3]), and implanted with either Synovex-S[4], Synovex-S + Finaplix-S[5] or Revalor[5] 20 days after arrival. Implants were equally represented in each pen. The weight on day 28 followed a 16-hour removal from water but not feed.

Daily gains were analyzed on an individual animal basis as a random design with initial weight included as a covariate. Feed dry matter intake and feed efficiency were analyzed on a pen basis as a random design.

Results and Discussion

Performance data for the first 28 days after arrival at the feedlot are presented in Table 2. Daily gains were considerable and probably due in part to weighing conditions. The steers had been transported 1035 miles to the feedlot and experienced a transit shrink of over 10%. However, although water was removed 16 hours prior to taking the 28-day weight, the steers had access to feed from the previous day. Differences in gut fill between initial and 28-day weights were likely but should not have affected treatment comparisons, since a common finishing diet was fed for 5 days prior to the 28-day weight. Intake of that diet averaged 22 lb of dry matter per day for both treatments. Daily gains were not affected by treatment ($P>.10$).

In contrast, daily dry matter intake of HE steers was 22% less than that of CONV fed steers ($P<.001$). This difference was evident across diets 1 through 4 but not with diet 5 (common finishing diet) as can be seen in Figure 1. The lower overall intake resulted in an improvement in feed efficiency of 23% for HE steers compared to CONV ($P<.001$). Because daily gains were virtually identical in spite of the higher protein levels of the HE diets, differences in intake and efficiency are more likely due to diet energy content. Unfortunately, it is not possible to calculate meaningful energy estimates for WDG based on steer performance and dry matter intakes because of likely gain inflation due to weighing conditions. However, if compared to published values for the other feeds in the diets, the metabolizable energy content of WDG necessary to result in similar gain from 22% less feed would have to be greater than its gross energy content prior to digestion and

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Table 1. Composition of conventional (CONV) and high energy (HE) diets fed during the receiving and step-up period (dry matter basis)

	CONV diets				HE diets				Finishing diet
Ingredient	1	2	3	4	1	2	3	4	5[a]
Rolled corn	40.78	54.93	64.93	74.93	40.64	54.93	64.93	74.93	84.93
Wet distillers grains					42.93	30.00	20.00	10.00	
Alfalfa hay	25.00	20.00							
Brome hay	25.00	20.00	30.00	20.00	10.00	10.00	10.00	10.00	10.00
Molasses	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Soybean meal	5.00								
Dicalcium phosphate	.60	.05	.05	.05		.05	.05	.05	.05
Potassium chloride		.16	.16	.16	1.40	.16	.16	.16	.16
Limestone	.63	1.52	1.52	1.52	1.90	1.52	1.52	1.52	1.52
Trace mineral salt	.50	.50	.50	.50	.50	.50	.50	.50	.50
Urea		.79	.79	.79		.79	.79	.79	.79
Premix[b]	.49	.05	.05	.05	.63	.05	.05	.05	.05
Analysis									
Crude protein, %[c]	13.1	11.9	12.0	12.0	20.4	22.0	17.8	13.8	12.0
NE_m, Mcal/cwt[d]	75.3	79.6	83.8	88.8	92.4	93.8	93.8	93.8	93.8
NE_g, Mcal/cwt[d]	47.8	51.6	55.1	59.6	63.2	64.2	64.2	64.2	64.1

[a]Common finishing diet.
[b]Provided Bovatec at 16.75 mg and vitamin A at 2321 IU per lb DM in diets 2 through 5.
[c]Chemical analysis.
[d]Calculated.

Table 2. Feedlot performance of yearling steers fed conventional (CONV) or high energy (HE) diets during the receiving and step-up periods (first 28 days on feed)[a]

Item	Diets		SE
	CONV	HE	
No. of steers	132	132	
Initial weight, lb	730	730	5.6
Weight gain, lb/day	4.39	4.41	.120
Dry matter intake, lb/day[b]	20.5	16.0	.09
Feed:gain[b]	4.76	3.68	.155

[a]Least squares means.
[b]Diet effect significant (P<.001).

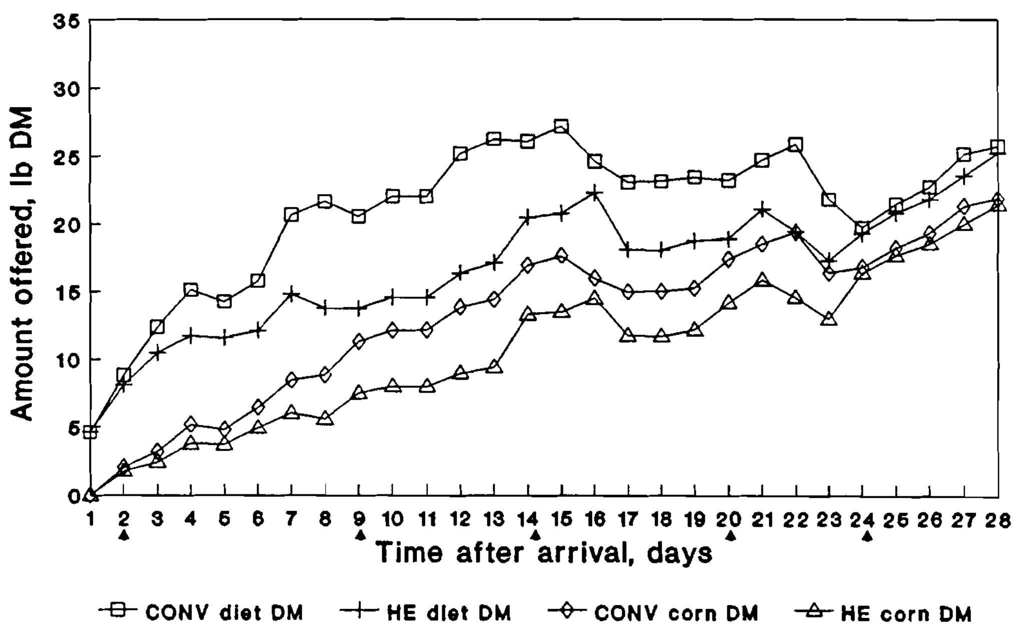

Figure 1. Daily feed/corn dry matter of conventional (CONV) and high energy (HE) diets offered. Arrows indicate diet switches.

metabolism, something which is clearly impossible. This implies that the presence of WDG improved utilization of the other feeds in the HE diets, an effect commonly referred to as a positive associative effect. In contrast, previous South Dakota research suggested that the energy content of WDG at up to 30% of finishin g diet dry matter appeared to be similar to rolled corn and did not alter the energy value of other feeds during a 110-day feeding period. The specific cause of a positive associative effect in the current study, if present, is unknown. Stresses of shipping and diet adaptation may have substantially altered interactions among nutrients.

No visible signs of acidosis and founder were evident in cattle on either treatment. Much of the energy contained in WDG is in the form of fat which is absorbed in the small intestine and corn fiber which is fermented in the rumen more slowly than starch. This should result in reduced acid load in the rumen and associated problems compared to diets with comparable energy coming from starch. Likewise, no treatment differences in incidence of other health problems (i.e., respiratory illness, bloat, coccidiosis, and footrot) were observed (P>.10).

In conclusion, these data suggest that intake during the receiving/step-up phase is not limited by bulk in diets containing up to 50% coarsely ground roughage. As a result, rate of gain would not be expected to improve by increasing the energy density of the diets above this level. However, considerable improvement in efficiency may be possible by increasing energy content by inclusion of high energy by-products, especially if they result in positive associative effects, as seems to be the case with WDG. Increasing diet energy content in this way does not perceptibly increase the risks of starch overload.

EFFECTS OF ADMINISTERING PROGESTERONE OR PROGESTERONE AND GnRH ON AGE AT PUBERTY IN CROSSBRED BEEF HEIFERS

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CATTLE 93-10

Summary

A study using 143 replacement beef heifers was conducted over a 3-year period to determine the effects that progesterone or progesterone and gonadotropin releasing hormone (GnRH) would have on age at puberty in beef heifers. Progesterone treated heifers were 21.8 and 38.9 days younger ($P<.05$) at puberty than control heifers in the first 2 years of the study, while progesterone plus GnRH treated heifers were 35.4 days ($P<.01$) and 31.2 days ($P<.05$) younger than controls. No difference ($P>.05$) in age at puberty was detected between groups in the third year. While progesterone and progesterone plus GnRH treated heifers had a higher conception rate ($P<.01$) to AI than controls in the first year of the study, calving records showed they experienced a higher rate of embryonic loss. However, calving rate still remained higher than in the control group. These differences were not observed in the second year and calving data for the final year of the study is currently not available.

Key Words: Beef Heifers, Puberty, Progesterone, GnRH, Fertility

Introduction

Replacement beef heifers must calve early in the calving season at 2 years of age to achieve maximum lifetime calf productivity. This implies that yearling heifers must be bred successfully in the early portion of the breeding season. Under typical production conditions, some replacement heifers will not reach puberty until after the onset of the breeding season, and a larger proportion will be in their first estrous cycle at first service. This situation is undesirable since improved conception rates have been realized when heifers are bred on their third or fourth estrus in comparison to the first. Therefore, methods which cause puberty to occur in heifers at an earlier age may be useful and economically advantageous to the producer, since induction of an earlier puberty will in turn cause more heifers to be cycling before the beginning of the breeding season. Several previous studies which have utilized hormone administration to prepuberal heifers to induce puberty at an earlier age have met with varying levels of success.

The following study was conducted to determine the effects that administration of progesterone, alone or in combination with gonadotropin releasing hormone (GnRH), would have on age at puberty and the subsequent breeding success in crossbred beef heifers.

Materials and Methods

The study was conducted over a 3-year period on the campus of South Dakota State University. One hundred forty-three crossbred beef heifers raised at the Antelope Range Livestock Station in northwestern South Dakota were randomly assigned to one of three treatments in late winter following weaning.

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Table 1 lists the number of days before the breeding season when treatments were applied and the average age and weight of the heifers at time of treatment according to year. Heifers assigned to treatment 1 were designated as controls and did not receive any hormone treatment. Heifers assigned to treatment 2 were given a Synchromate-B[4] norgestomet implant for 9 days. Heifers assigned to treatment 3 in the first 2 years of the study also received a norgestomet implant for 9 days. Upon removal of the norgestomet implant, a GnRH[5] implant was given for the following 9 days. In the last year of the study, heifers in treatment 3 were given a 2 mL injection containing 1000 μg GnRH subcutaneously following the norgestomet implant removal.

Table 1. Age and weight of heifers at time of hormone treatment

Year	Days before breeding season	Age, days	Wt, lb
1991	97	319	642
1992	120	291	604
1993	109	308	619

Blood samples were collected from all heifers via jugular venipuncture on a weekly basis beginning on the day of progesterone implantation. Upon centrifugation, blood sera was collected and progesterone concentration from each sample was determined with a one-step radioimmunoassay procedure. Samples containing a progesterone concentration exceeding 1 ng/mL were indicative of a functional corpus luteum at the time of collection. When a weekly sampling procedure is used, the exact sequence of high and low progesterone levels will vary from heifer to heifer since the normal luteal phase in the bovine lasts from 10 to 14 days. A heifer was considered to be cycling when her blood serum progesterone levels were over 1 ng/mL for 1 to 2 bleedings, followed by a decrease during the next 1 to 2 bleedings, which was succeeded by a similar fluctuation in progesterone over the next 3 to 4 weeks. Date of puberty was estimated to be 5 days before the first elevated progesterone concentration appeared. All heifers were weighed on a periodical basis and weight at puberty was calculated for each heifer through extrapolation of the two weighings most closely associated with the date of puberty.

In early May a 45-day breeding season was begun for each year. A 21-day artificial insemination period was followed by placement of a cleanup bull with the heifers until termination of the breeding season. Blood samples were collected weekly for four weeks from those heifers detected in estrus to monitor progesterone concentrations. Heifers displaying elevated levels of progesterone for 3 or more consecutive bleedings were considered to be pregnant. Pregnancy rates to the overall breeding season were determined via rectal palpation 60 days after the end of the breeding season. Pregnancy to AI was also determined through examination of the subsequent calving dates in the first two years of the study. Neither palpation or calving data for the 1992 born replacement heifers was available at the time of publication. Conception data derived from the progesterone assays were compared with the calving data in the first 2 years of the study to determine early embryonic loss.

Ten heifers had progesterone concentrations over 1 ng/mL on the first bleeding and were removed from the study. One heifer included in the 1993 study group never cycled and was also removed. The remaining 132 heifers cycled at least once during the period in which they were under study and were included in the analysis. Statistical analyses of age and weight at puberty

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by treatment were performed using the GLM procedures of SAS. Chi-square analysis was performed for the pregnancy data.

Results and Discussion

Age and weight at puberty for each treatment group within year is reported in Table 2. Progesterone treated heifers were 21.8 days and 38.9 days younger (P<.05) at puberty than control heifers in 1991 and 1992, respectively, although there was no difference in age in 1993. Progesterone plus GnRH treated heifers were 35.4 days younger in 1991 (P<.01) and 31.2 days younger in 1992 (P<.05) than control heifers. Age at puberty for these two groups in 1993 was not different. The lack of difference between treatment groups for age at puberty in 1993 may be partially attributed to the small number of heifers used in that year (n = 28).

There was no significant weight difference at puberty between progesterone treated and control heifers in 1991 and 1993. Progesterone treated heifers weighed 71.1 lb less at puberty than nontreated heifers in 1992 (P<.05). Progesterone plus GnRH treated heifers weighed 49.8 lb less at puberty than control heifers in 1991 (P<.05), but no differences were observed in 1992 and 1993. Since hormone treated heifers weighed less at puberty than controls, this suggests that the hormones used in the treatments accelerated physiological changes associated with puberty rather than causing puberty to occur because of increased body weights.

Table 2. Effects of progesterone and progesterone plus GnRH on age and weight at puberty

	Treatment		
	Control	Progesterone	Progesterone plus GnRH
1991			
Number of heifers	20	22	23
Age at puberty, days[a]	372.1 (6.8)[c]	350.3 (6.5)[b]	336.7 (6.4)[b]
Wt at puberty, lb[a]	703.8 (16.5)[b]	661.4 (15.7)[bc]	654.0 (15.4)[c]
1992			
Number of heifers	13	13	13
Age at puberty, days	351.9 (10.3)[c]	313.0 (10.3)[b]	320.7 (10.3)[b]
Wt at puberty, lb	711.5 (20.0)[c]	640.4 (20.0)[b]	665.2 (20.0)[bc]
1993			
Number of heifers	9	9	10
Age at puberty, days	360.7 (12.2)	352.9 (12.2)	352.0 (11.5)
Wt at puberty, lb	701.6 (26.9)	685.1 (26.9)	697.1 (25.5)

[a]Least squares means followed by standard errors.
[b,c]Means within a row lacking a common superscript letter differ (P<.05).

Table 3 lists the pregnancy rate to AI (according to progesterone concentrations), pregnancy to the overall breeding season, calving rate to AI, and overall calving rate. Pregnancy to AI according to progesterone differed among treatment groups in 1991 at the .01 level, although calving rate to AI for these heifers differed among treatment groups at the .05 level. No other differences in any year were detected. Although hormone treated heifers in 1991 had higher pregnancy rates to AI than controls, the reduced difference between groups at calving suggests that hormone treated heifers also had a higher rate of embryonic loss. This trend was not apparent in 1992.

The results of this study suggest that administration of progesterone or progesterone and GnRH to prepuberal heifers will cause puberty to occur at an earlier age. While heifers given progesterone plus GnRH were younger at puberty than their contemporary controls in 1991 and 1992, no such difference was noted in 1993. This may be explained by the mechanism of GnRH administration. In the first 2 years of the study a GnRH implant was given, whereas the heifers in 1993 received a GnRH injection. It is possible that the injection did not provide as prolonged a release as the implant, although it is difficult to determine if the progesterone plus GnRH treatment was ineffective for this reason. Since heifers treated with progesterone only did not reach puberty at an earlier age in that year either, the small number of heifers used in that year made it difficult to statistically determine any differences between treatments. While administering the hormone treatments immediately before the breeding season may not show a difference in age at puberty between treated heifers and controls, several reports have cited heifers must be of sufficient age and size to be able to respond to the hormone therapy as well. Our results suggest that administration of progesterone or progesterone plus GnRH are both effective in induction of puberty when given to heifers 97 to 120 days before the breeding season.

Table 3. Pregnancy and calving rates to AI and overall breeding season

Year/treatment	No. heifers	Pregnancy to AI[a]	Pregnancy to season[a]	Calving to AI[a]	Calving to season[a]
1991					
Control	20	8 (40.0)[c]	18 (90.0)	6 (30.0)[e]	18 (90.0)
Progesterone	22	15 (68.2)[b]	19 (86.4)	11 (50.0)[d]	19 (86.4)
Progesterone plus GnRH	23	19 (82.6)[b]	22 (95.7)	13 (56.5)[d]	21 (91.3)
1992					
Control	13	8 (61.5)	12 (92.3)	6 (46.2)	11 (84.6)
Progesterone	13	11 (84.6)	13 (100.0)	9 (69.2)	12 (92.3)
Progesterone plus GnRH	13	8 (61.5)	12 (92.3)	5 (38.5)	10 (76.9)
1993					
Control	9	6 (66.7)	NA[f]	NA	NA
Progesterone	9	9 (100.0)	NA	NA	NA
Progesterone plus GnRH	10	7 (70.0)	NA	NA	NA

[a]Actual values followed by percentage.
[b,c]Means within a column within year lacking a common superscript letter differ ($P<.01$).
[d,e]Means within a column within year lacking a common superscript letter differ ($P<.05$).
[f]Data not available at this time.

SAMPLING OF LARGE ROUND AND LARGE SQUARE BALES

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CATTLE 93-11

Summary

Four hay probes were used to sample four lots of hay. The lots of hay were as follows: alfalfa large round bales, alfalfa large square bales, alfalfa-grass mix large round bales, and alfalfa-grass mix large square bales. Probes used were as follows: E-Z Probe, John Skogberg handcrafted probe, Utah Hay Sampler, and Frontier Mills probe. Six bales from each lot were sampled. Dry matter (DM), crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) percentages and relative feed value (RFV) were predicted by near infrared reflectance spectroscopy. Bale variation within hay type was much greater than probe variation. Bale variation was significant for all measurements except DM. Probe type only affected NDF% and RFV.

Key Words: Hay Probes, Sampling Technique, Forage Analysis

Introduction

Forage analysis is a widely used tool for balancing rations for ruminant animals and for marketing hay. Laboratory personnel and producers are both concerned with the accuracy of forage quality analyses. Sampling of hay can be the greatest source of variation of hay analysis. To improve accuracy of sampling, it is recommended that a hay probe be used to take several samples ("probes") throughout a lot of hay. There are several hay probes commercially available and some producers make their own. The objectives of this experiment were to examine the variation of laboratory forage quality constituents due to probes and variation due to differences between bales sampled.

Materials and Methods

Four probes were used to sample four lots of hay. Six random bales within each lot were sampled with each probe. The side of the bale to be probed was assigned four regions, and probes were randomly assigned to regions within each bale sampled.

The probes used in this experiment represent the types often used in South Dakota. Probes used and their dimensions were as follows: 1) E-Z Probe (Techniserve, Inc., Madras, OR) - 1/2-in. internal diameter and 30 in. coring tube with attached canister; 2) a handcrafted probe (John Skogberg, Belle Fourche, SD) - 2 in. internal diameter and 30 in. coring tube with a serrated tip; 3) Utah Hay Sampler (c/o Judy A. Gale, Logan, UT) - 1/2 in. internal diameter and 19 in. coring tube with a serrated tip, auger-like threads on sampling end of coring tube, and attached canister; 4) Frontier Mills (Yankton, SD) -7/8 in. internal diameter and 30 in. coring tube with a serrated tip, auger-like threads on sampling end of coring tube, and attached canister. A 1/2-in. electric drill was attached to probes to take samples.

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The lots of hay probed were chosen to be representative of hay types and packages typical to South Dakota. The four lots were as follows: 1) alfalfa, large round bales (ALR); 2) alfalfa, large square bales (ALS); 3) alfalfa and grass mix, large round bales (MLR); and 4) alfalfa and grass mix, large square bales (MLS).

Forage quality constituents of all samples were predicted by near infrared reflectance spectroscopy (NIRS) using ISI software (Intrasoft International, University Park, PA), including DM, CP, ADF, and NDF percentages. Relative feed value (RFV) was calculated using the equation recommended by The Hay Marketing Task Force of the American Forage and Grassland Council.

Data were analyzed by the General Linear Model of SAS (SAS Institute, Cary, NC) for a nested factorial design using bales within hay type as an error term.

