Arkansas Steer Feedout Program, 1998-1999

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Story in Brief

The objective of the Arkansas Steer Feedout Program is to provide cow-calf producers information about the postweaning performance and carcass characteristics of their calves. Steers that were composed of more than 50% English, less than 50% Continental, and less than 25% Brahman breeding had a higher percentage that graded Choice than steers that did not satisfy the breed type description (67% vs. 31%). Hot carcass weight, quality grade, days on feed, feed cost per pound of gain, yield grade, medicine cost, and fat thickness were significant factors that affected the return over specified cost. With the information gained from this program, cow-calf producers can better evaluate their cattle breeding programs.

Introduction

The Steer Feedout Program allows producers to learn more about the characteristics of their calf crop and the factors that influence value beyond the weaned-calf phase. It is not a contest to compare breeds or breeders, or a retained ownership promotion program. It creates an opportunity for producers to determine how their calf crop fits the needs of the beef industry and provides information needed to determine whether changes in genetics or management factors are warranted.

Experimental Procedures

On November 5, 1998, 210 steers from 26 Arkansas producers representing 15 counties were placed on feed at Neill Cattle Company Feedyard at Welch, Oklahoma. Upon arrival, steers were eartagged, weighed, and processed (Synovex-S, Ivomec Plus, Vision 7, and Bovishield). Steers were sorted into two feeding groups on the basis of weight, frame, and condition. Management factors such as processing, medical treatments, and diets were the same as those for the other cattle in the feedyard. The feedyard manager selected animals for slaughter when they reached the weight and condition regarded as acceptable for the industry and market conditions. Steers were slaughtered in two groups (April 22 and May 26, 1999). The cattle were sold on a carcass weight basis with premiums and discounts for various quality grades, yield grades, and carcass weights. Feed, processing, medicine costs, and other feedyard expenses were financed by the feedyard. All expenses were deducted from the carcass income, and proceeds were sent to the owner.

Descriptive statistics were computed to describe general program results. Breed type of each steer enrolled in the program was used to group calves according to whether they fit the following criteria: $\geq$ 50 % English, $\leq$ 50% Continental, and $\leq$ 25% Brahman. The group main effect and interaction on the dependent variables yield grade, ribeye area, ribeye area/hot carcass cwt, ADG, dressing percentage, feed cost per pound of gain, and net return were determined using the PROC GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Fat thickness was used as a covariant in the model.

Steers were also grouped according to whether they fit an industry standard for carcass merit (at least Choice, yield grade $\leq$ 3.5, with a hot carcass weight between 550 and 950 lb). Data were analyzed in the same manner as the breeding group analysis. Least-squares means using SAS were computed and reported.

Factors affecting return over specified cost for all steers, the top 25% (based on return over specified costs) steers, and the bottom 25% steers were determined using the Stepwise method of PROC REG. Independent variables included in weight, percentage Brahman, percentage English, percentage Continental breeding, ADG, yield grade, quality grade, feed cost per pound of gain, hot carcass weight, days on feed, medicine cost, ribeye area, ribeye area/hot carcass cwt., and dressing percentage.

Results and Discussion

The financial report is summarized in Table 1. Average gross income per head was $746.18 with a range from $347 to $961. Expenses in Table 1 are those related to the feedlot phase of production. Return over specified cost reported in

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Table 1 does not include the value of the calves at the start of the feeding period. To determine the true profitability of feeding these calves and selling them on a quality-yield grade system, this value would have to be included.

The producers did an excellent job of weaning calves early and administering vaccines prior to shipment. Only 15 calves (7.1%) were treated for sickness. Average medicine cost per sick calf was $21.49. Medicine costs for the entire group averaged $1.43 per head. The health status of cattle in the feedyard usually has a major impact on performance and profit. Healthy steers had higher returns over specified costs ($470.34) than steers that became sick ($420.73; $P < 0.01$). In addition, healthy steers had a higher dressing percentage (63.9%) than those that became sick (61.6%; $P < 0.1$). No differences were detected between healthy steers and steers that became sick, for arrival weight, ADG, feed cost of gain, carcass value/cwt., ribeye area/cwt, carcass weight, ribeye area, and percent grading Choice ($P > 0.10$). This is probably due to the fact that so few steers became sick.

