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Arkansas Animal Science Department Report 2015

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ARKANSAS ANIMAL SCIENCE DEPARTMENT REPORT 2015

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INTRODUCTION

Welcome from the Department of Animal Science! This is the 18th edition of the *Arkansas Animal Science* publication. As always, thanks to the faculty, staff and graduate students in the Department of Animal Science and to Dr. Paul Beck for serving as editor along with Drs. Jason Apple, Shane Gadberry, Beth Kegley, and Charles Rosenkrans for serving as assistant editors. The associated publication *Arkansas Animal Science–Research Highlights* allows for those interested to quickly read, in a few brief statements, the impact of our research and extension programs. A weblink to the entire report is included within each highlight.

Readers are invited to view all programs of the Department of Animal Science at the departmental website at animalscience.uark.edu; the Livestock and Forestry Research Station website at Batesvillestation.uark.edu; the Southwest Research and Extension Center website at swrec.uark.edu; and the Southeast Research and Extension Center website at aaes.uark.edu/serec.

I am sure you will agree research generated from this Department will help in developing best management practices that will increase whole farm/ranch efficiency, and ultimately, increase producer profitability. We appreciate your interest in the work that we do to enhance animal production in this state.

Sincerely,

Michael Looper
Department Head

INTERPRETING STATISTICS

Scientists use statistics as a tool to determine which differences among treatments are real (and therefore biologically meaningful) and which differences are probably due to random occurrence (chance) or some other factors not related to the treatment.

Most data will be presented as means or averages of a specific group (usually the treatment). Statements of probability that treatment means differ will be found in most papers in this publication, in tables as well as in the text. These will look like ($P < 0.05$); ($P < 0.01$); or ($P < 0.001$) and mean that the probability (P) that any two treatment means differ entirely due to chance is less than 5, 1, or 0.1%, respectively. Using the example of $P < 0.05$, there is less than a 5% chance that the differences between the two treatment averages are really the same. Statistical differences among means are often indicated in tables by use of superscript letters. Treatments with any letter in common are not different, while treatments with no common letters are. Another way to report means is as mean + standard error (e.g., 9.1 + 1.2). The standard error of the mean (desig-nated SE or SEM) is a measure of how much variation is present in the data—the larger the SE, the more variation. If the difference between two means is less than two times the SE, then the treatments are usually not statistically different from one another. Other authors may report an LSD (least significant difference) value. When the difference between any two means is greater than or equal to the LSD value, then they are statistically different from one another. Another estimate of the amount of variation in a data set that may be used is the coefficient of variation (CV), which is the standard error expressed as a percentage of the mean. Orthogonal contrasts may be used when the interest is in reporting differences between specific combinations of treatments or to determine the type of response to the treatment (i.e., linear, quadratic, cubic, etc.).

Some experiments may report a correlation coefficient (r), which is a measure of the degree of association between two variables. Values can range from –1 to +1. A strong positive correlation (close to +1) between two variables indicates that if one variable has a high value then the other variable is likely to have a high value also. Similarly, low values of one variable tend to be associated with low values of the other variable. In contrast, a strong negative correlation coefficient (close to –1) indicates that high values of one variable tend to be associated with low values of the other variable. A correlation coefficient close to zero indicates that there is not much association between values of the two variables (i.e., the variables are independent). Correlation is merely a measure of association between two variables and does not imply cause and effect.

Other experiments may use similar procedures known as regression analysis to determine treatment differences. The regression coefficient (usually denoted as b) indicates the amount of change in a variable Y for each one unit increase in a variable X. In its simplest form (i.e. linear regression), the regression coefficient is simply the slope of a straight line. A regression equation can be used to predict the value of the dependent variable Y (e.g., performance) given a value of the independent variable X (e.g., treatment). A more complicated procedure, known as multiple regression, can be used to derive an equation that uses several independent variables to predict a single dependent variable. Associated statistics are r^2, the simple coefficient of determination, and R^2, the multiple coefficient of determination. These statistics indicate the proportion of the variation in the dependent variable that can be accounted for by the independent variables. Some authors may report the square root of the Mean Square for Error (RMSE) as an estimate of the standard deviation of the dependent variable.

Genetic studies may report estimates of heritability (h^2) or genetic correlation (r_g). Heritability estimates refer to that portion of the phenotypic variance in a population that is due to heredity. A genetic correlation is a measure of whether or not the same genes are affecting two traits and may vary from –1 to +1.

COMMON ABBREVIATIONS

Abbreviation	Term
ADFI	Average daily feed intake
ADG	Average daily gain
avg	Average
BW	Body weight
cc	Cubic centimeter
cm	Centimeter
CP	Crude protein
CV	Coefficient of variation
cwt	100 pounds
d	Day(s)
DM	Dry matter
DNA	Deoxyribonucleic acid
°C	Degrees Celsius
°F	Degrees Fahrenheit
EPD	Expected progeny difference
F/G	Feed:gain ratio
FSH	Follicle stimulating hormone
ft	Foot or feet
g	Grams(s)
gal	Gallon(s)
h	Hour(s)
in	Inch(es)
IU	International units
kcal	Kilocalories(s)
kg	Kilograms(s)
lb	Pound(s)
L	Liter(s)
LH	Lutenizing hormone
m	Meter(s)
mg	Milligram(s)
Meq	Milliequivalent(s)
Mcg	Microgram(s)
min	Minute(s)
mm	Millimeter(s)
mo	Month(s)
N	Nitrogen
NS	not significant
ng	nanogram(s)
ppb	parts per billion
ppm	parts per million
r	correlation coefficient
r^2	simple coefficient of determination
R^2	multiple coefficient of determination
s	Second(s)
SD	standard deviation
SE	standard error
SEM	standard error of the mean
TDN	total digestible nutrients
wk	week(s)
wt	Weight
yr	year(s)

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Effects of dairy slurry application and bale moisture concentration on voluntary intake and digestibility of alfalfa silage by sheep

J.K. Clark[1,2], B.C. Shanks[1], J.D. Caldwell[3], K.P. Coffey[2], W.K. Coblentz[4], R.E. Muck[5], D. Philipp[2], M.A. Borchardt[4], R.T. Rhein[2], A.N. Young[2], M.D. Basham[2], E.A. Backes[2], K.A. Center[2], W.E. Jokela[4], and M.G. Bertram[6]

Research Highlights

- Dairy slurry is a popular fertilizer, but its residual effects on intake and digestibility are not well known.
- Dairy slurry was applied to alfalfa immediately after the first harvest, 2 weeks later, or not at all.
- Alfalfa was baled at 2 different moisture concentrations and included alfalfa with no dairy slurry application.
- Baling at 47% moisture compared with 40% moisture tended to reduce digestibility.
- Time of dairy slurry application prior to subsequent harvest did not affect digestibility or intake.

Introduction

Using farmyard manure and slurry can reduce greenhouse gas issues and also reduce economic costs to farmers (Crotty et al., 2014). Dairy slurry is used commonly as a fertilizer in agriculture. However, residual effects of slurry application on intake and digestibility of alfalfa silage from subsequent harvests are not well known. The objective of this study was to determine how moisture concentration of alfalfa silage and timing of dairy slurry application relative to subsequent harvest affect intake and digestibility by sheep.

Materials and Methods

Pregnant crossbred ewes (n = 18; 3-5 year old; 105 ± 11.8 lbs) were stratified by body weight (BW) and allocated randomly each period to 1 of 6 treatments arranged in a 2 × 3 factorial consisting of high (HM; 46.8%) or low (LM; 39.7%) moisture at baling after no slurry application (NS), slurry applied to stubble immediately after removal of the previous cutting (S0), or slurry applied 14-day after the previous cutting (S14). Ewes were housed individually in 4.6 × 14.1-ft pens equipped with rubber mats for 2 periods consisting of a minimum of 11 days of dietary adaptation and 7 days of fecal collection. Ewes were offered chopped silage based on 10% refusal, were offered commercial sheep mineral (0.5 oz.) daily, and had *ad libitum* access to water. Total feces were swept from the floor twice daily, weighed, and dried at 50 °C to determine digestibility. Blood samples were collected from each ewe on the last day of each period and analyzed for complete blood counts (CBC). Data were analyzed using PROC MIXED of SAS (SAS Institute, Inc., Cary, N.C.). The experimental unit was individual ewe and treatment means are reported as least squares means.

Results and Discussion

Intake (lb/d) of dry matter (DM) and organic matter (OM) did not differ ($P \geq 0.05$) across moisture or slurry application treatments. However, DM and OM digestibility (%) tended ($P < 0.10$) to be greater from LM vs HM. Hematocrits and red blood cell concentrations were greater ($P \leq 0.05$) from S14 vs NS and S0. Lymphocytes were greater ($P < 0.05$) from LM vs HM and from NS vs S0 and S14. Hematocrits are the volume percentage of red blood cells; red blood cells are important for oxygen transportation in the body. High lymphocyte counts can be an indicator of some type of infection, but the lymphocyte count in the sheep used were not above the acceptable range for a healthy animal. Therefore, moisture concentration of alfalfa silage and time of dairy slurry application may not affect voluntary intake or NDF digestibility, but moisture concentration may have a slight effect on DM and OM digestibility. Also, moisture concentration of alfalfa silage and time of dairy slurry application may affect specific blood hemograms.

Implications

Producers may not see a difference in intake across moisture treatments, but DM and OM digestibility may be higher for low moisture than high moisture alfalfa silage. Producers may utilize dairy slurry as a fertilizer source without having negative effects on digestibility or intake of alfalfa silage in sheep.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Crotty et al. 2014. PLoS ONE. 9: e97516.

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Table 1. The effect of moisture concentration on voluntary intake and digestibility of alfalfa silage and complete blood counts in sheep.

	Treatments[a]			
Item[e]	**LM**	**HM**	**SEM[b]**	***P*-value**
DMI, lb/d	3.7	3.6	0.10	0.86
OMI, lb/d	3.3	3.3	0.09	0.90
DMD, %	65.6	64.0	0.56	0.08
OMD, %	64.8	63.0	0.59	0.09
WBC, K/µL	6.1	6.8	0.29	0.19
RBC, M/µL	10.8	10.7	0.13	0.71
LYM, %	39.7[c]	32.2[d]	1.54	0.01
HCT, %	35.8	35.4	0.40	0.58

[a] LM = low moisture; HM = high moisture.
[b] SEM = Pooled standard error of the mean.
[c-d] Means within a row without a common superscript differ ($P < 0.05$).
[e] DMI = dry matter intake; OMI = organic matter intake; DMD = dry matter digestibility; OMD = organic matter digestibility; WBC = white blood cell; RBC = red blood cell; LYM = lymphocytes; HCT = hematocrits.

Table 2. The effect of slurry application time on voluntary intake and digestibility of alfalfa silage and complete blood counts in sheep.

	Treatments[a]				
Item[e]	**NS**	**S0**	**S14**	**SEM[b]**	***P*-value**
DMI, lb/d	3.8	3.6	3.5	0.14	0.28
OMI, lb/d	3.5	3.3	3.2	0.13	0.26
DMD, %	65.6	63.9	64.9	0.82	0.36
OMD, %	65.1	62.9	63.6	0.88	0.22
WBC, K/µL	5.7	7.3	6.5	0.43	0.07
RBC, M/µL	10.3[d]	10.6[d]	11.4[c]	0.19	0.02
LYM, %	41.5[c]	33.5[d]	32.9[d]	2.29	0.04
HCT, %	34.8[d]	34.8[d]	37.2[c]	0.59	0.05

[a] NS = no slurry; S0 = slurry applied to stubble immediately after removal of the previous cutting; S14 = slurry applied 14 d after the previous cutting.
[b] SEM = Pooled standard error of the mean.
[c-d] Means within a row without a common superscript differ ($P < 0.05$).
[e] DMI = dry matter intake; OMI = organic matter intake; DMD = dry matter digestibility; OMD = organic matter digestibility; WBC = white blood cell; RBC = red blood cell; LYM = lymphocytes; HCT = hematocrits.

Influence of ergot alkaloid compounds on liver enzyme cytochrome P450

P. Dias-Morse[1], S. Alrashedi[2], and C. Rosenkrans, Jr.[1]

Research Highlights

- Effects of chemicals found in tall fescue and commercial drugs on liver enzyme activity were compared.
- Cytochrome P450 enzymes are responsible for metabolic clearance of toxins and drugs from the body.
- Some ergot alkaloids showed a concentration-dependent inhibition of cytochrome P450 enzyme activity.
- Recognizing enzyme inhibitors may help to avoid onset of toxicological conditions and resulting economic losses.

Introduction

Ergot alkaloid-related toxicological conditions have gained considerable attention because of subsequent economic losses in the livestock production systems. Strickland et al. (2011) estimated that losses to the livestock industry surpassed $1 billion annually. Although most ergot alkaloids and commercial drugs are metabolized by the liver enzyme system cytochrome P450, some ergot alkaloids and drugs can inhibit CYP450 activity. Furthermore, CYP-450 may have different affinities toward ergot alkaloids classes due to their structural differences, which alters ergot alkaloid metabolism (Moubarak et al., 2012).

Recently, sensitive assays were developed that allow investigators to assess the effects of drugs or toxins on CYP450 activity. Our objective was to determine the sensitivity of the P450-Glo assay to relatively low concentrations of bromocriptine (BC), dihydroergotamine (DHET), ergotamine (ET), and ergonovine (EN).

Materials and Methods

Procedures in this experiment were as described previously (Moubarak et al., 2012; Rosenkrans and Ezell, 2015). Briefly, commercially available ergot alkaloids [bromocriptine (BC), dihydroergotamine (DHET), ergotamine (ET), and ergonovine (EN)] were purchased from Sigma Chemical Co., St. Louis, Mo. Alkaloids were diluted in 100% methanol to achieve assay concentrations of 0, 1.56, 3.12, 6.25, 12.5, 25 and 50 μM. Diluted alkaloid solutions were added in triplicate wells of a 96-well plate and allowed to evaporate in the dark at room temperature. Following the manufacturers instructions, the activity of cytochrome P450 3A4 was determined (Promega™, Madison, Wis.). Luminescence was recorded, and CYP-450 inhibition for each ergot alkaloid was calculated as a percent of the control [(luminescence at 0 alkaloid concentration – luminescence at given concentration)/ luminescence at 0 alkaloid concentration]. For toxicity comparison of the ergot alkaloids, a 50% inhibitory concentration (IC_{50}) was calculated by plotting activity of CYP450 as percent of control against log values of corresponding ergot alkaloid concentrations (μM).

Statistical Analysis

Experimental design was a randomized complete block with a 4 × 6 factorial treatment structure (four ergot alkaloids at six concentrations). Each independent day of data collection was considered a block. Inhibition of CYP450 activity was analyzed using PROC MIXED of SAS 9.3v (SAS Institute, Inc., Cary, N.C.). Main affects were ergot alkaloid, concentration, and alkaloid by concentration interaction. When main affects F-tests were significant ($P < 0.05$), then means were separated using the Tukey method.

Results and Discussion

Inhibition of CYP450 was affected ($P < 0.05$) by an interaction between alkaloid and concentration (Fig. 1). The alkaloids, BC, DHET, and ET inhibited ($P < 0.05$) CYP450 activity in a concentration-dependent manner. Bromocriptine had the most ($P < 0.05$) potent inhibition when compared to the other alkaloids tested, nearly 50% inhibition at our lowest concentration (1.56 μM). The other alkaloids, DHET, ET, and EN had similar ($P > 0.05$) CYP-450 inhibition at lower concentrations (1.56 and 3.12 μM). Concentrations of DHET and ET greater than 6.25 μM inhibited ($P < 0.05$) CYP450 activity. Ergonovine initially inhibited CYP450 activity; however as EN concentrations increased, no inhibition was observed. Toxic effects of ergot alkaloid presented as inhibitory concentrations confirmed that BC was the most potent alkaloid-tested for CYP450 inhibition (IC_{50} = 1.35 μM; Fig. 2).

Cytochrome P450 enzymes play a major role in initial alkaloid biotransformation, alkaloid metabolism and detoxification. Our findings were similar to Moubarak et al. (2012) as well as Rosenkrans and Ezell (2015) and substantiated the inhibitory effects of BC, DHET and ET on CYP450 enzyme activity. Differences in alkaloid inhibition of CYP450 activity can be related to their chemical structure and binding affinities. Even at concentrations lower than 10 μM, BC, DHET and ET have the ability to inhibit 50% of CYP450 activity. Any disruption in normal enzyme function may impact alkaloid and drug metabolism and result in toxic substance accumulation in the body resulting in toxicosis.

Implications

Bromocriptine, dihydroergotamine, and ergotamine can be highly toxic inhibitors of cytochrome P450 activity even at relatively low concentrations. Fescue toxicosis leads to poor animal performance, such as decreased weaning weight, decreased average daily gain, reduced reproductive efficiency and milk production, prolonged

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gestation, etc. Our hope is to use the P450-Glo assay to identify animals or management practices that prevent or minimize ergot alkaloid poisoning of livestock.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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Moubarak et al. 2012. Agricultural Sciences. 3:1-4.
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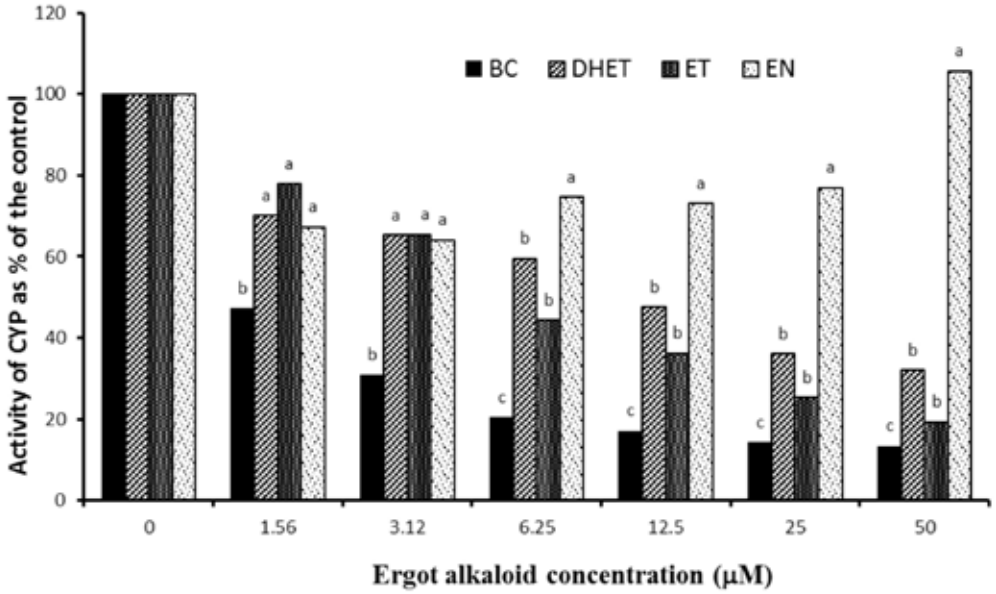

Fig. 1. Effect of alkaloid concentration on inhibition cytochrome P450 (CYP) activity. Alkaloids tested were BC- bromocriptine, DHET- dihydroergotamine, ET- ergotamine and EN- ergonovine. [a-c]Within a concentration, least squares means without a common superscript differ ($P < 0.05$).

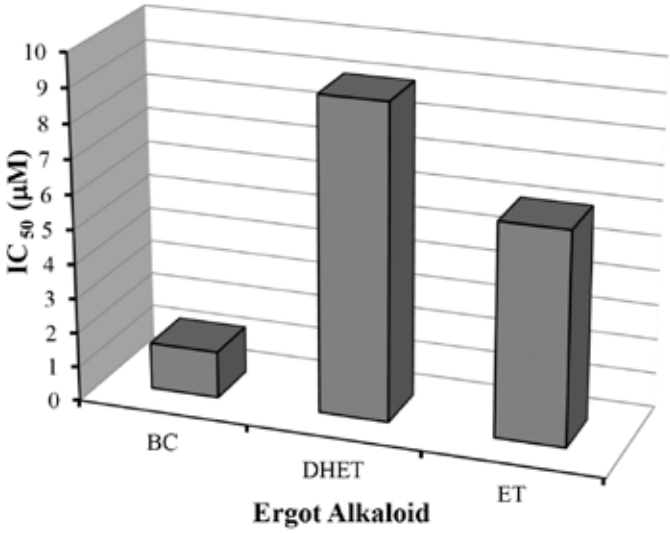

Fig. 2. Toxicity effect of ergot alkaloids presented by Inhibitory Concentration 50 (IC_{50}). Alkaloids tested were BC- bromocriptine, DHET- dihydroergotamine, ET- ergotamine and EN- ergonovine.

Yield of summer annual forages

D. Philipp and R. Rhein[1]

Research Highlights

- Teff, pearl millet, and sorghum-sudan were tested regarding dry matter yield during the summer of 2013.
- Sorghum-sudan generated 7,600 lbs/acre, pearl millet 5,200 lbs/acre, and teff 3,200 lbs/acre of dry matter in total over the growing season between 14 June and 5 September.
- Sorghum-sudan and pearl millet are considered excellent choice as summer annual forage if soil fertility is in check, planting is done correctly, and cut and/or grazed at the appropriate heights.

Introduction

Warm-season annual forages such as pearl millet (*Pennisetum americanum*) and sorghum-sudan (*Sorghum bicolor*) may fill forage gaps in NW Arkansas during droughty summer months. Being C-4 plants, these forages are more water-use efficient and drought-tolerant than their C-3 counterparts such as tall fescue or orchard-grass. For some time, teff grass (*Eragrostis teff*), also a summer annual grass, has been promoted as "emergency forage" that can be utilized during hot summer months in lieu of other traditional forages. In this pilot experiment, we compared these three forages with each other regarding forage mass production between June and September 2013.

Materials and Methods

The study was conducted at the University of Arkansas System Division of Agriculture's Animal Science Department North Farm in Fayetteville, Ark. The soil on the research site is a Captina silt loam slightly sloped in a southerly direction. 'Moxie' teff, 'Tifleaf 3' pearl millet, and 'Green Graze Supreme' sorghum-sudan were planted on 14 June 2013, with a 'Haybuster' no-till drill into a prepared seedbed at rates of 10, 20, and 30 lbs/acre, respectively. The site was fertilized with 60 lbs N/acre according of soil tests; no other nutrient was found to be deficient. All three forage treatments were replicated three times using a randomized complete block design to account for soil variability. The size of each experimental unit was 40 × 40 feet.