Results and Discussion

The four lots of hay were different for all measurements ($P<.01$, Table 1). All measures of bales within lots were different except DM ($P<.01$, Table 2). The means and ranges of means for all bales for DM, CP, ADF, and NDF percentages and RFV are 96.4 (96.0-96.9), 15.4 (14.3-16.2), 34.9 (33.8-36.2), 49.9 (48.4-52.0), and 122.7 (118.6-129.0), respectively. While these ranges are not as large as reported by Martin et al., (1992), it agrees with the recommendation for multiple samples within a lot.

Means of samples taken by four probes are given in Table 3. The probe used did not affect DM, CP, or ADF percentages. Samples taken by the Utah Hay Sampler were lower for NDF% ($P<.05$) and higher for RFV ($P<.01$). The interaction of probe x hay type for RFV tended to be significant ($P<.07$) due to greater variation between bale in alfalfa lots than alfalfa-grass mix lots. The ranges of means of DM, CP, ADF, and NDF percentages and RFV for the four probes are 95.8-96.5, 15.2-15.7, 34.4-35.1, 49.0-50.1, and 119.9-127.2, respectively.

In conclusion, bale variation is substantially higher than variation associated with different probes, even though NDF% and RFV were affected by one probe. This study further showed the need to sample several bales in a lot. Also, the data suggest sampling alfalfa-grass mix hay lots may be less difficult to sample than pure alfalfa hay lots, perhaps due to more leaf and stem separation of alfalfa during baling.

Acknowledgements

The authors gratefully acknowledged Lee Tucker, Experiment Station Statistician, for assistance with statistical analysis.

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Table 1. Analyses results by hay type

Measure	ALR[a]	ALS[a]	MLR[a]	MLS[a]	Significance[b]
n	24	24	24	24	
DM, %	97.1	97.2	95.9	95.4	NS
CP, %	21.1	20.4	9.1	10.9	**
ADF, %	30.7	29.5	39.0	40.4	**
NDF, %	40.3	38.4	61.4	59.6	**
RFV[c]	151.9	159.9	88.7	90.5	**

[a]ALR = alfalfa, large round bales, ALS = alfalfa large square bales, MLR = alfalfa-grass mix, large round bales, MLS = alfalfa-grass mix, large square bales.
[b]NS = nonsignificant, ** = P<.01.
[c]RFV = relative feed value.

Table 2. Analyses results by bale number

Measure	1	2	3	4	5	6	Significance[a]
n	16	16	16	16	16	16	
DM, %	96.9	96.6	96.3	96.2	96.4	96.0	NS
CP, %	15.7	16.2	15.6	14.3	16.0	14.4	**
ADF, %	33.8	35.0	34.2	35.0	36.2	35.1	**
NDF, %	48.7	49.1	48.4	50.7	50.7	52.0	**
RFV[b], %	129.0	121.4	126.0	119.9	118.6	121.5	**

[a]NS = nonsignificant, ** = P<.01.
[b]RFV = relative feed value.

Table 3. Analyses results by probe type

Measure	EZ[a]	SK[a]	UT[a]	YK[a]	Significance[b]
n	24	24	24	24	
DM, %	96.4	96.9	95.8	96.5	NS
CP, %	15.2	15.2	15.7	15.3	NS
ADF, %	34.9	35.1	34.4	35.1	NS
NDF, %	50.1	50.6	49.0	50.0	*
RFV[c]	122.6	119.9	127.2	121.3	**

[a]EZ = E-Z Probe, SK = handcrafted probe, UT = Utah Hay sampler, YK = Frontier Mills probe.
[b]NS = nonsignificant, * = P<.05 ** = P<.01.
[c]RFV = relative feed value.

ROLE OF SUPPLEMENT FORM FOR FINISHING YEARLING STEERS

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CATTLE 93-12

Summary

The impact of liquid, meal, and pelleted supplements on feedlot performance and liver abscesses was evaluated in yearling steers. Steers were fed 90% concentrate diets and test supplement sources for 105 days. The control diet included all supplemental feed ingredients in pelleted form. Four other diets included a liquid supplement that contained supplemental vitamins, minerals, and monensin and a dry supplement providing protein and tylosin all equal to the control. The protein-tylosin component was fed in meal or pelleted form. Overall, steers fed liquid supplements outperformed steers fed dry pelleted supplements with higher average daily gain ($P = .05$) and dry matter intake ($P < .05$). Interim average daily gain was greater when liquid supplements were fed only through the initial 56 days of the feeding period. Dry matter intake responses occurred in three of the four interim periods. No benefit was noted for pelleting the protein-tylosin mix, except during the initial 28 days. Liver abscesses were higher (17.5% vs 8.8%, $P = .10$) when diets contained no liquid supplement. Results indicate that including liquid supplements may increase uniformity of nutrient and feed additive consumption and thereby enhance cattle performance.

Key Words: Feedlot, Beef, Supplement

Introduction

Many of the most expensive components of feedlot diets are added at parts per million rates. We formulate the diets assuming uniform dispersion and consumption of these micro-ingredients and tend to blame poor responses on failure of the ingredient. In practical situations, it seems equally plausible that failure of the ration mix is to blame. Identifying the source and extent of mix uniformity problems may help us to reduce inefficiencies in the feedlot.

Bunk sampling is not a good method for quantifying mix and consumption uniformity. Gross mixing errors are detectible, but variation due to cattle sorting and sifting through the feed cannot be discerned. Tylosin[2] is a micro-ingredient effective in the control of liver abscesses. We postulated that diet mixes that provided for consistent consumption of tylosin would be detectable as reducing liver abscesses. The following experiment outlines how various diet supplementation methods affected feedlot performance and liver abscess frequency in yearling steers.

Materials and Methods

Yearling steers were used to determine performance responses to various methods of micro-ingredient supplementation for high grain diets. The scheme involved using dry supplements in meal or pelleted forms and liquid supplements that contained 0 or 10% crude fat (Table 1). All dry supplements contained tylosin. Liquid supplements (LS) provided all supplemental vitamins, macro and trace minerals,

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Table 1. Dietary treatments

Diet	Supplementation
Pelleted	All supplemental crude protein and micro-ingredients in pelleted form. No liquid supplement included.
No fat meal	SDSU Custom R540 and soybean meal + tylosin fed in meal form.
Fat meal	SDSU Custom R540 with 10% fat and soybean meal + tylosin fed in meal form.
No fat-pellet	SDSU Custom R540 and soybean meal + tylosin in pelleted form.
Fat-pellet	SDSU Custom R540 with 10% fat and soybean meal + tylosin in pelleted form.

and monensin[3]. When no liquid supplement was fed, all micro-ingredients were included in a complete pelleted supplement.

Steers (237 head) were assembled at the SDSU Research Feedlot between June 6 and June 18, 1992. During the assembly and subsequent receiving period, steers were fed (as fed basis) 10 lb whole shelled corn, 2 lb ground prairie hay, and .8 lb liquid supplement R540[4] per head daily. Initial body weights were determined in the morning before feeding on two consecutive days (July 6 and 7). Each steer was uniquely identified and implanted with Ralgro[5] on the first weigh day. This body weight was used for the allotment process. Allotment included stratifying weight and origin across each treatment and then into five replicate pens of eight head within treatment. Thirty steers were eliminated from the population prior to allotment because of unacceptable body weight. Seven steers were deleted at random during the allotment process to provide the 200 test subjects. When the second initial body weight was determined, steers were vaccinated against IBR, BVD, PI_3, H Somnus[6] and 7 clostridia sp[7] and were treated with the anthelmintic oxfendazole[8]. They were subsequently sorted to test pens and began receiving experimental diets (Table 2).

Initial feed delivery was restricted to 12.5 lb per head (DM basis). The quantity of feed delivered was then increased over time until steers could be fed to appetite (21 days). Feed bunk conditions were noted daily. Feed ingredients were sampled weekly to determine DM, CP, ADF, and ash content. The original hay source was depleted after 35 days and was replaced with oat silage (Table 2).

Interim individual weights were determined in the morning before feeding after 28, 56, 84, 105, and 106 days. Steers were implanted with Synovex-S[9] during the weighing process at 56 days. The consecutive final weights (105 and 106) were averaged and used as the final weight for a 105-day feeding study. The afternoon

[3]Rumensin, Elanco, Indianapolis, IN.
[4]SDSU Custom Mix R540, Farmland Industries, Kansas City, MO.
[5]Pitman-Moore, Terre Haute, IN.
[6]Res Vac-4, SmithKline Beecham, Bristol, TN.
[7]Ultrabac-7, SmithKline Beecham, Bristol, TN.
[8]Synanthic, Syntex Animal Health, Des Moines, IA.
[9]Syntex Animal Health, Des Moines, IA.

Table 2. Diet formulations[ab]

Item	1 to 35 days Pelleted	1 to 35 days With liquid	36 to 105 days Pelleted	36 to 105 days With liquid	EMS
Hay	10.000	10.000			
Oat silage			10.000	10.000	
Whole shelled corn	55.222	53.610	41.014	40.208	
High moisture corn	26.805	26.805			
Rolled corn			41.013	40.207	
Soybean meal, 44%	6.000	5.925	6.000	5.925	
Limestone	1.192	.060	1.192	.060	
Dicalcium phosphate	.059		.059		
Potassium chloride	.722		.722		
Liquid supplement		3.6000		3.6000	
Dry matter	84.1	83.3	73.6	73.0	1.28
Crude protein	11.6	11.7	11.8	11.9	.32
Acid detergent fiber	6.9	6.8	5.8	5.7	.62
Neutral detergent fiber	14.9	14.8	12.6	12.5	.70
Ash	4.2	3.9	4.3	4.0	.30

[a]All diets were formulated to contain 10 grams tylosin per ton and 27 grams Monensin per ton.
[b]All values, dry matter basis.

after the final weight determination, the steers were loaded onto semi-trailers and shipped 70 miles to the slaughter plant. Live weight for each treatment group was determined when cattle were unloaded at the packing plant. Mean postfeeding transit shrink was 3.3% for the five treatment groups (range 2.90 to 3.59%). Steers stood overnight with access to water before slaughter. Individual carcass data collected included hot carcass weight, federally assigned Yield and Quality grades, and number of abscessed livers in each treatment group. Carcass data were recovered on 195 of the 200 steers used in the experiment.

Pen mean feedlot performance variables were used in the statistical analysis. All interim weight data were based on full weights. The cumulative 105-day data included shrink on initial weight (2.5%) and final weight (3.5%). Data were analyzed by procedures appropriate for a completely random designed experiment. Main effects of dry vs liquid supplement, meal vs pelleted protein + tylosin, and liquid without fat vs liquid with fat were tested by orthogonal contrast. Carcass traits other than hot carcass weight were tested for heterogeneity by Chi Square analysis.

Results and Discussion

When abruptly starting cattle on high grain diets, much of the variation in feed intake observed during the initial 21 days is dictated by the cattle manager. The difference ($P<.05$) in dry matter intake (DMI) observed through day 28 between dry and liquid supplements is small (<.1%) and represents the difference in DM between dry pelleted and liquid supplements (Table 3).

During this initial 28-day period, average daily gains (ADG) were greater when diets contained LS ($P<.05$) and when protein + tylosin

Table 3. Interim and cumulative feedlot performance of steers fed various forms of supplement

	Supplement treatment					P		
	Pelleted	No fat Meal	Fat Meal	No fat Pellet	Fat Pellet	Pelleted vs others	Meal vs pellet	No fat vs Fat
Initial wt	796	800	797	797	800	NS	NS	NS
1 to 28 Days								
Body wt (28)	955	958	965	971	975	.0051	.0070	.1447
ADG	5.65	5.66	6.01	6.20	6.25	.0151	.0070	.1330
DMI	19.56	19.39	19.37	19.37	19.38	.0001	.1435	NS
F/G	3.47	3.47	3.23	3.13	3.10	.0080	.0089	.1292
29 to 56 Days								
Body wt (56)	1062	1079	1079	1085	1098	.0010	.0315	NS
ADG	3.85	4.31	4.07	4.09	4.41	.0627	NS	NS
DMI	23.29	23.99	23.54	23.75	23.74	NS	NS	NS
F/G	6.06	5.58	5.80	5.90	5.41	.0972	NS	NS
57 to 84 Days								
Body wt (84)	1151	1164	1171	1175	1186	.0538	NS	NS
ADG	3.18	3.04	3.29	3.21	3.12	NS	NS	NS
DMI	23.27	25.58	25.43	24.98	25.44	.0287	NS	NS
F/G	7.33	8.76	7.89	7.79	8.56	NS	NS	NS
85 to 105 Days								
Body wt (105)	1228	1246	1260	1262	1272	.0415	NS	NS
ADG	3.63	3.88	4.23	4.14	4.11	NS	NS	NS
DMI	23.96	25.34	26.04	25.82	25.91	.0411	NS	NS
F/G	6.73	6.87	6.23	6.29	6.35	NS	NS	NS
Cumulative (105 days)*								
ADG	3.89	4.02	4.18	4.20	4.27	.0546	NS	NS
DMI	22.43	23.46	23.43	23.32	23.46	.0333	NS	NS
F/G	5.77	5.86	5.62	5.56	5.51	NS	.1184	NS

NS = P>.15.
* Shrunk BW basis.

was pelleted (P<.01). Feed required/unit gain was lower (P<.01) for these treatments reflecting ADG differences. In subsequent periods feeding a LS continued to cause higher (P<.07) ADG and in most periods caused higher (P<.05) DMI. The only period in which DMI was not increased by feeding LS coincided with a change from dry hay to oat silage as the diet roughage source and a severe heat stress that lasted 3 days. Feeding LS increased cumulative ADG (P=.0544) and cumulative DMI (P<.05) without affecting feed/gain.

When feeding a LS or molasses, we anticipate increases in DMI due to increased palatability of feed. The logic continues that this is advantageous because increasing DMI increases production rates and efficiencies. The increased ADG and lower feed/gain observed during the initial 56 days on feed occurred while there were no appreciable differences in DMI. The uniformity of dispersion of micro-ingredients in the diet may be most critical during the initial feeding period and may have caused this response.

Weekly feed summaries showed that LS increased (P<.05) DMI during the periods when oat silage was fed. These diets were 73% DM. As such, LS would have done little to control dust in the diets and there was litte noticeable evidence of sorting or settling out of diet ingredients. These circumstances preclude the most obvious reasons for enhanced feed intake. Monensin can affect DMI by its dosage and consistency of daily intake. Since efficiencies were not affected by supplement form, the possibility exists that providing monensin in a LS causes an increased uniformity of monensin dispersion in the feed and subsequently more uniform monensin consumption. Erratic monensin intake would decrease DMI and ADG which may or may not alter feed/gain ratios.

Including 10% fat in the LS did not affect feedlot performance. None of the dietary treatments affected carcass traits (Table 4). The incidences (%) of liver abscesses were dry pelleted, 17.5%; LS 8.8%; control LS 7.5%; fat added LS 10.1%; protein + tylosin-meal 8.7% and protein + tylosin-pelleted 8.9%. Tylosin present as a micro-ingredient reduces the incidence of liver abscesses. The higher incidence of liver abscesses occurring when no LS was fed supports the concept that LS increased the uniformity of micro-ingredient consumption.

In summary, these results showed no advantage to including fat as a component of liquid supplements as used in this experiment. Liquid supplement did enhance feedlot performance over pelleted supplementation and that response appears to involve factors other than the diet palatability.

Table 4. Carcass traits of steers fed various forms of supplement

	Supplement treatment					P		
	Pelleted	No fat Meal	Fat Meal	No fat Pellet	Fat Pellet	Pelleted vs others	Meal vs pellet	No fat vs Fat
Dressing, %[a]	60.6	61.7	60.7	61.4	61.1			
Hot carcass wt	720	743	737	745	756	.0062	NS	NS
Yield grade 1, %	10	2.5	0	8.1	7.7			
Yield grade 2, %	62.5	55.0	66.7	56.8	53.9			
Yield grade 3, %	27.5	42.5	33.3	35.1	38.4			
Select, %[b]	55	37.5	35.9	51.3	48.7			
Choice, %[b]	45	62.5	64.1	48.7	51.3			
Liver abscesses, %[c]	17.5	5.0	12.5	10.0	7.7			

[a]Based on packing plant arrival weights.
[b]LS with meal vs pellet Chi square test (P=.1040).
[c]Significant pelleted vs others in Chi square test (P<.05).

AN EVALUATION OF THREE FEED MIXING WAGONS

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CATTLE 93-13

Summary

Three mixer wagons, a poor condition triple auger (PCA), a good condition triple auger (GCA), and a new reel type (RT) mixer, were evaluated after 2, 4, 6, and 8 minutes of mixing time. Two diets were used: a grower diet with 37.14% ground hay and 62.86% concentrate and a finisher diet with 10.22% ground hay and 89.78% concentrate on a dry matter basis. Concentrate included whole shelled corn, high moisture ear corn and pelleted and liquid supplements. The coefficient of variation among acid detergent fiber levels appeared to be the best indicator of adequacy of mix. The PCA mixer required 8 minutes to mix both the finisher and grower diets. The grower diet appeared adequately mixed after 2 minutes for the GCA mixer and after 6 minutes for the RT mixer. The finisher diet appeared adequately mixed after 4 minutes for both the GCA mixer and the RT mixer.

Key Words: Mixer Wagon, Ration Quality Control

Introduction

Ration quality control is an important component of feedlot management. Providing cattle with properly formulated and mixed diets is critical in maintaining uniform levels of feed intake and optimal performance. Previous research conducted at the Southeast South Dakota Experiment Farm has demonstrated that growing heifers consuming a completely mixed diet gained weight 10% more rapidly and converted feed 10% more efficiently than heifers consuming a diet where the ingredients were layered in the feed bunk.

There are several different types of mixing equipment available for producers to choose from. In addition, equipment that is currently used by many producers may be in need of major repair. The objective of this research was to evaluate how effective three different mixer wagons were in mixing two different ration types.

Materials and Methods

The mixers evaluated in this study included an Oswalt® triple auger mixer that was in good operating condition (GCA), a Little Augie® triple auger mixer that was in need of many repairs (PCA), and a Reel Augie® reel type (RT) mixer. The auger flighting was missing from one of the top augers near the rear of the PCA mixer.

Table 1 shows the ingredient and theoretical nutrient composition of the growing and finishing rations used in this study. For both the growing and finishing diets, whole shelled corn was added first to the mixers. Liquid supplement was distributed evenly across the top of the corn. The liquid supplement was then mixed into the corn for about 30 seconds prior to the addition of the remaining ingredients. The mixers were then stopped and the remaining ingredients were added in the following order for the growing diet: ground high moisture ear corn, soybean meal, pelleted supplement, switchgrass hay, and brome hay. The remaining ingredients were added to the finishing diet in the following order: soybean meal, pelleted supplement, and switchgrass hay.

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Table 1. Ingredient and nutrient composition of diets used to evaluate mixing equipment

Item[a]	Diet type	
	Grower	Finisher
Ingredient		
Whole shelled corn	28.44	79.93
Ground high moisture ear corn	21.99	--
Switchgrass hay	19.35	10.22
Bromegrass hay	17.79	--
Soybean meal	7.43	5.24
Liquid supplement	2.72	2.51
Pelleted supplement	2.28	2.10
Nutrient		
Dry matter	80.07	86.78
Crude protein	12.03	11.40
Acid detergent fiber	20.85	8.98

[a]Dry matter basis.

Once the last ingredient was added, the mixer was started and allowed to run for 2 minutes. The mixer was then stopped and a 2-quart sample was obtained off the top of the mixture from the front, middle, and back of the wagon. The mixer was then started again and stopped at 2-minute intervals and additional samples were obtained at each interval. Thus, three samples were obtained after 2, 4, 6, and 8 minutes of mixing. Samples were analyzed for dry matter, crude protein, acid detergent fiber (ADF), and ash according to standard wet chemistry procedures. ADF values were reported on an ash free basis.

Samples collected from the front, middle, and rear of the mixer were considered replicates 1, 2, and 3 at each time period. Mean values were calculated at each time period and the coefficient of variation was used as a criterion to determine adequacy of mix.

Results and Discussion

Table 2 shows the observed dry matter, crude protein, and ADF values for the various mixer ration types. Coefficients of variation are shown in Table 3. The coefficients of variation observed for dry matter content were extremely small for all mixers, rations, and time periods evaluated. Dry matter appears to have been adequately distributed throughout the mixtures. Most of the ingredients used in the formulation had similar dry matter contents. Therefore, it is not surprising that dry matter content can not be effectively used to evaluate the adequacy of ration mixing in these diets. Perhaps dry matter would be more useful if corn or sorghum silage or another wet feed was used in the formulation.