The average off-the-truck arrival weight was 636 lb (range = 380 to 920). The ADG, average days on feed, feed cost per pound of gain, and total cost per pound of gain were 2.93 lb (1.33 to 4.48), 181 d (166 to 200), $0.47 ($0.19 to $1.12), and $0.55 ($0.24 to $1.28), respectively.

The average carcass weight, ribeye area, dressing percentage, yield grade, and fat thickness were 743 lb (510 to 982), 12.4 in^2 (8.2 to 18.1), 63.8% (58.2% to 68.8%), 2.70 (0.94 to 4.88), and 0.37 in (0.12 to 1.00), respectively. Fifty-two percent of the carcasses graded Choice, whereas 37%, 10%, and 0.5% graded Select, Standard, and dark cutter, respectively. A few carcasses graded Prime (0.5%). Carcass value was $1.03 per cwt for Choice-Yield Grade 2 carcasses for both slaughter dates. The discount, however, for Select graded carcasses was greater for calves sold on May 26, 1999 ($8) than for calves sold on April 22, 1999 ($3).

The percentage English, Continental, and/or Brahman breeding were determined for each calf. Steers that were at least 50% English, no more than 50% Continental, and less than 25% Brahman were sorted into one group, and those steers that did not satisfy the breed-type criteria were placed in a second group (Table 2). Calves that fit the breed-type criteria graded 67% Choice compared with the calves that did not fit the breed-type criteria graded 31% Choice. A review of the data suggests there is enough evidence to support the recommendation that market cattle should be composed of at least 50% English, no more than 50% Continental, and less than 25% Brahman.

Listed below are seven significant factors that affected the return over specified costs in the 1998-99 Steer Feedout Program. Factors are listed from the most important to the least important.

Factors Affecting Returns Over Specified Cost

1. Hot Carcass Weight
2. Quality Grade
3. Days on Feed
4. Feed Cost of Gain
5. Yield Grade
6. Medicine Cost
7. Fat Thickness

1. Hot Carcass Weight—The relationship between hot carcass weight and feedlot returns over specified costs was positive; that is, as hot carcass weight increased, so did feedlot returns. The more carcass pounds sold, the greater the gross income and feedlot returns. Table 3 shows the relationship between hot carcass weight, total cost of gain, ADG, and feedlot returns over specified costs.

Hot carcass weight discounts were observed for carcasses weighing less than 550 lb and greater than 950 lb. Carcasses less than 550 lb were discounted an average of $25 per cwt and carcasses greater than 950 lb were discounted $18 per cwt.

2. Quality Grade—Cattle that graded Choice, Select, and Standard had returns over specified cost of $498, $431, $393, respectively. Marbling is the main factor that affects a calf's ability to grade Choice. Three main factors that affect marbling are: (1) the genetic ability to marble; (2) the maturity, or the physiological age, not the chronological age; and (3) diet. Some cattle breed associations report marbling EPDs in their sire summary. Carcass traits such as marbling are highly heritable; therefore, selecting high marbling EPD bulls can impact the marbling ability of their progeny. Breed type can also influence a calf's ability to grade Choice.

3. Days on Feed—Cattle were sold on April 22 or May 26, 1999. There was a negative relationship between days on feed and returns over specified cost. This means that on the average, the steers that were sold in April had a higher feedlot return over specified costs than those sold in May ($503 vs. $471).

A factor that affected the relationship between days on feed and feedlot return over specified costs was the price difference between Choice and Select quality grades on the two slaughter days. There was a $3 per cwt discount between Choice and Select carcasses on April 22 and an $8 per cwt discount between Choice and Select carcasses on May 26.

4. Feed Cost of Gain—Feed cost of gain had a negative relationship to feedlot return over specified costs. As feed cost of gain decreased, return over specified costs increased. Based upon returns over specified costs, the average feed cost of gain for the steers in the bottom 25% was $0.54/lb compared to $0.45/lb for the steers in the top 25%. The average feed cost per gain for all the steers was $0.47.

5. Yield Grade—Yield grades 1 to 3 have a positive impact on feedlot returns over specified costs ($451, $462, and $499 for yield grades 1, 2, and 3, respectively), but a negative impact for yield grades greater than 4 ($377).

6. Medicine Cost—Healthy calves had higher dressing percentage (63.9% vs. 61.6%) and higher feedlot returns over specified costs ($470 vs. $420) than calves that were treated for illness.