Forage mass was collected twice (31 July and 5 Sep) simulating a hay cut. Pearl millet was harvested at a canopy height of 30 inches leaving a 6-inch stubble and sorghum-sudan was cut at a canopy height of 36 inches and also leaving a 6-inch stubble. These parameters were based on recommendations for minimum harvesting heights by the UA Cooperative Extension Service (Factsheet FSA2032, Summer Annual Grasses). Teff was cut at a canopy height of 12 inches, leaving a stubble height of 4 inches. All grasses were in the vegetative growth stage at the time of the first cutting. At the second harvest, pearl millet, sorghum-sudan, and teff were harvested at canopy heights of 76, 82, and 16 inches respectively. At that cutting, all grasses were well advanced reproductively and were within the "seed development and ripening" growth stage. Harvest was performed with a research plot harvester (Wintersteiger Inc., Salt Lake City, Utah) equipped with an inbuilt weighing scale, cutting 3, 4.5-feet wide strips across the entire length of each plot. The weight of each harvested strip was recorded and combined for a composited weight. A subsample of the freshly harvested material was obtained from each plot to determine dry matter (DM) content by placing the samples in a forced-air oven for several days at 130 °F until no further weight loss was detected. The DM content for each plot was then used to determine the DM yield for each experimental unit. The data were statistically analyzed to determine differences in yield for each harvest date. The least-significant-difference (LSD) was used to denote differences between the means.

Results and Discussion

The results are displayed in Fig. 1. There was an interaction between species and harvest; thus, yields are presented in differently colored column segments which denote the two harvest dates. Sorghum-sudan generated twice as much forage mass at the first harvest than pearl millet, but the regrowth from both forages was similar at the second harvest date. Teff generated less forage mass than the other forages at either harvest date, although there was no statistical difference between teff and pearl millet at the July harvest at the chosen small probability level of statistical error.

Evident is the large amount of biomass generated by sorghum-sudan from planting until the first harvest. This verifies and confirms the high yield potential this crop has as a possible summer annual forage. In comparison, we also observed that the regrowth of pearl millet was less stemmy than that of sorghum-sudan as the latter develops very tall flower shoots towards the end of August, shortly before the second harvest date. Teff generated the least amount of biomass. This forage did generate about twice as much biomass during the regrowth phase, but so did pearl millet.

Implications

Pearl millet and sorghum-sudan are still the main choices for selecting summer annual forages. Teff appeared to be hardy, drought tolerant, and had good regrowth, but cannot reach the high levels of biomass accumulation like the other two species tested. Producers should make sure that when selecting high-yielding forages such

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as sorghum-sudan, soil preparation, fertilization, and management have to be optimal to achieve good results and maximize the yield potentials of these forages.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

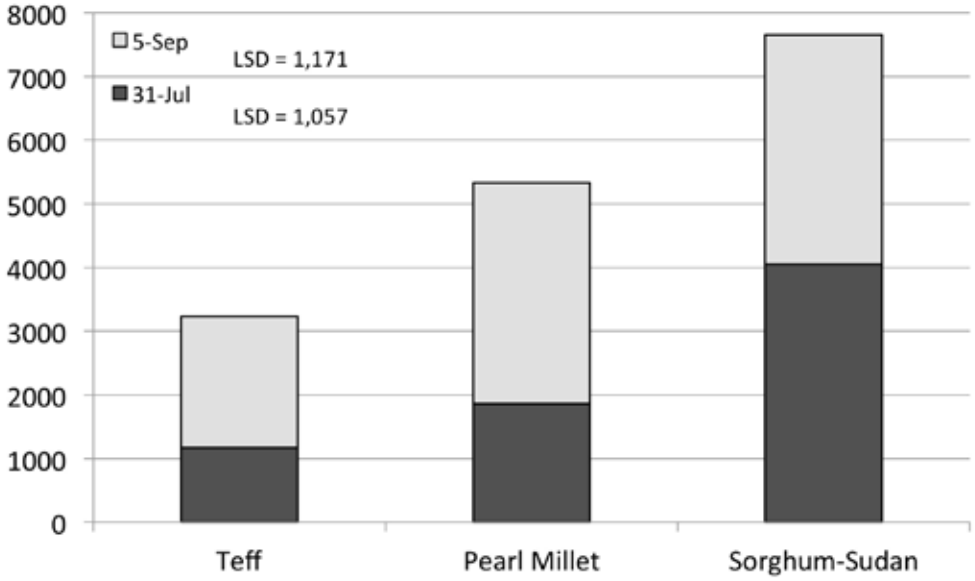

Fig. 1. Forage mass (lbs/acre) of annual warm-season grasses grown at the Fayetteville-location in 2013. Data are displayed in stacked columns to indicate total yield over the growing season. All forage were planted on 14 June.

Bulb yield and quality of forage brassicas

K. Simon[1], J. Jennings[1], D. Philipp[2], and R. Rhein[2]

Research Highlights

- Forage turnip varieties Appin and Barkant were evaluated for bulb yield and quality.
- Bulb yields of 2,900 lbs/acre were similar between the two varieties.
- Concentrations of crude protein, acid detergent fiber, neutral detergent fiber, and total digestible nutrients were similar for Appin and Barkant (10.5%, 21.3%, 22.7%, and 79.2%, respectively).
- Forage turnip bulbs have the potential for providing a high yielding and high quality cost-effective source of energy to livestock in late fall or early winter.

Introduction

Brassica species are being used as livestock feed around the world and have been predominantly used in temperate zones such as New Zealand. In the southern U.S., brassicas are an attractive choice of fall and early winter grazing for livestock. Brassicas are fast-growing, high in nutritive value, and thus complement the existing forage base by filling gaps in forage production. Commonly grown forage *brassica* species in Arkansas include: turnip, rape, and turnip × rape hybrids. In this study, we compared the bulb yield and quality of selected forage turnips.

Materials and Methods

Two forage turnips (Appin and Barkant) were harvested after 4 months of growth to compare total bulb dry matter (DM) production and quality. Brassicas were no-till drilled into a well-firmed, conventionally tilled seedbed at a seeding rate of 5 lbs/acre at the University of Arkansas System Division of Agriculture Animal Science North Farm, Fayetteville. The design used was a randomized complete block with 4 replications. Prior to planting on 26 August 2013, biomass growth at the experiment site was suppressed with glyphosate, and the area was disked twice then culti-packed. Plot size was 4 ft. × 25 ft. Immediately after planting, premixed fertilizer with Boron was applied to each plot according to Cooperative Extension Service soil test recommendations. Plots were harvested on 3 Dec. Bulbs were pulled from the entire plot by hand and weighed fresh. Subsamples were dried at 131 °F for DM yield determination. Bulb quality was analyzed at Dairy One Laboratory in Ithaca, N.Y. Statistical analyses using the SAS program (SAS Institute, Inc., Cary, N.C.) were performed to determine differences between means of yield and chemical composition.

Results and Discussion

Bulb production was limited until the plants reached 16 to 18 inches. However as the plant continued growing, a significant amount of bulb yield was produced (Fig. 1). Both varieties produced similar bulb DM lbs/acre (Appin 2,882; Barkant 2,884). Forage turnip produced a higher amount of bulb yield in addition to leaf yield. Bulb yield was 47% and 42% of the total yield for Appin and Barkant, respectively. Appin produced a small, round bulb (<5 in.) firmly anchored in the soil. Barkant produced a moderate, oval shaped bulb (4-8 in.), with 50% of the bulb above the soil surface. Concentrations of crude protein, acid detergent fiber, nutrient detergent fiber, and total digestible nutrients were similar for Appin (10.9%, 24.2%, 25%, and 78.3%, respectively) and Barkant (10.0%, 18.3%, 20.4%, and 80%, respectively; Table 1). The trace mineral content of Appin was higher than Barkant, possibly due to soil contamination. Iron content of Appin (1,276 mg/kg) was nearly twice that of Barkant (691 mg/kg).

Implications

Forage turnip bulbs have the potential for providing a high yielding and high quality cost-effective source of energy to livestock in late fall or early winter. The data indicate they could be a good source of grazing even after a hard freeze (25 °F) inhibits plant growth. Anecdotal evidence suggests that cattle will remove bulbs from the soil and eat them readily.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

[1] University of Arkansas System Division of Agriculture, Department of Animal Science, Little Rock, Ark.
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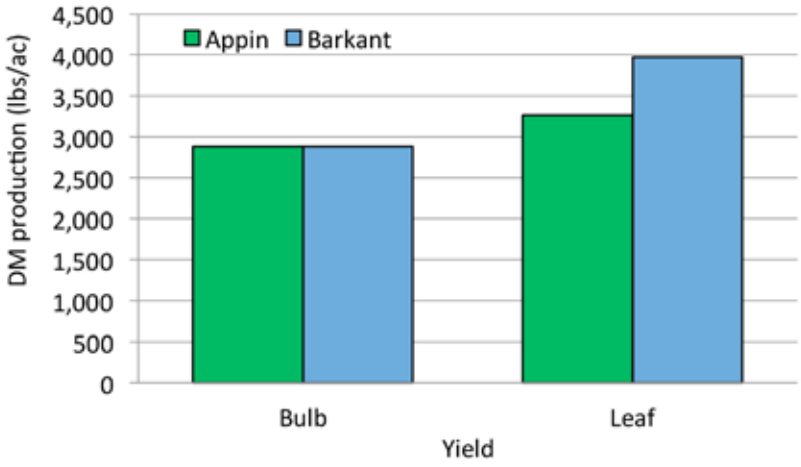

Fig. 1. Bulb yield of Appin and Barkant turnips after approximately 4 months of growth (Aug–Dec 2014). There was no significant difference between varieties for bulb yield. The leaf yield means are included for illustrative purposes.

Table 1. Bulb quality and mineral concentrations of forage turnips after a 4-months growth period in 2014 (n = 4/treatment).

	Variety			
Nutrients and Minerals	**Appin**	**Barkant**	**SEM**	***P*-value**
Crude protein (%)	10.9	10	1.2	0.32
Acid detergent fiber (%)	24.2	18.3	4.4	0.05
Neutral detergent fiber (%)	25	20.4	3.9	0.1
Total digestible nutrients (%)	78.2	80	1.3	0.03
Ca (%)	0.38	0.54	0.25	<0.001
P (%)	0.6	0.55	0.08	0.44
Mg (%)	0.24	0.15	0.05	<0.001
K (%)	2.8	3	0.34	0.61
Na (%)	0.49	0.18	0.22	0.03
Fe (ppm)	1276	691	442	0.05
Zn (ppm)	73	25.8	43.6	0.13
Cu (ppm)	27.8	8.8	13.4	0.03
Mn (ppm)	88	44	31.9	0.04
S (%)	0.59	0.47	0.08	0.01

Nutritive value of turnip leaves from two harvests

K. Simon[1], J. Jennings[1], D. Philipp[2], and R. Rhein[2]

Research Highlights

- Turnip varieties were compared regarding their leaf nutritive value at an October and November harvest.
- Values of crude protein (>15%) and total digestible nutrients (>60%) exceed beef cow requirements.
- Turnips are suited as an energy source and protein supplement.

Introduction

Brassica species are being used as livestock feed around the world and have been predominantly used in temperate zones such as New Zealand. In the southern U.S., brassicas are an attractive choice of fall and early winter grazing for livestock. Brassicas are fast-growing, high in nutritive value, and thus complement the existing forage base by filling gaps in forage production. Commonly grown forage brassica species in Arkansas include: turnip, rape, and turnip × rape hybrids. In this study, we evaluated the nutritive value of brassica leaves from two harvest dates.

Materials and Methods

Two forage turnip (Appin and Barkant), 3 forage rape (Barsica, Bonar, and Winfred), 3 forage turnip × rape hybrids (Pasja, T-Raptor, and Vivant), a commonly used garden turnip variety (Seven-top), and a radish (Aerifi) were compared for total leaf nutritive value after 6 and 13 weeks of growth. Brassicas were no-till drilled into a well-firmed, conventionally tilled seedbed at a seeding rate of 5 lbs/acre at the University of Arkansas System Division of Agriculture Animal Science North Farm in Fayetteville in two separate experiments using the same layout. The design used was a randomized complete block with 4 replications. Prior to planting on 26 August 2014, biomass growth at the experiment site was suppressed with glyphosate, and the area was disked twice, culti-packed, and rolled. Plot size was 4 ft. × 25 ft. Immediately after planting, premixed fertilizer with Boron was applied to each plot according to Cooperative Extension Service soil test recommendations. Plots were harvested on 2 Oct in one experiment and harvested on 24 Nov in the other experiment using a small, self-propelled sickle bar mower. Total leaf matter was collected and weighed in the field; a subsample was collected to determine dry matter and nutritive value. For the purpose of this report, only data for crude protein (CP) and total digestible nutrients (TDN) will be reported. Statistical analyses using the SAS program (SAS Institute, Cary, N.C.) was performed to determine differences between the varieties.

Results and Discussion

Data for CP and TDN are presented in Figs. 1 and 2, respectively. Our results indicate that there are relative large differences in CP concentrations for the October harvest, ranging from 27% to 32%. At the November harvest, CP appeared to be less variable among brassicas evaluated and averaged 20% CP. With regard to TDN, results showed small variability among the varieties and averaged 80% for the October harvest. Differences among the means became more evident at the November harvest with values ranging from 67% to 76%.

Our data indicate that higher CP values were not reflected in higher TDN values. At the November harvest, CP values were close to CP values from stockpiled tall fescue (Jennings et al., 2012). Values of TDN from the November harvest were also similar to TDN values from tall fescue based on the same publication. Overall, CP and TDN values observed were greater than the nutritional requirements for dry and lactating beef cows.

Implications

Our results corroborated that turnips leafs provide high levels of nutrients and high levels of TDN. For balancing a ration and forage for grazing, it may be feasible to use turnips as a supplement alongside forages lower in nutritive value.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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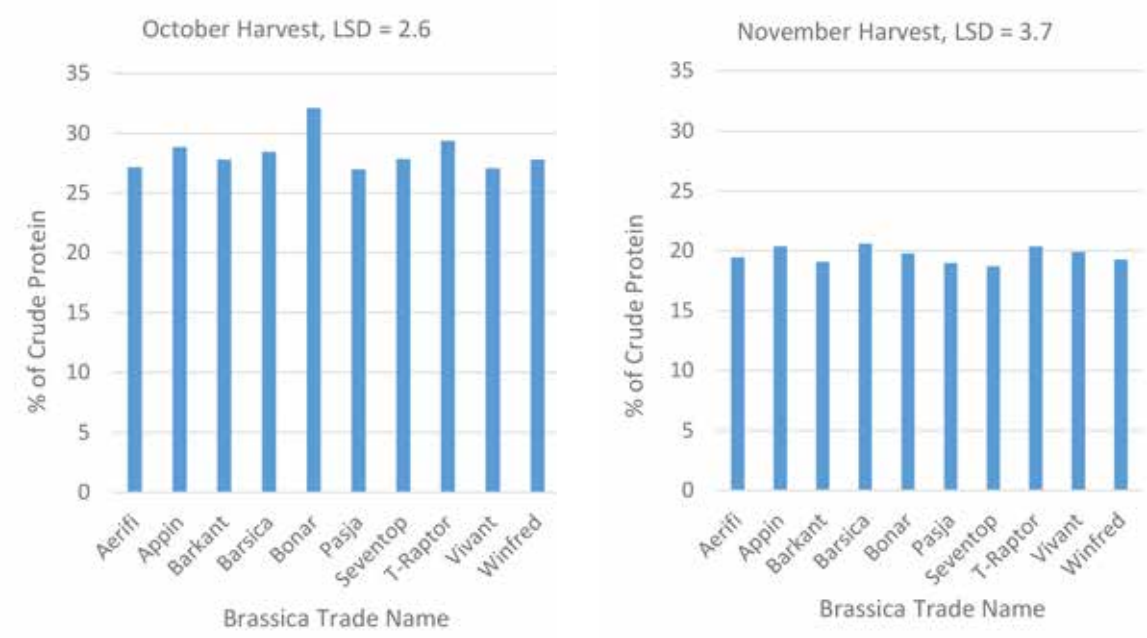

Fig. 1. Crude protein (CP) concentrations (%) in Brassica above-ground biomass from two harvests. LSD = least significant difference.

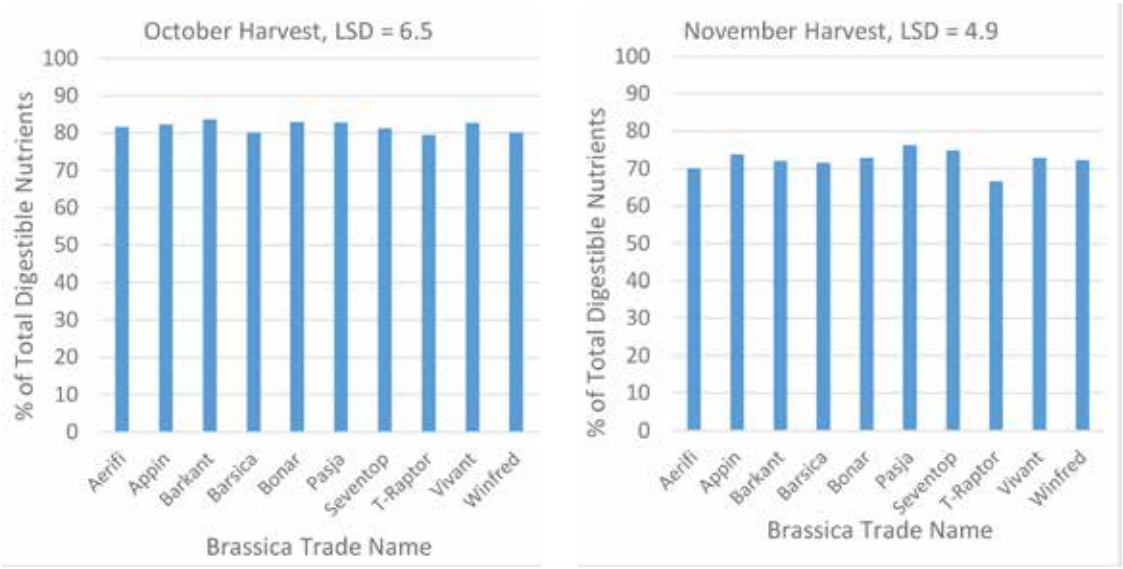

Fig. 2. Total digestible nutrient (TDN) concentrations (%) in Brassica above-ground biomass from two harvests. LSD = least significant difference.

Effects of dam age on growth performance and carcass traits of crossbred steer progeny

E. Backes[1], J. Powell[1], F. Pohlman[1], J. Richeson[2], K. Anschutz[1], J. Hornsby[1], J. Reynolds[1], B. Lindsey, Jr.[1], and B. Shoulders[1]

Research Highlights

- Dam age has been reported to affect offspring performance.
- The effect of dam age on steer growth and carcass performance was investigated.
- Calf birth weight, calf weaning weights, and ribeye area were affected by dam age.
- Dams greater than 7 years old produced heavier calves at birth and weaning than dams younger than 3 years old.

Introduction

Marlowe and Gaines (1958) reported that the most productive cows in a cow herd are approximately 6 years old or older; however, little current research is published regarding the effects of dam age on calf performance. Also, little current research is published to determine the effects of dam age on carcass quality measurements of male calves arriving at the packing plant. Therefore, the purpose of this research is to evaluate the effects of dam age on Angus crossbred steer performance and carcass quality measurements located at the University of Arkansas System Division of Agriculture beef cattle research station.

Materials and Methods

Over three consecutive years, a total of 166 fall-calving, mixed-aged Angus and Angus- crossbred cows bred to Angus or Hereford sires were utilized to determine the effects of dam age on offspring performance. Dams were allocated to 1 of 4 age groups representing: 1) 3 and under (Age3); 2) 4 to 6 years old (Age4-6); 3) 7 to 10 years old (Age7-10); and 4) 11 and older (Age11+). The maximum cow age was 15 years old. Cattle were housed at the University of Arkansas' beef research unit and had access to pastures containing predominately endophyte-infected tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh]. Calves were processed at birth (September to November) according to standard farm protocol and weaned in May. Steers remained on the farm unit of origin and were grazed as 1 group until July, approximately 2 months after weaning, and were then transported to the West Texas A&M research feedlot, located in Canyon, Texas and remained there until harvest. Steers were all fed a standard feedlot diet consisting predominately of sweet bran and were housed in similar pens. When steers met the desired degree of finish (1/2 in backfat thickness), they were transported a to meat processing plant in Friona, Texas. Carcass measurements were determined upon harvest, by a trained observer located at the meat processing plant.

Calf performance and carcass measurements were analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Calf was considered the experimental unit and year and sire within treatment were considered random effects. Quality grade was analyzed using Chi-square of SAS. Weaning weights (WW) were adjusted according to a modified version of the beef improvement guidelines and were determined using the equation: WW = ((WW – birth weight)/WW)* 205 + birth weight (BIF, 2002). In this modified version, dam age was not included in the equation due to dam age being considered the treatments. Marbling was converted to numeric values and analyzed as described by May et al. (1992). Significance level was set at $P \leq 0.05$. All treatment means were reported as least squares means.

Results and Discussion

The effects of dam age on male calf performance and carcass measurements are described in Table 1. Calves born to Age11+ greater ($P < 0.01$) birth weight compared with Age3 and Age4-6. Calf adjusted WW was greater ($P < 0.01$) from Age11+ and Age7-10 compared with Age3. This study agrees with Marlowe and Gaines (1958), who reported that the most productive cows were 6 years old or greater and the least productive cows were less than 3 years old.

Hot carcass weights were similar ($P = 0.57$) amongst steers from different age cows. Yield grade, backfat thickness, marbling, as well as kidney, pelvic, and heart fat did not differ ($P \geq 0.23$) amongst steers from different age cows. A possible reason for these traits being similar between treatments is that steers from each of these age groups were fed a common endpoint degree of finish. Calves whose dams were Age3, Age4-6, and Age7-10 had greater ($P = 0.03$) ribeye area compared to calves whose dam were Age11+. Percentage of calves grading choice or select did not differ ($P = 0.51$) between dam age groups, perhaps the result of finishing to a common backfat thickness.