The crude protein coefficients of variation reported for the finishing diet mixed with the PCA mixer suggest that the optimum mix time for the finishing diet is 8 minutes. The other coefficients of variation reported for crude protein were not very useful in evaluating the mixers.

ADF values are much more variable and the most useful measure in evaluating the adequacy of diet mix. ADF values ranged from essentially 0 for the liquid supplement to 46.32% for the switchgrass hay. As a result of this wide range in ADF composition, reduced coefficients of variation may indicate an adequate mix.

Table 2. Mean nutrient composition for grower and finisher diet for each mixer wagon

		Diet type					
	Time,	Grower			Finisher		
Variable	min.	PCA[a]	GCA[b]	RT[c]	PCA	GCA	RT
Dry matter	2	80.43	81.41	79.83	85.95	86.60	86.92
	4	81.51	81.10	79.92	85.32	86.44	86.87
	6	80.75	81.05	79.94	85.28	86.52	86.96
	8	80.55	80.97	80.02	85.72	86.79	86.97
Crude protein	2	12.53	12.15	11.81	11.06	11.07	11.65
	4	12.39	12.29	10.96	11.09	11.07	12.11
	6	12.13	12.58	10.90	11.73	11.28	11.95
	8	12.65	12.56	12.05	11.97	11.33	11.70
Acid detergent fiber	2	21.91	23.11	28.78	21.57	11.28	10.68
	4	23.65	22.98	27.87	16.78	11.80	9.94
	6	24.04	22.52	29.11	12.14	10.70	10.48
	8	24.04	22.72	25.82	11.09	10.03	10.11

[a]Poor conditioned auger.
[b]Good conditioned auger.
[c]Reel type.

The PCA mixer required 8 minutes to adequately mix the grower and finisher diets. The coefficients of variation declined over time from 35.25% to 13.36% for the grower diet and from 92.05% to 8.47% for the finisher diet.

The GCA mixer appeared to adequately mix the grower diet after 2 minutes and the finisher diet after 4 minutes. The RT mixer appeared to require 6 minutes for the grower diet and 4 minutes for the finisher diet.

The observed ADF content for both diets for all three mixers over all mixing times was greater than the theoretical levels calculated for each diet. All feed commodities were sampled and actual ADF values were used to calculate theoretical values. However, ration samples were obtained from the top of the mixer. The corn (4.56% ADF) was always the first ingredient added, while the hay (46.32 or 41.07% ADF) was the last ingredient added to the mixer. It appears as if it is difficult to obtain a uniform mix from top to bottom in all of these mixers. A more accurate sample may be obtained directly from the feed bunk. This allows the ration to also mix as it is delivered to the bunk.

The data reported in this paper support the contention that each feed mixer and ration type should be evaluated to determine optimum time of mixing. Obtaining several samples from the entire length of the feed bunk may be a more desirable sampling procedure than obtaining samples directly from the top of the mixer wagon.

Acknowledgements

The authors wish to thank Sioux Automation of Sioux Center, IA, for providing the mixers used in this study. Our thanks are also extended to Farmers Implement and Irrigation and Case Power and Equipment of Brookings for providing tractors to power the mixing equipment.

Table 3. Coefficients of variation for the grower and finisher diet for each mixer wagon

		Diet type					
	Time,	Grower			Finisher		
Variable	min.	PCA[a]	GCA[b]	RT[c]	PCA	GCA	RT
Dry matter	2	1.90	.32	.08	.52	.10	.47
	4	1.35	.17	.36	.26	.51	.29
	6	1.50	.32	.27	.27	.20	.39
	8	.91	.21	.36	.18	.22	.43
Crude protein	2	8.15	4.62	.54	21.87	1.59	1.83
	4	10.80	4.64	5.74	11.89	2.42	3.95
	6	5.80	4.46	3.97	4.79	2.08	2.80
	8	4.88	3.12	3.65	3.13	1.96	4.11
Acid detergent fiber	2	35.25	2.88	16.10	92.05	15.64	17.74
	4	26.65	11.08	17.36	64.50	5.03	5.73
	6	19.18	10.56	6.16	14.04	7.49	7.19
	8	13.36	8.57	10.14	8.47	5.25	6.46

[a]Poor conditioned auger.
[b]Good conditioned auger.
[c]Reel type.

CHAPS SUMMARY FOR SOUTH DAKOTA, 1992

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CATTLE 93-14

Summary

Calving distribution and calf performance data were summarized from the CHAPS (Cow Herd Appraisal of Performance Software) analyses of 102 South Dakota cow herds. CHAPS uses beef cow weaning weight records to calculate adjusted 205-day weights and ratios, keep lifetime production records on cows, calculate Most Probable Producing Ability estimates for cows, produce a sire summary, and analyze production according to cow age and 21-day calving periods. The 1992 summary represents 11,661 cows for an average of 114 cows per herd. The herds ranged in size from 10 to 616 head. The average midpoint of the calving season for these herds was April 6. The average actual birth and weaning weights were 82.5 and 551.0 lb, respectively, with the average age at weaning 211.4 days. Overall, 80.6% of the females calved by day 42 of their respective calving seasons, although there was considerable disparity in the percentage calved by day 42 between the HIGH and LOW (94 vs 61%) calving distribution herds. This difference is important since actual weaning weights declined 25 to 35 lb for each 21 days later that calves were born. In addition to these data for the state summary, CHAPS provides valuable information for making within herd selection and management decisions.

Key Words: Cow-Calf, Performance Records

Introduction

A computer program for evaluating cow herd productivity was acquired in 1989 by the SDSU Extension Service and placed in most of the county extension offices. The program is called CHAPS which stands for Cow Herd Appraisal of Performance Software. CHAPS uses standard beef cow weaning weight records to adjust weaning weights and calculate 205-day ratios. In addition, the program keeps lifetime production records on cows, calculates MPPA (Most Probable Producing Ability) for cows, produces a sire summary and analyzes birth dates and weaning weights to give a calving distribution and production analysis by cow age and 21-day calving periods. CHAPS records are summarized to develop a state database to provide producers a basis for comparative analysis of their herds' productivity.

Data of particular interest in the summary were the percentage of calves born in 21-day segments of the calving season. Calving distribution provides an excellent indication of reproductive performance and provides a producer a tool to utilize in troubleshooting reproduction, nutrition and management problems within the various age groups of cows in the herd. CHAPS determines the start of the first 21-day period as 285 days after either bull turn in or the start of artificial insemination on the 3-year-old or older cows. Any cows or heifers calving ahead of that date are considered Early. The calving distribution and performance of the 34 herds with the highest percentage calved by the end of the first 42 days (HIGH) are compared to the 34 herds with the lowest percentage calved by the end of the first 42 days (LOW).

This report summarizes the data from the 102 CHAPS herds in South Dakota for 1992. The

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data are also summarized according to region of the state with SE representing counties east of the Missouri River and south of Highway 14, NE representing counties east of the Missouri River and north of Highway 14, and WR representing counties west of the Missouri River.

Results and Discussion

Herd Demographics

The 1992 CHAPS summary for South Dakota represents 11,661 cows from 102 herds. There were 33 herds from the SE, 41 herds from the NE, and 28 herds from WR. The average herd size was 114 cows with a range of 10 to 616 cows.

The age distribution of the cows in the summary appears in Table 1. In these herds, 16.0% were first calf 2-year-olds and approximately 47.5% from 5 to 9 years of age. In these herds, 41.2% were under 5 years and 11.3% were 10 years or older. The average cow age was approximately 5.7 years. As expected, actual weaning weights were highest for the 5- to 9-year-old age group with gradient increases from 2-year-olds through 5- to 9-year-olds similar to the age of dam adjustments recommended by the Beef Improvement Federation.

The average start of the calving season (mature cows) was March 13 and the average weigh date was November 5. The average midpoint of the calving season was April 7.

Performance

The average actual birth and weaning weights were 82.5 and 551 lb, respectively, with an average age at weaning of 211.4 days. The averages for weight per day of age and adjusted 205-day weight were 2.61 lb per day and 557.6 lb, respectively. The average reported preweaning death loss was 2.2% with a range of 0.% to 20.7%.

Table 1. Number and percentage of cows by age in 1992 CHAPS summary

Age of cow, year	Number of cows	% of total	Weaning weight
2	1860	16.0	483
3	1553	13.3	506
4	1390	11.9	528
5-9	5537	47.5	542
10 and over	1321	11.3	534

Calving Distribution

The percentage of cows calving in each 21-day calving period and the corresponding actual weaning weights are shown in Table 2 for all cows and the HIGH and LOW calving distribution groups. Across all herds, 50.1% of the calves were born by the end of the first 21-day period, 80.6% by 42 days, and 91.7% by the end of the third 21-day period. While this overall level of reproductive performance is quite good, there is still considerable disparity among the herds. This is evident when the cumulative calving percentages for the HIGH and LOW groups are compared at the end of the first 21-day period (67.7 vs 26.6%), the second 21-day period (93.6 vs 60.6%), or the third 21-day period (98.4 vs 81.6%).

When the cumulative percentages calved are examined for the various cow ages, the advantage of the HIGH herds becomes apparent in two primary areas (Table 3). First, the HIGH herds bred more heifers to calve ahead of the main herd which helped them get a higher percentage of their heifers calved by the end of the first 21-day period (83.3 vs 42.9%). Secondly, the HIGH herds were able to get their 2-year-olds bred back more quickly, resulting in a higher percentage of 3-year-olds calved in the first 42 days (92.6 vs 58.2%).

Table 2. Percentage of cows calving and average actual weaning weight by 21-day calving period for all cows and for high and low calving-distribution groups

	All cows		HIGH[a]		LOW[a]	
21-day period	%	Weight	%	Weight	%	Weight
Early	6.1	562	9.8	561	2.8	611
1st	44.0	568	57.9	567	23.8	578
2nd	30.5	544	25.9	530	34.0	572
3rd	11.5	517	4.8	489	21.0	545
4th	5.1	486	1.0	418	12.0	511
Late	2.2	453	.2	386	5.6	475
Average wt		551		558		555
Avg calving date	April 7		April 1		April 12	
Avg start date for calving cows	March 13		March 17		March 7	
Weaning date	November 5		October 29		November 12	

[a]HIGH = 34 herds with highest percentage calved in first 42 days. LOW = 34 herds with lowest percentage calved in first 42 days.

In past summaries, the advantages in calving distribution resulted in higher actual weights for the HIGH herds. However, in 1992 there was little difference in weaning weights between HIGH and LOW herds. This is a result of a longer calf production time for the LOW herds as they started calving earlier (March 7 vs March 17) and were weighed later in the fall (November 12 vs October 29). So even though output was similar, the LOW herds are likely to have higher feed costs, especially with the 10-day earlier start to the calving season.

Regional Comparisons

Performance and herd traits are compared among the three regions in Table 4. Herds in the NE started calving later and herds east of the Missouri River weighed calves approximately 2 weeks later in the fall than those WR. This is at least partially due to the wet, rainy conditions in eastern South Dakota in the fall of 1992.

Average herd size was slightly smaller in the SE and the higher preweaning death losses occurred in the NE, although differences were minor. WR herds calved more heifers ahead of the cow herd and had the highest percentage of cows calved in the first 42 days of the calving season.

Herds in the SE had the longest calf production time and WR herds had the highest weight per day of age and the highest adjusted 205-day weights. WR herds had the most desirable herd uniformity scores.

Conclusion

CHAPS provides valuable information for South Dakota beef producers. By participating in CHAPS and contributing to state and local data bases, individual producers can not only evaluate the performance of their own herd but also compare to other herds with similar resources. If you are interested in enrolling your herd in CHAPS, contact your county extension agent, local veterinarian, or an extension beef specialist at SDSU.

Table 3. Average cumulative percentage calved by 21-day calving periods within age group for all cows and high and low calving distribution groups

Age	Group	% of each age group				
		Early	1st	2nd	3rd	4th
2	All	28.8	68.0	88.2	95.2	98.5
	HIGH	43.1	83.3	96.3	99.6	99.7
	LOW	10.6	42.9	74.8	89.3	96.8
3	All	2.3	48.0	80.0	92.2	97.8
	HIGH	3.8	62.6	92.6	97.8	99.5
	LOW	2.5	25.1	58.2	81.7	95.2
4	All	2.4	48.2	81.7	94.0	98.3
	HIGH	2.7	64.2	92.8	98.0	99.1
	LOW	2.5	26.2	62.7	84.5	99.5
5-9	All	1.8	46.9	79.2	91.5	97.0
	HIGH	3.0	66.6	94.2	98.9	99.7
	LOW	1.2	23.1	57.4	79.1	92.4
10 and over	All	.7	44.3	77.9	90.9	97.2
	HIGH	.7	59.4	91.3	98.0	99.5
	LOW	.9	24.4	59.4	82.5	94.3

Table 4. CHAPS ~~trait~~ comparisons for herds in the south~~eastern~~ (SE), northeastern (NE), and west-river (WR) regions of South Dakota

	SE	NE	WR
Avg start of calving	March 7	March 18	March 9
Mean calving date	April 6	April 10	April 1
Avg weigh date	November 11	November 8	October 24
Total cows	95	119	127
Calf death loss, %	1.7	2.7	2.1
Age at weaning	218	210	205
Weight/day	2.60	2.55	2.70
Actual calf weight	567	534	557
Adjusted 205-day weight	549	547	583
Herd uniformity score	84	83	75

OPTIMUM MONENSIN LEVELS IN FEEDER CALF RECEIVING DIETS

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CATTLE 93-15

Summary

Monensin was fed in the receiving diets of recently weaned calves at a rate of 0, 10, 20, or 30 g per ton (air dry basis) or 100 or 200 mg per head daily to determine effects on feed intake and coccidia control. The 240 steer calves used originated from western rangelands and had no previous exposure to milled feeds or confinement. During the first week in the feedlot, monensin fed at 30 g per ton depressed feed intake by 5% and the depression response was linear ($P<.001$) over the range of dosages tested. This reduction in feed intake did not affect average daily gain or calf health. Over 90% of these calves were shedding coccidia oocysts on the first day in the feedlot. Monensin began to suppress ($P<.01$) oocyst shedding after 10 days on feed and this effect persisted throughout the 84-day experiment. The percentage of calves within a treatment that were not shedding oocysts improved as monensin dosage was increased. These data indicate that intake sensitivity to monensin is primarily related to daily intake of the drug rather than drug concentration in the diet. Furthermore, monensin can be included in receiving calf diets at sufficiently high levels to reduce coccidia oocyst shedding without depressing performance.

Key Words: Calf, Receiving, Monensin, Coccidiosis

Introduction

Newly received feeder calves are susceptible to coccidiosis and preventative measures are indicated for most feedlots. The ionophores currently available for beef cattle diets are approved for the control and prevention of coccidiosis and could be used for these purposes as well as to increase daily gains of feeder cattle. In reference to the ionophore monensin, there is considerable debate regarding when monensin can be included in the diet and at what rate it should be fed. The concerns evolve from the necessary adaptation of cattle to diets containing monensin to avoid significant reductions in feed intake.

An important aspect of this concern is whether adaptation is a function of the concentration of monensin in the feed or if adaptation is in response to the daily dosage consumed by the calf. In newly weaned calves that have not previously been confined or fed, feed intakes are so low (<1.5% body weight) that diets containing 30 g per ton monensin would only provide 125 mg of drug per day. This level of ionophore intake may be low enough to facilitate the adaptation process even though most cattle feeders would interpret the 30 g per ton feeding rate as excessively high for this purpose.

In a previous experiment conducted at this station, we found that feeding 10, 20, or 30 g per ton monensin had minimal effects on feed intake. These diets consistently reduced coccidia oocyst

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shedding within 18 days after weaning. Since intake responses and the severity of coccidiosis infections can be highly variable from year to year, this research was repeated and is described here.

Materials and Methods

Steer calves were obtained from two ranches in western South Dakota. The calves had not been confined or exposed to milled feeds prior to weaning and shipment (375 miles) to the SDSU research feedlot near Brookings, SD. On arrival at the feedlot, calves had access to long hay and fresh water. Within 24 hours of weaning calves were vaccinated, weighed, and individually identified. Allotment to pens and feeding of experimental diets occurred the following day (48 hours postweaning). Six diets based on corn silage (Table 1) were formulated to provide 0 (0), 11 (10), 22 (20), or 33 (30) g per ton monensin (DMB) or to provide 100 (100) or 200 (200) mg monensin per day. Steers were fed these diets to appetite once daily for 85 days. Five pens of eight steers were assigned to each treatment. This resulted in 30 pens containing a total of 240 steers. Initial feedlot weight of the steers was 548 $\pm$ 1 lb.

Table 1. Basal receiving diet formulation

Item	% dry matter basis
Hay	15.00
Corn silage	74.68
SBM[a]	9.33
$CaCo_3$[a]	.59
Trace mineral salt[a]	.30
Fat[a]	.10
	100.0

[a]Included as a supplement that provides micronutrients at levels that meet or exceed NRC requirements. Monensin was included in the pelleted supplement.

Fecal samples were obtained directly from each steer twice weekly during the initial 4 weeks on test and again on days 54 and 81. Samples were individually packaged and submitted to the SDSU Animal Disease Research and Diagnostic Laboratory for quantifying the oocyst contamination. Oocyst shedding was categorized as A = 0 per g feces, B = 1 to 99 oocyst per g, C = 100 to 499 oocyst per g and D = >499 oocysts per gram.

Feed ingredient samples were obtained and analyzed weekly for determining dry matter intakes and diet nutrient composition (Table 2). Calf health was monitored daily. Morbid calves were removed from the original pen, treated, and penned individually with access to the assigned test diet. Upon recovery calves were returned to their original pen and sick pen intakes were added back into the pen data. One steer each from treatments 0 and 10 died of respiratory illness while in sick pens and performance data from these two individuals were deleted. Steers were individually weighed in the morning before feeding after 27, 55, 84, and 85 days. The final two body weight determinations were averaged and used as the final weight.

Feedlot performance data were evaluated on a pen mean basis using AOV appropriate for a completely random design. Means separations were done by orthogonal contrast including the following treatment comparisons: 0 vs all others, 10 vs 20 and 30, 20 vs 30, 30 vs 200 mg/day, and 100 mg/d vs 200 mg/day. Oocyst shedding was evaluated as discrete data by Chi square analysis of individual observations within sampling day.

Dry matter offered was restricted to 4.9 lb for the initial 3 days as we usually do when starting naive calves on feed. From that point feed deliveries were gradually increased to allow ad libitum intakes.

Results and Discussion

It was originally intended that steers on treatment 200 would receive 100 mg monensin daily for 5 days before feeding the 200-mg dosage. Inadvertently, they were fed 200 mg per day during the initial 7 days at which time

Table 2. Diet nutrient analysis[a]

	Treatment[b]						
Item	0	10	20	30	100	200	SEM
Dry matter	46.32	46.32	46.32	46.33	46.30	46.33	.44
Crude protein	10.61	10.66	10.56	10.69	10.77	10.73	.21
Neutral detergent fiber	46.64	46.64	46.64	46.64	46.66	46.64	1.19
Acid detergent fiber	25.60	25.60	25.60	27.74	25.61	25.59	1.27
Ash	6.05	6.29	6.11	5.99	6.44	6.14	.13

[a]All values except dry matter on dry matter basis, n = 13.
[b]Monensin, grams per ton diet, air dry basis, or mg per head daily.

reduced intakes (Table 3) made the error obvious to us. Monensin dosage was then reduced to 100 mg/day for the next 7 days and then increased again to 200 mg/day. This corresponded to the resumption of a more normal intake pattern.

There were no significant (P>.10) differences in feedlot performance attributable to monensin dosage in any of the interim or cumulative data sets (Table 4). This is consistent with results obtained in the previous experiment. Since the 0, 10, 20, and 30 treatments were similar for each of the 2 years research, these data were pooled, blocked by year, and monensin concentration effects on feedlot performance were revaluated. This provided 10 pens or 80 steers per treatment.

In the pooled data (Table 5), intakes during the initial period declined linearly (P<.05) with increasing monensin concentration. Intakes on treatment 30 were 5.5% lower than those on treatment 0. Gains were unaffected and feed/gain improved (P<.10) in response to lowered intakes. During the second month postreceiving average daily gain tended to decrease (P=.070) with increasing dietary monensin concentration, although intakes were no longer depressed by treatments (P>.20). In the first experiment, performance during the third month in the feedlot was quite low due to a variety of factors including a deterioration in silage quality and poor weather. However, when data from only the second experiment are evaluated, there is still no cumulative response to dietary monensin concentrations over the 0 to 30 g/ton range of treatments.

As previously observed, 96% of the calves were shedding coccidia oocysts when they arrived at the feedlot. Monensin began to suppress oocyst shedding (P<.05) by day 10 in this experiment (Table 6). The percentage of calves not shedding oocysts appeared dosage dependent and increased from 16% for control to 72% for treatment 100. Differences due to treatment persisted throughout the 81-day fecal sampling. No clinical symptoms of coccidiosis were evident in the course of the feeding period.