7. Fat Thickness—Fat thickness is the number one factor that determines yield grade. Cattle that are short and have 0.8 in or more fat thickness at slaughter will be discounted as yield grade 4s. Therefore, calves less than 42 in tall (at the hip) at 7 mo of age are too small.

Table 4 summarizes the performance and carcass data from the steers that were in the bottom 25% and top 25%

(based on returns over specified costs) and the average of all the steers. The five main factors that predicted net returns of steers in the bottom 25% were feed cost of gain, quality grade, medicine cost, dressing percentage, and fat thickness. In summary, the calves in the bottom 25% had high feed and medicine cost and low dressing percent, and failed to grade Choice. The cattle that performed the best were medium to large framed and heavy muscled, gained well, had a high dressing percentage, did not get sick, and graded Choice.

The beef cattle industry has set the standard that quality grade should be Choice, yield grade ≤ 3.5, and hot carcass weight between 550 and 950 lb. This year, 50% of the Arkansas calves fit all those requirements. Steers that met the industry standards had higher ADG (3.0 vs. 2.8 lb) and averaged $77 more per head than those that did not fit the industry standards ($P < 0.01$). They had higher carcass values ($1.04 vs. $0.97) because they graded Choice, they were not discounted for yield grades greater than 4.0, and no carcasses were outside the weight range (550 to 950 lb).

Implications

Extremes in feedlot return over specified costs, health costs, performance factors, and carcass parameters exist in the beef industry. A producer's goal should be to reduce these variables and produce a product that meets the needs of all segments of the beef industry. Value-based marketing at all levels of the industry is rapidly becoming a reality. Ranchers who produce a product that meets the demands will be more competitive in the market place.

Acknowledgment

The Arkansas Steer Feedout Program would like to thank the Arkansas Cattlemen's Association for sponsoring the Steer Feedout Tour.

Table 1. 1998-99 Arkansas steer feedout summary—financial results.

Item	Average	Range
Gross income	$746.18	$347 to $961
Expenses		
Feed	$240.06	$170 to $309
Medicine	1.25	0 to 47.11
Processing	11.46	11.42 to 11.49
Yardage	12.23	11.31 to 13.35
Fees	1.00	1.00
Interest	5.36	4.61 to 6.14
Freight	8.17	6.13 to 10.24
Total	$279.53	$207 to $349
Return over specified costs	$466.65	$32 to $669

Table 2. Performance and carcass data of Arkansas steers that did or did not fit the breed-type criteria.[1]

	Fit breed-type criteria	Did not fit breed-type criteria	Significance
Percent grading Choice	67%	31%	P < 0.01
Yield grade Ribeye area, in^2	2.0	1.7	P < 0.01
Ribeye area/100 lb carcass weight	11.9	13.2	P < 0.01
Average daily gain, lb	3.12	3.00	NS[2]
Dressing percentage	63.2%	64.2%	P < 0.01
Hot carcass weight, lb	750	775	NS
Carcass value	$1.02	$0.99	P = 0.02
Feed cost per pound of gain	$0.42	$0.48	P = 0.03
Return over specified costs	$493	$481	NS
Percentage that met industry standards	67%	27%	P < 0.01

[1] At least 50% English, no more than 50% Continental, and less than 25% Brahman.

[2] NS = not significant.

Table 3. Summary of hot carcass weight, total cost of gain, ADG, and feedlot returns over specified cost.

Hot carcass weight, lb	Total cost of gain/lb	ADG, lb	Feedlot returns over specified cost
<600	$0.70	2.1	$238
600-699	$0.59	2.5	$263
700-799	$0.54	3.0	$347
800-899	$0.52	3.3	$544

Table 4. Performance of the bottom 25%, average, and top 25% steers based on return over specified costs.

	Bottom 25%	Average	Top 25%
No. steers	52	206[1]	52
In weight, lb	591	636	691
Muscle score	1.2	1.2	1.1
Frame score			
Large	31%	56%	67%
Medium	69%	44%	33%
Final weight, lb	1065	1165	1290
ADG, lb	2.47[a]	2.93	3.30[b]
Gross income	$638	$746	$860
Carcass value/lb	$0.95[a]	$1.00	$1.03[b]
Hot carcass weight, lb	673	743	825
Dressing percentage	63.2%	63.8%	64.4%
Interest	$5.80	$5.36	$4.93
Medicine	$2.11[a]	$1.25	$0.86[b]
Total feed cost per head	$246	$240	$249
Total expense	$287	$280	$287
Return over specified costs	$351[a]	$467	$573[b]
Days on feed	192[a]	181	170[b]
Feed cost/lb of gain	$0.54[a]	$0.47	$0.45[b]
Total cost/lb of gain	$0.63[a]	$0.55	$0.53[b]
Ribeye area, in^2	11.6[a]	12.4	13.2[b]
Fat thickness, in	0.38	0.37	0.37
Quality grade			
Prime	0%	0.5%	2%
Choice	20%[a]	52%	75%[b]
Select	56%[a]	37%	23%[b]
Standard	21%	10%	0%
Dark Cutter	2%	0.5%	0%
Yield grade	1.9	2.7	2.7