Implications

Based on these results, dam age affected pre-weaning performance of crossbred male calves. However, dam age had minimal effects on carcass traits when steers were finished to a common compositional endpoint. Further research is warranted to determine the effects of dam age on calf performance and length of finishing period on carcass composition.

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Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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Table 1. Performance and carcass measurements in crossbred steers whose dams differed in age.

	Dam age (years)[a]					
Item	**Age3**	**Age4-6**	**Age7-10**	**Age11+**	**SEM[b]**	***P*-value**
n	23	87	38	18		
Birth weight, lb	60[e]	75[e]	80[d]	87[c]	4.23	<0.01
Adjusted weaning wt, lb	386[e]	452[d]	478[c]	465[cd]	26.5	<0.01
HCW, lb[f]	785	812	808	813	18.1	0.57
REA, in^{2}[g]	13.4[c]	13.0[c]	13.1[c]	12.3[d]	0.23	0.03
Yield Grade	3.3	3.2	3.2	3.4	0.04	0.58
Backfat thickness, in	0.67	0.65	0.62	0.64	13.6	0.76
KPH, %[h]	3.2	3.0	2.9	3.2	0.37	0.23
Marbling	451	452	429	448	20.7	0.31
Select, n, (%)[i]	4 (18%)	20 (27%)	18 (35%)	6 (33%)	--	--
Choice, n, (%)[i]	18 (82%)	53 (73%)	34 (65%)	12 (67%)	--	--

[a] Age3 = dam age < 3 years of age; Age4-6 = dam age between 4 to 6 years old; Age7-10 = dam age between 7 to 10 years old; Age = dam age > 11 years old.

[b] SEM = Pooled standard error of the mean.

[c-e] Means within a row without common superscript differ ($P < 0.05$).

[f] HCW = Hot carcass weight.

[g] REA = ribeye area.

[h] KPH = kidney, pelvic, heart fat %.

[i] Percentage of Choice and Select did not differ ($P = 0.51$) amongst age groups.

Effects of long-acting eprinomectin or a combination of moxidectin and oxfendazole on post-weaning heifer performance over a 154-day grazing season

E. Backes, J. Powell, E. Kegley, J. Hornsby, J. Reynolds, K. Anschutz, D. Galloway, and W. Galyen[1]

Research Highlights

- Internal parasites can cause detrimental effects on cattle performance.
- Cattle were treated with various dewormer regimens.
- Treated heifers had improved growth performance over a 154-day grazing season.
- Fecal egg counts where reduced in treated heifers up to 84 days of grazing.

Introduction

Southern states account for approximately 40% of the cattle in the United States (USDA-NASS, 2014). Similarly, internal parasites flourish in the southern states and can account for annual losses of approximately 2.5 million dollars, and these losses can occur through decreased cattle gains (Kunkle et al., 2013; Rehbein et al., 2013) and potential decreases in reproductive performance. Recently, a new long-acting eprinomectin, commonly called LongRange™, was released on the market and has been reported to be an effective dewormer for beef cattle (Kunkle et al., 2013; Rehbein et al., 2013) with efficacy persisting for approximately 150 days (Soll et al., 2013). Therefore, the objective of this study was to evaluate the effects of LongRange™ compared to conventional dewormers and a negative control on growth and fecal egg counts in fall-born, crossbred replacement heifers over a 154-day grazing season.

Materials and Methods

This study was conducted at the University of Arkansas System Division of Agriculture stocker unit (Savoy, Ark.). Beginning 2 June 2014, 83 head of newly weaned crossbred beef heifers (495 ± 7.9 lb initial body weight; BW) were allocated randomly to 1of 3 deworming treatments based on day -14 BW and fecal egg count (FEC) collections, and days of age. Treatments consisted of: 1) no dewormer administered (CON; n = 28); 2) combination of pour-on moxidectin and oxfendazole oral drench (Cydectin©/ Synanthic© combination; COMBO; n = 28; Boehringer Ingelheim Vetmedica, St. Joseph, Mo.); and 3) long-acting eprinomectin (LongRange™; LR; n = 27; Merial Limited, Duluth, Ga.) and were applied at a recommended dose, on day 0. Heifers treated with COMBO had moxidectin applied topically along the midline of the back and oxfendazole given orally. Long-acting eprinomectin was administered subcutaneously in the neck to respective heifers. Heifers grazed in individual treatment groups for the duration of the 154-day grazing season on 25-acre pastures that consisted predominately of endophyte-infected tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh] and were offered a corn-gluten supplement daily at 1% of body weight.

Body weight and body condition scores (BCS; 1 = emaciated; 9 = obese) were determined on days 0, 14, 28, 84, 112, 140, and 154 of the study. Heifer FEC were collected and processed according to the Yazwinski et al. (1994) method on days 0, 14, 28, 84, and 154. Heifer performance and fecal egg counts were analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Individual heifer was considered the experimental unit. All treatment means were reported as least squares means.

Results and Discussion

Body weights were similar on day 0, 14, and 28 of the study; however, on day 84, heifer BW tended ($P = 0.06$) to be greater for LR; intermediate for COMBO; and were lowest for CON heifers (Table 1). On day 112, LR-treated heifers weighed more ($P < 0.01$) than CON heifers; whereas on days 140 and 154 of the study, LR-treated heifers were heavier ($P < 0.01$) than both COMBO-treated and CON heifers. This study agrees with Kunkle et al. (2013) and Rehbein et al. (2013), whom reported improved growth performance in dewormed cattle compared to untreated cattle, suggesting that treatment against gastrointestinal parasites during the grazing season positively impacts gain performance and ultimately increases producer output.

Average daily gain (ADG) was similar ($P = 0.99$) over the first 2 weeks of the trial, but LR-treated heifers had greater ($P = 0.03$) ADG than COMBO-treated heifers between days 14 to 28. During the following 8 weeks (day 28 to 84), LR-treated heifers gained more ($P < 0.01$) rapidly than either COMBO-treated or CON heifers; however, between days 84 and 112, LR-treated heifers had the greatest ($P < 0.01$) ADG and COMBO-treated heifers had greater ($P < 0.01$) ADG than CON heifers. Average daily gains from day 112 to 140 did not differ ($P = 0.18$) between treatments; however, LR-treated heifers tended ($P = 0.10$) to have greater ADG compared with COMBO-treated and CON heifers. Overall, ADG was greater ($P \leq 0.01$) from LR-treated heifers compared with COMBO-treated and CON heifers.

Body condition scores were similar ($P \geq 0.46$) among treatments during the first 4 weeks of the trial; however, from day 84 to the conclusion of the feeding trial, LR-treated heifers had greater ($P < 0.10$) BCS than CON heifers.

Fecal egg counts were similar ($P = 0.16$) among treatments at the initiation (day 0) of the study; however, at 2 and 4 weeks after treatment, LR- and COMBO-treated heifers had considerable lower

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($P < 0.01$) FEC compared with CON heifers. More importantly by day 84, LR-treated heifers still had the least ($P < 0.01$) FEC, and COMBO-treated heifers had nearly half ($P < 0.01$) the FEC compared with CON heifers, yet by the end of the 154-day feeding trial, FEC did not differ ($P = 0.23$) among treatments.

Implications

Based on these results, treatment against gastrointestinal nematodes in newly weaned heifers calves improved performance measurements. Also, the use of long-acting eprinomectin or moxidectin/oxfendazole combination dewormer positively affected FEC counts, up to 84 days, when compared to non-treated heifers.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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Table 1. Performance measurements and fecal egg counts (geometric means; GM) by fall-born heifers treated with various dewormers post-weaning.

	Treatments[a]				
Item	CON	COMBO	LR	SEM[b]	*P*-value
Body Weight, lb					
Day 0	495	495	497	12.1	0.98
Day 14	502	502	504	11.9	0.99
Day 28	515	513	522	16.1	0.84
Day 84	579^{y}	592^{xy}	621^{x}	13.2	0.06
Day 112	602^{d}	634^{cd}	664^{c}	13.4	<0.01
Day 140	636^{d}	669^{d}	709^{c}	13.6	<0.01
Day 154	649d	669^{d}	712^{c}	14.3	<0.01
ADG, lb/day[f]					
Day 0 to 14	0.50	0.50	0.48	0.163	0.99
Day 14 to 28	0.94^{cd}	0.75^{d}	1.28^{c}	0.143	0.03
Day 28 to 84	1.13^{d}	1.42^{d}	1.78^{c}	0.770	<0.01
Day 84 to 112	0.85^{e}	1.48^{d}	1.55^{c}	0.068	<0.01
Day 112 to 140	1.19	1.25	1.58	0.888	0.18
Day 140 to 154	0.89^{y}	0.0^{z}	0.18^{x}	0.308	0.10
Overall	0.99^{d}	1.12^{d}	1.39^{c}	0.044	<0.01
BCS[f]					
Day 0	5.1	5.1	5.1	0.06	0.99
Day 14	5.2	5.1	5.1	0.07	0.46
Day 28	5.0	5.0	5.0	--	1.00
Day 84	5.2^{d}	5.4^{cd}	5.5^{c}	0.09	0.03
Day 112	5.1^{y}	5.2^{xy}	5.3^{x}	0.07	0.10
Day 140	5.6^{d}	5.8^{cd}	5.9^{c}	0.08	0.04
Day 154	5.4^{d}	5.6^{cd}	5.8^{c}	0.10	0.05
FEC, eggs/gram (GM)[h]					
Day 0	35	23	26	0.1	0.16
Day 14	68^{c}	1^{d}	4^{d}	0.1	<0.01
Day 28	144^{c}	5^{d}	8^{d}	0.1	<0.01
Day 84	164^{c}	80^{d}	6^{e}	0.1	<0.01
Day 154	15	9	17	0.1	0.23

[a] Con = Control; Combo = moxidectin/oxfendazole combination; and LR = long-acting eprinomectin.
[b] SEM = Pooled standard error of the mean.
[c-e] Means within a row without common superscript differ ($P \leq 0.05$).
[x-y] Indicates a tendency ($P \leq 0.10$); Means within a row without common superscript tended to differ ($P \leq 0.05$).
[f] ADG = average daily gain.
[g] BCS = Body condition score; 1 = emaciated; 9= obese.
[h] FEC = fecal egg counts.

Performance measurements from Spring-calving cows and their calves over a 230-day grazing season treated near calving with either long-acting eprinomectin or oxfendazole

E. Backes[1], J. Powell[1], D. Hubbell, III[2], J. Tucker[2], W. Galyen[1], and L. Meyer[1]

Research Highlights

- Internal parasites can cause detrimental effects on cattle performance.
- Cows and calves were treated with various dewormer regimens and rotationally grazed for 230 days.
- Cow performance did not differ amongst dewormer treatments.
- Gastrointestinal burdens remained low throughout the 230-day grazing period.
- Calf weaning weights were greatest from calves nursing oxfendazole treated cows.

Introduction

According to the USDA Animal and Plant Health Inspection Service (USDA-APHIS, 2009), slightly fewer than 60% of cows and replacement heifers are not treated for gastrointestinal parasites at least once a year, and 41% of calves are not dewormed prior to weaning. However, gastrointestinal parasites flourish in the southern states, especially in the spring and summer months, and cause monetary losses to cattle producers, via decreased growth and performance (Perry and Randolph, 1999). Furthermore, southern states account for approximately 11.8 million beef cattle, which represent roughly 40% of the U.S. cattle herd (USDA-NASS, 2014).

LongRange™, a long-acting injectable eprinomectin dewormer, has recently been released for parasite control in cattle. Soll et al. (2013) reported that LongRange™ was an effective dewormer for approximately 150 days. Also when compared with untreated cattle, LongRange™ was reported to improve cattle performance (Kunkle et al., 2013; Rehbein et al., 2013) and lower fecal egg counts (FEC; Kunkle et al., 2013). The objective of the current study was to evaluate the effects of long-acting eprinomectin treatment on fecal egg count reduction and herd performance when administered to spring-calving cows treated approximately 5 days before initiation of the calving season and compared it to an oxfendazole treated group and a negative control.

Materials and Methods

Eighty-two spring-calving cows (1239 ± 17.8 lb initial body weight; BW) located at the University of Arkansas System Division of Agriculture Livestock and Forestry Research Station, near Batesville, Ark. were utilized for this study. Cows were stratified by prior BW, body condition score (BCS), and FEC and were randomly allocated to 1 of 3 deworming treatments consisting of: 1) control (CON; no anthelmintic administered; n = 27); 2) long-acting eprinomectin (LongRange™; LR; n = 28; Merial Limited, Duluth, Ga.); and 3) oxfendazole (Synanthic©; SYN; n = 27; Boehringer Ingelheim Vetmedica, St. Joseph, Mo.). Beginning mid-February, approximately 5 days before initiation of calving season, cattle were administered respective anthelmintic treatment (day 0). Cows and their calves rotationally grazed on 6-acre mixed-grass pastures in groups of approximately 13 or 14 head each, from mid-February to October, in individual treatment groups. During the calving season (February through April), cows were offered 6 lb/head/day of soyhull pellets. Body weight, BCS, and FEC (Yazwinski et al., 1994) were determined on day 0, 14, 91, 154, and 230 and hair coat scores (HCS; 1 = short, slick hair coat; 5 = full winter hair coat) were evaluated on day 0, 91, 154.

Spring-born calves were weaned on 29 September 2014. At weaning, calves were administered the same dewormer regimens as their dams, at a recommended dose, and were grazed in a similar pattern. Post-weaning calves were offered 3 lb/head/day of corn gluten supplement. Body weight, BCS, and FEC (Yazwinski et al., 1994) were taken on days 230 (weaning), 240 (14-day post-weaning), and 328 (98-day post-weaning).

Cattle performance and FEC were analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Individual animal was considered the experimental unit. All treatment means were reported as least squares means.

Results and Discussion

Cow BW did not differ ($P \geq 0.26$) amongst treatments on any observation day of the 230-day grazing period (Table 1). Cow BCS did not differ ($P \geq 0.25$) on day 0 or 14. However, on day 91, SYN treated cows exhibited the greatest ($P = 0.03$) BCS; CON was intermediate, and LR exhibited the lowest BCS. Cow BCS did not differ ($P \geq 0.35$) on days 154 and 230 of the study across deworming treatments. Cow HCS did not differ ($P \geq 0.25$) across treatments on days 0 and 154; however, on day 91, LR and CON had greater ($P < 0.01$) HCS compared to SYN. Fecal egg counts were very low at the start of the study and remained at low levels for the duration of the grazing season across all treatments. Cattle housed at the Livestock and Forestry Research Station, are rotationally grazed year round and that could be a possible explanation for the low parasitic burdens. There is a decreased chance cows would pick up the infective stage larvae in this style of grazing management. Cow FEC did not differ ($P \geq 0.11$) on days 0 and 91. However, FEC were lower ($P \leq 0.02$) for LR and SYN compared to CON on days 14 and

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154 of the study. At weaning (day 230), FEC were greater from LR ($P < 0.01$) compared with CON and SYN.

Calf birth weights did not differ ($P \geq 0.05$) amongst treatments and averaged 88-89 lb. Weaning weights were greater ($P = 0.05$) for calves from SYN-treated dams; calves from CON were intermediate; calves nursing LR-treated dams exhibited the lowest weaning weights. Calf gain was similar ($P \geq 0.05$) on days 14 (day 244) and 98 (day 328) post-weaning (Table 2). Calf average daily gain (ADG) was greater ($P < 0.01$) for LR treated calves on days 230 to 244 compared with CON and SYN-treated calves, but did not differ ($P = 0.27$) across treatments on days 244 to 328. Overall ADG for the 98 day post-weaning period was greatest ($P = 0.05$) for LR-treated calves; intermediate for SYN-treated calves; and lowest for CON calves. Calf FEC was greatest ($P < 0.01$) for CON calves compared with SYN- and LR- treated calves at weaning and 14 and 98 days post-weaning.

Implications

In the present study, treatment against gastrointestinal parasites prior to the initiation of the calving season had minimal effects on spring-calving cows performance; however, positive effects were noted on nematode FEC from day 0 until day 154 of the study. Calf weaning weights were positively affected when dams were treated with oxfendazole. Treatment of calves with long-acting eprinomectin or oxfendazole resulted in higher average daily gains for calves post-weaning.

Acknowledgments

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Table 1. Performance measurements and fecal egg counts (geometric means; GM) by Spring-calving cows using different deworming regimens.

	Treatments[a]				
Item	CON	LR	SYN	SEM[b]	*P*-value
Body weight, lb					
Day 0	1260	1218	1236	14.0	0.61
Day 14	1326	1260	1267	14.5	0.26
Day 98	1223	1168	1214	14.7	0.42
Day 154	1254	1227	1221	15.0	0.76
Day 230	1249	1260	1260	14.6	0.95
BCS[f]					
Day 0	5.6	5.6	5.7	0.09	0.89
Day 14	5.8	5.8	5.9	0.06	0.25
Day 91	5.9[cd]	5.8[d]	6.0[c]	0.05	0.03
Day 154	5.9	6.0	5.9	0.03	0.35
Day 230	5.8	5.7	5.7	0.11	0.68
HCS[g]					
Day 0	4.9	4.9	5.0	0.02	0.61
Day 91	2.8[c]	3.5[c]	1.7[d]	0.25	<0.01
Day 154	2.7	3.0	2.7	0.24	0.63
FEC, eggs/gram (GM)[h]					
Day 0	3.0	2.8	2.5	0.08	0.84
Day 14	3.0[c]	1.2[d]	1.0[d]	0.05	<0.01
Day 91	1.5	1.6	1.2	0.06	0.11
Day 154	2.5[c]	1.4[d]	1.6[d]	0.07	0.02
Day 230	2.4[d]	5.4[c]	1.9[d]	0.08	<0.01

[a] CON = Control; LR = long-acting eprinomectin; SYN =oxfendazole.
[b] SEM = Pooled standard error of the mean.
[c-e] Means within a row without common superscript differ ($P \leq 0.05$).
[f] BCS = Body condition score; 1 to 9 scale; 1 = emaciated; 9 = obese.
[g] HCS = Hair coat shedding score; 1 = short, slick hair coat; 5 = full winter coat.
[h] FEC = Fecal egg counts.

Table 2. Performance measurements and fecal egg counts (geometric means; GM) by spring-born calves post-weaning.

	Treatments[a]				
Item	**CON**	**LR**	**SYN**	**SEM[b]**	***P*-value**
Body weight, lb					
Day 230	534[cd]	518d	560[c]	12.3	0.05
Day 14	525	538	555	12.6	0.25
Day 98	567	571	600	12.7	0.17
ADG[f]					
Day 230 to 244	-0.6[d]	1.4[c]	-0.3[d]	0.25	<0.01
Day 244 to 328	0.5	0.3	0.06	0.06	0.27
Overall	0.3[d]	0.5[c]	0.4[cd]	0.06	0.05
FEC, eggs/gram (GM)[g]					
Day 230	49.2[c]	20.5[d]	20.0[d]	0.06	<0.01
Day 244	88.3[c]	12.7[d]	2.3[e]	0.07	<0.01
Day 328	305.7[c]	63.5[e]	200.7[d]	0.07	<0.01

[a] CON = Control; LR = long-acting eprinomectin; SYN =oxfendazole.

[b] SEM = Pooled standard error of the mean.

[c-e] Means within a row without common superscript differ ($P \leq 0.05$).

[f] ADG = Average daily gain.

[g] FEC = Fecal egg counts.

Effect of Supplementation of Developing Replacement Heifers with Rumensin or Gainpro on Gain and Pregnancy Rates

P. Beck[1], W. Galyen[2], D. Hubbell[3], J. Tucker[3], T. Hess[3], and M. Cravey[4]

Research Highlights

- This research was conducted to determine the effects of supplementation of growing replacement heifers with Rumensin® or Gainpro® on body weight (BW) gain and pregnancy rates.
- Heifers from spring calving (Block 1; n = 70 heifers; mean BW 458 ± 47.8 lbs; mean age 231 ± 17.0 days) and fall calving (Block 2; n = 72 heifers; mean BW 496 ± 69.9 lbs; mean age 276 ± 12.8 d) were used to test the effects of Gainpro or Rumensin on growth performance and development of beef replacement heifers.
- The body weight at breeding for heifers fed Gainpro (757 lbs) and Rumensin (763 lbs) did not differ ($P = 0.55$) and were 28 lbs greater ($P = 0.04$) than Control (733 lbs) heifers.
- Average daily gains of developing replacement heifers were 10% greater ($P < 0.01$) for Rumensin and Gainpro than Control during the development period.
- There were no differences ($P \geq 0.17$) in AI pregnancy rate (31%) or total pregnancy rate (82%).

Introduction

Medicated feed additives, such as Bovatec®, Rumensin®, and Gainpro®, have been used for years to effectively increase body weight (BW) gain of growing cattle on pasture or fed hay. Recent decline in the number of cows in the national cowherd has piqued the interest of producers to once again retain heifers into the breeding herd. With recent increases in feed costs, producers have increasingly become interested in forage-based programs that will supply required nutrients to growing beef cattle without daily feeding of mixed diets. There is data available that indicates that supplying Rumensin to developing replacement heifers improves fertility and decreases age at puberty (Lalman et al., 1993), but there is limited replicated research investigating the utility of Gainpro in similar production systems. Therefore, this research was conducted to determine the effects of supplementation of growing replacement heifers with Rumensin or Gainpro on BW gain and reproductive rates.

Materials and Methods

This study was designed to test the effects of providing developing replacement heifers with Gainpro or Rumensin on BW gain, performance, and reproductive rates. Heifers from spring calving (Block 1; n = 70 heifers; mean BW 458 ± 47.8 lbs; mean age 231 ± 17.0 days) and fall calving (Block 2; n = 72 heifers; mean BW 496 ± 69.9 lbs; mean age 276 ± 12.8 d) were used to test the effects of Gainpro or Rumensin fed in corn gluten feed-based supplements on pasture in comparison with non-medicated (Control) supplements. There were three treatments utilized in this experiment: 1) Control–supplements included a mineral and vitamin premix not containing any medicated feed additive; 2) Gainpro–supplements provided a mineral and vitamin premix designed to supply 15 mg of Bambermycin daily; 3) Rumensin–supplements provided a mineral and vitamin premix designed to supply 200 mg/day of monensin.