We have consistently observed that calves raised on western rangelands and coming into the feedlot directly after weaning are infected with coccidia. Some prophylactic measure should be used even though calves are not showing any clinical signs of coccidiosis. In this experiment monensin effectively reduced coccidia oocyst shedding, indicating that it may be a suitable prophylactic treatment. Including monensin in the receiving diets did cause some (5%) reduction in feed intake. There was no evidence that monensin delayed calves from accepting feed, but rather it limited the total amount of feed consumed daily. In this situation, calf gains and health were not adversely affected by including monensin in the receiving diets, which is supportive of the interpretation that monensin effects on feed intake were not detrimental to the calf.

Table 3. Weekly dry matter intake summary[a]

Item	Treatment[b]						P<[c]				
	0	10	20	30	100	200	0 vs rest	10 vs 20,30	20 vs 30	30 vs 200	100 vs 200
1 to 7 days	7.12	7.10	6.86	6.79	6.50	6.14	.0003	.0242	NS	.0001	.0136
8 to 14 days	9.92	10.10	9.38	8.87	8.88	8.73	.0591	.0288	NS	NS	NS
15 to 21 days	12.38	11.22	11.64	11.76	11.90	11.56	.1457	NS	NS	NS	NS
22 to 28 days	15.73	15.73	15.41	14.85	15.41	14.62	.1343	.1260	NS	NS	NS
29 to 35 days	15.61	15.87	15.85	15.10	16.06	15.56	NS	NS	.1150	NS	NS
36 to 42 days	15.80	15.01	15.97	15.20	16.21	15.19	NS	NS	NS	NS	.0689

[a]Pounds per head per day.
[b]Monensin concentration, g/ton air dry basis or mg/head.
[c]NS = P>.15.

Table 4. 84-day feedlot performance summary

	Treatment[a]						
Item	0	10	20	30	100	200	SEM
Initial wt, lb	546	549	549	548	547	549	1.4
Days 1 to 27							
Body weight, day 27	625	621	621	621	622	624	4.9
Avg daily gain, lb	2.93	2.67	2.81	2.70	2.80	2.76	.168
Dry matter intake, lb	10.65	10.32	10.18	10.04	9.98	9.72	.255
Feed/gain, lb	3.70	3.98	3.63	3.75	3.60	3.54	.202
Gain/feed, lb/cwt	27.03	25.10	27.53	26.70	27.79	28.25	1.526
Days 28-55							
Body weight, day 55	682	675	677	671	683	682	4.6
Avg daily gain, lb	2.04	1.94	1.97	1.79	2.16	2.08	.106
Dry matter intake, lb	15.57	15.73	15.75	15.16	15.83	15.20	.292
Feed/gain, lb	7.64	8.28	8.03	8.61	7.38	7.43	.469
Gain/feed, lb/cwt	13.09	12.08	12.45	11.61	13.54	13.46	.655
Days 56 to 84							
Body weight, day 84	742	738	749	734	749	746	4.3
Avg daily gain, lb	2.05	2.16	2.38	2.19	2.29	2.23	.099
Dry matter intake, lb	17.03	16.95	17.33	16.60	16.82	16.65	.271
Feed/gain, lb	8.39	7.87	7.46	7.63	7.36	7.54	.390
Gain/feed, lb/cwt	11.91	12.71	13.41	13.10	13.59	13.27	.697
Days 1 to 84							
Avg daily gain, lb	2.33	2.25	2.38	2.22	2.41	2.35	.056
Dry matter intake, lb	14.49	14.41	14.51	14.01	14.29	13.94	.221
Feed/gain, lb	6.25	6.44	6.09	6.32	5.93	5.94	.172
Gain/feed, lb/cwt	16.00	15.53	16.41	15.82	16.86	16.85	.518

[a]Monensin level, g/ton air dry basis or mg/head.

Table 5. Pooled performance data when newly received feeder calf diets contain monensin

Item	Treatment[a] 0	10	20	30	SEM
Period 1[b]					
ADG	2.71	2.56	2.67	2.69	.101
DMI[e]	10.64	10.46	10.04	10.06	.149
F/G[f]	4.00	4.15	3.78	3.76	.131
Period 2[c]					
ADG[f]	2.53	2.54	2.41	2.35	.080
DMI	16.13	16.27	15.83	15.83	.265
F/G	6.61	6.82	6.84	7.15	.268
Period 3[d]					
ADG	1.47	1.46	1.67	1.56	.094
DMI	16.87	16.62	16.25	16.66	.329
F/G	14.22	16.11	14.74	12.88	1.967
Cumulative					
ADG	2.26	2.21	2.27	2.22	.046
DMI	14.52	14.43	14.03	14.15	.203
F/G	6.48	6.55	6.19	6.37	.132

[a]Monensin concentration, g/ton air dry basis or mg/head.
[b]Experiment 1 = 29 days, experiment 2 = 27 days.
[c]Experiment 1 = 28 days, experiment 2 = 28 days.
[d]Experiment 1 = 25 days, experiment 2 = 29 days.
[e]Linear ($P<.05$).
[f]Linear ($P<.10$).

Table 6. Frequency of calves shedding oocysts[a]

Sample day[b]	Oocyst[c] counts	Treatment[d] 0	10	20	30	100	200
		Percentage of calves					
0	0	5.41	5.26	5.41	0.0	0.0	7.89
	1-99	35.14	39.47	43.24	55.00	48.72	50.00
	100-499	59.46	55.26	51.35	45.00	51.28	42.11
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
3	0	2.63	7.69	7.50	10.26	7.89	2.56
	1-99	65.79	71.79	62.50	56.41	68.42	71.79
	100-499	18.42	7.69	17.50	23.08	13.16	17.95
	500 +	13.16	12.82	12.50	10.26	10.53	7.69
6	0	13.51	18.92	12.82	23.08	23.68	21.62
	1-99	72.97	67.57	79.49	71.79	71.05	72.97
	100-499	13.51	13.51	7.69	5.13	5.26	5.41
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
10[e]	0	16.22	35.90	45.00	32.50	72.97	62.16
	1-99	78.38	61.54	47.50	67.50	24.32	37.84
	100-499	5.41	0.0	5.00	0.0	0.0	0.0
	500 +	0.0	2.56	2.50	0.0	2.70	0.0
13[e]	0	23.08	50.00	58.97	57.50	70.00	72.50
	1-99	74.36	50.00	38.46	42.50	30.00	27.50
	100-499	2.56	0.0	2.56	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
17	0	74.36	87.50	92.50	90.00	92.50	95.00
	1-99	23.08	12.50	7.50	7.50	7.50	5.00
	100-499	2.56	0.0	0.0	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	2.50	0.0	0.0
20[e]	0	44.44	72.50	85.00	76.92	75.00	81.58
	1-99	55.56	27.50	15.00	23.08	25.00	18.42
	100-499	0.0	0.0	0.0	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
24[f]	0	70.27	77.78	82.05	95.00	90.00	85.00
	1-99	29.73	22.22	17.95	5.00	10.00	15.00
	100-499	0.0	0.0	0.0	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
26[e]	0	50.00	70.00	90.00	92.50	82.05	79.49
	1-99	50.00	30.00	7.50	7.50	17.95	20.51
	100-499	0.0	0.0	2.50	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
54[e]	0	47.37	77.78	91.89	94.74	92.31	92.50
	1-99	52.63	19.44	8.11	5.26	7.69	5.00
	100-499	0.0	2.78	0.0	0.0	0.0	2.50
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
81[e]	0	74.36	90.0	100.0	97.44	92.11	100.00
	1-99	25.64	10.00	0.0	2.56	5.26	0.0
	100-499	0.0	0.0	0.0	0.0	2.63	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0

[a]Percentage of calves within a treatment that were shedding oocysts at the rate listed.
[b]Days in the feedlot prior to sampling.
[c]Oocyst counts per gram feces.
[d]Monensin level as g/T or mg/head.
[e]Percentages differ between monensin treatments (P<.001).
[f]Percentages differ between monensin treatments (P=.055).

BOVINE TOE ABSCESSES

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CATTLE 93-16

Summary

Toe abscesses were diagnosed in five Midwestern feedlot lameness outbreaks submitted to the Animal Disease Research and Diagnostic Laboratory during the 1992-93 winter. Affected cattle developed severe lameness from 3 days to 3 weeks after feedlot arrival. Close examination of feet revealed abnormal hoof wear, separation of the hoof wall from the sole, and drainage and swelling of affected feet. Treatment of the problem included corrective foot trimming to allow drainage and antibiotic therapy. Causes of the problem included abrasive and traumatic injuries which allowed bacteria to infect the foot. Hooves were softer and more prone to damage because of unusually wet weather conditions the previous summer and fall. Prevention tips include bedding rough surfaces and preventing traumatic foot injuries.

Key Words: Lameness, Toe Abscess, Infection

Introduction

An unusual lameness problem was observed in scattered Midwestern feedlots during the winter of 1992-93. Severe lameness developed several days to three weeks postarrival. Hind feet were usually affected, but front feet could also be involved in severe cases. Affected calves were gaunt and reluctant to move. Response to treatment was poor and some animals eventually died. Calves or tissues were submitted to the Animal Disease Research and Diagnostic Laboratory, Brookings, SD, for diagnostic assistance from five feedlots.

Materials and Methods

Calves and/or tissues with toe abscesses were received from five different feedlots with complaints of lameness problems during the winter of 1992-93 (Table 1). The calves were necropsied and affected feet were split on a band saw. Various tissues were collected for bacteriology, virology, histopathology, parasitology, hematology, and toxicology exams according to the decisions of the pathologist on duty. Cases selected for the study demonstrated variable degrees of abnormal hoof wear, separation of the sole from the hoof wall, and inflammation of the corium (vascular layer between the hoof wall and third phalanx [coffin bone]).

Results and Discussion

Toe abscesses have not been widely described in the literature. One previous report was found in the popular press describing toe abscesses in Kansas feedlots. Cattle examined in this study came from different feedlots in the region served by the lab (Table 1). The origins of the affected calves included South Dakota and Montana. Various breeds were affected. Lameness developed from a few days to three weeks after feedlot arrival. Weights ranged from 500-700 lbs. The cases were presented to the lab between December and March. Morbidity ranged from a few animals up to 75%. Mortality was 7% in the worst group. Affected calves failed to gain and often finished behind penmates.

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Table 1. Toe abscess cases, 1992-1993

Case	Tissues/animals received	Feedlot location	Morbidity, %	Mortality, no.
1	1 live calf	SD	30	12
2	1 dead calf/amputated toe	IA	75	8
3	2 live calves	SD	1	2
4	3 dead calves	SD	1	3
5	2 feet	NE	5	2

Case	Bacteria isolated	Other lesions
1	*Actinomyces pyogenes*	Cellulitis, lung abscesses
2	*A. pyogenes/Bacteroides melaninogenicus*	Arthritis, tendinitis
3	*A. pyogenes/B. melaninogenicus*	Osteomyelitis, arthritis, lung abscesses
4		Sloughed hoof, osteomyelitis
5		Osteomyelitis,, nephritis

Clinical symptoms included severe lameness in affected legs. The lateral claws of the hind feet were most commonly affected, but medial hind claws and front feet also had lesions in some cases. The calves were usually gaunt and reluctant to move. Early examination of affected animals revealed abnormal wear of the hoof, extreme tenderness of affected digits, and elevated temperatures. As the problem developed, swelling developed at the coronary band, and separation of the hoof wall and sole at the white line occurred. Untreated calves sometimes sloughed toes. Infection spread up the legs causing arthritis and cellulitis in some cases. Additional spread of infection to internal sites occurred in three of five cases.

Splitting the affected digits on a band saw revealed internal lesions including laminitis, osteomyelitis of second and third phalanges, arthritis, tendinitis, cellulitis, necrosis and abscessation of the third phalanx (P3), and sole abscesses.

Of the three cases cultured, *Actinomyces pyogenes* was found in affected digits, and *Bacteroides melaninogenicus* was found in two of the three cases. *A. pyogenes* and *B. melaninogenicus*, spread from infected feet, were isolated from the lung of one calf. Two cases were not cultured. These bacterial isolates are commonly found in suppurative processes of cattle. It is interesting to note that *Fusobacterium necrophorum*, a common isolate in footrot, was not identified.

No viral agents were identified in the tissues submitted. Liver selenium in one case was high, but not in the toxic range.

Weather conditions were unusually wet in the region last year. These conditions tended to soften hoof walls. When cattle were sorted, processed, or on rough abrasive surfaces, the hooves were quickly rasped away. As the wall of the hoof was worn away, the vascular area was exposed, providing an ideal portal for bacteria to enter the foot. Bacteria sometimes ascended the leg, following along vessels causing abscesses and cellulitis along the way. The sudden turning movements used by cattle when sorted may lead to tearing and separation of the hoof wall from the sole and further white line abscessation. Standing for excessive periods (during trucking) and other traumatic events will lead to softening of solar horn and solar hemorrhage. The hemorrhages in the horn form a point of weakness which can lead to solar penetration, sole ulcers, or white line abscessation. Rough, uneven concrete surfaces may also traumatize the feet leading to infection and abscessation.

Treatment of affected animals may include trimming toes to assist in drainage of exudate and antibiotic therapy. Early treatment is imperative because chronic infections respond poorly to treatment. Foot injuries can be reduced by handling cattle as quietly as possible, by sorting and processing cattle on dirt or deep sand, by replacing damaged surfaces, and by getting an accurate diagnosis for lameness problems.

SDSU

EFFECTS OF GROWTH PATTERN ON MUSCLE GROWTH, NUCLEI NUMBER, PROTEIN ACCRETION, AND BODY COMPOSITION IN HEIFERS

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CATTLE 93-17

Summary

The effects of compensatory growth on accretion of muscle mass, protein mass, and nuclei number of the supraspinatus and semitendinosus muscles were evaluated using seven serial slaughter groups of Angus x Limousin heifer calves (n = 28, BW 270 ± 9.5 kg). Fractional growth rates of carcass protein and fat were also evaluated. To achieve compensatory growth, energy intake was restricted for 88 days (Phase 1) followed by ad libitum feeding of a high energy diet (Phase 2) [LH]. Controls were allowed continuous ad libitum access to the high energy diet (HH). Muscle weights, body composition samples, and muscle biopsies were collected at various weight (465 vs 500 kg) or age (88 vs 186 days) constants. Phase 1 energy restriction limited body weight, carcass weight, carcass protein mass, and carcass fat mass (P<.05). This was the result of the limited tissue fractional growth rates. The fractional growth rate of protein for heifers exhibiting compensatory growth was not increased but was maintained until maximum carcass protein mass was attained. Maximum carcass protein mass was attained by a weight of 465 kg. Any further increase in carcass weight was primarily attributed to an increase of carcass fat mass regardless of previous management. Energy restriction limited muscle, protein, and nuclei accretion rates. Heifers exhibiting compensatory growth sustained a linear growth potential until maximum muscle mass occurred at an end point similar to cattle not exhibiting compensatory growth. Muscle nuclei maintained a constant relationship to muscle mass independent of nutritional treatment, muscle type (supraspinatus vs semitendinosus), or days on feed. These data indicate compensatory growth alters the growth curve without affecting the mechanisms of growth.

Key Words: Beef, Compensatory Growth, Muscle

Introduction

Beef cattle demonstrate improvements in production and biological efficiencies during compensatory growth. The mechanisms involved in this response are not clearly understood. Muscle growth can occur through either hyperplasia (increased cell numbers) or hypertrophy (increased cell size), and differences in this growth mechanism may play a role in the efficiency of compensatory growth. Based upon the concept of the DNA unit where a given amount of DNA has physiological control over a finite amount of cell cytoplasm, hyperplasia occurs with concomitant DNA accretion. The skeletal muscle cell is multinucleated and incapable of cell division. The ultimate size of the muscle would therefore be determined by the number of nuclei. Postnatal accretion of DNA that has been observed has been attributed to the differentiation of muscle satellite cells. Thus, DNA accretion or satellite cell recruitment has been suggested as a prerequisite for muscle growth. It has been demonstrated that muscle

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growth in steers over 300 kg BW was hypertrophic in nature, whereas others have attributed a major portion of muscle growth at heavier BW to hyperplasia. The reason for these contrasting conclusions is undoubtedly important as we elucidate the mechanisms involved in regulation of skeletal muscle growth. In the present study, the effects of compensatory growth, age, and body weight (BW) on body composition, DNA, and muscle accretion were evaluated.

Materials and Methods

Fifty-eight Limousin x Angus heifer calves were vaccinated for IBR, BVD, PI_3, BRSV, 7-way clostridia, and Haemophilus within 24 hours of feedlot arrival. Ivermectin[4] was used for parasite control. Anabolic implants were not utilized. Twenty-eight heifers (BW = 270 $\pm$ 9.5 kg) were selected for uniformity of BW and type from this group of 58 calves for a serial slaughter experiment. These heifers were allotted to seven slaughter groups of four for comparison of body composition at various time and BW constants (Figure 1). The remaining 30 heifers were allotted to pens of five for comparisons of feedlot performance (previously reported data[5]).

Initial BW was the average of the BW measured on each of the first 2 days of the experiment. One pen was slaughtered on day 0 for initial body composition and muscle characterization. The six remaining groups were allotted to diets (Table 1) either of low energy (LED) to impose growth restriction or high energy (HED) provided ad libitum to allow for maximal growth (Phase 1). Energy values of feedstuffs and animal requirements for gain were based on NRC (1984).

One pen from each treatment was slaughtered at the end of Phase 1 (day 88). During Phase 2, heifers fed LED were switched to HED (LH) to achieve compensatory growth, while HED heifers continued on HED (HH). The remaining pens were slaughtered when pen average BW approached 465 or 500 kg (Figure 1).

After decapitation and prior to hide removal, approximately 200-g tissue biopsies were taken from the supraspinatus and the semitendinosus muscles and immediately frozen in liquid N. Samples were pulverized in a Waring blender under liquid N and analyzed for protein and DNA concentrations. Bovine serum albumin and calf thymus DNA from Sigma[6] were used as standards.

Supraspinatus and semitendinosus muscles were dissected and weighed from the opposite side of the hot carcass from where the biopsies were obtained. Predicted muscle mass of protein (g) and nuclei number (6.2 pg DNA) were calculated using the Proc Reg procedure of SAS. Comparisons of two regression lines were performed. Data of regression equations not significantly different (P>.10) were pooled.

The chemical analysis of the 9-10-11th rib soft tissue was used to estimate carcass soft tissue composition. Tissue fractional growth rates were calculated using the equation $(M_1 - M_O/T) / [(M_1 + M_O)/2]$, where M_O = initial tissue measure, M_1 = final tissue measure, and T = time, day. Carcass composition data were tested by procedures appropriate for a completely random design with carcass representing the experiment unit. Data were analyzed on a BW constant (465 vs 500 kg) or a time constant (88 vs 186 days) basis. Analysis of variance was accomplished using the GLM procedure and CONTRAST option of SAS.

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[4]MSD AGVET, Division of Merck and Co., Inc. Rahway, NJ.
[5]S.D. Agr. Exp. Sta. Beef Report CATTLE 91-12:48-51.
[6]Sigma, St. Louis, MO.

Table 1. Experimental diet compositions[a]

Ingredient	Diet: Low energy[b]	Diet: High energy[c]
Hay	-	10.00
Wheat straw	15.00	-
Corn silage	74.94	-
Whole shelled corn	-	81.61
Soybean meal, 44%	9.21	4.60
Molasses	-	2.25
Trace mineralized salt	.30	.30
Calcium carbonate	.55	1.01
Potassium chloride	-	.23
Nutrient composition		
Crude protein, %	11.04	11.77
Calcium, %	.439	.505
Phosphorus	.235	.290
Potassium, %	1.146	.803
NE_m, Mcal/kg	1.53	2.06
NE_g, Mcal/kg	.85	1.36

[a]Percentage of dry matter unless otherwise stated.

[b]Provides 33 mg/kg lasalocid day 1 to 36, 27.6 mg/kg of monensin day 37 to 88 and 2205 IU/kg supplemental vitamin A.

[c]Provides 33 mg/kg lasalocid and 2205 IU/kg supplemental vitamin A.