Values within rows with unlike superscripts are significantly different ($P < 0.01$).

[1] Four calves were not used in this data set. One calf died, one was railed, and two were returned to their owners.

Current and Subsequent Season Effects of Parasite Control in Arkansas Stocker Calves

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Story in Brief

Four nematocidal regimens were evaluated for parasite control in stocker calves during mid- and late-season grazing on contaminated pasture. Six naturally infected, 6-mo-old calves were randomly allocated to each of 10 equivalent and adjoining 4-acre pastures. All animals on two randomly designated pastures received one of the five treatments: (1) control; (2) ivermectin (IVOMEC Merial Ltd) on day 0 as a subcutaneous injection at the rate of 0.2 mg/kg BW; (3) ivermectin (as described above) on days 0 and 56; (4) fenbendazole (SAFEGUARD Intervet) as a drench at the rate of 10 mg/kg BW on day 0 and 5 mg/kg BW on day 56; and (5) ivermectin sustained-release bolus (IVOMEC SR Bolus Merial Ltd). Body weights and fecal parasite egg counts were obtained at approximately 4-wk intervals until trial termination at day 133 (November 17, 1998), at which time all cattle were removed from the pastures. On March 1, 1999, and continuing until March 31, 1999, two parasite-free tracer calves were placed on each of the control and bolus treatment group pastures, and subsequently sacrificed for nematode quantifications after 30 d in confinement. For the performance portion of the study, fecal parasite egg counts were highest for the control groups, lowest for the bolus groups, and intermediate for the fenbendazole and injectable ivermectin groups. In general, weight gains were inversely proportional to egg counts, with ADG greatest for the bolus-treated cattle (1.23 lb/head/d), lowest for the controls (0.55 lb/head/d), and intermediate for the fenbendazole and injectable ivermectin groups (0.93 to 0.95 lb/head/d). Benefits of parasite control beyond the short-term effects of enhanced performance of treated cattle were illustrated by the tracer calf nematode counts. Average total burdens in tracer calves from control pastures were 3.8 times greater than those recovered from tracers removed from the bolus treatment group pastures.

Introduction

Stocker cattle production in Arkansas is an intensive process with high stocking rates, short duration, and great production demands occurring simultaneously with each group of calves. These types of operations are extremely susceptible to the detriment of a vast number of pathogens, with nematodiasis being of premier incidence and concern. The following study was designed to assess several nematocidal strategies that are common in our state and to measure the degree to which parasitisms acquired by future stocker calves are influenced by current parasite control measures.

Experimental Procedures

In May and early June of 1998, a group of stocker calves was assembled from local sale barns and producers. All animals were male castrates and approximately 6 mo of age at acquisition. On June 11, 1998 (trial day –26), the animals were fecal sampled for parasite egg counts per 0.5 g of feces. The animals were subsequently ranked in accordance with the above egg counts and bracketed into six groups of 10 animals per group. Within each bracket, the animals were randomly allocated for eventual placement onto one of the 10 study pastures. Pastures were then randomly assigned one of five treatment group designations (two pastures/treatment group). All pastures were adjoining and identical in size (4 acres), prior contamination (2 yr of grazing by naturally infected cattle) and herbage type (fescue).

Four different nematocidal regimes, plus a control, were investigated. The five treatment group designations were:

1. Control—no treatment.
2. Fenbendazole—Given as SAFEGUARD as an oral drench at the rate of 10 mg/kg BW on day 0 (anticipating arrested *Ostertagia*) and 5 mg/kg BW on day 56.
3. Ivermectin on day 0—Given as IVOMEC as a subcutaneous injection at the dosage rate of 0.2 mg/kg BW.
4. Ivermectin on day 0 and 56—Given each time as IVOMEC as a subcutaneous injection at the dosage rate of 0.2 mg/kg BW.