Supplements (corn gluten feed) containing the treatment materials (0.25 lb/day of the respective mineral supplement) were offered daily (2.25 lb/day total supplement rate) to heifers on pasture. Mineral premixes containing the treatment materials included: Control Mineral G0771AAA (ADM Alliance Nutrition, Inc., Quincy, Ill.) which supplied no medicated feed additive; GAINPRO® Test Mineral G0771AOZ (ADM Alliance Nutrition, Inc., Quincy, Ill.) which supplied 120 g/ton Bambermycins; and MoreMan's® Grower Mineral RU-1620 (ADM Alliance Nutrition, Inc., Quincy, Ill.) which supplied 1,620 g/ton monensin.

Study Site and Pasture Management

This research was conducted at the University of Arkansas System Division of Agriculture Livestock and Forestry Branch Station located near Batesville, Ark. Heifer calves in Block 1 were housed in 14, 5-acre pastures consisting primarily of Duramax tall fescue, a non-toxic endophyte infected tall fescue cultivar. Pastures were fertilized with 150 lb ammonium nitrate per acre (50 units of actual N) in September and February. Pastures were allowed to accumulate forage mass until 29 October 2013 at which time 5 heifers were placed on each pasture. Each pasture was divided into 4 paddocks and rotationally grazed by the heifers assigned to that particular pasture. Residence time on each paddock was one week allowing for 21-days of rest for each paddock before grazing of regrowth.

Heifer calves in Block 2 grazed 12, 5-acre bermudagrass pastures from 24 June 2014 to 2 October 2014 at which time heifers were moved to Duramax tall fescue pastures until breeding on 2 December 2014. Pastures were fertilized with 150 lb ammonium nitrate per acre (50 units of actual N) in June, July and October. While heifers were on bermudagrass pastures, continuous grazing management

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was used. After heifers were moved to tall fescue pastures, grazing was managed using rotational grazing as described previously.

Cattle Management

In the first block, spring-born heifer calves (n = 70) from the Livestock and Forestry Research Station (n = 56) and Southwest Research and Extension Center (n = 14) cowherds were used. Heifers were weaned and preconditioned, and allocated to 14 groups by BW and source herd, these groups were then randomly assigned to pastures which were then randomly assigned to the 3 treatments (n = 4 pastures for Controls, and n = 5 pastures for Gainpro and Rumensin). Heifers remained on study from 29 October 2013 to 5 May 2014 (188 days). From 3 February 2014 to 17 March 2014 (35-days), slow regrowth of tall fescue and ice and snow cover made it necessary that hay be fed (11.8% CP and 56.6% TDN DM basis). During the hay-feeding period, treatment supplementation was ended and heifers were placed on a single paddock and resided there until grazing was reinitiated for the spring season.

In the second block, fall-born heifer calves (n = 72) from the Livestock and Forestry Research Station (n = 60) and Southeast Research and Extension Center (n = 2) cowherds were used. Heifers were weaned and preconditioned, and allocated to 12 groups by BW and source herd, these groups were then randomly assigned to pastures which were then randomly assigned to the 3 treatments (n = 4 pastures per treatment). Cattle were stocked at 6 calves/pasture. Heifers remained on study from 24 June to 2 December 2014 (161 days).

Heifers were maintained on pastures and fed supplements until artificial insemination (AI) breeding on 6 May 2013 (Block 1) or 2 December 2014 (Block 2), at which time the heifers were comingled on a single pasture. Heat detection patches (Estrotect) were placed on the tailhead of each heifer to assist with heat detection. Heifers were observed for heat for 7 days, then injected with prostaglandin on day 7 of breeding, and heifers were bred on standing heat for 72 hours. Heifers not observed in heat were not exposed to AI. Sires used for AI were low birthweight Angus. Two low-birthweight bulls that had passed a breeding soundness exam were placed with the heifers 14-day following AI for a 46-day breeding season. One month following AI and removal of bulls, pregnancy rate was determined via ultrasound sonography in order to determine first service AI pregnancy rates. Heifers were palpated via rectal palpation in October to determine total pregnancy rates.

Heifers were weighed full on two consecutive dates at the initiation and termination of the study and at 28-day intervals. Heifers were weighed (full) at weekly intervals, from early 10 March through AI breeding in May. At each weighing, blood was collected via jugular veinipuncture and stored as serum. Serum was analyzed for progesterone with the date of first estrus being defined as the first day of two consecutive samples with ≥1 ng progesterone/ml of serum or when a single sample was analyzed to contain >2 ng progesterone/ml of serum. Prior to breeding, reproductive tract scores (1 to 5 scale) were determined by ultrasound in Block 1 and by rectal palpation in Block 2.

Statistical Analysis

Animal performance was analyzed as a randomized complete block design using the mixed procedures of SAS (SAS Institute Inc., Cary, N.C.). Reproductive data (AI conception, pregnancy percentage, percentage of heifers cyclic before breeding) was analyzed using the glimmix procedure of SAS. Pasture group within each block was deemed the experimental unit and heifer within pasture the sampling unit. Least-squares means for animal performance and reproduction were separated using contrasts: Control vs Medicated and Gainpro vs Rumensin.

Results and Discussion

Heifer Performance

The body weight at breeding for heifers fed Gainpro (757 lbs) and Rumensin (763 lbs) did not differ ($P = 0.55$) and were 28 lbs greater ($P = 0.04$) than Control (733 lbs) heifers (Table 1). The heifers averaged 67% of their estimated mature body weight which is slightly above the target body weight (65% of mature body weight) for developing heifers for breeding, indicating that the development systems used were adequate for reproductive success regardless of treatment. Average daily gains of developing replacement heifers were 10% greater ($P < 0.01$) for Rumensin and Gainpro than Control during the development period.

Prior to breeding, reproductive tract scores (1 to 5 scale) were 3.5 across all treatments indicating that on the average most heifers were on the precipice of their cycling activity at the time of this assessment before the breeding season. Age and BW at first puberty (of those heifers cycling prior to breeding) were not affected by treatment ($P \geq 0.70$), but the percentage of heifers determined to be cyclic pre-breeding was numerically ($P \geq 0.40$) greater in Rumensin (72%) treatment than Control (63%) or Gainpro (65%). There were no differences ($P \geq 0.27$) in AI pregnancy rate (31%) or total pregnancy rate (82%).

These results indicate that Gainpro and Rumensin have the potential to improve performance of heifers being developed for replacements, but this did not improve pregnancy rates of heifers.

Acknowledgments

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Table 1. Effect of medicated feed additive on performance of developing replacement heifers.

	Treatment				Contrast[1]	
Body weight (BW), lb	**Control**	**Gainpro®**	**Rumensin®**	**SE**	**1**	**2**
Initial	473	474	481	19.7	0.71	0.55
Final	733	757	763	10.2	0.04	0.69
% of estimated mature body weight	66	67	67	0.9	0.15	0.72
Average daily gain, lb/d	1.49	1.63	1.62	0.04	<0.01	0.89
Reproductive Tract Score	3.4	3.6	3.5	0.29	0.34	0.40
Pregnancy, %	82	81	83	6.9	0.21	0.65
AI pregnancy, %	36	31	23	6.8	0.17	0.19
Cycling pre-breeding, %	55	56	72	10.9	0.49	0.25
Age at puberty, d	377	366	369	6.8	0.27	0.66
BW at puberty, lb	688	658	664	18.4	0.24	0.77

[1] Treatment least-squares means were separated using the contrasts: 1–Control vs Gainpro and Rumensin; 2–Rumensin vs Gainpro.

Anti-mullerian hormone and follicle counts as predictors of superovulatory response and embryo production in beef cattle

K. Center[1], D. Dixon[2], and R. Rorie[1]

Research Highlights

- A study investigated the use of anti-mullerian hormone and/or follicle counts as a predictor of subsequent superovulatory response and embryo production in beef cows.
- Embryo donor cows with the highest concentrations of anti-mullerian hormone in circulation produced more embryos after superovulation and embryo collection.
- Donor cows with the highest number of follicles at the start of superovulation also produced more embryos after superovulation and embryo collection.
- There was no relationship between anti-mullerian hormone or follicle counts and the quality of embryos collected.
- Results indicate that both anti-mullerian concentration and follicle counts are predictive of superovulatory response in beef embryo donor cows.

Introduction

Since the development of cattle superovulation and non-surgical embryo recovery in the 1970s, the unpredictability of the superovulatory response has remained a major obstacle to further improvement. An average response to superovulation is about 12 total and 6 transferable quality embryos, although 15% to 20% of donors do not respond to superovulation (Hasler, 2014). The purpose of superovulation is to stimulate a number of small antral follicles to grow and mature, resulting in multiple ovulations. Therefore, the pool of small antral follicles available for stimulation would be expected to dictate the superovulatory response.

Anti-Mullerian hormone (AMH) is produced by cells within follicles (Vigier et al., 1984) and reflects the total pool of follicles within the ovaries. Because there is a positive relationship between the number of small follicles with the ovaries and serum concentrations of AMH, the measurement of AMH might be used to predict superovulatory response in embryo donor cows. Alternatively, the use of ultrasonography to count the number of small follicles present at the start of superovulation might also be useful for predicting superovulatory response. Therefore, the present study was conducted to investigate the use of AMH and/or follicle counts as predictors of subsequent superovulatory response and embryo production in beef cows.

Materials and Methods

A total of 79 beef cows and heifers ranging from yearling heifers to 13-year-old cows were housed at the Food Animal Veterinary Services donor care facility located in Rensselaer, Ind. A total of 99 embryo collections were performed, representing 79 donor cows of which 20 were collected twice. Depending upon scheduling, client preference and donor history, superovulatory treatment was initiated either during the luteal phase of cow's natural estrous cycle, or after insertion of a progesterone controlled internal drug release device. Cows were superovulated with twice daily decreasing doses of follicle stimulating hormone (FSH; Follitropin-V) over a 4-day period.

Before the initiation of superovulation, ultrasonography was used to scan the ovaries of each donor to record the number of 3 mm to 5 mm follicles present. Concurrent with ultrasonography, a blood sample was collected via tail vein from each cow, and the recovered serum was stored in a chest freezer until analysis for AMH. Serum samples were shipped to Texas A&M Veterinary Diagnostic Laboratory where a bovine AMH enzyme-linked immunosorbent assay kit (Bovine AMH ELISA AL-114) was used to determine AMH concentration in serum samples.

Non-surgical embryo recoveries were performed about 7 days after estrus and insemination. At the time of embryo collection, the ovaries of donor cows were palpated to estimate the number of corpora lutea (CL) present on each ovary. Recovered embryos were evaluated for stage of development (morula, early blastocyst or blastocyst) and morphological quality (grade 1, 2, degenerate or unfertilized), using standards established by the International Embryo Transfer Society.

Variables considered in the data analysis were embryo donor breed, superovulation protocol, AMH concentration, follicle and corpus luteum number, total, transferable, degenerate embryos, and unfertilized ova. Frequency distribution was used to assign AMH concentration measured in serum samples to quartiles. Analysis of variance was then used to make comparisons between AMH quartiles for number of 3 mm to 5 mm follicles, number of corpora lutea at embryo collection, number of embryos recovered, and the percentages of transferrable and degenerate embryos, and unfertilized ova. Frequency distribution was also used to assign follicle counts to quartiles. Analysis of variance was then used to make comparisons between follicle quartiles and number of corpora lutea at embryo collection, number of embryos recovered, and the percentages of transferrable and degenerate embryos, and unfertilized ova. All values are expressed as the mean ± SEM. Statistical differences were considered significant where $P < 0.05$.

Results and Discussion

Anti-Mullerian hormone measured in serum samples ranged from 0.013 to 0.898 ng/mL, with a mean of 0.293 ng/mL. The

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distribution of AMH concentrations was divided into quartiles (AMH Q1 through Q4, with Q1 the lowest and Q4 the highest, ng/mL) for analysis. Donor cows in AMH Q4 had a greater ($P < 0.001$) number of 3 to 5 mm follicles at the start of superovulation than did donors in either Q1 or Q2 (Table 1). Cows in AMH Q3 were intermediate for mean number of follicles. At the time of embryo collection, cows in AMH Q3 and 4 had more palpable CL than cows in AMH Q1 ($P < 0.001$). The mean number of CL for cows in AMH Q2 was intermediate and similar ($P > 0.10$) to those in both AMH Q 1 and 3. The mean number of embryos recovered for donor cows in AMH Q4 was greater ($P < 0.001$) than those recovered from cows in either AMH Q1 or 2, but similar to that of AMH Q3. The percentage of recovered embryos that were classified as transferrable, degenerate or unfertilized were similar ($P \geq 0.275$) across AMH quartiles.

The number of 3 mm to 5 mm follicles counted on the ovaries of donor cows ranged from 5 to over 30, with a mean of 16. In order to determine if follicle counts at the start of superovulation might be predictive of subsequent superovulatory response, the distribution of follicle counts were also divided into quartiles (F Q1 through Q4, with Q1 the lowest and Q4 the highest) for analysis (Table 2). Donor cows with higher follicle counts (F Q3 and 4) at the start of superovulation had more ($P < 0.001$) palpable CL at embryo collection than donor cows in F Q1 or 2. More embryos were recovered from cows with the highest follicle counts (F Q4) as compared with cows having lower (F Q1 and 2) follicle counts ($P < 0.001$). The number of embryos recovered from donors in F Q3 was intermediate and similar ($P > 0.10$) to that of donors in F Q1, 2 and 4. The percentage of transferable embryos and unfertilized ova were similar ($P \geq 0.688$) across follicle count quartiles. The mean percentage of degenerate embryos was greater for donor cows in F Q3 than any other follicle quartile ($P = 0.002$).

The ability to make adjustments to superovulatory regimens based on predicted superovulatory response of individual donors would be of great benefit to the embryo transfer (ET) industry moving forward. This study confirms that relative AMH concentration in circulation is positively correlated with number of small antral follicles in the ovaries of cows and might be used to either predict superovulatory response, or possibly adjust superovulatory regimen to improve superovulatory response. Antral follicle counts at the initiation of superovulatory treatments might be a more practical alternative to AMH for embryo transfer practitioners to use in predicting superovulatory response.

The number of embryos classified as transferrable, degenerate or unfertilized was not related to either serum AMH concentration or follicle counts. Fertilization rate can vary depending on semen quality and concentration, insemination timing and technique, and inherit fertility of the bull. Embryo morphological quality after fertilization can be influenced by many of the same factors, as well as uterine environment. While circulating AMH had little measurable effect on fertilization rate or embryo morphological quality in the current study, it still might be useful for improving fertilization rate and embryo quality. For instance, donor cows that over stimulate from superovulatory treatment often produce unfertilized oocytes and embryos of poor quality. The use of either AMH or follicle counts to predict and adjust superovulatory treatment accordingly might allow embryo transfer practitioners to avoid over stimulation of donor cows.

Implications

These results suggest that relative concentrations of anti-mullerian hormone in circulation, and the number of follicles present on the ovaries at the start of superovulation are predictors of superovulatory response and embryo production in beef cows. Additional studies are needed to determine the effectiveness of using either anti-mullerian hormone concentration or follicle counts to adjust superovulatory regimens for improved response.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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Table 1. Quartile categorization of anti-mullerian hormone concentrations as predictor of superovulatory outcomes.

	Quartile of anti-mullerian hormone concentration				
Item	**Q1**	**Q2**	**Q3**	**Q4**	***P*-value**
AMH, ng/mL	0.013 – 0.068	0.069 – 0.263	0.264 – 0.363	0.364 – 0.898	
No. of donors	26	22	24	24	
No of follicles	13.46 ± 0.91^{b}	14.95 ± 0.98^{b}	16.79 ± 0.94^{ab}	19.33 ± 0.94^{a}	0.001
No. of CL	11.62 ± 1.54^{c}	13.68 ± 1.67^{bc}	17.58 ± 1.60^{ab}	20.54 ± 1.60^{a}	0.001
No. of embryos	9.77 ± 1.76^{b}	9.36 ± 1.91^{b}	15.50 ± 1.83^{ab}	20.13 ± 1.83^{a}	0.001
Transferable %	69.32 ± 6.62	57.06 ± 7.08	58.75 ± 6.62	51.05 ± 6.62	0.275
Degenerate %	5.52 ± 2.52	7.89 ± 2.69	9.40 ± 2.52	9.87 ± 2.52	0.614
Unfertilized %	25.16 ± 6.73	35.06 ± 7.19	31.85 ± 6.73	39.09 ± 6.73	0.519

^{a,b,c} Numbers within rows without common superscripts differ ($P \leq 0.05$).

Table 2. Quartile categorization of follicle counts as a predictor of superovulatory response and embryo production.

	Quartile of follicle counts				
Item	**Q1**	**Q2**	**Q3**	**Q4**	***P*-value**
No. of donors	26	35	20	18	
Follicle range	5 - 12	13 -17	18 - 20	21 – 30	
No. of CL	10.65 ± 1.40[b]	13.51 ± 1.20[b]	19.15 ± 1.59[a]	23.33 ± 1.68[a]	0.001
No. of embryos	9.62 ± 1.79[b]	11.57 ± 1.55[b]	16.50 ± 2.04[ab]	20.00 ± 2.16[a]	0.001
Transferable %	58.20 ± 6.44	64.77 ± 5.63	54.51 ± 7.53	58.46 ± 7.97	0.716
Degenerate %	4.82 ± 2.23[b]	6.71 ± 1.95[b]	17.09 ± 2.61[a]	5.38 ± 2.76[b]	0.002
Unfertilized %	36.99 ± 6.44	28.53 ± 5.63	28.39 ± 7.54	36.16 ± 7.97	0.688

[a,b]Numbers within rows without common superscripts differ ($P \leq 0.05$).

Effects of prepartum and postpartum dietary copper and sulfur supplementation on maternal trace mineral metabolism

J. Hawley, B. Kegley, J. Reynolds, P. Hornsby, and D. Galloway[1]

Research Highlights

- This study examined effect of pre- and postpartum dietary supplementation on maternal plasma minerals concentrations.
- Copper (0 vs. 6 to 8 mg copper/kg) and sulfur (0.15% vs. 0.55% sulfur) were used in a 2 × 2 factorial arrangement.
- Dietary copper and sulfur supplementation did not affect the majority of maternal plasma minerals.
- Maternal plasma copper concentrations were increased by copper supplementation.
- Multiple low plasma mineral concentrations suggest the potential for mineral deficiencies.

Introduction

Distillers' grains have been used as livestock feed for a number of years, but recent increases in availability due to growing interest in processing corn for ethanol production have increased the opportunities for cattle producers at every level to feed distillers' grains. As a result, distillers' grain use has become more widespread in cow-calf operations as a feed source. Sulfuric acid is used during ethanol production for pH adjustment to optimize fermentation and distillation conditions; however, this has had the unintended consequence of contributing to elevated sulfur (S) concentrations in distillers' grains. Accordingly, the effects of excess dietary S on prepartum nutritional management and postnatal calf growth have gained interest, because dietary concentrations of S have increased as the consumption of distillers grains have increased. Previous research has evaluated the effects of prepartum nutritional management and postnatal calf growth (Wu et al., 2006; Funston et al., 2010). However, to our knowledge, the influence of pre- and postpartum S supplementation on maternal trace mineral metabolism has not been investigated; therefore, the objective of this study was to evaluate the influence of pre- and postpartum dietary copper (Cu) and S supplementation on maternal plasma minerals.

Materials and Methods

Animals and Experimental Design

Thirty-six gestating (approximately 20 mo of age; average 170 ± 16 day of gestation), primiparous beef heifers (initial body weight [BW] = 875 ± 54.7 lb) of predominantly Angus breeding were blocked by initial BW, body condition score (1 = thin, emaciated to 9 = fat, obese; as described by Godfrey et al., 1988), and predicted calving date (calculated by fetal age, as determined by transrectal ultrasonography). Blocks were assigned randomly to 1 of 12, 2.4-ha mixed grass pastures (3 heifers/pasture) for a 260-day (12 May 2014 to 28 January 2015) maternal nutrition study. Pastures were assigned randomly to 1 of 4 treatments (2 × 2 factorial arrangement; Table 1): 1) 0.15% S and no supplemental Cu (LoSNoCu); 2) 0.15% S and supplemental Cu (LoSAddCu); 3) 0.55% S and no supplemental Cu (HiSNoCu); or 4) 0.55% S and supplemental Cu (HiSAddCu). Treatments were formulated to meet, or exceed, nutrient requirements during late gestation, with the exception of Cu and S. A basal ration consisting of cracked corn and soybean meal, with an average 6 mg Cu/kg in the total dry matter (DM), was used to deliver each treatment. Heifers receiving LoSNoCu were offered the basal diet to which sodium sulfate was added to achieve 0.15% S in the total diet DM; whereas heifers receiving LoSAddCu, were offered the basal with added sodium sulfate and tribasic copper chloride to achieve an additional 6 to 8 mg Cu/kg in the total diet DM. Moreover, heifers receiving HiSNoCu were offered the basal diet to which sodium sulfate was added to achieve 0.55% S in the total diet and tribasic copper chloride was included to provide an additional 6 to 8 mg Cu/kg in the HiAddCu supplement. Heifers were offered supplement once daily at 4.0 lb/heifer (as-fed basis), and intake adjustments were made to compensate for energy needs during late gestation. Heifers grazed mixed grass pasture (0.18% S, 5 mg Cu/kg, 12.0% crude protein [CP], 37.9% acid detergent fiber [ADF], 68.8% neutral detergent fiber [NDF], and 7.3% ash, DM basis). Moreover, when forage became limited, heifers were provided free-choice access to predominantly fescue hay (0.14% S, 6 mg Cu/kg, 12.1% CP, 44.9% ADF, 73.5% NDF, and 5.7% ash, DM basis) in quantities sufficient to ensure *ad libitum* access. The median calving date was 28 August 2014 (range 8 August to 16 October 2014). When a heifer was removed from study, it was for reasons unrelated to treatments: 4 heifers were removed for reproductive failure, 2 died early postpartum, and 1 was removed because her calf died.