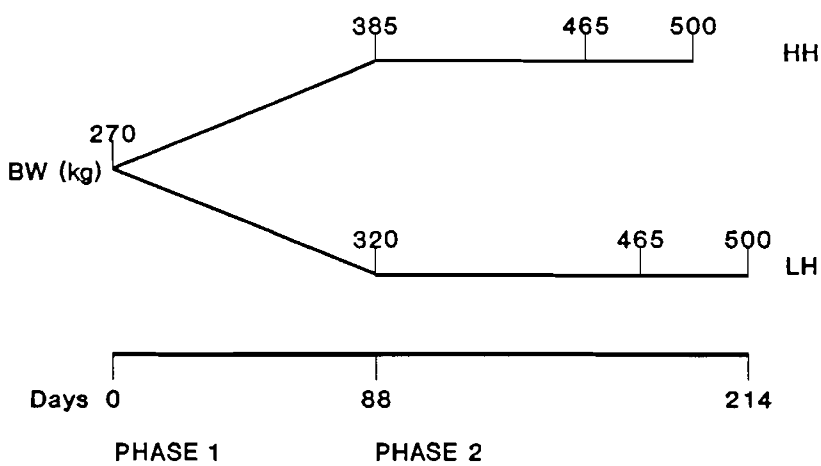

Figure 1. Serial slaughter points (n = 4).

Results and Discussion

At the end of Phase 1 (day 88), both body weight (BW) and carcass weight (CW) were lowerfor the energy restricted heifers ($P<.05$, Table 2). This also resulted in a lower carcass protein mass (CPM) and carcass fat mass (CFM) [$P<.05$, Table 2]. During Phase 2 (day 186), CW was lower for the LH than HH heifers ($P<.05$, Table 2). After 186 days on feed, CPM was similar ($P>.05$, Table 2), whereas CFM was lower for LH than HH ($P<.05$, Table 2). The difference in CW is primarily attributable to the differences in CFM.

Contrasts performed at constant BW of 465 or 500 kg (Table 3) resulted in CW, CPM, and CFM being similar within BW group. Contrasts between BW groups (465 vs 500 kg) demonstrated that CW was greater at 500 kg BW ($P>.05$, Table 3). This increase in CW did not result from an increase in CPM, which was similar ($P>.10$, Table 3). Carcass fat mass increased from 465 to 500 kg BW ($P<.05$, Table 3). As a result, differences in CW can probably be attributed to increases in CFM.

To determine differences in the rate of tissue accretion, the fractional growth rate (FGR) of protein (FGR_P), and fat (FGR_F) were calculated. At the end of Phase 1, the FGR_P and FGR_F were lower for the energy restricted heifers. During realimentation, the opposite occurred. The FGR_P and the FGR_F were higher for LH than HH ($P<.05$, Table 4). Under a normal sigmoidal curve, the FGR_P gradually decreases as the animal reaches maturity. This occurred with the HH heifers as the FGR_P and FGR_F decreased. During this same period, the FGR_P for the LH heifers was maintained, while the FGR_F increased. Compensatory growth has been characterized as having a more efficient FGR_P. This was not apparent in this study. Either an increase in the FGR_P did not occur or had already occurred prior to the measurement made in this study. Increases in visceral mass which were not measured in this study may also account for an increase in FGR_P.

Table 2. Carcass tissue mass contrasts on an age constant basis

	Phase 1		Phase 2		
Item	LH	HH	LH	HH	SEM
Body weight, kg[a]	319	386	472	499	
Carcass weight, kg[a]	197	243	292	311	
Protein, kg[a]	31	36	43	41	.6
Fat, kg[ab]	34	55	75	97	1.9

[a]Growth pattern differs within Phase 1 ($P<.05$).
[b]Growth pattern differs within Phase 2 ($P<.05$).

Table 3. Carcass tissue mass contrasts on a weight constant basis

	465 kg BW		500 kg BW		
Item	LH	HH	LH	HH	SEM
Carcass weight, kg	292	297	311	319	
Protein, kg	43	41	43	41	.7
Fat, kg[a]	75	85	99	97	2.3

[a]Growth pattern differs at BW endpoint ($P<.05$).

Table 4. Fractional growth rate contrasts on an age constant basis

	Phase 1		Phase 2		
Item	LH	HH	LH	HH	SEM
Protein, %/day[a]	.34	.51	.34	.11	.015
Fat, %/day[a]	.43	.92	.81	.52	.023

[a]Growth pattern differs within phase (P<.05).

It appears that energy restriction limits protein accretion while compensatory growth maintains a linear growth potential until maximal protein mass similar to contemporaries is attained. Any further growth is comprised mainly of fat deposition (Figure 2). For these heifers, maximal protein growth had occurred by 465 kg BW.

Regression equations describing growth of tissue components over time in days for LH and HH treatments during Phase 1 are presented in Table 5. The accretion rates of the supraspinatus (SS) and semitendinosus (ST) muscle mass, nuclei number (NN), and protein mass (PROT) were greater when feed was provided ad libitum in Phase 1 (P<.10). When Phases 1 and 2 were pooled (Table 6), heifers on the LH treatment maintained linear accretion rates of muscle mass (Figure 3), PROT (Figure 4), and NN (Figure 5) for both SS and ST muscles (P<.10), while HH responses were quadratic (P<.10), reflecting a leveling off of growth in this treatment.

Protein accretion vs NN (Figure 6) was linear (P<.01) for ST but quadratic (P<.01) for SS, indicating a lag in hypertrophic PROT accretion for SS at heavier BW. This suggests that different muscles may exhibit differing rates of hyperplastic or hypertrophic growth. Increases of NN per unit of muscle mass maintained a linear relationship (P<.05) and were not affected (P>.10) by muscle (SS vs ST) or treatment (LH vs HH) [Figure 7]. This is consistent with the hypothesis that DNA accretion is a prerequisite for muscle growth and could ultimately determine muscle mass.

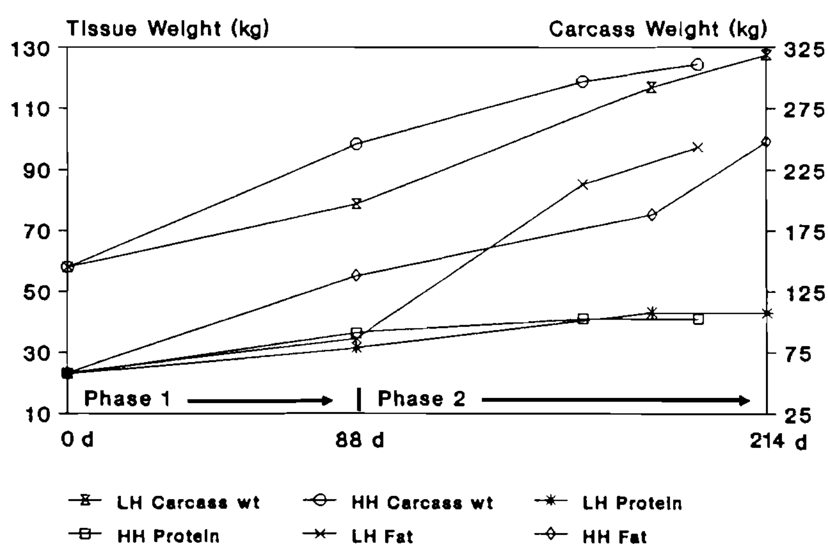

Figure 2. Carcass tissue accretion rates.

Table 5. Effect of time on tissue components (Phase 1)[a]

Y	Treatment	Intercept	b_1	r^2
Supraspinatus (kg)	LH	.65	.0024	.988
	HH	.65	.0038	.926
Semitendinosus (kg)	LH	1.22	.0042	.670
	HH	1.22	.0082	.865
Supraspinatus nuclei number[b]	LH	52.09	.1485	.829
	HH	52.09	.2422	.852
Semitendinosus nuclei number[b]	LH	86.27	.3418	.614
	HH	86.27	.7142	.913
Supraspinatus protein (g)	LH	102.14	.3614	.933
	HH	102.14	.5543	.956
Semitendinosus protein (g)	LH	204.22	.6231	.873
	HH	205.22	1.4108	.930

[a]Where Y = dependent variable as kg, g, or nuclei number and X = days since inception of the experiment.
[b]Nuclei number x 10^6.

Table 6. Effect of time on tissue components (Phases 1 and 2)[a]

Y	Treatment	Intercept	b_1	b^2	r^2
Supraspinatus (kg)	LH	.661	.0021		.845
	HH	.654	.0042	-.000012	.860
Semitendinosus (kg)	LH	1.255	.0036		.743
	HH	1.217	.0129	-.000052	.713
Supraspinatus nuclei number[b]	LH	51.929	.1785		.779
	HH	52.162	.2920	-.000616	.872
Semitendinosus nuclei number[b]	LH	86.461	.3157		.831
	HH	86.016	1.1187	-.004430	.896
Supraspinatus protein (g)	LH	10.684	.3973		.969
	HH	102.201	.7698	-.002490	.937
Semitendinosus protein (g)	LH	201.946	.6976		.968
	HH	205.049	2.1212	-.008626	.902

[a]Where Y = dependent variable as kg, g, or nuclei number and X = days since inception of the experiment.
[b]Nuclei number x 10^6.

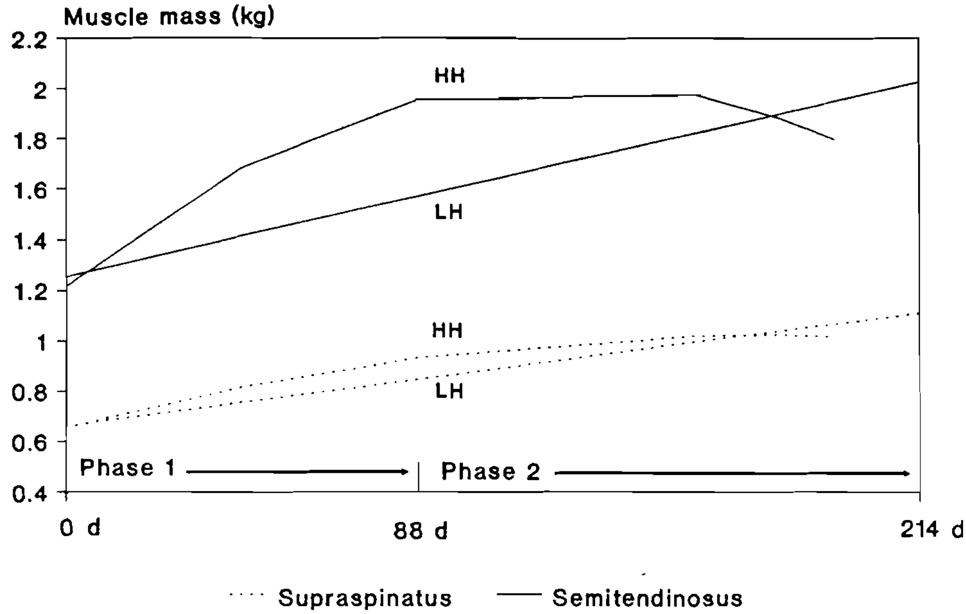

Figure 3. Muscle mass accretion rate.

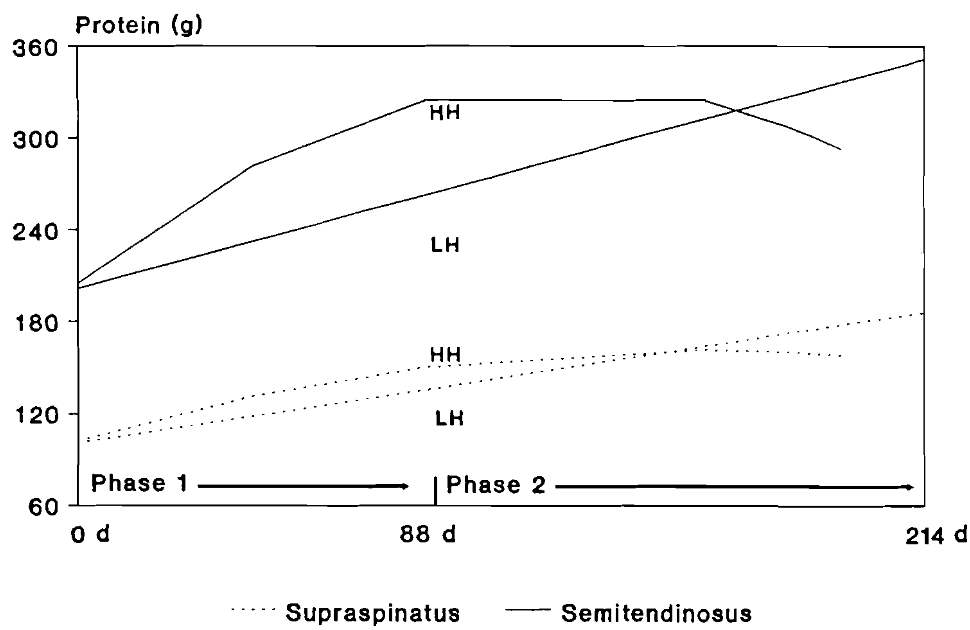

Figure 4. Muscle protein mass accretion rate.

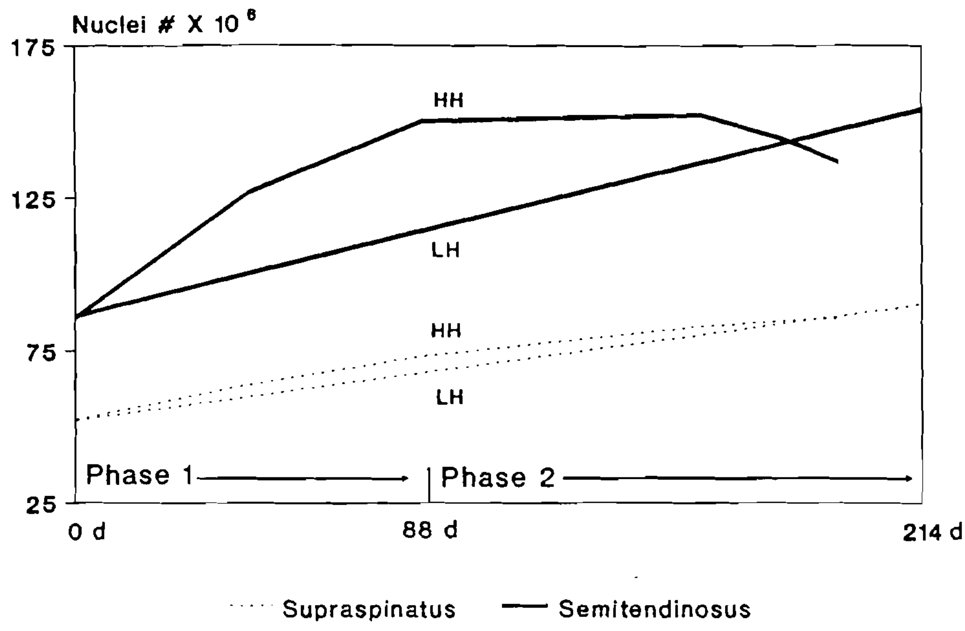

Figure 5. Muscle nuclei accretion rate.

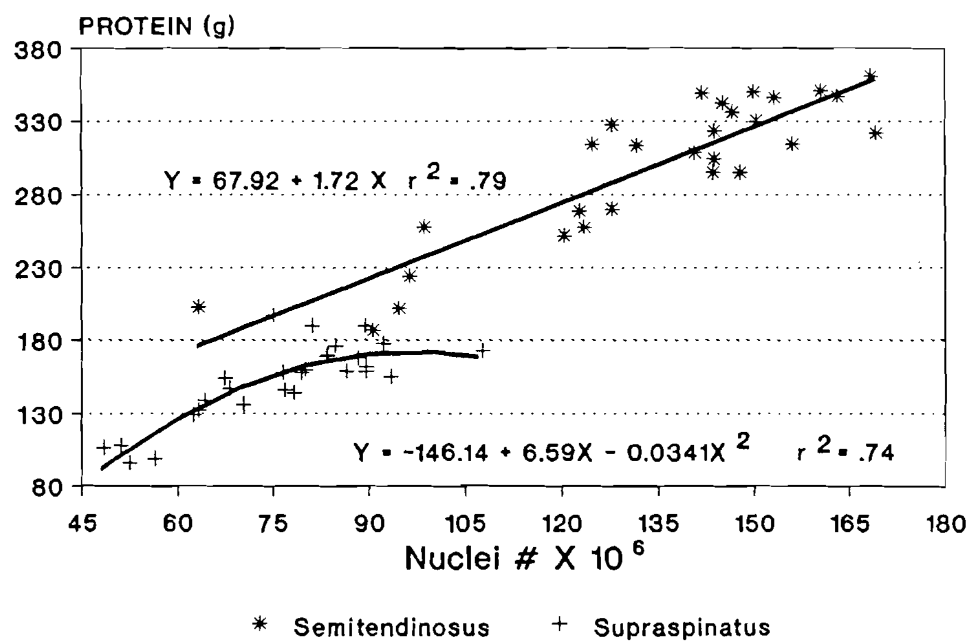

Figure 6. Relationship of nuclei number to muscle protein mass.

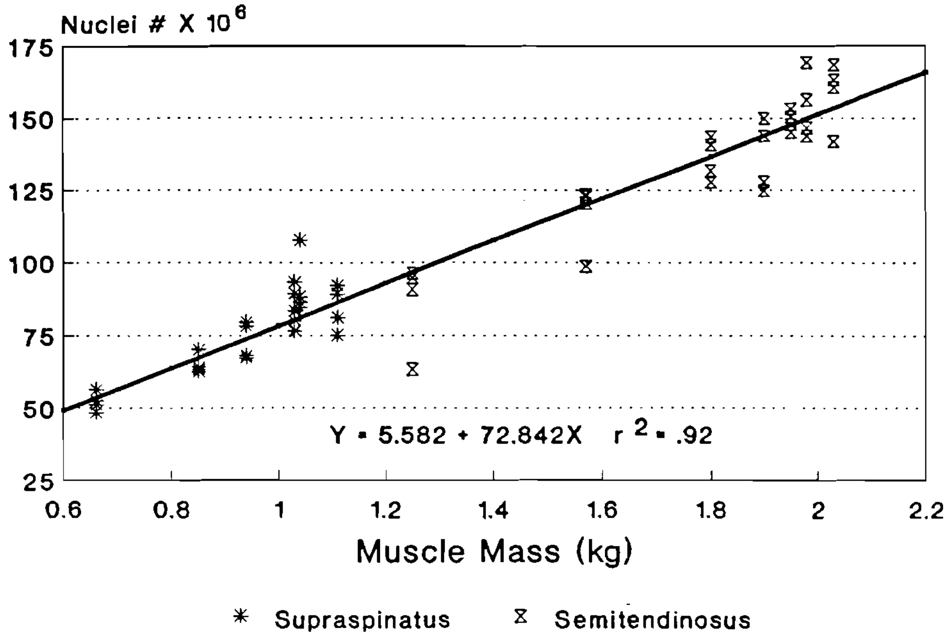

Figure 7. Relationship of nuclei number to muscle mass (coefficients differ from zero, P<.01).

SOUTH DAKOTA RETAINED OWNERSHIP DEMONSTRATION

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CATTLE 93-18

Summary

Three hundred eighty-eight calves representing 59 cow-calf producers were consigned to a custom feedlot. Steer calves consigned in October weighed 601 lb initially, gained 3.03 lb per head daily, and averaged 1148 lb at slaughter after an average of 182 days on feed. Average cost of gain and profitability were $53.94 per cwt and $90.38 per head, respectively. Steers consigned in January weighed 775 lb initially, gained 3.31 lb per head daily, and averaged 1245 lb at slaughter after 142 days on feed. Average cost of gain and profitability were $50.67 per cwt and $55.66 per head, respectively. Heifers consigned in January weighed 718 lb initially, gained 3.10 lb per head daily, and averaged 1123 lb at slaughter after 131 days on feed. Average cost of gain and profitability were $52.39 per cwt and $64.59 per head, respectively. Average daily gain, dressing percentage, quality grade, and cost of gain appeared to impact profitability. Quality grade was especially important for cattle consigned in January. These cattle were sold later in the season when the choice-select price margin was wider as compared to the spread of early marketed cattle consigned in October.

Key Words: Retained Ownership, Feedlot Performance, Feedlot Profitability

Introduction

Retained ownership of feeder calves has been shown to consistently improve profitability of cow-calf operations. Average profit for cattle enrolled in the first 2 years of the South Dakota Retained Ownership Demonstration were $26.00 per head. The range in profitability for all of the groups of five was from -$63.72 to $131.36. An understanding of factors influencing the profitability of retained ownership is essential in order to successfully use retained ownership as a market alternative.

The overall objective of this multi-year program is to evaluate retained ownership as a marketing alternative for cow-calf producers. This report summarizes data from the third year of the project.

Materials and Methods

Eighteen cow-calf producers consigned 31 groups of five steer calves to a custom feedlot[4] in mid-October of 1992.

Thirty-one cow-calf producers consigned 34 groups of five steer calves to the feedlot at the end of January 1993. Twelve cow-calf producers consigned 13 groups of five heifer calves to the feedlot at the end of January 1993. These cattle had been weaned in the fall and backgrounded at home prior to feedlot arrival.