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5. Ivermectin Sustained-Release Bolus (ISRB)—Given on day 0 at the rate of one bolus per animal.

The actual trial was started on July 7, 1998 (trial day 0), with each animal being weighed, treated according to allocation, fecal sampled for parasite egg counts, and placed on its designated pasture. Subsequently, all animals were weighed and fecal sampled at approximately 28-d intervals until November 17, 1998 (trial day 133).

During the study, control animals, as a group, shed the most parasite eggs and ISRB-treated animals shed the least. Therefore, in order to determine the extent to which pasture infectivities at the start of the subsequent grazing season might be influenced by previous degree of parasite control, two parasite-free tracer calves were placed on each of the control and ISRB pastures the following spring for a 30-d grazing period (March 1 to March 31, 1999). After grazing, the tracers were placed on concrete for 21 d prior to necropsy for parasite recovery. No cattle grazed on the experimental pastures between the time of study-calf removal and the placement of tracer calves.

All parasite egg counts, coprocultures, and infective larva identifications were performed according to standard techniques (Thienport et al., 1979). Nematode counts in tracer calves were also conducted according to standardized procedures (Yazwinski et al., 1997). The data were analyzed for variance with general linear models (SAS Inst. Inc., Cary, NC). Prior to analysis, all egg and nematode counts were transformed to the log 10 ($x + 1$).

Results and Discussion

Strongyle egg counts for the production phase of the study are presented in Table 1. Counts for the treatment groups were equivalent on day 0. For all remaining sample dates, ISRB-treated cattle were negative for parasite eggs (with the exception of one calf on trial day 105), with counts lower than control calf levels at every post-treatment date ($P \leq 0.05$). Egg counts for calves receiving repeated fenbendazole treatments were lower ($P < 0.05$) than control calf levels until the final sample date. Calves treated with ivermectin, either on day 0 only or on days 0 and 56, had egg counts significantly lower than control calf levels on every post-treatment sampling date with the exception of day 105.

Average daily gains are given in Table 2. Rates of gain for the first 56 d of the study were not significantly influenced by treatment. For the remainder of the grazing study (days 56 to 133) and for the total 133-d grazing period, control animal gains were significantly lower than gains made by any of the treated animal groups ($P < 0.05$).

Nematode counts obtained from the tracer calves placed on control and ISRB calf pastures are summarized in Table 3. Prior grazing by ISRB-treated calves lowered the availability of all infective nematodes combined ($P < 0.05$) with the greatest decrease seen with *Trichostrongylus axei* (99.5% reduction; $P \leq 0.01$).

These data clearly illustrate that pasture contamination and animal performance are directly influenced by parasite control measures. It is especially noteworthy that fall grazing by ISRB-treated calves significantly reduced challenge to subsequent, spring-placed tracers by 76.7% (8,946 vs. 2,324 total nematodes). Parasitisms encountered by calves during an entire grazing period are to a great degree the result of initial pasture challenge. As illustrated in this study, timely use of "complete" (ISRB) nematocidal control greatly depresses subsequent parasitisms.

For the most part, nematode egg counts and weight gains for calves reflected trends which were to be expected. An exception to this was seen with the calves that were given injectable ivermectin on days 0 and 56. Egg counts for both pasture groups were significantly ($P \leq 0.05$) lower on day 28 than on day 0, indicating treatment effectiveness at the onset of the study. Egg counts on day 84, however, were significantly decreased from day 56 levels for only one of the two pastured groups. The pasture group which did not have significant egg count reductions also displayed the lower ADGs for the treatment group.

Implications

A decrease in ivermectin effectiveness, similar to what is documented above, has been sporadically encountered by farmers in Arkansas for several years. Research is currently ongoing at the University of Arkansas to further define this infrequent condition as well as develop managerial means to maintain improvements in animal well-being that result from effective parasite control.

Literature Cited

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Table 1. Arithmetic means of strongyle EP 1/2G counts by treatment group and trial day.