Sample Collection and Analysis.

Blood was collected every 28 d and within 24 h postpartum via jugular venipuncture, centrifuged for plasma separation, and plasma stored at -4 °F until analysis. Plasma was deproteinated, centrifuged at 2060 × g for 20 min, and supernatant analyzed for trace mineral content by the University of Arkansas System Division of Agriculture Altheimer Laboratory.

Grab samples of the supplements fed to each group were collected daily and composited over 28-day periods within group, whereas clipped forage samples (simulated grazed) were obtained every 28-day and composited within group. Grab samples of the hay fed to each group were collected as bales were fed and composited over 28-day periods within group. Samples of supplements, forage, and hay were dried at 122 °F in a forced-air oven until a constant weight to determine DM. Dried samples were ground in a Wiley Mill (Thomas Scientific, Swedesboro, N.J.) through a 1-mm screen. Samples were analyzed for CP via total combustion (Rapid Combus-

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tion Method, Elementar Americas Inc., Mt. Laurel, N.J.) and sequentially for NDF and ADF (Van Soest method, ANKOM Technology Corp., Fairport, N.Y.). Mineral concentrations were determined via inductively coupled plasma spectroscopy at the Altheimer Laboratory after wet ashing duplicate samples. Samples were predigested in a heating block at 176 °F for 30 min, followed by digestion at 239 °F for 1 h.

Statistical Analysis

Plasma mineral data were analyzed as repeated measures using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) by means of a compound symmetry covariance structure, with heifer as the experimental unit. Means were partitioned at the 5% level of significance by way of 3 preplanned contrasts: 1) the main effect of Cu supplementation; 2) the main effect of S supplementation; and 3) Cu supplementation × S supplementation interaction. Statistical significance was declared at $P < 0.05$.

Results and Discussion

Prepartum and postpartum dietary Cu and S supplementation did not affect the majority of maternal plasma minerals; however, prepartum and postpartum plasma Cu concentrations were increased ($P = 0.02$) by Cu when supplementing 0.55% S (Table 2). Likewise, parturition plasma Cu concentrations were increased by Cu ($P < 0.01$) regardless of S source. The marginal range for assessing cattle Cu status is 0.5 to 0.7 mg Cu/L (Kincaid, 1999). Thus, the values occurring below this range indicate the potential for dysfunction when supplementing 0.55% S. Although cattle maintained normal plasma zinc (Zn) concentrations (0.8 to 1.4 mg Zn/L; Kincaid, 1999) throughout the study, those fed 0.55% S experienced lower ($P < 0.01$) plasma Zn concentrations when compared to those fed 0.15% S. The marginal range for assessing calcium status in periparturient cows is 50 to 80 mg calcium/L (Underwood et al., 1999). Even though cows experienced comparable ($P \geq 0.15$) plasma calcium concentrations, the values occurring in and below this range suggest the potential for deficiency. The marginal range for assessing the risk of iron deprivation in cattle is 0.49 to 1.00 mg iron/L, and, although cattle experienced similar ($P \geq 0.08$) plasma iron concentrations, the values occurring in and below this range suggest the potential for iron deficiency.

Implications

These results suggest that pre- and postpartum dietary copper and sulfur supplementation did not affect the majority of maternal plasma minerals; however, multiple low plasma mineral concentrations may suggest the potential for mineral deficiencies.

Acknowledgments

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Table 1. Nutrient composition of supplements.

	Supplement[a,b]			
Ingredient	**LoSNoCu**	**LoSAddCu**	**HiSNoCu**	**HiSAddCu**
Composition, as-fed basis				
Cracked corn, %	86.5	86.5	75.1	75.1
Soybean meal, %	8.0	8.0	10.0	10.0
Salt, white, %	1.0	1.0	1.0	1.0
Limestone, %	1.9	1.9	1.9	1.9
Vitamin A, D, E premix[c], %	0.1	0.1	0.1	0.1
Rumensin® premix[d], %	0.4	0.4	0.4	0.4
Sodium sulfate, anhydrous,%	--	--	9.4	9.4
Trace mineral premix A[e]	+	--	+	--
Trace mineral premix B[f]	--	+	--	+
Molasses, %	2.5	2.5	2.5	2.5
Composition[g], analyzed (dry matter basis)				
Crude protein, %	11.5	12.0	12.9	12.5
Calcium, %	0.77	0.97	1.09	1.21
Phosphorous, %	0.33	0.34	0.32	0.30
Potassium, %	0.56	0.60	0.64	0.62
Magnesium, %	0.12	0.13	0.12	0.12
Sodium, %	0.67	0.59	3.79	3.70
Sulfur, %	0.30	0.21	2.21	2.29
Iron, mg/kg	131	130	172	169
Manganese, mg/kg	79	95	126	120
Zinc, mg/kg	100	114	139	136
Copper, mg/kg	6	29	14	40
Molybdenum, mg/kg	ND[h]	ND	ND	ND

[a] Fed at a rate of 4.0 lb/d to heifers grazing mixed grass pasture and also offered *ad libitum* access to predominantly fescue hay when forage became limiting.

[b] LoSNoCu = 0.15% S and no supplemental Cu; LoSAddCu = 0.15% S and 6 to 8 mg/kg supplemental Cu; HiSNoCu = 0.55% S and no supplemental Cu; HiSAddCu = 0.55% S and 0.55% S and 6 to 8 mg/kg supplemental Cu.

[c] Provided when fed at 4.0 lb/d: 16,000 IU vitamin A; 3,200 IU vitamin D; and 2 IU vitamin E.

[d] Rumensin (Elanco Animal Health; Indianapolis, Ind.) provided 160 mg of monensin/d when fed at 4.0 lb/d.

[e] Provided when fed at 4.0 lb/d: 0.9 mg cobalt; 4.5 mg iodine; 180 mg manganese; 0.9 mg selenium; and 270 mg zinc.

[f] Provided when fed at 4.0 lb/d: 0.9 mg cobalt; 63 mg copper; 4.5 mg iodine; 180 mg manganese; 0.9 mg selenium; and 270 mg zinc.

[g] Values represent sample averages: 0.15% sulfur, no copper added = 18 samples; 0.15% sulfur, added copper = 18; 0.55% sulfur, no copper added = 20; 0.55% sulfur, added copper = 20.

[h] ND = not detected.

Table 2. Mean plasma mineral concentrations for heifers fed experimental supplements.

	Supplement[a]					Contrast[b]		
Mineral	**LoSNoCu**	**LoSAddCu**	**HiSNoCu**	**HiSAddCu**	**SEM[c]**	**1**	**2**	**3**
Excluding parturition	---------- mg/L ----------							
Calcium	52.0	52.8	51.3	53.8	1.02	0.86	0.15	0.43
Phosphorous	44.4	42.8	42.2	43.7	1.07	0.56	0.95	0.17
Potassium	121.3	120.3	117.8	121.6	1.86	0.58	0.46	0.23
Magnesium	10.3	11.8	10.7	11.0	0.56	0.75	0.14	0.32
Sulfur	35.9	34.4	37.6	37.0	1.61	0.22	0.53	0.80
Iron	1.02	1.01	1.00	0.99	1.01	0.74	0.89	1.00
Zinc	0.85	0.82	0.78	0.88	0.03	0.91	0.27	0.07
Copper	0.56	0.55	0.43	0.50	0.03	0.02	0.40	0.27
Molybdenum	ND[d]	ND	ND	ND	--	--	--	--
Parturition								
Calcium	52.9	47.6	54.6	49.2	3.65	0.66	0.15	1.00
Phosphorous	39.8	36.9	37.9	36.2	1.91	0.51	0.24	0.76
Potassium	112.7	109.5	110.2	109.1	1.99	0.48	0.29	0.59
Magnesium	9.9	9.5	10.3	10.4	0.81	0.44	0.89	0.79
Sulfur	37.4	36.1	38.1	38.1	2.05	0.51	0.75	0.74
Iron	0.58	0.41	0.63	0.49	0.09	0.43	0.08	0.83
Zinc	0.54	0.53	0.62	0.71	0.04	< 0.01	0.37	0.21
Copper	0.56	0.61	0.42	0.51	0.03	< 0.01	0.05	0.49
Molybdenum	ND	ND	ND	ND	--	--	--	--

[a] LoSNoCu = 0.15% S and no supplemental Cu; LoSAddCu = 0.15% S and 6 to 8 mg/kg supplemental Cu; HiSNoCu = 0.55% S and no supplemental Cu; HiSAddCu = 0.55% S and 0.55% S and 6 to 8 mg/kg supplemental Cu.

[b] 1 = copper main effect; 2 = sulfur main effect; 3 = interaction.

[c] SEM = standard error of the mean.

[d] ND = not detected.

Associations between heifer endocrine profiles and reproductive efficiency

L. Meyer[1], T. Devine[1], M. Looper[1], D. Philipp[1], D. Hubbell, III[2], R. Rorie[1], and C. Rosenkrans, Jr[1]

Research Highlights

- Blood samples from growing heifers were used to determine if hormones could predict reproductive efficiency.
- Pre-breeding concentrations of cortisol, insulin-like growth factor-I, and prolactin increased in beef heifers.
- Hormone concentrations accounted for 30-44% of variation in adjusted calf weaning weight and cow efficiency.
- Individual hormones were less effective predictors of heifer performance compared to a combination of hormones.
- Biomarkers of cow efficiency, such as hormones, may serve as decision tools for cattle producers.

Introduction

The beef cattle herd in Arkansas, and the United States as a whole have declined dramatically during the last decade. That decline in cow numbers has resulted from various factors including drought and high input costs. To rebuild the state and national cow herd a large number of replacement heifers are required. Cattle producers face a selection decision; will they develop their own replacement heifers, or purchase replacements? For profitability purposes, the earlier that decision can be made with confidence, the lower the input costs.

Circulating hormone concentrations can be representative of an animal's growth and development. Insulin-like growth factor I (IGF-I) concentrations generally increase as animal size increases; whereas, prolactin (PRL), and cortisol (CORT) are typically associated with stress response which results in reduced productivity. Our objective was to determine the relationships between hormone concentrations during heifer development and reproductive efficiency.

Materials and Methods

Spring-born, Charolais × Balancer heifers calves (n = 65; 394 ± 66 lb; 255 ± 12 days of age) were transported approximately 193 miles from the Livestock and Forestry Research Station near Batesville, Ark. to the Arkansas Research and Extension Center in Fayetteville, Ark. Heifers grazed pastures as a single group. Pastures consisted of non-toxic, novel-endophyte-infected, tall fescue, as well as orchardgrass, and cool-season annuals. During the 195 day grazing period, blood samples were collected on day 0, 106, and 195. Serum was prepared and analyzed via validated radioimmunoassay for CORT, IGF-I, and PRL.

On day 195, estrous synchronization was initiated by inserting an intravaginal, controlled internal drug-releasing device (EAZI-BREED CIDR, Zoetis, Kalamazoo, Mich.) in each heifer. On day 211, the CIDR was removed and on day 213 each heifer received an injection of gonadotropin-releasing hormone (Factrel, 100 µg i.m.; Zoetis). Prostaglandin F2α (Lutalyse, 25 mg i.m.; Zoetis) was administered 1 week (day 220) after gonadotropin-releasing hormone. All heifers were artificially inseminated (AI) with frozen-thawed semen 10 to 19 hours after observed estrus (day 222 to 223 of the experiment). Twelve days after AI, all heifers were exposed for 28 days to Angus bulls.

Following the breeding season, heifers were returned to the Livestock and Forestry Research Station. Heifer calving date, birth weight, and calf and dam weaning weights were determined. Cow efficiency was calculated by dividing 205 day adjusted calf weight by cow weight at weaning. All animal procedures were approved by University of Arkansas' Institutional Animal Care and Use Committee (#13021).

When F-tests were significant ($P < 0.01$), then least squares means were separated by experimental date and compared using the Tukey method. Multiple regression analyses (Stepwise procedure) were used to predict adjusted calf weaning weight, and cow efficiency.

Results and Discussion

Replacement heifer selection is a key management decision for cow-calf enterprises. Endocrine values may be useful predictors of heifer reproductive success. Identification of potential replacement heifers prior to breeding would allow producers to make culling decisions earlier in the production cycle.

Blood samples were collected from heifers after weaning (day 0), at a yearling age (day 106), and at prebreeding (day 195). Figure 1 presents the concentrations of CORT, IGF-I, and PRL throughout the growing phase of this experiment. Both PRL and IGF-I increased ($P < 0.01$) over time. Concentrations of CORT, and PRL-to-CORT ratio also increased ($P < 0.01$) over time but reached a plateau from day 106 to 195 (ratio = 0.33, 3.19, and 3.36; respectively for day 0, 106, and 195).

Hormone concentrations were used to predict calf weaning weight, and cow weight at weaning, as well as cow efficiency. Various combinations of hormones accounted for 30% to 44% variation in those response traits (Table 1). Prolactin was negatively associated with weaning weights; whereas, IGF-I was positively related to adjusted calf weaning weight and cow efficiency. The PRL-to-CORT ratio (day 0) also was positively related to cow efficiency. Our study verifies the growing body of evidence that suggest CORT, IGF-I, and PRL are associated with cattle reproduction (Looper et al., 2010). In addition, mathematical combinations of those endocrine

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messengers were more informative predictors of heifer performance than individual hormones. Blood metabolites combined with physical measurements can be useful in prediction of future cattle performance (Looper et al., 2002; 2008).

Implications

As the U.S. cowherd continues to rebuild, beef producers need management tools that assist in replacement heifer selection. Decisions early in the production cycle should optimize profitability. Hormones may serve as biomarkers of cow efficiency and help cattle producers make decisions regarding replacement heifers. Hormone combinations were more effective predictors of heifer reproductive efficiency than individual hormones. Continued research with blood metabolites combined with physical measurements of heifers should prove beneficial to cattle producers.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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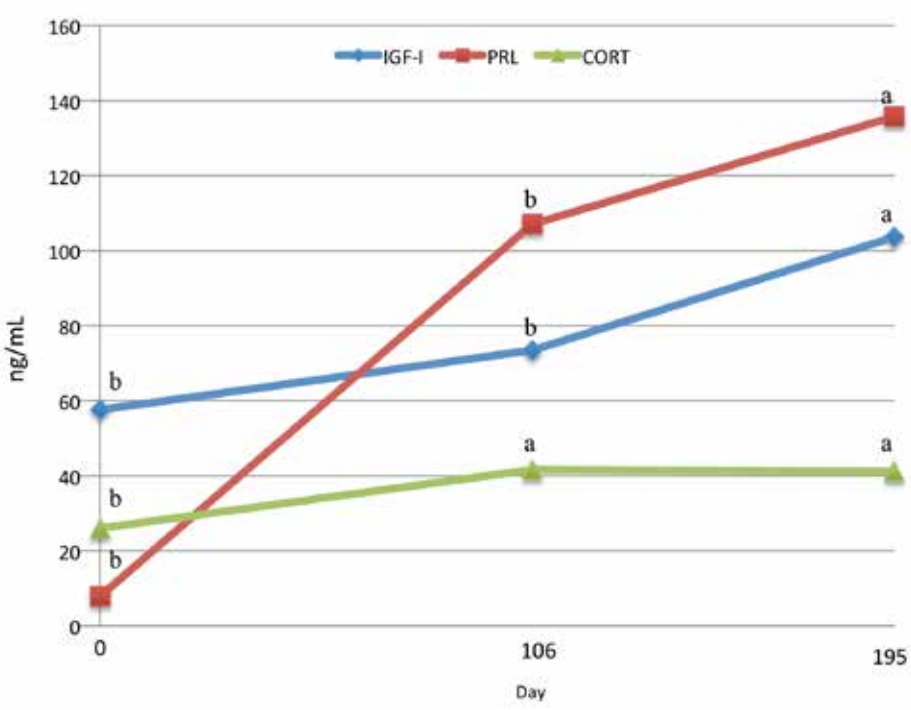

Fig. 1. Concentrations of insulin-like growth factor I (IGF-I), prolactin (PRL), and cortisol (CORT) from heifers after weaning (day 0), yearling (day 106), and prebreeding (day 195). [a,b]Within a hormone, concentrations without a common superscripts differ ($P < 0.01$).

Table 1. Regression equations of cattle performance traits on hormone[a] concentrations and coefficients of variation (R^2).

Trait	Regression equation	R^2
Adj 205 d weaning weight	196 - 0.1(PRL d 0) + 0.17(IGF-I d 195)	30%
Cow weaning weight	492 - 2.79(PRL d 0) - 0.32(PRL d 106)	35%
Cow efficiency	0.37 + 0.11(PRL:CORT d 0) + 0.0005(IGF-I d 195)	44%

[a] PRL = prolactin; IGF-I = insulin-like growth factor- I; CORT = cortisol

Evaluation of winter hair coat shedding and subsequent herd performance in crossbred beef cattle

J. Powell, B. Kutz, E. Backes, L. Meyer, B. Shoulders and K. Anschutz[1]

Research Highlights

- Slow shedding of a winter hair coat may lead to heat stress in beef cattle.
- Month of winter hair coat shedding was recorded each year for a beef cattle herd of approximately 200 cows.
- Adjusted calf birth, cow body weight at weaning and cow pre-breeding body weight were affected by winter hair coat shedding.
- Adjusted calf weaning weights and artificial insemination pregnancy rates tended to be affected by winter hair coat shedding.

Introduction

During summer months, cattle in the southeastern U.S. must endure heat stress due to the warm temperatures and a humid environment. Heat stress can effect production traits and performance in cattle (Bilby et al., 2008). Thick winter hair coats help to maintain core body temperature during cold seasons; however, as environmental temperatures increase through spring and summer months, cattle with thick, unshed, winter hair coats can suffer with heat stress. In the southeastern U.S., cattle that do not shed their winter coat efficiently exhibit signs of impaired production traits such as reduced calf weaning weights (Gray et al., 2011). The objective of this study was to measure variation in hair coat shedding and determine potential effect of coat shedding on production traits in cows housed at the University of Arkansas System Division of Agriculture Beef Cattle Research Unit at Savoy, Ark.

Material and Methods

Cattle utilized for the study were located at the University of Arkansas' Beef Cattle Research Unit. The herd was comprised of approximately 200 Angus-based commercial cows and heifers that calved from September to November and weaned their calves in May. Observations were made on cows (age range 2 to 16 years) from March through September of 2012, 2013, and 2014 and included cow age, calving date, calf birth weight, calf weaning weight, cow body weight at weaning, body condition score (BCS) at weaning, cow body weight at pre-breeding, BCS at pre-breeding, artificial insemination (AI) pregnancy rate and overall seasonal pregnancy rate.

Cattle were evaluated by two trained personnel each year for hair shedding scores from March through September at monthly intervals. Shedding scores were on a 5 point scale as described in Table 1 (Gray et al., 2011). Month of first shedding (MFS) was defined as the first month a cow's hair coat was scored a 3 or less (at least 50% shed). For each cow, the effect of MFS on objective performance measures (weights, BCS, pregnancy status, etc.) were analyzed utilizing the FREQ and GLM procedures of SAS (SAS Institute, Inc., Cary, N.C.). Calf birth weights and calf weaning weights were adjusted according to Beef Improvement Federation (BIF, 2010) standards for age of cow and gender of calf. Statistical significance was considered for a *P*-value of less than or equal to 0.05, and a tendency was considered for a *P*-value between 0.1 and 0.05.

Results and Discussion

Cow age was not different ($P = 0.60$) between MFS groups with mean ages being 5.4, 5.2, and 4.9 years for May, June and July, respectively (Table 1). Adjusted calf birth weight was greatest ($P < 0.01$) for cows exhibiting MFS in May and not different for cows exhibiting MFS in June or July. Adjusted calf weaning weight tended to be greatest ($P = 0.09$) for cows with MFS in May, least for June, and intermediate for July, with cows exhibiting adjusted calf weaning weights of 487, 465, and 473 lb, respectively. Cow body weight at weaning was greatest ($P = 0.02$) in cows exhibiting MFS in May (1126 lb), intermediate in cows with MFS in June (1089 lb) and lowest in cows with MFS in July (1059 lb). Even though BCS for cows at weaning tended to be greater ($P = 0.09$) for cows with MFS in May compared to cows with MFS in July, BCS of cows pre-breeding was not ($P = 0.15$) affected by MFS. Overall pregnancy rate was similar [$X^2 = (2, N = 535) = 2.84$, $P = 0.24$] for cows exhibiting MFS in May, June or July. In these data, MFS score had a tendency [X^2 (2, N = 508) = 4.88, $P = 0.09$] to impact artificial insemination pregnancy rates, with cows exhibiting MFS in May having the greatest AI pregnancy rate (54.5%), intermediate in cows with MFS in June (48.1%) and lowest in cows with MFS in July (37.5%).

Implications

In these data, MFS score had a tendency to impact AI pregnancy rates and adjusted calf weaning weight. Shedding of the winter hair coat was noted to affect adjusted calf birth weight and maternal body weight at weaning.

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Table 1. Hair coat shedding score scale.

Hair coat shedding score	Explanation
5	Thick winter coat (0% shed)
4	Shedding has begun (25% shed)
3	Half of shedding is complete (50% shed)
2	Most of shedding is complete (75% shed)
1	Slick summer coat (100% shed)

Table 2. Effect of month of first shedding (MFS) on cowherd performance parameters from 2012-2014.

	MFS[1]			
Item	**May**	**June**	**July**	**P-value**
Cow age, years	5.36 ± 0.29	5.17 ± 0.15	4.93 ± 0.33	0.60
Cow body weight at weaning, lb	1126.0 ± 15.8[a]	1089.0 ± 8.6[b]	1059.0 ± 17.7[b]	0.02
Cow BCS at weaning	5.21 ± 0.07	5.15 ± 0.04	4.99 ± 0.08	0.09
Cow body weight pre-breeding, lb	1192.0 ± 18[a]	1131.0 ± 9.5[b]	1124.0 ± 19.9[b]	<0.01
Cow BCS pre-breeding	5.64 ± 0.10	5.45 ± 0.05	5.56 ± 0.10	0.15
AI pregnancy rate, %	54.6	48.1	37.5	0.09
Overall seasonal pregnancy rate, %	89.0	84.3	90.4	0.24
Adjusted calf birth weight, lb	82.6 ± 1.3[a]	76.7 ± 0.7[b]	75.1 ± 1.5[b]	<0.01
Adjusted calf weaning weight, lb	487.0 ± 9.1	465.0 ± 4.8	473.0 ± 10.2	0.09

[1] MFS was determined when hair coat was equal to or less than 3 (50% shed).
[a,b] Means without a common superscript differ $P < 0.05$.