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Processing procedures included weighing, measuring hip height, and determining initial fat thickness with an ultrasound unit on all cattle that arrived in the fall. Cattle that arrived in the winter were not measured for hip height or initial fat thickness.

All cattle were treated with Ivomec[5] to control parasites and implanted with Synovex-S[6] (steers) or Synovex-H[6] (heifers). All calves received 7-way clostridial bacterin and were vaccinated for IBR, BVD, PI_3, BRSV, and Hemophilus somnus. Cattle that arrived in the fall were given the appropriate booster vaccinations on day 21 in the lot and were reimplanted in late January. Cattle that arrived in late January were not given booster vaccinations and were not reimplanted.

Following processing all cattle were fed long stem alfalfa grass hay and the October calves were fed a commercial receiving feed[7]. The winter cattle received a growing ration (Table 1). Over a several day period as the fall cattle became accustomed to eating at the bunk, the hay was removed and the receiving feed was increased until cattle were eating about 3% of their body weight. At this point, a growing ration

Table 1. Composition of diets fed to cattle

	Diet		
Item	Grower	Winter finisher	Final finisher
Ingredient[a]			
Mixed silage[b]	63.68	28.24	23.44
High moisture corn	--	13.43	14.35
Rolled corn	33.06	53.73	57.40
Supplement[c]	3.07	4.41	4.62
Mineral	.19	.19	.19
Nutrient[d]			
Crude protein, %	13.24	12.94	12.88
Ne_m, Mcal/cwt	85.26	92.83	94.85
NE_g, Mcal/cwt	53.00	60.47	62.47
Calcium, %	.75	.62	.59
Phosphorus, %	.36	.37	.38
Vitamin A, IU/lb	4485	3549	3323
Rumensin, g/ton	21.5	22.5	23.0

[a]Percentage, as fed.
[b]Approximate as fed composition: corn 33.3%, cane 33.3%, and alfalfa 33.3%.
[c]Sup-R-Lix, Purina Mills, Inc.
[d]Dry matter basis.

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[5]Product of MSDAGVET, Rahway, NJ.
[6]Product of Syntex Animal Health, West Des Moines, IA.
[7]Pre-Con, product of Purina Mills, Inc., St. Louis, MO.

gradually replaced the receiving feed. Calves were then stepped up through a series of intermediate diets until the cattle were on a winter finishing ration (Table 1) by day 30 in the feedlot. They received this ration until early March when they were switched to the final finishing ration. Over a couple of day period as intake by the winter cattle increased, the hay was removed from the diet and cattle were stepped up through a series of intermediate rations to the winter finisher diet. In early March these cattle were also switched to the final finishing ration.

Since all cattle were fed in one of three pens, individual feed bills were calculated from performance data according to equations published by the National Research Council. Cattle were weighed approximately every 6 weeks. Ration energy density was calculated for each feeding program from the average performance for each pen. An estimate of individual intake was calculated for each calf using calf weight, daily gain, and ration energy density.

Feed, yardage, and veterinary bills were financed through a commercial bank[8]. Death loss for each pen was shared by all participants in the pen. Producers were sent periodic progress reports and copies of their feed bills. Each group of five cattle was slaughtered when three from the group appeared to reach .4 inch of fat over the 12th rib.

Results and Discussion

A wide variety of cattle types were represented in the program. Initial weight, hip height, and fat thickness are displayed in Table 2. Cattle placed on feed in October averaged 601 lb and ranged from 414 to 844 lb. They averaged 45.59 inches tall at the hip and carried .16 inch of backfat. Cattle placed on feed in January had been weaned in the fall and backgrounded at the ranch prior to feedlot arrival. Steers averaged 775 lb, while heifers averaged 718 lb.

Feedlot performance information is shown in Table 3. Cattle were weighed full the day prior to slaughter. Slaughter weight for each steer was computed by applying a 4% pencil shrink to this full weight. Slaughter weight was greater for the January steers as compared with the January heifers or October steers (1245 vs 1123 and 1148 lb, respectively). Average daily gain was also greater for January steers than for the January heifers or October steers (3.31 vs 3.10 and 3.03 lb per head daily, respectively). January heifers were fed fewer days than January steers or October steers (131 vs 142 and 182 days, respectively).

Actual average dry matter intake was 20.56, 23.20, and 22.43 lb per head daily for the October steers, January steers, and January heifers, respectively. Feed to gain ratios were 6.79, 7.01, and 7.24 lb dry matter per pound gain for the October steers, January steers, and January heifers, respectively.

Table 4 shows carcass data collected for the cattle. Carcasses of the January steers were heavier than carcasses of the October steers or January heifers. Dressing percentage, fat thickness, ribeye area, and calculated yield grade were greater for January steers than for October steers or January heifers. Percentage choice carcasses for the October steers, January steers, and January heifers were 53.33, 53.25, and 58.46, respectively.

Table 5 shows the feeding period costs for the cattle. Feed and yardage expenses were greater for the October steers than the January steers or heifers due to additional time on feed. Veterinary and death loss costs were much higher for the October steers than for the January steers or heifers. January cattle were backgrounded at the home ranch and probably

[8]Tri-County State Bank, Kimball, SD.

Table 2. Initial data for retained ownership cattle

	Weight, lb	Hip height, in.	Fat thickness, in.
October steers			
Average	601	45.59	.16
Range	414-844	42.00-51.50	.08-.28
Standard deviation	71	1.76	.04
Range (5 head)	480-788	42.7-49.75	.10-.22
January steers			
Average	775		
Range	530-1030		
Standard deviation	92		
Range (5 head)	647-966		
January heifers			
Average	718		
Range	544-894		
Standard deviation	88		
Range (5 head)	576-834		

Table 3. Feedlot performance for retained ownership cattle

	Slaughter weight, lb	Average daily gain, lb	Days fed
October steers			
Average	1148	3.03	182
Range	929-1511	1.89-4.22	158-237
Standard deviation	93	.39	23
Range (5 head)	1008-1310	2.40-3.57	158-237
January steers			
Average	1245	3.31	142
Range	1004-1542	1.98-4.75	104-153
Standard deviation	102	.46	13
Range (5 head)	1109-1449	2.73-4.02	104-153
January heifers			
Average	1123	3.10	131
Range	931-1346	2.17-3.98	104-153
Standard deviation	80	.36	22
Range (5 head)	1032-1237	2.73-3.65	104-153

Table 4. Carcass data for retained ownership cattle

	Hot carcass wt, lb	Dressing percent	Fat thickness, in.	Rib eye area, in.^{2}	Kidney, heart, and pelvic fat, %	Calculated yield grade, units	Marbling score, units[a]	Percent choice
October steers								
Average	724	63.07	.39	12.70	2.71	2.70	4.91	53.33
Range	576-964	58.93-68.85	.10-.80	10.50-16.40	1.50-4.00	1.32-4.12	3.60-7.10	
Standard deviation	64	1.72	.14	1.16	.53	.53	.53	
Range (5 head)	642-832	60.90-67.04	.23-.59	11.56-14.64	1.88-3.20	2.06-3.32	4.18-5.68	0-100
January steers								
Average	790	63.63	.41	13.15	2.48	2.83	4.82	53.25
Range	616-964	56.31-69.24	.10-.90	9.80-18.20	1.00-3.50	1.13-4.76	3.30-6.50	
Standard deviation	67	1.93	.16	1.37	.52	.69	.54	
Range (5 head)	681-913	58.76-67.16	.23-.68	11.04-15.12	1.70-3.20	1.79-3.98	4.03-5.40	0-100
January heifers								
Average	703	62.63	.39	12.71	2.62	2.60	4.81	58.46
Range	592-783	56.92-66.27	.10-1.00	11.00-15.00	2.00-3.50	1.17-4.42	3.60-6.30	
Standard deviation	56	2.05	.16	1.14	.48	.64	.60	
Range (5 head)	653-804	60.18-65.04	.22-.62	11.34-13.66	2.38-3.00	1.97-3.42	4.15-5.72	0-100

[a] 4.00 = Slight^{0}, 5.00 = Small^{0}.

Table 5. Feeding period costs[a]

Item	October steers	January steers	January heifers
Feed	206.03	180.92	158.73
Yardage	27.35	21.33	19.65
Veterinary	15.08	4.98	4.85
Interest[b]	7.94	2.99	2.47
Trucking[c]	8.06	8.57	7.88
Marketing	1.47	1.47	1.47
Death loss	15.00	0.00	0.00
Total	280.93	220.26	195.05
Feed cost of gain[d], $/cwt	39.45	41.49	42.49
Total cost of gain[d], $/cwt	53.94	50.67	52.39
Break-even sale price, $/cwt	75.06	73.58	73.87

[a] Dollars per head.
[b] Interest on feed, yardage, and veterinary expenses only.
[c] Trucking to packing plant only.
[d] Pay weight basis.

experienced most of the death loss and veterinary expenses at home prior to feedlot arrival.

Feed and total cost of gain are expressed on a pay weight to pay weight basis. Feed cost of gain was lowest for the October steers, yet their total cost of gain was greater than that observed for the January cattle. Initial pay weight was assumed to be 4% greater than the initial weight obtained at the feedyard. The full weight obtained the day prior to slaughter less the 4% pencil shrink was assumed to equal finished pay weight. Break-even sale prices were $75.06, $73.58, and $73.87 per cwt for the October steers, January steers, and January heifers, respectively.

Table 6 shows the initial and sale values and profitability of cattle fed in the program. Initial price for the October steers was established by using numerous sale barn reports for the last 3 weeks in October and regressing price on pay weight (Figure 1). The same technique was used for predicting the January prices (Figures 2 and 3). Equations predicting price are displayed in Table 7. No attempt was made to adjust the initial prices for breed type, frame size, initial condition, or location.

All cattle were sold on a grade and yield basis. Table 8 displays the steer carcass prices that were obtained for the cattle. A seasonal decline in the base choice price and a widening of the choice-select spread was observed. A greater number of the October steers were sold at the earlier marketing dates, resulting in a higher price being paid for these cattle as compared with the January steers or heifers. Likewise, over half of the heifers were sold prior to June 1, while over 80% of the January steers were sold after June 1, resulting in a greater price for the January heifers than the January steers.

Profits, excluding calf interest and trucking to the lot, were $113.70, $55.66, and $64.59 for the October steers, January steers, and January heifers, respectively. If opportunity interest on the calf was 7%, interest charges and profitability would have been $19.46 and $94.24, $18.92 and $36.74, and $15.75 and $48.84 per head for the October steers, January steers, and January heifers, respectively. Annual return on investment

Table 6. Profitability of retained ownership steers and heifers

Item	October steers	January steers	January heifers
Initial pay weight, lb	625	805	746
Price, $/cwt	89.41	86.62	85.31
Initial value, $	558.81	697.29	636.41
Hot carcass wt, lb	724	792	712
Price, $/cwt	131.69	122.88	125.85
Sale value, $	953.44	973.21	896.05
Profit, $/head[a]	113.70	55.66	64.59
Annual return on investment, %	40.81	20.49	28.28

[a] Excludes calf interest and trucking to the feedlot.

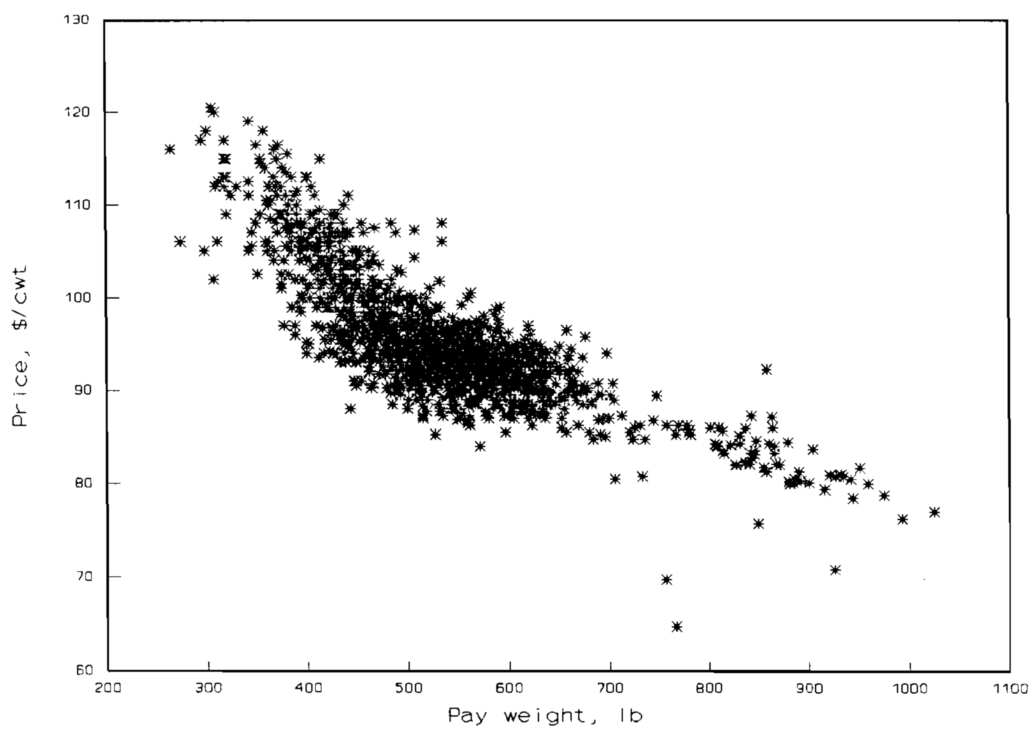

Figure 1. Relationship between price and pay weight of steers for late October 1992.

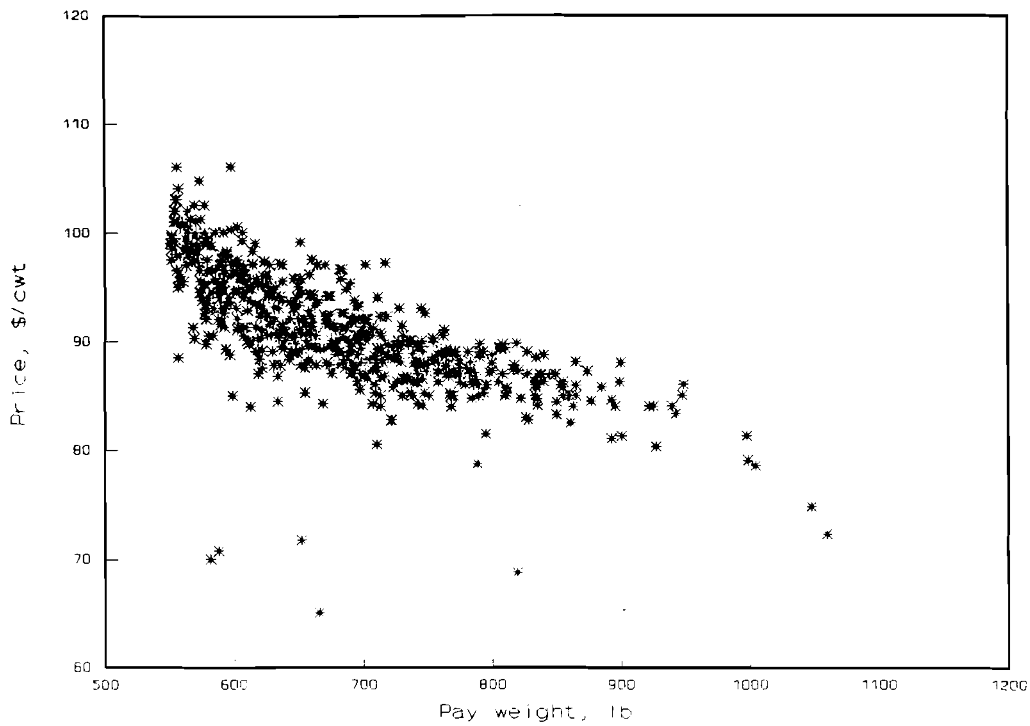

Figure 2. Relationship between price and pay weight of steers for late January 1993.

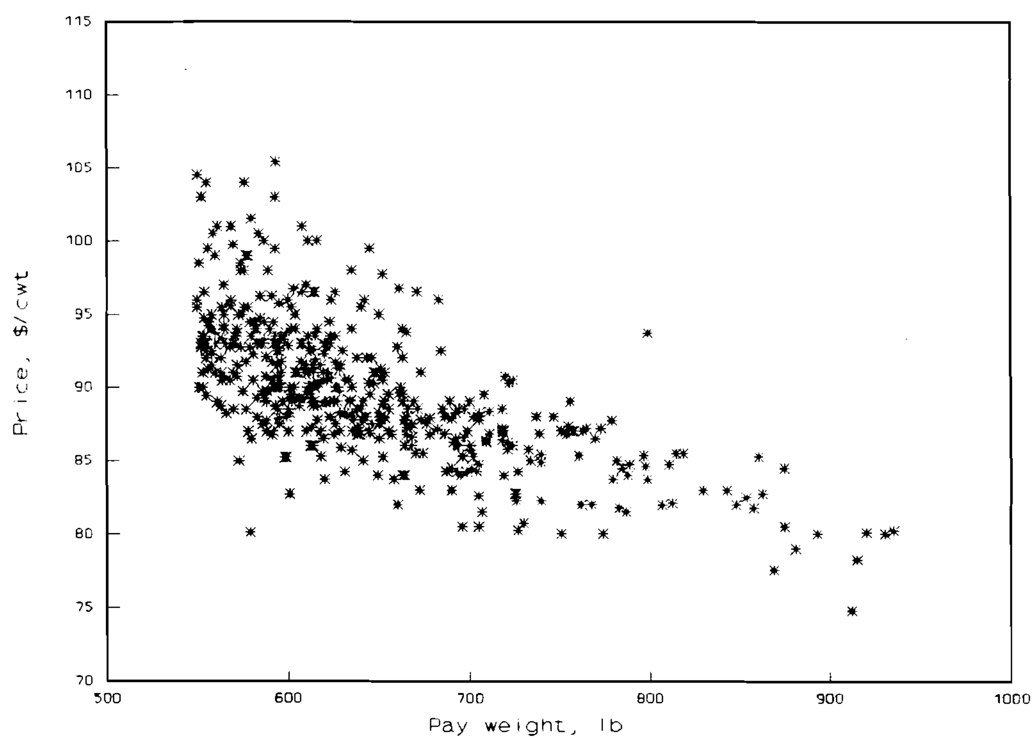

Figure 3. Relationsip between price and pay weight of heifers for late January 1993.

Table 7. Equations predicting initial price

Cattle	n	Equation[a]	R^2	Sy.x
October steers	1683	$146.8276 - .13812\ wt + .000074\ wt^2$	.70	3.4618
January steers	630	$151.6995 - .13311\ wt + .000064\ wt^2$	.55	3.5188
January heifers	489	$146.1425 - .12773\ wt + .000061\ wt^2$	.47	3.4324

[a]Weight = pay weight in lb.

Table 8. Carcass prices paid for cattle

	Number of cattle sold			Base		
Market date	October steers	January steers	January heifers	choice price[a]	Select discount[a]	Heifer discount[a]
March 23	39			134.00	2.00	
April 1	43			135.00	3.00	
May 5	58	5	20	134.00	5.00	1.50
May 25		25	15	134.00	10.00	1.00
June 10	10	55		126.00	10.00	
June 24		84	30	126.00	8.00	1.00

[a]$ per cwt carcass.

(initial calf value) was 40.81, 20.49, and 28.28% for the October steers, January steers, and January heifers, respectively.

The variability in profitability between individual cattle and between groups of five head was tremendous (Table 9). The poorest profitability group of five cattle lost $14.95 per head. The most profitable group of five cattle made over $150 per head. Annual return on investment for the groups of five ranged from -6.46 to 57.64%.

Another way to express retained ownership profitability is to use slaughter value and feedlot costs to back calculate the value of the calves when they entered the feedlot. October steers, January steers, and January heifers were worth $953.44, $973.21, and $896.05 per head at slaughter, respectively. Total feeding costs were $280.93, $220.26, and $195.05 per head for the October steers, January steers, and January heifers, respectively. Therefore, the calves were worth $672.51, $752.95, and $701.00 at feedlot arrival for the October steers, January steers, and January heifers, respectively. Average pay weights on the calves were 625, 805, and 746 lb for the October steers, January steers, and January heifers, respectively. Thus, October steers were worth $107.60 per cwt, January steers were worth $93.53 per cwt, and January heifers were worth $94.97 per cwt. These values represent premiums of $14.46, $6.91, and $8.66 per cwt above the fed cattle market at time of placement for the October steers, January steers, and January heifers, respectively.