Co-product feeds as supplements for cows offered poor quality tall fescue hay

O. Sanders, K. Coffey, A. Young, K. Bottoms, and D. Philipp[1]

Research Highlights

- Individual co-product feedstuffs have their benefits and limitations as supplements for cattle consuming high forage diets.
- Limited information is available about mixtures of different co-product feedstuffs.
- Lactating and non-lactating cows were fed distillers grains plus solubles, soybean hulls, or a mix of both at 0.5% of body weight.
- Supplement type did not affect forage intake or digestibility, but propionate concentrations were greater from distiller's grains.
- Cows offered distillers grains may derive greater energy from their diet than those offered equal quantities of soyhulls or a mixture.

Introduction

Low-quality forages such as tall fescue, often require supplementation in order to meet the nutritional requirements of ruminant animals. Co-products such as distiller's dried grains plus solubles (DDGS) or soybean hulls (SH) make good feedstuffs for supplementing forage-based ruminant diets because of their high digestible fiber content. However, both of these co-products have advantages and limitations when used individually. Little information is available about the associative effects of feeding combinations of co-product feedstuffs on a diet of primarily low-quality forage. Therefore, the objectives of this study were to determine the impact of supplementation with SH, DDGS, or a 50:50 mixture of the 2 (MIX) on intake, digestibility, and ruminal fermentation characteristics in lactating and non-lactating ruminally cannulated beef cows fed low-quality tall fescue hay.

Materials and Methods

Three lactating and 3 non-pregnant, non-lactating ruminally cannulated Angus × Gelbvieh crossbred beef cows (1497 ± 41.0 lb body weight; BW) were offered tall fescue hay for *ad libitum* consumption from large round bales along with supplements fed at 0.5% of BW of each individual cow. Supplements fed included SH, DDGS, and MIX.

The experimental design used in the study was a replicated 3 × 3 Latin Square within each production status that continued for 6, 21-day periods. Briefly, each cow received each supplement twice during the 6 periods, and within each period, each supplement was offered to one lactating and one open cow. This provided a total of 6 observations on each supplement within each production status. During the course of the experiment, the cows were housed together in a drylot pen and then sorted randomly into individual pens each day and offered their respective supplements at 4:00 PM. Calves of the lactating cows were not allowed in the pen with their dams while their dams were offered their supplements. The cows were allowed 30 min to consume the supplements and then were returned to their drylot pen.

Beginning on day 8 of each period, 10 g of titanium dioxide (TiO_2) was added to the supplement as an external marker. Fecal grab samples were gathered from each cow during the morning and afternoon along with samples of the tall fescue hay, SH, and DDGS each day during the last 7 days of each period. Samples were dried to a constant weight at 50 °C in a forced-air drying oven.

On day 15 of the study, an extra cow was used to gather a sample of consumed hay via the ruminal evacuation technique. Total ruminal contents were removed, and the cow was returned to the drylot pen and allowed to consume tall fescue for fifteen minutes. After the allotted time, the masticate sample was removed from the rumen, and the original contents were returned to the rumen. Masticate samples were freeze-dried, ground, and composited by period for further analyses. This process was repeated on day 21 of each period.

Also on day 21 of each period, rumen fluid samples were taken from each cow at 2-hour intervals from 4:00 PM through 12:00 AM to correspond to times immediately prior to feeding and 2, 4, 6, and 8 hours after feeding. Rumen fluid samples were subsequently analyzed for concentrations of volatile fatty acids (VFA). The cows remained in their respective pens without access to hay during the period between 4:00 PM and 12:00 AM. The following morning, the cows were gathered, weighed, and assigned to their new supplement for the beginning of the next period.

Fecal samples were analyzed for TiO_2 concentrations as an external marker and supplement, masticate, and fecal samples were analyzed for concentrations of alkaline-peroxide lignin (APL) as an internal marker. Fecal output, digestibility, and forage intake were then calculated by the following equations:

$$\text{Fecal output, lb} = \frac{\text{dose of } TiO_2}{\text{fecal concentration of } TiO_2}$$

$$\text{DM digestibility, \%} = 100 - 100 \times \frac{\text{APL concentration in the feed}}{\text{APL concentration in feces}}$$

$$\text{DM intake, lb} = \frac{\text{Fecal DM output}}{1 - \left(\frac{\text{diet digestibility}}{100}\right)}$$

Statistical analysis was conducted using the mixed models procedure of SAS (SAS Institute, Cary, N.C., USA). Cow was considered the experimental unit.

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Results and Discussion

Fiber concentrations of DDGS and SH were similar to published values for these commodities (NDF = 50 and 64% for DDGS and SH, respectively). Masticate samples gathered by the rumen evacuation procedure were high in neutral-detergent fiber (74%) and indicative of a poor-quality tall fescue hay.

Although body weight differed ($P < 0.05$) because of status, effects of supplement ($P = 0.47$) or status ($P = 0.19$) were not observed for BW change during the 21-day feeding periods (Table 1). Forage and total DM intake (g/kg BW) were greater ($P < 0.05$) by lactating cows compared with open cows, but were not different ($P \geq 0.19$) among supplements. Total tract (Table 1) or ruminal (data not shown) digestibilities were not affected ($P \geq 0.19$) by production status or supplement treatment.

Ruminal ammonia nitrogen concentrations were greater ($P < 0.05$) from DDGS than from SH or MIX whereas total VFA were greater ($P < 0.05$) from SH compared with MIX and from MIX compared with DDGS (data not shown). We would expect greater ruminal ammonia concentrations from DDGS because of the greater protein content of DDGS. However, it is not known why total VFA would be greater from SH and lowest from DDGS.

The supplement × sampling time interaction affected ($P < 0.05$) molar concentrations of propionate (Fig. 1). Immediately prior to feeding, molar concentrations of propionate did not differ ($P > 0.10$) between SH and MIX, or between MIX and DDGS, but were greater ($P < 0.05$) from DDGS compared with SH. At 2 hour to 8 hour post-feeding, molar concentrations of propionate were greater ($P < 0.05$) from DDGS compared with MIX and from MIX compared with SH.

Ruminal ammonia nitrogen is used by the ruminal microbes for growth. This growth generally leads to greater forage digestibility, which was not observed in this study. Propionate is the most efficiently used VFA produced in the rumen, resulting in greater energy for the ruminant animal than from the other VFA.

Implications

Overall, minimal differences were observed for intake or digestibility because of the supplements offered. However, since both ruminal ammonia and propionate were greatest when cows were fed distillers grains, we conclude that distiller's grains may better meet both the energy and protein requirements of cows offered poor-quality hay than soybean hulls or a mixture of the two.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

Table 1. Body weight and change, intake, and digestibility by lactating and non-lactating cows offered a basal diet of tall fescue hay and supplemented with soybean hulls, distillers dried grains, or a mix of the two at 0.5% of cow body weight.

	Supplement			Status		
Item	Distillers	Mix	Soyhulls	Lactating	Open	Effect[a]
Body Wt, lb	1494	1491	1497	1397	1609	St
Body Wt Change, lb	-1	11	5	0	11	ns
Forage intake, % of BW	2.7	2.7	2.2	3.0	2.0	St
Total DM intake, % of BW	3.1	3.2	2.6	3.5	2.5	St
Forage DM digestibility, %	72	72	67	72	69	ns
Diet DM digestibility, %	72	73	69	72	71	ns

[a] ns = not significant; St = status effect ($P < 0.05$).

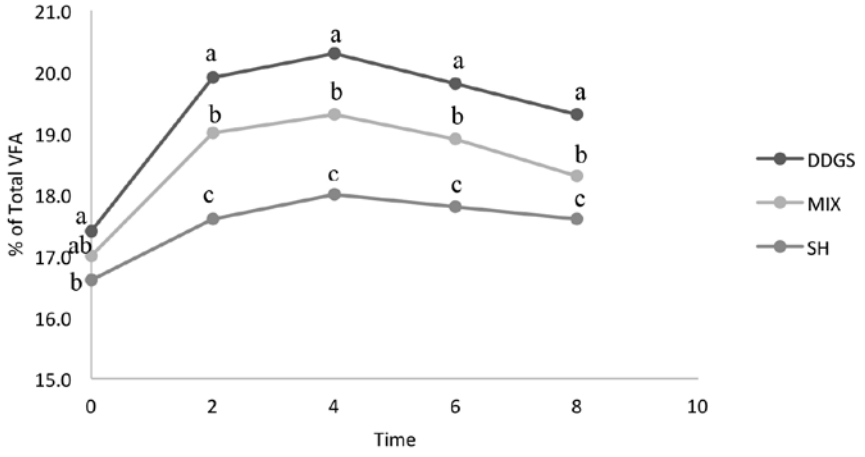

Fig. 1. Molar percent of propionate over time after feeding co-product feedstuffs. DDGS = distillers dried grains with solubles; MIX = 50:50 mixture of DDGS and soybean hulls; SH = soybean hulls; VFA = volatile fatty acids.
[a,b,c] Means within a sampling time without a common superscript differ ($P < 0.05$).

Growth performance of Holstein steers supplemented with or without methionine while grazing cool-season forages

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Research Highlights

- Methionine is an essential amino acid that, if deficient, can limit productivity; supplemental methionine may be beneficial when dietary crude protein is provided by forage and bypass protein is provided by bacteria.
- Holstein steers were grazed on cool-season forages from May to July, while being supplemented with or without MFP™, a rumen-protected methionine supplement.
- Body condition scores, body weight, gain, and average daily gain did not differ between treatments throughout the study.
- Available forage tended to be greater for MFP-supplemented steers than for non-supplemented steers.
- Therefore, in this study supplementing steers on pasture with MFP did not improve performance, but resulted in increased available forage.

Introduction

In previous research, MFP™, a calcium salt of a methionine hydroxyl analog (Novus International Inc., St. Charles, Mo.) was shown to improve body weights (BW), average daily gain (ADG), and total gain when cattle were fed medium quality hay (Bax et al., 2014). The addition of methionine to medium and low quality forage-based diets in cattle has been shown to increase urea utilization in the rumen; and because microbial protein is the predominant metabolizable protein source in forage-fed ruminants, methionine would be expected to be the first limiting amino acid in grazing cattle or cattle fed hay (Hersom et al., 2009). As a result of increased microbial activity, diet digestibility is increased, which may result in an increase in forage intake and average daily gain (Momont et al., 1993). Therefore, the objective was to evaluate the growth performance by steers supplemented with or without MFP while rotationally grazing cool-season forages.

Materials and Methods

This study was conducted at the Green Acres Farm in Montgomery City, Mo. On 8 May 2014, a total of 80 (431 ± 4.6 lb BW) Holstein steers were stratified by body weight and were allocated randomly to 1 of 2 treatments: 1) control supplement (C; 5 replications) or control supplement plus MFP (5 replications). Each replication had access to a 1-acre alfalfa (*Medicago sativa*), bromegrass (*Bromus inermis*), and orchardgrass (*Dactylis glomerata*) pasture. Pastures were evaluated using rising disk meters throughout the study to estimate available forage. A soybean hull/wheat middling pelleted supplement was offered daily at 8:00 AM at 0.5% of BW; in addition, the supplement contained minerals and vitamins (Table 1). Treatment was provided at 1.17% of supplement dry matter resulting in an average intake of approximately 13.5 g/day of MFP. Steers were weighed and body condition scores were evaluated on a 5 point scale (1 = very thin to 5 = excessively over conditioned) every 21 days for the duration of the 71-day study (Edmonson et al., 1989). The amount of supplement offered was adjusted every 21 days to maintain supplement offering at 0.5% of body weight. Steers were also offered *ad libitum* access to water and shelter. Performance and available forage measurements were analyzed using PROC MIXED of SAS (SAS Institute, Inc., Cary, N.C.), with pasture or group of animals as the experimental unit. Effects of treatment, day, and treatment × day interaction were included in the model. All data are reported as least squares means.

Results and Discussion

Body condition scores, BW, gain, and ADG did not differ ($P \geq 0.22$) between treatments throughout the study (Table 2). Available forage tended ($P = 0.10$) to be greater from MFP compared with the Control supplement. A treatment × date interaction ten-dency ($P = 0.10$) was observed for available forage with day 71 Control (2545.6 lb/ac) having the lowest available forage compared with all other treatments and dates (forage data not shown in tabular form). In contrast to this study, steers fed medium quality hay in late fall and supplemented with the same soybean hull and wheat middling-based diet plus a rumen-protected methionine, MFP, saw an improvement of 5.09 lbs ADG than steers offered the same basal diet without MFP (Bax et al., 2014). Therefore, in this study, supplementing steers on pasture with MFP did not improve performance; however, supplementing with MFP may result in less consumption of available forage.

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Implications

Based on these results, producers may not see an increase in growth performance by offering MFP™ to growing steers being grazed on cool-season forages.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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Table 1. Ingredients in supplements for Holstein steers grazing cool-season forages.

	Treatment[a]	
Ingredient, % of dry matter	**MFP™**	**C**
Soybean hulls	64.02	65.27
Wheat middling	24.97	24.97
Soybean oil	2.00	2.00
Molasses	3.99	3.99
MFP	1.25	0.00
Di-calcium phosphate	1.00	1.00
Calcium carbonate	1.20	1.20
Magnesium oxide	0.20	0.20
Salt	0.40	0.40
Vitamin ADE premix	0.88	0.88
Zinc sulfate	0.039	0.039
Manganese sulfate	0.035	0.035
Copper sulfate	0.019	0.019
Cobalt sulfate	0.0004	0.004
Ethylenediamine dihydroiodide	0.00031	0.00031
Sodium selenite	0.00016	0.00016
Total	100	100

[a]C = control; MFP™ = methionine supplement.

Table 2. Growth performance by Holstein steers grazing cool-season forages supplemented with or without MFP™.

	Treatment[a]			
Item	**MFP™**	**C**	**SEM[b]**	***P*-value**
Body condition score[c]				
Day 0	2.4	2.4	0.003	0.40
Day 21	2.7	2.7	0.10	0.48
Day 42	2.6	2.6	0.04	0.53
Day 71	2.7	2.7	0.04	0.21
Body weight, lb				
Day 0	432.1	431.0	2.76	0.68
Day 21	446.8	446.4	7.97	0.96
Day 42	473.0	479.8	8.87	0.47
Day 71	528.4	536.6	10.63	0.49
Average daily gain, lb				
Day 0 to 21	0.68	0.73	0.361	0.95
Day 22 to 42	1.32	1.67	0.273	0.24
Day 43 to 71	1.85	1.89	0.150	0.82
Gain, lb				
Day 0 to 21	15.2	15.6	7.94	0.95
Day 22 to 42	26.2	33.7	5.46	0.24
Day 43 to 71	55.44	56.5	4.50	0.82

[a] C = control; MFP™ = methionine supplement.
[b] Pooled standard error of the mean.
[c] Body condition score: 1 = very thin, 5 = excessively over conditioned.

Effects of Gainpro or Rumensin on health and performance of receiving cattle

W. Galyen[1], T. Hess[2], D. Hubbell[2], S. Gadberry[3], B. Kegley[1], M. Cravey[4], J. Powell[1], E. Backes[1], L. Meyer[1], and P. Beck[5]

Research Highlights

- This study was conducted to evaluate the performance of newly received steers supplemented with pelleted corn gluten and moderate quality free choice hay with or without added Gainpro® or Rumensin®.
- No differences in sickness, death loss or chronically sick designated steers were found throughout the entire study.
- The addition of Rumensin reduced coccidia counts when compared to Gainpro and the untreated control group.
- Adding Gainpro increased overall average daily gains by 0.26 lbs per day and ending body weight by 12 lbs, and the addition of Rumensin increased overall average daily gains by 0.41 lbs per day and ending body weight by 22 lbs.

Introduction

Receiving cattle are often provided medicated supplements following arrival to stocker operations in order to improve gain performance and feed efficiency. The ionophores Rumensin® and Bovatec® also supply the added benefit of reducing coccidiosis. Feeding Rumensin is often discouraged due to decreased palatability and refusal of consumption by new calves. Gainpro® is often cited as having no palatability issues, but has not been shown to prevent coccidia shedding. Therefore the objectives of this study were to evaluate the effects of Gainpro on coccidia counts compared to Rumensin and compare cattle performance for both.

Materials and Methods

Growing steers and bulls were received on 3 different dates, once in the fall and twice in the spring, the first having 150 head with an average body weight of 459 lbs, the second having 99 head with an average body weight of 470 lbs, and the third having 149 head with an average body weight of 483 lbs. When received, cattle were tested for bovine viral diarrhea–persistent infection (BVD-PI), implanted with 40 mg trenbolone acetate and 8 mg estradiol, dewormed, and vaccinated using an 8-way blackleg vaccine and a modified live respiratory vaccine and bulls were castrated. All cattle were then weighed on two consecutive days to establish a solid beginning weight for the trial and revaccinated 14 days later. Calves were then sorted into 1-acre grass trap pens based on weight and initial castrate status. Cattle were given free choice access to moderate quality hay and received 2 lbs of corn gluten pellets daily, with one-third of pens receiving added Gainpro at a rate of 20 mg/ head/day, one-third receiving added Rumensin at a rate of 0.35 mg/lb of body weight/day, and one-third receiving no additional supplementation. Steers were weighed every 14 days and fecal samples were collected from 6 steers per pen on day of arrival, and 14 days and 28 days after initiation of the study for evaluation of coccidia infection. Additionally for pens in Gainpro treatment, water was treated with Corid for 5 days starting 14 days from the beginning of the study to reduce coccidia infection. Cattle were considered chronic after 5 treatments of antibiotics and gaining less than 0.5 lb/day. Steers remained on treatment in receiving pens for a minimum of 42 days and a maximum of 84 days, based on the availability of wheat pasture for subsequent grazing. Data were statistically analyzed to measure the effects of treatment on rate of illness, growth performance, and coccidia infection.

Results and Discussion

There were no differences in number of sick cattle, death loss, or number of cattle determined to be chronically sick (data not shown). The group treated with Rumensin was found to have decreased coccidia oocyst counts compared to the untreated and Gainpro treated groups. No cattle were found to have signs of coccidiosis (bloody scours and diarrhea, data not shown). The effect of Gainpro and Rumensin on average daily gain during the receiving phase is presented in Table 1 and body weight is presented in Fig. 1. When the receiving trial ended the body weight and average daily gains for the untreated steers were less than the Gainpro-treated steers, which tended to be less than the Rumensin-treated steers.

Implications

Adding Gainpro or Rumensin to receiving cattle supplement can have a positive effect on body weights and average daily gains, with Rumensin having the added benefit of reducing counts of coccidia oocysts. No differences were found in number of sick cattle, death loss, or number of chronically designated sick cattle.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

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Table 1. The effect of Gainpro® or Rumensin® on average daily gains of high risk steers during receiving.

	Control	Gainpro	Rumensin	Standard Error	*P*=
Day 0 to14; lb/day	1.66	1.70	1.94	0.50	0.31
Day 14 to 28; lb/day	1.37[a]	1.69[b]	1.70[b]	0.39	0.01
Day 28 to 42; lb/day	1.05[a]	1.23[ab]	1.47[b]	0.14	0.09
Overall	1.08[x]	1.34[y]	1.49[z]	0.16	<0.0001

[ab] Within a row, means without a common superscript differ ($P < 0.05$).

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

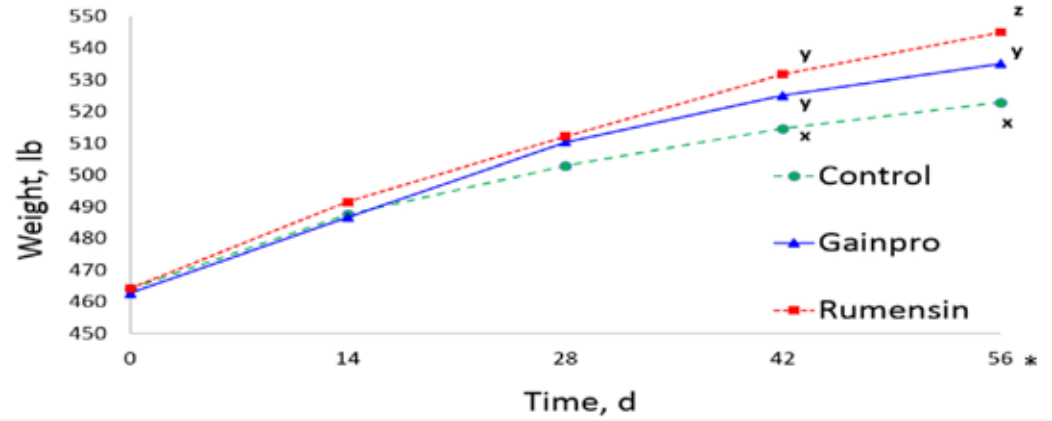

Fig. 1. The effect of Rumensin® or Gainpro® on body weight of high-risk steers during receiving.
***Day 56 denotes Average Ending Body Weight which differed for each block.**
[x,y,z] Within a row, means without a common superscript differ ($P < 0.10$).

Effects of Gainpro or Rumensin on steers grazing wheat pasture

W. Galyen[1], Tom Hess[2], Don Hubbell[2], Shane Gadberry[3], Beth Kegley[1], M. Cravey[4], J. Powell[1], and P. Beck[5]

Research Highlights

- Steers were provided free choice mineral designed to supply 200 mg Rumensin® per steer daily, 20 mg Gainpro® per steer daily, or free choice mineral with no medicated feed additive.
- Steers were previously on a receiving study to see the effects of Rumensin and Gainpro on health and performance, steers stayed on the same treatment during receiving and grazing.
- Average daily gains of steers grazing wheat pasture were increased by 0.2 lbs/day overall with Rumensin compared with the Gainpro and Control treatments, which were similar.
- Body weight was greater at the beginning of the study and at the end with Rumensin compared to Gainpro and Control treatments.
- Supplementing free choice mineral with Rumensin increased growth performance throughout grazing.