Data from the previous 2 years of this study clearly demonstrated that average daily gain, dressing percentage, quality grade, and total cost of gain were the most important factors contributing to profitability. Tables 10, 11, and 12 illustrate how these and other variables impacted profitability in this latest year's data. Average daily gain, dressing percentage, and quality grade were greater for higher profit cattle than lower profit cattle. Total cost of gain was greater for lower profit steers than higher profit steers. However, cost of gain appears to not be an important source of variation in profit for the heifers.

Table 9. Variation in profitability

	Profit, $/head	Annual return, %	Fall calf premium, $/cwt
October steers			
Average	113.70	40.81	18.41
Range	-26.81-217.27	-8.40-74.62	-4.07-32.36
Standard deviation	42.23	15.27	6.78
Range (5 head)	52.86-177.36	16.66-58.01	11.95-26.32
January steers			
Average	55.66	20.49	6.91
Range	-78.02-214.39	-32.44-93.96	-12.85-27.49
Standard deviation	50.93	19.97	6.46
Range (5 head)	-14.95-134.65	-6.46-57.64	-2.59-16.71
January heifers			
Average	64.59	28.28	8.66
Range	-65.73-159.79	-24.49-82.85	-8.66-19.25
Standard deviation	39.80	18.57	5.23
Range (5 head)	44.72-104.64	19.28-54.66	5.64-13.18

Table 10. Value of select variables for low, middle, and high profit groups of October placed calves

	Profit group		
Variable	Low 1/3	Mid 1/3	High 1/3
Profit, $/head	64.08	114.52	158.26
Average daily gain, lb	2.75	3.10	3.23
Initial weight, lb	594	601	609
Finished weight, lb	1103	1149	1193
Dressing percent	62.13	62.86	64.23
Days fed	187	178	182
Cost of gain, $/cwt	55.57	53.22	53.02
Percentage choice	34	58	68

Table 11. Value of select variables for low, middle, and high profit groups of January steers

Variable	Profit group Low 1/3	Mid 1/3	High 1/3
Profit, $/head	-1.34	56.19	117.24
Average daily gain, lb	3.14	3.29	3.51
Initial weight, lb	782	767	775
Finished weight, lb	1234	1231	1269
Dressing percent	63.42	63.44	64.17
Days fed	144	141	141
Cost of gain, $/cwt	51.82	50.55	49.66
Percentage choice	13	51	96

Table 12. Value of select variables for low, middle, and high profit groups of January heifers

Variable	Profit group Low 1/3	Mid 1/3	High 1/3
Profit, $/head	19.52	64.27	112.76
Average daily gain, lb	2.90	3.22	3.17
Initial weight, lb	675	752	725
Finished weight, lb	1088	1143	1134
Dressing percent	62.57	63.24	64.32
Days fed	143	121	130
Cost of gain, $/cwt	52.01	53.13	52.03
Percentage choice	43	32	100

Carcass quality was more important in the cattle placed in the feedlot in January as compared to cattle placed in October. This was most likely due to the wide choice-select spread at late marketing dates when most of the January cattle were sold as compared with the narrow choice-select spread at early marketing dates when most of the October cattle were sold.

Acknowledgements

Support for this project was contributed by Purina Mills, Inc., MSDAGVET, and Syntex Animal Health. The time and effort contributed by numerous private industry personnel who served on the project steering committee are also greatly appreciated. They included Bob Goetz, Kimball; Ron Bauer, Platte; John Heiberger, Bridgewater; Ed Blair, Vale; Rod Larsen, Kimball; Dr. Bruce Naasz, Kimball; Dr. Arnie Fleck, Sioux City, IA; Jim Honomichl, Mitchell; and Ron Frederick, Selby. Appreciation is also expressed to numerous SDSU faculty, graduate students, staff, and extension agents who contributed to the project.

EFFECT OF SLAUGHTER CATTLE MARKETING METHOD ON THE PRODUCTION SIGNALS SENT TO BEEF PRODUCERS

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CATTLE 93-19

Summary

Data collected from 759 steer calves that were consigned to the South Dakota Retained Ownership Demonstration were utilized to examine the effect of slaughter cattle marketing methods on production signals sent to beef producers. Marketing systems examined included basing price on live weight (LW), dressed weight (DW), grade and dressed weight (G and Y), or Excel Corporation's proposed muscle scoring system (MS). Profitability per head averaged $6.64, $23.54, $26.00, and $27.09 for the LW, DW, G and Y, and MS marketing systems, respectively. For the LW pricing system, average daily gain, cost of gain, initial feedlot weight, and days fed accounted for 86.6% of the variation in profitability. For the DW pricing system, average daily gain, dressing percentage, cost of gain, initial feedlot weight, and days fed accounted for 92.9% of the variation in profitability. Average daily gain, dressing percentage, quality grade, cost of gain, and days fed accounted for 83.1% of the variation in profit for the G and Y marketing system. Average daily gain, dressing percentage, cost of gain, days fed, carcass fatness, quality grade, and rib eye area explained 75.6% of the variation in profitability for the MS pricing system. Only the MS pricing system rewarded production of muscle and penalized the production of carcass fat. Current fed cattle pricing systems used in the industry fail to transfer consumer demand for lean beef to beef producers.

Key Words: Feedlot Profitability, Retained Ownership, Value Based Marketing, Consumer Demand

Introduction

Research at the retail level has shown that consumers demand a leaner and more consistent cut of beef at a competitive price. Currently, an average of 88 pounds of excess fat is on each steer slaughtered in the United States adding up to over 2 billion pounds at a cost to the industry of about $2 billion annually. Excess fat production is stimulated by a marketing system that places the same value on trimmable fat as on edible lean.

Research has shown that, in 1979, 98% of the cattle in the Southern Plains and 82% of the cattle in the western corn belt were marketed on a live weight basis. The trend seems to be toward more cattle being marketed "in the beef" or grade and yield, but in 1986 still less than one-third of all cattle were marketed on a grade and yield basis. In the Southern Plains less than 10% of the cattle were marketed grade and yield.

The objective of this paper is to determine the production factors and/or carcass quality and cutability factors that are rewarded under various marketing methods. Four marketing methods are examined. They included 1) selling on a live weight basis, 2) selling on a carcass weight basis (in the beef), 3) selling on a dressed weight and grade basis (grade and yield), and 4) selling

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under a value based marketing system (Excel muscle scoring system[3]).

Materials and Methods

In October of 1990, 69 groups of 5 steer calves representing 53 producers and, in October of 1991, 84 groups of 5 steer calves representing 57 producers were placed on feed as part of the South Dakota State University Retained Ownership Demonstration Project. Initial data such as weight, hip height, and fat thickness[4] were measured and recorded for each of the steers. Producers filled out questionnaires concerning breed type and pre-feedlot arrival management. Age, sire breed, dam bred, and whether or not the calves were creep fed, vaccinated, or weaned for more than 5 days prior to feedlot arrival were recorded for each steer. Initial value for each steer was calculated using the following equations:

Price Fall 1990 ($/cwt) = 135.4826 - .06226 x pay weight

Price Fall 1991 ($/cwt) = 163.3314 - .1806 x pay weight + .000107 x pay weight^2

where pay weight equals feedlot arrival weight times 1.04. These equations were generated by regressing price on pay weight for feeder cattle auctions across South Dakota held in October of each year.

Cattle were fed at a custom feedyard[5] in Central South Dakota. Feeding management procedures were typical for commercial feedyards. Cattle were fed rolled corn and corn silage based diets in open pens that had windbreaks, mounds, fence-line feed bunks, and feeding aprons. Cattle were weighed full at 5 to 6-week intervals and feed intake for individual steers was calculated using body weight, daily gain, and ration energy density according to net energy equations.

The groups of five cattle were each marketed on a grade and yield basis when three steers out of each group of five were estimated to have over .4 in. of fat over the 12th rib. Opinions of South Dakota State University Beef Cattle specialists and the commercial feedyard operator were used to determine which groups of cattle were sold on a particular date. The choice market price and discounts for Select, Yield grade 4 ($10-12/cwt), heavy ($10/cwt) or light ($12/cwt) carcasses were negotiated with a commercial cattle buyer in a competitive market. The average live and dressed weight market prices for similar types of steers were obtained from Data Transmission Network Corporation for the western corn belt region for each marketing date. Prices were obtained for the value based marketing approach proposed by Excel Corporation by applying premiums and discounts to the choice and select carcass prices. Those premiums and discounts were a $2/cwt premium if fat thickness was less than .45 in. and rib eye area/cwt carcass weight exceeded 1.8 in.^{2}, $1/cwt discount if fat thickness was between .6 and .8 in. or if rib eye area ratio was between 1.4 and 1.7 in.^{2}, and $10/cwt discount if fat thickness was greater than .8 in. or if the rib eye ratio was less than 1.4 in.^{2}. Market prices for the various marketing methods are shown in Table 1.

Profit for each steer was calculated using prices generated for all four marketing techniques. Regression procedures were used to identify which variables best explained the variation in profit under each marketing method. Forward selection regression was used to partition the coefficient of determination (R^2) into a partial R^2 which measures the additional variation each variable is explaining as it is entered into the model.

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[3]Excel Corporation, Wichita, KS.
[4]Determined by ultrasound.
[5]R and L Feedyard, Kimball, SD

Table 1. Market prices (dollars per cwt) for the various marketing methods

Marketing date	Live weight	Dressed weight	Grade and yield	
			Choice	Select
First year 1991:				
April 10	80.00	127.50	130.00	125.00
May 2	78.75	125.50	129.00	122.00
May 8	78.00	124.00	128.00	120.00
May 9	78.00	124.00	128.00	120.00
June 20	72.00	115.00	119.00	111.00
Second year 1992:				
March 31	76.75	124.00	125.00	123.00
April 14	76.65	123.00	126.00	124.00
April 23	75.00	120.00	122.00	119.00
May 19	75.00	118.50	125.00	119.00

Results and Discussion

Table 2 displays the initial and feedlot performance data for the steers. Cattle averaged 547 lb at 204 days of age when they entered the feedlot. The variation in weight, frame, and age was tremendous. Straightbreds or crosses involving 23 breed types were utilized in the study.

Slaughter data for each steer are shown in Table 3. Steers averaged 1,123 lb, ranging from 804 to 1,406 lb. None of the carcasses exceeded 950 lb and thus were not subjected to heavy weight carcass discounts. Several carcasses, however, were penalized for being too light. Throughout the study, carcasses less than 550 lb were discounted $12 per cwt. Fat thickness averaged .44 in. and 65% of the steers had greater than .4 in. of fat cover, indicating that the slaughter endpoint objective was met.

Profitability of the cattle under each of the four marketing methods is shown in Table 4. Profits were estimated to be at the lowest level when cattle were marketed on a live weight basis. Under a live pricing system, the buyer must estimate grade, dressing percentage, cutability, and carcass defects or trim. It appears as if the price offered is low enough to protect the buyer from inaccurately estimating one or more of these factors.

Marketing cattle on a dressed weight basis was slightly less profitable than marketing grade and yield or according to a value based system. Buyers purchasing cattle "in the beef" do not need to estimate dressing percentage to establish price. Under grade and yield marketing or by purchasing cattle according to a value based marketing system, the buyer does not run the risk of inaccurately estimating grade, dressing percentage, cutability, or carcass trim. Therefore, prices offered for cattle may be higher than those offered under live or dressed weight pricing. However, the risk does not disappear. Risk of inaccurately estimating carcass value is transferred to the seller. As one moves from live pricing toward value based marketing, the variation in profit also increased. The variance in profit, an indicator of risk, was nearly twofold larger for grade and yield or value based pricing as for live pricing.

Results from the forward selection regression procedures are displayed in Table 5. For the live

Table 2. Initial and feedlot performance data for steers in the South Dakota Retained Ownership Demonstration

Variable	Average	Standard deviation	Minimum	Maximum
Initial height, in.	44.14	1.97	38.50	50.00
Initial fat, in.	.074	.039	.000	.200
Initial weight, lb	547	72	346	790
Initial age, days	204	20	145	293
Days fed	195	18	166	242
Average daily gain, lb	2.96	.36	1.54	4.16
Feed cost of gain, $/cwt	40.59	3.22	31.78	60.07
Total cost of gain, $/cwt[a]	54.43	4.53	41.77	93.48

[a]Includes feed, yardage, veterinary, interest on operating capital, death loss, trucking to slaughter, and marketing expenses. Excludes interest on the calf.

Table 3. Slaughter data for the steers marketed from the South Dakota Retained Ownership Demonstration

Variable	Average	Standard deviation	Minimum	Maximum
Live weight, lb	1123	104	804	1406
Hot carcass wt, lb	718	74	464	936
Dressing percent	63.89	1.91	57.39	70.43
Marbling score, units[a]	4.74	.59	3.00	8.00
Yield grade, units[b]	2.81	.68	.49	5.06
Fat thickness, in.	.44	.15	.10	1.10
Rib eye area, sq. in.	12.50	1.60	8.70	18.60
Rib eye area/100 lb carcass weight	1.74	.16	1.29	2.38

[a]4.00 = Slight^{o}, 5.00 = Small^{o}. Forty-one percent of the cattle graded low choice or higher.
[b]Calculated from fat thickness, hot carcass weight, kidney fat, and rib eye area.

Table 4. Mean profit ($/head) and the dispersion about the mean under each of the four marketing methods

Method	Profit	Variance	Minimum	Maximum
Live	6.64[c]	1206	-127.49	140.10
Rail	23.54[d]	1742	-129.95	130.97
G and Y[a]	26.00[e]	2594	-150.83	163.73
MS[b]	27.09[e]	2330	-147.16	185.90

[a]Grade and yield.
[b]Muscle score.
[c,d,e]Means in same column with different superscripts differ (P<.05).

weight pricing procedures, average daily gain explained 55.5% of the variation in profit. For every .1 lb increase in daily gain, profitability was predicted to improve by $3.23 per head. Total cost of gain came into the model second and explained an additional 20.5% of the variation in profit. Initial weight entered the model third and days fed entered fourth. These variables accounted for an additional 7.6 and 3.1% of the variation in profit, respectively.

Average daily gain accounted for 35.1% of the variation in profit and also entered the dressed weight pricing model first. However, dressing percentage entered the model second and explained an additional 37.5% of the variation in profit. Total cost of gain, initial weight, and days fed entered the model in that order and accounted for 11.48, 4.9, and 4.0% additional variation in profit, respectively.

Average daily gain and dressing percentage were the first and second variables entering the grade and yield pricing model and accounted for 29.2 and an additional 30.7% of the variation. Quality grade accounted for an additional 16% of the variation in profit. If a carcass graded choice or better, profit was improved by $38.91 per head as compared with carcasses grading select or lower. Total cost of gain and days fed were the fourth and fifth variables to enter the model and explained an additional 4.2 and 1.5% of the variation in profitability, respectively. Hot carcass weight was the final variable to enter and accounted for an additional 1.5% of the variation in profit.

For the muscle scoring system method of pricing, gain and dressing percentage entered the model first and second, accounting for 29.3 and an additional 27.2% of the variation in profit, respectively. Total cost of gain and days fed accounted for an additional 6.3 and 3.3% of the variation, respectively. The carcass traits of fat thickness, quality grade, and rib eye area were the next variables to enter the model explaining an additional 3.4, 5.0, and 1.0% of the variation, respectively. For each .1 in. of additional fat cover over the 12th rib, profitability was reduced by $5.72 per head. If a carcass graded choice or better, profit was improved by $23.48 as compared to carcasses grading select or lower. For each additional 1 $in.^2$ of rib eye area, profit improved by $4.47 per head.

These data clearly show that feedlot production variables are important contributors to profitability. However, their importance decreases as one moves from live pricing toward a value based pricing system. The muscle scoring system appears to do the best job of rewarding producers for high quality, lean beef production. It was the only pricing system that rewarded carcass muscling and penalized carcass fat. Under the grade and yield system, discounts are also applied to excessively fat carcasses. However, they are not applied until a carcass reaches a yield grade that is greater than 3.99.

Table 5. Summary of regression statistics for equations predicting dollars per head profit

Variable	Parameter	Standard deviation	Partial R^2
Live weight method, R^2 = .866:			
Intercept	209.80	12.41	
Average daily gain, lb	32.27	1.69	.555
Total cost of gain, $/cwt	-6.00	.15	.205
Initial weight, lb	.18	.01	.076
Days	-.35	.03	.031
Dressed weight method, R^2 = .929:			
Intercept	-709.54	17.31	
Average daily gain, lb	37.43	1.48	.351
Dressing percent	14.61	.24	.375
Total cost of gain, $/cwt	-5.63	.13	.114
Initial weight, lb	.17	.01	.049
Days	-.49	.02	.040
Grade and yield method, R^2 = .831:			
Intercept	-645.55	46.29	
Average daily gain, lb	26.48	4.71	.292
Dressing percent	12.62	.56	.307
Quality grade[a]	38.91	1.64	.160
Total cost of gain, $/cwt	-4.17	.25	.042
Days	-.70	.06	.015
Hot carcass weight, lb	.19	.02	.015
Muscle Scoring System, R^2 = .756:			
Intercept	-651.32	40.55	
Average daily gain, lb	44.26	3.39	.293
Dressing percent	13.53	.58	.272
Total cost of gain, $/cwt	-3.83	.23	.063
Days	-.77	.06	.033
Fat thickness, in.	-57.15	6.89	.034
Quality grade[a]	23.48	1.88	.050
Rib eye area, sq. in.	4.47	.84	.010

[a]Data entered as 0 = Select or lower, 1 = Choice or higher.

Average daily gain and days fed contribute to profitability in two ways. First, they have a direct effect on cost of gain. Rapid gains dilute out maintenance feed costs and lead to reduced days on feed. Fewer days on feed generally result in less yardage and interest costs accruing against the cattle. The second area that gain and days fed play a role is in determining market price. In the first year of this study prices were higher when cattle first started going to market. Prices declined significantly by the final marketing date. In both years of this study, the choice-select price margin widened at later marketing dates. Cattle having heavier initial weights, rapid gain, and reduced days on feed generally received greater market prices at slaughter and were thus more profitable.

In order to gain insight on how the decreasing market may have impacted the regression analysis, average prices for all of the cattle were calculated and the analysis was run again. Prices used were $76.55 and $122.13 per cwt for the LW and DW marketing methods, respectively. Base choice and select prices used for the G and Y and MS marketing systems were $125.66 and $120.45. A discount of $12 per cwt was applied for light, heavy, or yield grade 4 carcasses for the G and Y method. The same premiums and discounts that were used previously for the MS system were used again.

Table 6 displays the results from the regression analysis after the influence of the declining slaughter cattle market was removed. When variations in market price associated with time are removed, each model explains a higher percentage of the variation in profit. The R^2 is improved by 6.7, 3.6, 8.3, and 16.7 units for the LW, DW, G and Y, and MS marketing methods, respectively.

For the LW method, average daily gain continues to be the most important factor explaining profitability. Over 70% of the variation in profitability is explained by daily gain. For each .1 lb improvement in gain, profit improves by $6.43 per head. Previously, days fed was negatively related to profit (regression coefficient = -.35) and only explained 3.1% of the variation. Days fed are now positively related to profit and account for 15.2% of the variation. For each additional day on feed, profit is improved by $.54 per head. Additional days on feed, provided cattle are continuing to gain weight rapidly and convert feed efficiently, tend to dilute out costs such as veterinary expenses, death loss, marketing expenses, trucking, and the initial calf costs over more pounds of gain, therefore improving profitability.

Previously, average daily gain also was the first variable to enter each of the marketing methods where carcass prices were used. When the variation associated with the declining market is removed from the data, hot carcass weight is the first variable to enter the model. The importance of daily gain is greatly reduced. Partial R^2 for gain is reduced from .351 to .054 for the DW marketing method model and gain does not account for any of the variation in profit for the G and Y and MS marketing method models. Initial weight explains an additional 33.0, 22.9, and 23.7% of the variation in profit for the DW, G and Y, and MS marketing methods, respectively. For each additional pound of initial weight, profit is reduced by $.21, $.33, and $.36 per head for the DW, G and Y, and MS systems, respectively. For cattle with lighter starting weights, maintenance energy requirements are less and are diluted out over more pounds of total gain, thus improving profit.

Dressing percentage is a significant source of variation for only the G and Y and MS pricing methods. However, the partial R^2 is considerably lower than what it was previously (.047 and .047 vs .307 and .272 for G and Y and MS, respectively). For the DW pricing method, hot carcass weight is positively related to profit (partial R^2 = .489) and finish weight is negatively related to profit (partial R^2 = .069). Hot carcass weight divided by finish weight define dressing percentage. Therefore, dressing percentage is being rewarded by this marketing method.

Carcass quality grade appears to be slightly more important for G and Y and MS systems

Table 6. Summary of regression statistics for equations predicting dollars per head profit assuming a stable slaughter cattle market

Variable	Parameter	Standard deviation	Partial R^2
Live weight method, R^2 = .933:			
Intercept	-180.27	7.18	
Average daily gain, lb	64.34	1.91	.702
Days fed	.54	.02	.152
Total cost of gain, $/cwt	-2.02	.07	.079
Dressed weight method, R^2 = .965:			
Intercept	-79.39	5.45	
Hot carcass weight, lb	1.20	.01	.489
Initial weight, lb	-.21	.01	.330
Finish weight, lb	-.56	.01	.069
Average daily gain, lb	28.97	1.20	.054
Total cost of gain, $/cwt	-1.85	.08	.024
Grade and yield method, R^2 = .914:			
Intercept	-489.51	18.77	
Hot carcass weight, lb	.54	.01	.414
Initial weight, lb	-.33	.02	.229
Quality grade[a]	37.97	1.07	.181
Dressing percent	7.32	.33	.047
Total cost of gain, $/cwt	-1.97	.16	.031
Days fed	-.35	.03	.013
Muscle Scoring System, R^2 = .923:			
Intercept	-458.36	17.70	
Hot carcass weight, lb	.55	.01	.419
Initial weight, lb	-.36	.01	.237
Quality grade[a]	37.22	1.03	.139
Dressing percent	7.71	.31	.047
Fat thickness, in.	-68.91	3.37	.031
Total cost of gain, $/cwt	-2.02	.15	.034
Days fed	-.42	.03	.018

[a]Data entered as 0 = Select or lower, 1 = Choice or higher.

once market price decline is removed from the data. Fat thickness accounted for an additional 3.1% of the variation in profitability for the MS system. As fat thickness increased by .1 in., profitability was reduced by $6.89.

Implications

As more calves and fewer yearlings continue to be placed on feed, seasonal patterns in slaughter cattle prices will likely continue with the high price perhaps occurring in April. Therefore, feedlot production variables of average daily gain and days fed will continue to be important determinants of profitability. If the feedlot owns the cattle, perhaps selling on a live basis is warranted as feedlot production variables are rewarded to the exclusion of carcass quality and cutability. For retained ownership cattle, selling according to a value based marketing system is warranted if the cow-calf producer has successfully selected for carcass merit as part of the breeding program. Since most cattle are sold on a live basis and selling on a live basis rewards feedlot production, it is understandable that most beef producers have to date concentrated their efforts on growth rate and related traits. Current slaughter cattle pricing methods favor the production of excess fat and do not transmit the desire of the consumer for lean beef to the producer. Of the four methods examined in this paper, only the MS method discouraged fat production. A value based marketing system is needed before beef producers will seriously consider producing the consistent and lean product apparently desired by consumers. The current yield grade system may work if the appropriate premiums are paid for yield grades 1 and 2 cattle and discounts are assessed for yield grades 3.6 or greater.

FEEDLOT PERFORMANCE AND CARCASS TRAITS OF CULL COWS FED FOR SLAUGHTER

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CATTLE 93-20

Summary

This trial was designed to evaluate how various factors impact the value added process of feeding cull cows. Specific management criteria evaluated included initial body condition, days on feed, implants, and cow age. Feedlot performance and carcass trait changes due to these factors were compared. Prolonging the feeding period from 50 to 77 or 105 days tended ($P=.10$) to increase average daily gain and dry matter intake ($P<.01$) and had no ($P>.15$) effect on feed/gain. This response is similar to short term adaptation and feeding of young cattle. Added days on feed increased ($P<.001$) dressing percentage, ribeye area, and ribfat thickness while decreasing ($P<.001$) lean age. Days on feed did not improve fat color. Older cows gained slower ($P<.001$) and were lighter muscled than young cows. Longer feeding periods progressively increased the number of high quality carcasses produced.

Key Words: Cows, Carcass, Implant, Feedlot

Introduction

Cull cows can be looked upon as a by-product of the feeder calf industry. In the fall at weaning these cows are typically in thin condition and market value is low. Previous research has indicated that these cows can be fed efficiently for periods of 50 or 60 days to increase market weight and to take advantage of the seasonality of slaughter cow prices. Previous management has typically involved feeding programs with substantial proportions of roughage. The experiment described here evaluated the impact of days on feed, trenbolone acetate implants, and other factors on the feedlot performance and carcass traits of cull cows fed a typical feedlot finishing diet.

Materials and Methods

Cull cows were purchased from sale barns throughout South Dakota during November and December, 1991. The cows were fed a mix of grass hay and wheat straw during assembly and up to initiating the feeding study. Only 231 of the 306 cows purchased were suitable to feed. Advanced pregnancies were the primary reason cows were culled from the group. Others had to be eliminated because of severe emaciation.

Cows were sorted based on condition into two groups. Condition score on the very thin cows ranged from 1 to 2.5. Condition score of the remaining cows ranged from 3 to 6. Age was determined by dental examination. Young cows were 4 years and younger. Middle aged cows were up to 8 years of age. Old cows were up to 10 or 11 years of age. Very old cows had few if any teeth remaining. Individual weight and breed type were noted.

Allotment was done to allow age, breed type, and allotment weight to be stratified across implant and days on feed groups but within condition score since cows in better body condition would have a greater initial weight. Cows were sorted into 36 pens of 6 cows each.

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The allotment weight was taken 5 days before the study began to accommodate the complex allotment scheme. Initial test weights were taken on two consecutive days and averaged. At this time cows received a labeled dosage of Tramisol[3] and cows designated for implant treatments received Finaplix-H[4]. The finishing diet (Table 1) was fed starting 2 days before initial weights were taken. Initially (4 days) feed deliveries were restricted to 13.55 lb per head per day to normalize fill and allow adaptation to diet. Feed deliveries were then gradually increased to appetite. Cows were fed once daily.

Table 1. Finishing diet for feeding cull cows

Item	%, DM basis
Corn silage	15.00
Whole shelled corn	75.63
Soybean meal	5.77
Liquid supplement	3.60
Crude protein	11.3
Calcium	.503
Phosphorus	.309
Potassium	.949
NE_m, Mcal/cwt	93.6
NE_g, Mcal/cwt	62.5
Vitamin A, IU/lb	1350
Monensin, g/T	26.77

In the final arrangement there were 18 pens of thin cows and 18 pens of cows carrying more condition. Eighteen pens of cows received implants and 18 pens of cows were not implanted. Age and breed were stratified across pens. On each slaughter date 12 pens of cows were removed from the test. Initial body condition and implant treatments were equally represented in each slaughter date. This allotment required 216 cows. The 15 cows remaining were selected to be representative of the entire population and served as an initial slaughter group for measuring carcass changes with time on feed. Subsequent slaughter dates were 50, 77, and 105 days after the initial body weights were determined. Two consecutive final body weights followed a 4-day intake restriction to 16.15 lb to normalize fill. The following morning cows were slaughtered at Federal Beef, West Fargo, ND.

Dependent variables considered were average daily gain (ADG), average daily dry matter intake (DMI), feed conversion (F/G), carcass weight, ribfat thickness, ribeye area, fat color (1 to 9, 9 = yellow), marbling score, lean age and bone age. Feedlot performance variables were evaluated on a pen mean basis. Carcass traits were evaluated using individual observations as the experimental unit. The data were analyzed by procedures appropriate for a 2 x 2 x 3 arrangement of treatments (condition x implant x days on feed) using the GLM model in SAS. To evaluate age effects on cow feeding performance, data were re-evaluated with a model including only age. Preplanned age comparisons of least square means were accomplished using the PDIFF option in the GLM model of SAS.

Results and Discussion

One cow suffered polioencephalomalasia and did not recover. Two carcasses were condemned at slaughter. Data for these individuals were deleted from the overall data set. In a commercial situation, these losses are critical, but this experiment was not large enough to establish a typical death/carcass loss value. Seventy of the original 306 cows purchased were more than 5 months pregnant and were resold as breeding cows. Purchase price on the cows averaged $500. Sale price on the pregnant cows averaged slightly over $700. Commercial feeders

[3]Pitman Moore, Inc., Mundelein, IL.
[4]Hoescht-Roussel, Somerville, NJ.

should do pregnancy diagnosis to determine how cows will be handled. Effectiveness of abortaficents decline in pregnancies greater than 150 days and should not be used at that stage of pregnancy. Slaughtering pregnant cows lowers the dressing percentage and value of the carcass. Because of these factors, resale of cows in advanced pregnancy becomes an attractive alternative regardless of the breeding cow market.

Gains were quite good throughout the 105-day feeding period and tended to increase ($P = .1016$) with days on feed (Table 2). This is probably a response to the initial level of feed intake and to environmental factors. Weather during February and March was very undesirable for feeding cattle. Implanting and body condition did not affect rate of gain. Feed intakes were high considering the energy density of the diet. The adaptation to diet that occurred during the initial 21 days on feed caused DMI to be lower for the cows slaughtered at day 50. Feed intake patterns up to 50 days were similar for all three slaughter groups. Implanted cows consumed less ($P<.05$) feed than nonimplanted cows. This was an unexpected response. Comparable studies are not available to determine if this is a consistent response in mature beef cattle. Cows receiving implants were also more ($P=.0534$) efficient than nonimplanted cows. Thin cows tended to consume less feed ($P<.10$) than fleshy cows but did not exhibit more efficient gains. The fleshy cows in this study were still thin enough to exhibit compensatory gains if indeed this phenomenon occurs in mature animals. Feed/gain values of 9 are high compared to values for younger cattle. Processing the grain component may have been beneficial considering the high dry matter intakes observed.

Carcass weight continued to increase ($P<.001$) through 105 days, although dressing percentage peaked after 77 days (Table 3). Fleshy cows produced heavier ($P<.0001$) carcasses as expected from the heavier initial weights. Being fleshy also resulted in a higher ($P<.001$) dressing percentage. Ribeye area increased ($P<.0001$) markedly with longer feeding periods. This is a good indication that lean tissue accretion was occurring in these cows and that fat is not the only component of weight gains. Fleshy cows had larger ($P<.001$) ribeyes than cows that were initially thin. This is consistent with previous research from our labs indicating that muscle atrophy occurs when cows drop below a condition score of 4. Implants tended ($P=.1016$) to increase ribeye area which is consistent with their effects in young growing animals.

Lean age decreased ($P<.0001$) quadratically with increasing days on feed. Feeding beyond 105 days would have made little improvement in this trait. Marbling scores followed a similar favorable pattern as changes in lean age. Based on regression analysis, feeding another 10 to 15 days would have produced optimal carcass traits. Beyond that point, increases in carcass quality would be minimal and ribfat thickness would become excessive.

Older cows (>8 years) gained slower ($P<.0001$) and produced lighter ($P<.0001$) carcasses with smaller ($P<.001$) ribeyes than younger cows (Table 4). The differences in carcass traits observed can be related to the slower gains and lighter weights at the time of slaughter. The older cows were not fatter, suggesting that other physiological, genetic, or anatomical (dentures) factors were limiting growth.

After 105 days, nearly half of the carcasses produced in this study graded average utility or higher (Table 5). Regression analysis predicted that an additional 10 to 15 days on feed would probably increase this to a maximum of about 60% quality cow carcasses which would improve their retail value. After 77 days, selling cows on the rail increased their market value over live price bids. This margin of return increased even further after 105 days. Increases in dressing percentage and quality grades both contribute to the positive margins noted for selling cows on the rail. Crude profitability can be calculated for these cows. Base figures used were purchase cost 995 lb at \$47/cwt, yardage 20¢/day, carcass

Table 2. Effects of days on feed, implants and initial body condition on feedlot performance of cull cows

	Days on feed			Implant		Initial body condition		P[a]		
	50	77	105	Control	Finaplix-H	Thin	Fleshy	DOF[b]	Implant	Condition
Initial wt, lb	1009	995	995	999	1000	965	1034	.0574	NS	.0001
Final wt, lb	1150	1223	1321	1224	1238	1195	1268	.0001	.0956	.0001
ADG[c], lb	2.81	2.97	3.10	2.89	3.03	2.95	2.97	.1016	NS	NS
DMI[d], lb	24.89	27.04	28.04	26.97	26.35	26.57	26.75	.0001	.0370	.0984
Feed/gain	8.99	9.20	9.09	9.44	8.74	9.09	9.09	NS	.0534	NS

[a]Probability.
[b]Days on feed.
[c]Average daily gain.
[d]Dry matter intake.

Table 3. Effects of days on feed, implants and initial body condition on the feedlot performance of cull cows

	Days on feed				Implant		Condition		P[a]		
	0	50	77	105	Control	Finaplix-H	Thin	Fleshy	DOF[b]	Implant	Condition
Carcass wt, lb	503	613	693	761	683	693	648	704	.0001	NS	.0001
Dressing percentage	48.1	53.3	57.1	57.6	55.9	56.0	55.0	55.9	.0001	NS	.0003
Ribfat, in.	.07	.18	.36	.49	.36	.33	.29	.36	.0001	NS	.0273
Ribeye area, $in.^2$	9.32	10.68	11.68	12.26	11.35	11.72	10.90	11.89	.0001	.1016	.0010
KPH, %	.039	.033	.077	.107	.067	.076	.062	.077	.0001	.0894	.0008
Marbling	131	218	334	367	315	297	290	300	.0001	NS	.0240
Fat color[d]	7.1	8.1	8.3	8.3	8.3	8.2	8.1	8.2	NS	NS	.0559
Bone age[e]	522	529	531	546	538	533	528	541	NS	NS	NS
Lean age[e]	586	465	409	389	418	424	420	443	.0001	NS	NS

[a]Probability level.
[b]Days on feed.
[c]Devoid = 0; practically devoid = 101 to 200; traces = 201 to 300.
[d]1 = white; 10 = yellow.
[e]A0 to A100 = 101 to 200; B0 to B100 = 201 to 300.

Table 4. Effect of age on growth rate and carcass traits of cull cows[a]

	Age group[b]				P[c]		
	Young	Middle	Old	Very old	Y v M[c]	M v O	O v VO
Initial wt, lb	995	1015	994	927	NS	NS	.0222
Final wt, lb	1292	1325	1238	1178	NS	.0011	.1137
ADG, lb	3.25	3.35	2.74	2.64	NS	.0001	NS
Carcass wt, lb	724	709	655	608	NS	.0008	.0389
Dressing percentage	56.8	55.9	55.2	54.1	NS	NS	.1161
Ribfat, in.	.30	.36	.31	.29	NS	NS	NS
Ribeye area, in.^{2}	12.3	12.0	11.0	10.1	NS	.0005	.0209
KPH, %	0.5	0.7	0.7	0.7	NS	NS	NS
Marbling[d]	279	296	293	302	NS	NS	NS
Fat color[e]	8.5	7.8	8.3	8.8	.0344	.0009	.0589
Bone age[f]	466	506	556	596	.0956	.0001	.0236
Lean age[f]	426	423	438	441	NS	NS	NS

[a]Least squares means.
[b]Y = Young; M = Middle; O = Old; VO = Very old.
[c]Probability.
[d]Devoid = 0; Practically devoid = 101 to 200; Traces = 201 to 300.
[e]1 = White; 9 = Yellow.
[f]A0 to A100 - 101 to 200; B0 to B100 = 201 to 300.

Table 5. Frequency distribution of quality grades with time on feed[ab]

	Canner	Cutter			Utility			Commercial			Standard			Choice
		-	0	+	-	0	+	-	0	+	-	0	+	-
Day 0	64	0	14	14	7	0	0	0	0	0	0	0	0	0
Day 50	17	25	0	31	18	4	1	0	0	0	1	0	0	0
Day 77	8	7	0	14	43	14	7	3	1	0	0	0	1	1
Day 105	0	4	0	15	32	34	7	6	0	0	0	0	1	0

[a]Values within a row represent the percentage of those cows slaughtered on the designated date.
[b]Effect of days on feed (P<.0001).

price $97/cwt, and feed costs $90/T. Crude returns were $53.49/head, $82.97/head, and $105.10/head for cows fed 50, 77, or 105 days, respectively. Changes in carcass price to reflect improvements in quality grades would have further increased the profitability of an extended feeding period.

The quality of carcasses produced by cull cows can be markedly improved by feeding high grain diets for over 100 days. Although feed conversions were poorer than observed when feeding young cattle, this is still a very profitable practice. Further research into the form of grain used may improve feed efficiency. The gross value of cull cows can be increased well over $250 per head by feeding, which could translate into $45,000,000 annually in South Dakota. Further steps should be taken to refine the practice of feeding cull cows and to ensure these programs are made available to local beef producers.

The faculty members of the **Animal and Range Sciences Department** are always ready to answer your questions. Our Brookings phone number is (605) 688-5166. Staff members in Rapid City (RC) can be reached at (605) 394-2236. Please feel free to give any one of us a call.

FACULTY

	SPECIALTY	RESPONSIBILITY
BIRKELO, Carl P.	Ruminant Nutrition	Research, Teaching
BOGGS, Donald L.	Beef Cattle Nutrition and Management	Extension
COSTELLO, William J.	Meat Science	Teaching, Research
GARTNER, F. Robert (RC)	Range Science	Research, Teaching
GEE, Dan H.	Evaluation/Marketing	Teaching
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JOHNSON, James R. (RC)	Range Science	Extension, Research
JOHNSON, Patricia S.	Range Science	Research, Teaching
KNUTSON, Mary K.	Livestock Judging Team Coach	Teaching, Recruiting and Advisement
KRONBERG, Scott	Range Science	Research, Teaching
LIBAL, George W.	Swine Nutrition and Management	Research, Teaching
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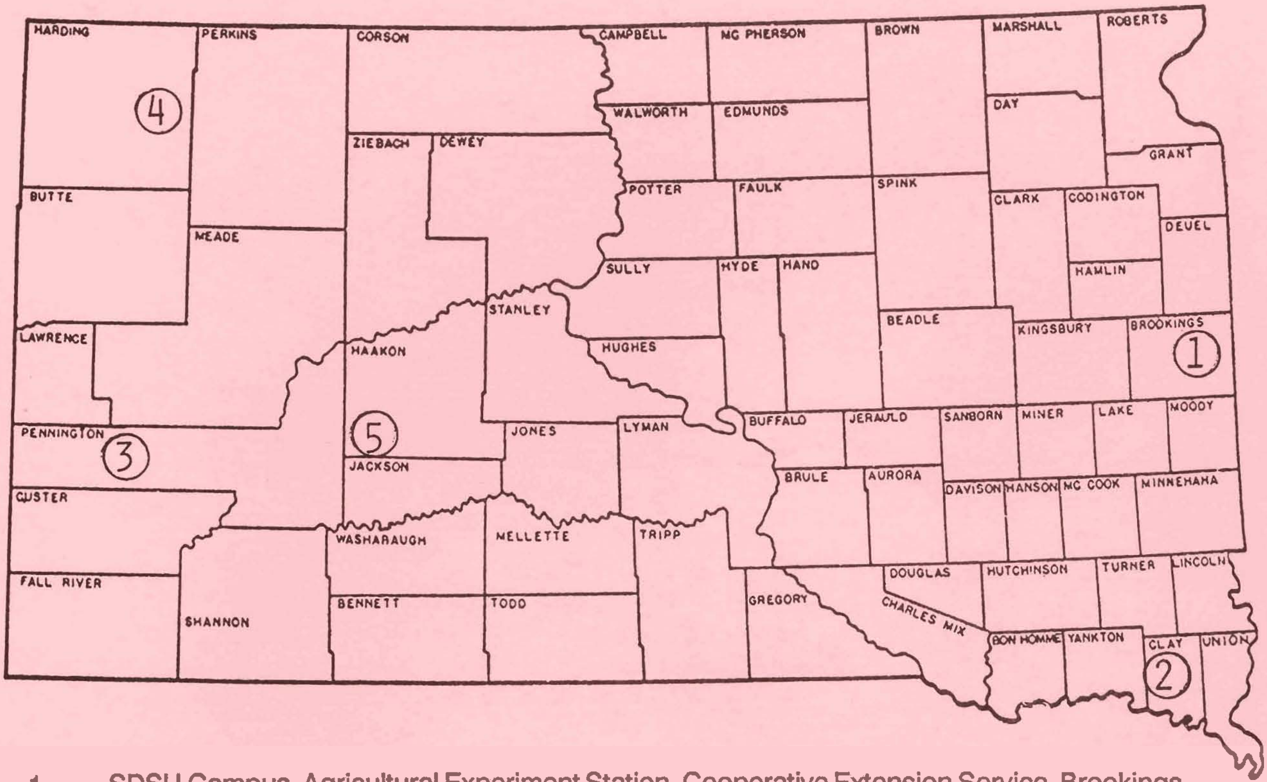

1. SDSU Campus, Agricultural Experiment Station, Cooperative Extension Service, Brookings.

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