Introduction

Wheat pasture is a high-quality forage capable of producing gains in excess of 2 lbs/day. Average daily gains have been shown to increase with the supplementation of Rumensin® to cattle grazing wheat pastures. Little published data is available on the effects of Gainpro® on the performance of steers grazing wheat pasture.

Materials and Methods

Three groups of cattle were received, 1 in the fall, and 2 in the spring. During the receiving period, steers were supplemented with non-medicated corn gluten feed-based supplement (Control) or the supplement supplying Rumensin or Gainpro with access to free choice hay. Following receiving, steers were then assigned to wheat pastures based on previous treatment and body weight. All cattle being designated as chronically ill, received 5 treatments of antibiotics for bovine respiratory disease, or had receiving gains of less than 0.5 lbs/day were excluded from the grazing trial. All cattle that were blind, lame, or significantly heavier or lighter than the average population were also excluded from the grazing trial. In the fall, wheat pastures were 4 acres in size and stocked at a density of 4 calves per pasture (116 calves with average body weight = 539 ± 37.5 lbs) for 76 to 104 days, and in the spring the wheat pastures were 2 acres and stocked at a density of 4 calves per pasture (199 calves with average body weight = 537 ± 48.8 lbs) for 38 to 56 days.

Pastures, which are part of a long-term wheat establishment study, were established using conventional or no-till cropping techniques, with each supplementation treatment evenly distributed across each tillage treatment. Prior to turn out on wheat, steers were implanted with Component TE-G with Tylan (Elanco Animal Health, Greenfield, Ind.). During grazing, steers received free choice mineral (target mineral intake 0.25 lbs/day) with the addition of Rumensin, designed to supply 200 mg daily per steer, or Gainpro, designed to supply 20 mg daily per steer, or no additional treatment supplied in the mineral (Control). Cattle were weighed full on 2 consecutive days at the initiation of grazing and then again on a single day on 28-day intervals until the end of grazing at which time they were weighed again on 2 consecutive days full.

Results and Discussion

Initial body weights (Table 1) were not different ($P = 0.74$) for the Control and Gainpro treatments (average body weight = 532 ± 44.8 lbs) at the initiation of the grazing study, but were less ($P < 0.01$) than the body weights for the Rumensin treatment (average body weight = 550 ± 44.3 lbs). This is likely due to the increased average daily gains of the Rumensin treatment during the receiving phase of the study. Body weights continued to be greater ($P < 0.01$) for the Rumensin group on day 28, at day 56, and at the completion of the trial. Body weights were not different ($P \geq 0.14$) throughout the study for the Control and Gainpro treatments. At the end of grazing, steers fed Rumensin (766 ± 53.9 lbs) weighed 38 lbs more than the Control group (727 ± 53.9 lbs) and 30 lbs more than the Gainpro group (736 ± 53.9 lbs).

During the initial 28-day grazing period, steers that received Rumensin (2.25 lbs/day) as part of their free choice mineral and Control steers (2.19 lbs/day) had average daily gains that exceeded ($P < 0.01$) the Gainpro steers (1.74 lbs/day) by 0.45 to 0.50 lbs/day (Table 1). Average daily gains during the grazing period from day 28 to day 56 were not different ($P = 0.88$) for Control and Gainpro treatments (3.76 lbs/day) but were 0.22 lbs/day less ($P < 0.01$) than Rumensin (3.99 lbs/day). During the final grazing period (from day 56 until calves were removed from pastures) there was no difference in average daily gains ($P = 0.20$) but performance of Rumensin and Gainpro were numerically

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0.20 lbs/day greater than the Control group. Overall average daily gains were not different ($P = 0.42$) for the Control (2.73 lbs/day) and Gainpro (2.82 lbs/day) treatments but were 10% greater ($P \leq 0.05$) for Rumensin (3.03 lbs/day).

Implications

When supplied in a self-fed mineral supplement, Rumensin increased average daily gains and body weights throughout wheat pasture grazing. Gainpro resulted in no differences in average daily gains or body weights compared to a non-treated control group, when offered in a self-fed mineral supplement.

Acknowledgments

Funding provided by the University of Arkansas System Division of Agriculture.

Table 1. Effect of Rumensin® or Gainpro® in free choice mineral supplement on performance of growing steers grazing wheat pasture.

	Average Daily Gain				
Item	**Control**	**Gainpro**	**Rumensin**	**SE**	***P*=**
Body weight, lb					
Initial	531[b]	533[b]	550[a]	4.5	<0.01
Day 28	592[b]	582[b]	613[a]	5.1	<0.01
Day 56	706[b]	688[b]	716[a]	7.0	<0.01
Final	728[b]	736[b]	766[a]	5.9	<0.01
Average Daily Gain, lb/day					
Day 0 to 28	2.19[a]	1.74[b]	2.25[a]	0.14	<0.01
Day 28 to 56	3.75[z]	3.77[z]	3.99[y]	0.12	0.07
Day 56 to Final	2.80	3.04	3.10	0.12	0.20
Overall	2.73[b]	2.82[b]	3.03[a]	0.11	0.02

[ab] Within a row, means without a common superscript differ ($P < 0.05$).
[yz] Within a row, means without a common superscript differ ($P < 0.10$).

Evaluation of antibiotic metaphylactic therapy for receiving calves at risk for bovine respiratory disease

J. Hawley[1], B. Kegley[1], P. Beck[2], J. Powell[1], J. Reynolds[1], and P. Hornsby[1]

Research Highlights

- This study evaluated antibiotic metaphylactic therapy for receiving calves at risk for bovine respiratory disease.
- Calves received single dose injection of EXCEDE® (1.5 mL/100 lbs body weight) or Micotil® (2.0 mL/100 lbs body weight).
- Performance did not differ between antibiotic metaphylactic treatments.
- Micotil was more economical and effective in reducing antibiotic treatments for bovine respiratory disease.

Introduction

Bovine respiratory disease (BRD) causes significant economic and production losses in the cattle industry. Calves thought at risk to develop BRD frequently receive immunizations and metaphylactic antimicrobial therapy to mitigate this risk (Guthrie et al., 2004; Thomson et al., 2006). Metaphylactic programs can significantly reduce negative health effects and improve feed performance in cattle stricken with BRD (Nickell et al., 2010). The objective of this study was to evaluate the efficacy of single dose metaphylactic ceftiofur crystalline free acid ([EXCEDE®] 1.5 mL/100 lbs body weight [BW]) or tilmicosin phosphate ([Micotil] 2.0 mL/100 lbs BW) injection on measures of performance and animal health in receiving calves at risk for BRD.

Materials and Methods

Animals, Treatment Allocation, and Processing

A total of 303 crossbred bull (n = 39) and steer (n = 264) calves (initial BW = 464 ± 27.7 lb) were purchased from livestock auctions in Florida and transported to the University of Arkansas System Division of Agriculture's Agricultural Experiment Station (Receiving Unit) located near Savoy, Ark. Cattle were received on 3 dates (block) with arrival dates of 14 September (n = 108) and 2 November 2012 (n = 99) and 12 January 2013 (n = 96). For each block, 8 pens (4 pens/treatment) were used. On arrival (day -1), cattle were weighed (unshrunk), assigned a unique ear identification tag, and arrival castrate status (bull or steer) was determined. The following day (day 0), bulls and steers were stratified by castrate status and weight. Castrate status was equally distributed to treatments by assigning a similar number of bull and steer calves to each treatment pen. Pens were then assigned randomly to single dose antimicrobial metaphylaxis: 1) EXCEDE (Zoetis, Florham Park, N.J.) administered subcutaneously (SC) in the middle one-third of the posterior aspect of the ear or 2) Micotil (Elanco Animal Health, Greenfield, Ind.) administered SC in the neck. In addition to receiving their assigned metaphylactic antimicrobial therapy on day 0, calves were treated for internal parasites with ivermectin (1.0 mL/100 lbs BW; Ivomec Plus; Merial Limited, Duluth, Ga.) and administered a pentavalent modified-live virus respiratory (Pyramid 5; Boehringer Ingelheim Vetmedica, St. Joseph, Mo.) and a multivalent clostridial/tetanus bacterin-toxoid (Covexin 8; Merck Animal Health, Summit, N.J.) vaccine. Calves were implanted (Component TE-G with Tylan; Elanco Animal Health, Greenfield, Ind.) and ear-notched to test for the presence of cattle persistently infected with bovine viral diarrhea virus using the antigen-capture ELISA (ACE) method (Idexx Laboratories, Inc., Westbrook, Maine) at a commercial laboratory (Cattle Stats, LLC, Oklahoma City, Okla.). All calves tested negative for the virus. Bull calves were castrated by banding (California Bander, Inosol Co. LLC, El Centro, Calif.). On day 14, calves were revaccinated with the same pentavalent modified-live virus respiratory vaccine.

Routine Feeding Procedures

Cattle were assigned to 0.45-ha pens and provided 2.0 lbs per calf (as-fed basis) of a receiving supplement (15.5% crude protein, dry matter basis) and free-choice access to bermudagrass hay (15.4% crude protein, 37.5% acid detergent fiber, 72.5% neutral detergent fiber, and 8.7% ash, dry matter basis). Supplement was offered daily and increased to a maximum of 4.0 lbs/calf daily as calves began consuming the supplement. Calves were fed over a 45- (block I), 47- (block II), or 46-day (block III) backgrounding period. Body weight measurements were collected for each block at the beginning and end of the study on two consecutive days prior to supplement feeding. Interim BW were collected prior to supplement feeding on day 17 and 31 (block I), day 18 and 32 (block II), and day 17 and 31 (block III). Average daily gain was calculated for interim and final periods based on averages of initial and final BW that were taken on 2 consecutive days.

Assessment, Treatment, and Removal of Morbid Cattle

After arrival metaphylaxis, a 72-hour post-treatment interval (PTI) was implemented; therefore, calves were observed each morning beginning on day 4 of the study for clinical signs of BRD by 2 Receiving Unit personnel having a combined 35 years' experience evaluating cattle with BRD. Calves displaying signs of BRD were removed from pens for further evaluation. Animals were weighed and rectal temperature (RT) evaluated. To be considered a case of BRD, calves had to meet one of the two following definitions based on presenting clinical signs (Perino et al., 1998): 1) clinical impression score (CIS) ≥1 and a RT of ≥104.0 °F; or 2) CIS ≥2 regardless of RT. All calves that met the treatment criteria for BRD were treated with a single SC dose of enrofloxacin (5.7 mL/100 lbs BW; Baytril; Bayer Animal Health, Shawnee Mission, Kan.). A 48-hour PTI was implemented following administration of

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enrofloxacin, and a second RT was recorded upon expiration of the initial antibiotic PTI. If the second RT was ≥104.0 °F, the calf was treated with florfenicol SC (6 mL/100 lbs BW; Nuflor; Intervet/Merck Animal Health, Summit, N.J.). A 96-hour PTI was implemented for cattle administered florfenicol, and RT was evaluated upon expiration of the second antibiotic PTI. If the second RT was ≥104.0 °F, the calf received oxytetracycline SC (4.5 mL/100 lbs BW; Biomycin 200; Boehringer Ingelheim Vetmedica Inc., St. Joseph, Mo.). A 48-hour PTI was implemented for cattle administered oxytetracycline, and RT was evaluated upon expiration of the third antibiotic PTI. Cattle that continued to display BRD symptoms after the third treatment were considered chronically ill and no further antibiotic treatment was administered. Three calves were identified as chronic. If at any time a re-check RT was <104 °F, the animal was left untreated unless further symptoms developed. Occurrences of BRD in calves 21 days after administration of previous BRD therapy were considered new episodes. After antibiotic treatments, cattle were returned to their home pens. Animals that died during the study were transferred to the University of Arkansas Veterinary Diagnostic Laboratory for necropsy and disposal. In block III, one calf was euthanized for reasons unrelated to treatments. Data obtained from this calf and those identified as chronic were retained for data analyses.

Statistical Analysis

Performance data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Initial BW was included as a covariate in the analysis. Data were tested using a compound symmetry covariance structure with pen as the experimental unit. Binary morbidity response variables (morbidity, treated with second antibiotic, and treated with third antibiotic) were analyzed using the GLIMMIX procedure by means of a variance components covariance structure, with calf as the experimental unit. Continuous morbidity response variables (day first treated, RT at first treatment, RT 48 hours after treatment, day second treated, treatments per calf, metaphylaxis cost, BRD treatment cost, and total cost/calf) were analyzed using the MIXED procedure by means of a variance components covariance structure, with calf as the experimental unit. Statistical significance was declared at $P < 0.05$, tendencies at $0.05 \leq P < 0.10$, and trends at $0.10 \leq P \leq 0.15$.

Results and Discussion

No differences ($P \geq 0.23$) in average daily gains were observed between antibiotic metaphylactic treatments (Table 1). A negative control or nonmedicated group of calves (i.e., no antimicrobial metaphylaxis administered on arrival) was not included in the study design; therefore, it was not possible to determine a morbidity baseline. There was a trend ($P = 0.13$) for morbidity (calves treated at least once for BRD) rates to differ between metaphylactic treatments. Calves receiving EXCEDE were 1.52 (95% confidence interval = [0.88, 2.61]) times more likely to be treated once for BRD. Furthermore, the number of morbid animals requiring 2 antibiotic treatments tended ($P = 0.05$) to differ. Calves receiving EXCEDE were 2.09 (95% confidence interval = [1.01, 4.32]) times more likely to be treated twice for BRD. Similarly, differences were also observed in the number of morbid animals requiring 3 antibiotic treatments ($P = 0.01$). Calves receiving EXCEDE were 5.63 (95% confidence interval = [1.43, 22.19]) times more likely to be treated three times for BRD. There was a trend ($P = 0.10$; Table 2) for antibiotic metaphylaxis to impact the days to treatment with the first antibiotic. The average days from arrival until first treatment for BRD was increased to 14.1 days for the EXCEDE treated calves compared to 10.9 days for the Micotil treated calves. Similarly, antibiotic metaphylaxis tended ($P = 0.05$) to impact the days to treatment with the second antibiotic. The average days from arrival until second treatment for BRD was increased to 19.3 days for the EXCEDE treated calves compared to 12.3 days for the Micotil treated calves. Antibiotic metaphylaxis did not impact RT at treatment ($P \geq 0.25$). The reduction in BRD morbidity rate for Micotil treated calves tended to result in fewer ($P = 0.07$; Table 2) antibiotic treatments per calf and $5.62/calf less ($P \leq 0.05$) antibiotic costs.

Implications

Based on these results, Micotil was more cost effective and efficacious in reducing antibiotic treatments for bovine respiratory disease in receiving calves at risk for disease.

Acknowledgments

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Table 1. Least square means for effects of antibiotic metaphylaxis on performance.

	Treatment			
Item	EXCEDE®	Micotil®	SEM	*P*-value
Initial body weight,[a] lbs	464	463	2.20	0.85
Final body weight,[a] lbs	586	589	2.20	0.50
Average daily gain, lbs/d				
day 0 to 14	3.27	3.15	0.13	0.52
day 15 to 28	2.07	2.43	0.20	0.23
day 29 to 46	2.37	2.37	0.08	0.96
day 0 to 46	2.64	2.71	0.09	0.56

[a] Analyses conducted using body weight on day 0 as a covariate.

Table 2. Effects of antibiotic metaphylaxis on calf health and cost of bovine respiratory disease (BRD) therapy.

	Treatment			
Item	**EXCEDE®**	**Micotil®**	**SEM**	***P*-value**
Day first treated	14.1	10.9	1.36	0.10
Rectal temperature at treatment, °F	104.9	105.1	0.22	0.89
Rectal temperature 48 hours after treatment, °F	103.3	103.5	0.22	0.25
Day second treated	19.3	12.3	2.38	0.05
Treatments per calf[a]	0.38	0.23	0.06	0.07
Metaphylaxis cost,[b] $	13.19	12.56	0.08	< 0.0001
BRD treatment cost,[c] $	23.83	19.09	1.68	0.05
Total cost per calf,[d] $	37.49	31.88	1.72	0.03

[a] Number of antibiotic treatments administered per calf for calves receiving BRD therapy.

[b] Metaphylaxis cost assuming a value of $1.90/mL for EXCEDE (Pfizer Animal Health, Exaton, N.Y.) and $1.36/mL for Micotil (Elanco Animal Health, Greenfield, Ind.).

[c] Treatment cost for BRD assuming a value of $0.50/mL for Baytril (Bayer Animal Health, Shawnee Mission, Kan.), $0.52/mL for Nuflor (Intervet/Merck Animal Health, Summit, N.J.), and $0.09/mL for Biomycin (Boehringer Ingelheim Vetmedica Inc., St. Joseph, Mo.).

[d] Sum of the metaphylaxis cost and treatment cost for BRD for calves receiving BRD therapy.

Effects of excess dietary sulfur on growth performance, sulfhemoglobin concentrations, and tissue mineral concentrations in growing-finishing beef cattle

J. Hawley, B. Kegley, J. Reynolds, D. Galloway, and P. Hornsby[1]

Research Highlights

- Steers consumed 0.15% or 0.40% dietary sulfur for 114-day growing and 123-day finishing phases.
- This study examined growth performance and sulfhemoglobin, plasma, liver, and *longissimus* muscle mineral concentrations.
- Feeding diets with 0.40% sulfur had no appreciable effect on performance.
- There was a trend for high dietary sulfur to increase the incidence of bloat.
- Diets had no appreciable effect on sulfhemoglobin, plasma, liver, and *longissimus* muscle mineral concentrations.

Introduction

Distillers' grains may reduce feed costs without sacrificing performance. However, distillers' grains also present significant challenges. The nutrient concentrations in distillers' grains can be highly variable. Distillers' grains can have concentrations of 0.8% sulfur (S) or greater (Buckner et al., 2008). The maximum tolerable concentration, the level above which negative performance occurs, is 0.5% S for roughage diets and 0.3% S for high concentrate diets (NRC, 2005). While S is an essential component of the ruminant's diet and serves many biological functions, excess dietary S will interfere with the digestion and absorption of other minerals, particularly the trace mineral, copper (Cu), and reduce intakes. Moreover when sulfur is ingested in excess, rumen microbes produce too much hydrogen sulfide. Hydrogen sulfide is readily absorbed through the rumen wall into the blood stream and binds to hemoglobin to create sulfhemoglobin [SHb]. Sulfhemoglobin reduces the blood's ability to carry oxygen to tissues and interferes with cellular energy production. The objective of this study was to evaluate the effects of excess dietary S on weight gain, feed conversion, SHb concentrations, and plasma, liver, and *longissimus* muscle (LM) mineral concentrations in growing-finishing cattle.

Materials and Methods

Animals and Experimental Design

Twenty steers (initial body weight [BW] = 624 ± 15.9 lbs) of predominantly Angus breeding were stratified by initial BW and assigned randomly to 1 of 6 pens (3 to 4 steers/pen) for a 114-day (18 October 2012 to 7 February 2013) growing phase. Pens were assigned randomly to 1 of 2 dietary treatments: 1) low (0.15%) S or 2) high (0.40%) S. Steers grazed mixed grass pasture (0.27% S, 17.8% crude protein [CP], 26.8% acid detergent fiber [ADF], 57.1% neutral detergent fiber [NDF], and 10.4% ash, dry matter [DM] basis) and were supplemented with a corn and soybean meal ration (low S treatment; 0.26 % S, 14.9% CP, DM basis) that met the NRC (2000) requirement of 0.15% S in the total diet DM. High-S steers were offered an identical supplement to which sodium sulfate was added to achieve 0.40% S (1.12% S, 14.5% CP, DM basis) in the total diet DM. Moreover, steers were provided free-choice access to bermudagrass hay (0.32% S, 18.8% CP, 33.4% ADF, 71.0% NDF, and 10.3% ash, DM basis) in quantities sufficient to ensure *ad libitum* access to forage. When the average BW of the steers reached 823 ± 0.4 lb, steers were stratified by BW and assigned randomly to 16 drylot pens (1 to 2 steers/pen; 8 pens/dietary treatment). Steers remained on the same dietary treatment for a 123-day (8 February to 11 June 2013) finishing phase. Low-S steers were offered a corn and soybean meal finishing ration (0.17% S, 14.3% CP, DM basis) that met the NRC (2000) requirement of 0.15% S in the total diet DM. High-S steers were offered an identical ration except sodium sulfate was added to achieve 0.40% S (0.38% S, 15.1% CP, DM basis) in the total diet DM. Steers were offered supplement once daily.

Animal Performance

Steers were weighed on 2 consecutive days at the beginning and conclusion of each phase. Interim weights were collected every 28 days. Average daily gain was calculated for interim and final periods based on averages of initial and final BW that were taken on 2 consecutive days. Feed intake was measured during the finishing phase. Bloat was assessed by evaluation of the left flank and bloat severity scored on a 0-1 scale: (0, no bloat; 1, bloat). Scoring was undertaken by two trained personnel throughout. A drench (Therabloat; Zoetis Animal Health, Florham Park, N.J.) was administered to manage excessive bloating.

Sulfhemoglobin

Blood was collected every 28 days via jugular venipuncture. Whole blood SHb concentrations were determined using the methods described by Evelyn and Malloy (1938). Sulfhemoglobin concentrations were determined within 8 hours of sample collection.

Plasma Minerals

Blood was collected every 28 days via jugular venipuncture, centrifuged for plasma separation, and plasma stored at -4 °F until analysis. Plasma was deproteinated, centrifuged at 2060 × g for 20 minutes, and supernatant analyzed for trace mineral content by the University of Arkansas System Division of Agriculture's Altheimer Laboratory, Fayetteville, Ark.

Liver and Muscle Minerals

Steers were harvested in a commercial abattoir (average BW = 1246 ± 84.7 lbs; Creekstone Farms, Arkansas City, Kan.). Liver samples were collected immediately postmortem, frozen in liquid nitrogen, and

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stored at -112 °F until analysis. *Longissimus* muscle samples were collected from 1-in-thick steaks obtained from rib sections aged 14 days at 39 °F before fabrication. Liver samples were dried at 212 °F in a gravity convection oven before duplicate samples were subjected to wet ashing. Samples of LM were removed from day 0 simulated retail display steaks, freeze-dried for 72 hours, and homogenized with a blender before duplicate samples were subjected to wet ashing. Liver and LM samples were analyzed for trace mineral content by the Altheimer Laboratory.

Statistical Analysis

Performance, SHb, and plasma, liver, and LM mineral data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) by means of a variance components covariance structure. Pen was the experimental unit for the performance data, whereas steer was the experimental unit for the SHb and mineral data. Bloat data were analyzed using the GLIMMIX procedure of SAS by means of a variance components covariance structure, with steer as the experimental unit. Statistical significance was declared at $P < 0.05$, tendencies at $0.05 \leq P < 0.10$, and trends at $0.10 \leq P \leq 0.15$.

Results and Discussion

Dietary S did not affect average daily gain [ADG] during the growing phase. Steers fed 0.40% S experienced similar ($P = 0.52$) ADG when compared to steers fed 0.15% S (2.43 and 2.34 lbs/day, respectively). During the finishing phase, however, steers fed 0.40% S tended to have lower ADG ($P = 0.07$; 2.65 and 3.04 lbs/day, respectively) and lower dry matter intake ($P < 0.001$; 23.46 and 26.41 lbs/day, respectively) than steers that did not receive additional S. Steers fed 0.40% S experienced a comparable ($P = 0.30$) finishing phase gain-to-feed ratio when compared to steers fed 0.15% S (0.12 and 0.11, respectively). There was a trend for dietary S ($P = 0.15$) to affect the incidence of bloat. Steers fed 0.40% S were 0.55 (95% confidence interval = [0.24, 1.26]) times more likely to experience bloat than steers that did not receive additional S. While SHb concentrations remained within normal limits throughout the study, a treatment × day interaction ($P < 0.01$; Fig. 1) was observed. Dietary S did not affect plasma zinc (Zn) concentrations. Steers fed 0.40% S sustained deficient, equivalent ($P = 0.42$) plasma Zn concentrations when compared to steers fed 0.15% S (0.64 and 0.61 mg Zn/L, respectively). Normal values typically lie within the range 0.8 to 1.2 mg Zn/L (Underwood and Suttle, 1999). Although steers maintained normal plasma Cu concentrations throughout the study, steers fed 0.40% S had lower plasma Cu concentrations ($P < 0.01$) when compared to steers fed 0.15% S (1.14 and 1.20 mg Cu/L, respectively). Dietary S did not affect the majority of liver mineral concentrations ($P \geq 0.24$; Table 1), however, steers fed 0.40% S had greater liver calcium ($P < 0.05$) concentrations. While dietary S did not affect the majority of LM mineral concentrations ($P \geq 0.35$), steers fed 0.40% S tended to have lower Cu and calcium LM mineral concentrations ($P = 0.11$) when compared to steers fed 0.15% S.

Implications

These results suggest that supplementing beef cattle diets with 0.40% sulfur had no appreciable effects on steer performance, sulfhemoglobin concentrations, or plasma, liver, and *longissimus* muscle mineral concentrations.

Acknowledgments

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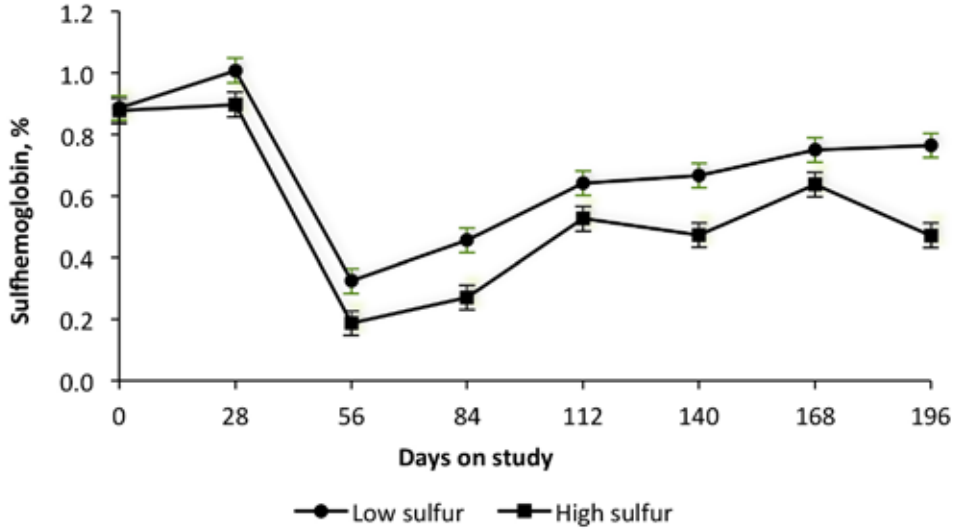

Fig. 1. Blood sulfhemoglobin concentrations (as a percentage of total hemoglobin; treatment × day, $P < 0.01$) for steers fed low (0.15%) or high (0.40%) sulfur. Error bars represent standard error of the mean.

Table 1. Least-squares means for liver and *longissimus* muscle mineral concentrations for steers fed low (0.15%) or high (0.40%) sulfur.

	Treatment			
Item	**Low sulfur**	**High sulfur**	**SEM**	***P* – value**
Liver minerals				
Calcium, %	0.10	0.11	0.004	0.03
Magnesium, %	0.26	0.27	0.007	0.24
Phosphorous, %	4.7	4.8	0.12	0.52
Potassium, %	4.2	4.4	0.11	0.08
Sodium, %	0.84	0.81	0.04	0.68
Sulfur, %	2.60	2.64	0.06	0.62
Cobalt, mg/kg	2.7	2.9	0.17	0.34
Copper, mg/kg	691	810	52.2	0.11
Iron, mg/kg	718	617	46.1	0.13
Manganese, mg/kg	32	34	1.4	0.38
Zinc, mg/kg	475	479	19.3	0.88
Longissimus muscle minerals				
Calcium, %	0.02	0.03	0.002	0.11
Magnesium, %	0.09	0.09	0.004	0.96
Phosphorous, %	0.72	0.74	0.02	0.60
Potassium, %	1.32	1.33	0.03	0.73
Sodium, %	0.27	0.25	0.01	0.39
Sulfur, %	0.68	0.69	0.01	0.65
Copper, mg/kg	1.82	1.64	0.08	0.11
Iron, mg/kg	60	62	2.1	0.38
Zinc, mg/kg	1.62	1.72	0.08	0.35

Effects of excess dietary sulfur on fatty acid composition in muscle of beef cattle

J. Hawley, B. Kegley, D. Galloway, J. Yancey, and J. Apple[1]

Research Highlights

- Steers consumed 0.15% or 0.40% dietary sulfur for 114-day growing and 123-day finishing phases.
- Fatty acid composition was determined in *longissimus* muscle samples.
- Dietary sulfur did not alter percentages of total saturated, monounsaturated, or trans fatty acids.
- High dietary sulfur tended to decrease polyunsaturated fatty acid percentages.
- This study found a trend for diets with 0.40% sulfur to result in a more favorable omega-6-to-omega-3 ratio.

Introduction

The increased production of distillers' grains is leading the beef industry to use distillers' grains as a feed source. Sulfur (S) accumulates in distillers' grains due to an additive effect from typical processing practices. Distillers' grains can have concentrations of 0.8% S or greater (Buckner et al., 2008). Corn contains about 0.11% S. Several additional chemicals utilized during production processes quickly contribute to higher S levels in the finished product: sulfuric acid; sulfamic acid; and sodium bisulfite. Accordingly, the metabolism of S in ruminants has gained interest, because dietary concentrations of S have increased as the consumption of distillers grains have increased. No studies have assessed the effect of dietary S and extended aging on beef muscle fatty acid composition. The objective of this study was to evaluate the effects of excess dietary S on beef *longissimus* muscle (LM) fatty acid composition.

Materials and Methods

Twenty steers (initial body weight [BW] = 624 ± 15.9 lbs) of predominantly Angus breeding were stratified by initial BW and assigned randomly to 1 of 6 pens (3 to 4 steers/pen) for a 114-day (18 October 2012 to 7 February 2013) growing phase. Pens were assigned randomly to 1 of 2 dietary treatments: 1) low (0.15%) S or 2) high (0.40%) S (Table 1). Steers grazed mixed grass pasture (0.27% S, 17.8% crude protein [CP], 26.8% acid detergent fiber [ADF], 57.1% neutral detergent fiber [NDF], and 10.4% ash, dry matter [DM] basis) and were supplemented to meet nutrient requirements with a corn and soybean meal ration (low-S treatment; 0.26 % S, 14.9% CP, DM basis). High-S steers were offered an identical supplement to which sodium sulfate was added to achieve 0.40% S (1.12% S, 14.5% CP, DM basis) in the total diet DM. Moreover, steers were provided free-choice access to bermudagrass hay (0.32% S, 18.8% CP, 33.4% ADF, 71.0% NDF, and 10.3% ash, DM basis) in quantities sufficient to ensure *ad libitum* access to forage. When the average BW of the steers reached 823 ± 0.4 lbs, steers were stratified by BW and assigned randomly to 16 dry-lot pens (1 to 2 steers/pen; 8 pens/dietary treatment). Steers remained on the same dietary treatment for a 123-day (8 February to 11 June 2013) finishing phase. Low-S steers were offered a corn and soybean meal finishing ration (0.17% S, 14.3% CP, DM basis) that met the National Research Council requirement of 0.15% S in the total diet DM. High-S steers were offered an identical ration except sodium sulfate was added to achieve 0.40% S (0.38% S, 15.1% CP, DM basis) in the total diet DM.

Slaughter and Steak Fabrication

Steers were harvested in a commercial abattoir (Creekstone Farms, Arkansas City, Kan.). Following a 48-hour chilling period, boneless rib sections were collected during carcass fabrication, vacuum-packaged, and transported to the University of Arkansas Red Meat Abattoir. Rib sections were aged 14 days (36 °F), fabricated into 1-in-steaks, vacuum-packaged, and stored at -4 °F until further analysis.

Fatty Acid Composition Analysis

Samples of LM were removed from day 0 and 7 simulated retail display steaks, freeze-dried for 72 hours, and homogenized with a blender before duplicate samples were subjected to direct transesterification. Supplement samples were dried at 122 °F in a forced-air oven and ground in a Wiley Mill (Thomas Scientific, Swedesboro, N.J.) through a 1-mm screen before duplicate samples were subjected to direct transesterification. An internal standard was prepared in hexane, and 1 mL was added to each 16 × 125-mm screw-cap tube. The hexane was evaporated leaving the internal standard. Samples were added to tubes and incubated in 2.0 mL of 0.2 M methanolic potassium hydroxide at 122 °F for 30 minutes with vortex-mixing 2 to 3 times/minute until samples were dissolved (Murrieta et al., 2003). Tubes were allowed to cool to room temperature, and 1 mL of saturated sodium chloride was added to each tube. Two milliliters of hexane were added to the tubes. Tubes were vortexed and centrifuged to separate the phases.

An approximate 1-mL portion of the hexane layer, containing the fatty acid methyl esters, was transferred to gas-liquid chromatography vials containing a 1.0-mm bed of anhydrous sodium sulfate. Fatty acid methyl esters separation was achieved by gas-liquid chromatography (Agilent Technologies, Inc., Wilmington, Del.) with a 100-m capillary column (Supelco Park, Bellefonte, Pa.) and helium as a carrier gas at 0.5 mL/minute with a 1:50 split ratio. Oven temperature was maintained at 302 °F for 5 minutes, increased at 39.2 °F/minute to 381.2 °F for 15 minutes, and then increased at 36.5 °F/minute to 455 °F for 16.25 minutes. Injector and detector temperatures were 482 °F, and identification of fatty acid methyl esters peaks was accomplished using purified standards (Supelco, Nu-Chek Prep, Elysian, Minn.; and Matreya, Pleasant Gap, Pa.).

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Statistical Analysis

Fatty acid composition data were analyzed as repeated measures using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) by means of a compound symmetry covariance structure, with steer as the experimental unit. Statistical significance was declared at $P < 0.05$, tendencies at $0.05 \leq P < 0.10$, and trends at $0.10 \leq P \leq 0.15$.

Results and Discussion

Dietary S did not alter the percentages of total saturated ($P = 0.87$), monounsaturated ($P = 0.63$), or trans ($P = 0.36$) fatty acids; however, dietary S tended ($P = 0.07$) to effect polyunsaturated fatty acid percentages (Table 2). *Longissimus* muscle from steers fed 0.40% S had lower percentages of linoleic (18:2*n*-6; $P = 0.05$) and dihomo-γ-linoleic (20:3*n*-6; $P = 0.01$) acids when compared with LM from steers fed 0.15% S. Moreover, LM from steers fed 0.40% S tended ($P = 0.07$) to have a lower percentage of docosapentaenoic acid (22:5*n*-3) than LM from steers fed 0.15% S. Similarly, there was a trend ($P = 0.12$) for LM from steers fed 0.40% S to have a lower percentage of arachidonic acids (20:4*n*-6) when compared with LM from steers fed 0.15% S. Conversely, there was a trend ($P = 0.15$) for the percentage of total conjugated linoleic fatty acids to be greater for LM from steers fed 0.40% S than LM from steers fed 0.15% S. Recently, nutritionists have focused on the balance between omega-3 and omega-6 polyunsaturated fatty acids. The recommendation is for a ratio of less than 4 (Wood et al., 2003). Beef can be manipulated towards a more favorable omega-6-to-omega-3 ratio. Supplementing beef cattle diets with 0.40% S decreased omega-6 deposition ($P = 0.05$), and trended towards a more favorable omega-6-to-omega-3 ratio ($P = 0.14$).

Implications

Results of this study suggest supplementing beef cattle diets with 0.40% sulfur had no appreciable effects on the percentages of total saturated, monounsaturated, or *trans* fatty acids. However, dietary sulfur tended to effect polyunsaturated fatty acid percentages, and supplementing beef cattle diets with 0.40% sulfur trended towards a more favorable omega-6-to-omega-3 ratio.

Acknowledgments

Appreciation is expressed to the Arkansas Beef Council for funding this research. Funding also provided by the University of Arkansas System Division of Agriculture.

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Table 1. Fatty acid (FA) composition of low (0.15%) or high (0.40%) sulfur corn and soybean meal supplements fed to steers (as fed basis).

	Treatment[a]			
	Growing phase		Finishing phase	
FA composition, %	Low sulfur	High sulfur	Low sulfur	High sulfur
Saturated FA				
Total[b]	18.82	18.47	17.84	17.57
Myristic (14:0)	ND[c]	ND	ND	0.069
Palmitic (16:0)	15.29	15.03	14.72	14.44
Stearic (18:0)	2.83	2.77	2.46	2.48
Arachidic (20:0)	0.70	0.67	0.66	0.58
Monounsatured FA				
Total[d]	30.28	29.89	26.82	27.33
Palmitoleic (16:1*cis*)	0.08	ND	0.09	0.18
Total 18:1*trans* FA	0.08	ND	ND	ND
Oleic (18:1*cis*9)	29.88	29.65	25.60	25.16
Vaccenic (18:1*cis*11)	ND	ND	0.89	1.75
Gadoleic (20:1*cis*11)	0.24	0.24	0.24	0.24
Polyunsaturated FA				
Total[e]	48.80	50.12	54.41	54.30
Linoleic (18:2*n*-6)	46.44	47.78	52.41	52.32
α-Linolenic (18:3*n*-3)	1.26	1.37	1.37	1.38
Eicosapentaenoic (20:5*n*-3)	0.26	0.25	0.25	0.27
Docosahexaenoic (22:6*n*-3)	0.84	0.72	0.38	0.33

[a] Values represent sample averages: low sulfur, day 0 = 19-20 samples; day 7 = 10; high sulfur, day 0 = 19; day 7 = 15-16.
[b] Sum of the weight percentages of capric, lauric, myristic, pentadecanoic, palmitic, margaric, stearic, and arachidic acids.
[c] ND = not detected.
[d] Sum of the weight percentages of myristoleic, palmitelaidic, palmitoleic, heptadecenoic, total 18: 1*t* FA, oleic, vaccenic, and gadoleic acids.
[e] Sum of the weight percentages of linoleic, total conjugated linoleic, α-linolenic, γ-linolenic, eicosadienoic, eicosatrienoic, dihomo-γ-linolenic, arachidonic, eicosapentaenoic, docosapentaenoic, and docosahexaenoic acids.

Table 2. Fatty acid (FA) composition of beef *longissimus* muscle for steers fed of low (0.15%) or high (0.40%) sulfur.

	Treatment[a]							
	Low sulfur		High sulfur			*P* – value[b]		
FA composition, %	Day 0	Day 7	Day 0	Day 7	SEM	TRT	DAY	T × D
Saturated FA, Total[c]	46.07	45.74	45.60	45.93	0.631	0.87	1.00	0.26
Capric (10:0)	0.030	0.017	0.039	0.015	0.008	0.66	0.03	0.49
Lauric (12:0)	0.042	0.036	0.049	0.046	0.009	0.41	0.59	0.85
Myristic (14:0)	2.80	2.76	2.65	2.71	0.142	0.61	0.88	0.33
Pentadecanoic (15:0)	0.38	0.37	0.37	0.37	0.023	0.82	0.87	0.77
Palmitic (16:0)	27.58	27.79	26.80	27.22	0.456	0.31	0.06	0.48
Margaric (17:0)	1.13	1.13	1.08	1.08	0.042	0.39	0.83	0.90
Stearic (18:0)	14.02	13.50	14.60	14.39	0.433	0.19	0.23	0.60
Arachidic (20:0)	0.078	0.072	0.084	0.078	0.003	0.01	0.16	0.44
Monounsatured FA, Total[d]	46.77	46.99	47.42	47.43	0.663	0.63	0.95	0.43
Myristoleic (14:1)	0.66	0.67	0.62	0.65	0.053	0.61	0.36	0.65
Palmitelaidic (16:1*trans*)	0.25	0.24	0.27	0.25	0.011	0.26	0.07	0.77
Palmitoleic (16:1*cis*)	3.44	3.58	3.23	3.31	0.122	0.15	0.16	0.71
Heptadecenoic (17:1*trans*)	0.099	0.093	0.109	0.102	0.007	0.32	0.20	0.87
Total 18:1*trans* FA	1.62	1.46	1.71	1.58	0.105	0.42	0.08	0.91
Oleic (18:1*cis*9)	38.17	38.29	38.89	38.85	0.729	0.54	0.84	0.71
Vaccenic (18:1*cis*11)	2.36	2.49	2.41	2.29	0.076	0.38	0.92	0.08
Gadoleic (20:1*cis*11)	0.18	0.17	0.18	0.18	0.013	0.67	0.57	0.72
Polyunsaturated FA, Total[e]	4.26	4.64	4.01	3.87	0.250	0.07	0.63	0.30
Linoleic (18:2*n*-6)	2.26	2.45	2.05	2.01	0.146	0.05	0.57	0.42
Total conjugated linoleic[f]	0.35	0.28	0.41	0.36	0.043	0.15	0.13	0.78
α-Linolenic (18:3*n*-3)	0.20	0.21	0.22	0.21	0.013	0.46	0.52	0.33
γ-Linolenic (18:3*n*-6)	0.20	0.21	0.22	0.21	0.013	0.47	0.52	0.33
Eicosadienoic (20:2)	0.021	0.004	0.014	0.007	0.007	0.82	0.07	0.45
Dihomo-γ-linoleic (20:3*n*-6)	0.20	0.24	0.17	0.17	0.019	0.01	0.31	0.42
Arachidonic (20:4*n*-6)	0.53	0.68	0.48	0.48	0.073	0.12	0.32	0.30
Eicosapentaenoic (20:5*n*-3)	0.20	0.21	0.19	0.19	0.012	0.29	0.54	0.59
Docosapentaenoic (22:5*n*-3)	0.26	0.37	0.25	0.25	0.034	0.07	0.13	0.13
Docosahexaenoic (22:6*n*-3)	0.013	0.014	0.018	ND[g]	0.007	0.68	0.13	0.09
Total *trans* FA[h]	1.97	1.79	2.10	1.93	0.117	0.36	0.07	0.94
Total omega-6 FA[i]	3.21	3.59	2.92	2.86	0.231	0.05	0.48	0.36
Total omega-3 FA[j]	0.67	0.82	0.68	0.65	0.050	0.12	0.25	0.09
Omega-6:omega-3[k]	4.68	4.72	4.31	4.40	0.167	0.14	0.46	0.77
Polyunsatured FA:saturated FA[l]	0.092	0.101	0.088	0.084	0.006	0.07	0.66	0.25

[a] Values represent sample averages: low sulfur, day 0 – 19, 20 samples; day 7 – 10; high sulfur, day 0 = 19; day 7 = 15-16.
[b] Trt = treatment; T x D = treatment x day.
[c] Sum of the weight percentages of capric, lauric, myristic, pentadecanoic, palmitic, margaric, stearic, and arachidic acids.
[d] Sum of the weight percentages of myristolei, palmitelaidic, palmitoleic, heptadecenoic, total 18: 1*t*FA, oleic, vaccenic, and gadoleic acids.
[e] Sum of the weight percentages of linoleic, total conjugated linoleic, α-linolenic, γ-linolenic, eicosadienoic, dihomo- γ-linolenic, arachidonic, eicosapentaenoic, docosapentaenoic, and docosahexaenoic acids.
[f] Sum of the weight percentages of the isomers 18:2c9*t*11, 18:2c9c11; 18:2c10c12; and 18:2*t*9*t*11 (isomer data not shown).
[g] ND = not detected.
[h] Sum of the weight percentages of palmitelaidic, heptadecenoic, and total 18:1*trans*FA.
[i] Sum of the weight percentages of linoleic, γ-linolenic, dihomo- γ-linolenic, and arachidonic acids.
[j] Sum of the weight percentages of α-linolenic, eicosapentaenoic, docosapentaenoic, and docosahexaenoic acids.
[k] Total omega-6 FA/total omega-3 FA.
[l] Total polyunsaturated FA/total saturated FA.

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