	Treatment group				
Trial day	Control	FBZ on days 0 and 56	IVM on day 0	IVM on days 0 and 56	ISRB
0	112.4	97.7	84.2	79.3	90.7
28	70.3[a]	0.1[b]	1.3[b]	4.1[b]	0.0[b]
56	246.3[a]	12.7[c]	37.4[b]	48.1[b]	0.0[d]
84	268.9[a]	0.2[d]	80.2[b]	19.8[c]	0.0[d]
105	139.5[a]	10.3[b]	46.7[a,b]	63.0[a,b]	0.3[c]
133	97.1[a]	80.3[a]	38.3[b]	29.3[b]	0.0[c]

Means on the same line with unlike superscripts are significantly different ($P \leq 0.05$), for data transformed to the log 10 [x + 1].

FBZ = fenbendazole; IVM = ivermectin; ISRB = ivermectin sustained-release bolus.

Table 2. ADGs (lb) by treatment group and study period.

	Days of study		
Treatment group	0–56	56–133	0–133
Control	0.62	0.44[c]	0.53[c]
FBZ on days 0 and 56	0.71	1.12[a,b]	0.95[a,b]
IVM on day 0	0.97	0.93[b]	0.93[a,b]
IVM on days 0 and 56	0.71	1.06[b]	0.93[b]
ISRB	0.88	1.48[a]	1.23[a]

Means in the same column with unlike superscripts are significantly different ($P \leq 0.05$).

FBZ = fenbendazole; IVM = ivermectin; ISRB = ivermectin sustained-release bolus.

Table 3. Nematode count arithmetic means for tracer calves placed on ISRB and control pastures (two tracer calves per pasture, two pastures per treatment).

	Tracer calves from:	
Nematode	Control pasture	ISRB pasture
Ostertagia spp. as:		
Adult	5,579	1,466
Developing fourth-stage larvae	188	132
Inhibited (early fourth-stage) larvae	1,071[a]	246[b]
Trichostrongylus axei	196[c]	1[d]
Nematodirus helvetianus	16	37
Cooperia spp.	1,896	442
All nematodes	8,946[a]	2,324[b]

Means on the same line are significantly different for data transformed to the log 10 [x + 1], at the 5% ([a,b]) and 1% ([c,d]) levels of probability.

ISRB = ivermectin sustained-release bolus.

Flunixin Meglumine as Adjunct Therapy for Bovine Respiratory Disease in Stocker Cattle

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Story in Brief

There is increasing pressure from consumers to reduce the amounts of antibiotics used in food animals, primarily because of concerns about the development of antibiotic-resistant bacteria. The objectives of this study were to examine the use of nonsteroidal anti-inflammatory drugs to enhance bovine respiratory disease therapy. Ninety-six stocker calves were purchased from several salebarns in Central Arkansas and delivered as a group to the University of Arkansas Beef Cattle Research Facility at Savoy. The calves were blocked by weight (bulls were stratified through the treatment groups) and randomly assigned to one of 16 grass lots (1.1 acres) with six calves per lot. Calves with clinical signs of bovine respiratory disease (BRD) from group 1 were treated with flunixin meglumine (Benamine, Schering-Plough Animal Health Corp., Union, NJ) at 2.2 mg/kg BW intravenously (IV) and tilmicosin phosphate (Micotil, Elanco Animal Health, Indianapolis, IN) at 10 mg/kg subcutaneously (SC). Calves with clinical signs of BRD from group 2 were treated with tilmicosin phosphate at 10 mg/kg SC. The percentage of treatment successes was higher in group 1 than in group 2 (88% vs. 61%, P = 0.06). The combined percentage of treatment failures and BRD relapses was less in group 1 than in group 2 (5% vs. 38%, P = 0.02). The total medication cost per head for group 1 was less than the cost for group 2 ($14.66 vs. $18.10, P = 0.10). The ADG (lb per head/d) over the 35-d backgrounding period was not different between groups (2.2 vs. 2.4, P = 0.51). The flunixin meglumine/tilmicosin phosphate therapy was more successful for treating BRD than using tilmicosin phosphate alone.

Introduction

Bovine respiratory disease (BRD) is a complex syndrome caused by several viruses complicated by secondary bacterial infections. The economic consequences of this syndrome are considerable, in terms of loss from death, decreased growth performance, increased medication costs, and labor. There is a wide variety of therapeutic options, most of which involve the use of antibiotics.

There is increasing pressure from consumers to reduce the use of antibiotics in food animals, primarily because of concerns about the development of antibiotic-resistant bacteria. In addition, the trade barriers with regards to antibiotics in food animals established by the European Union will have significant economic impact on U.S. producers. It will become important for industry and producers to seek therapies that will reduce the use of antibiotics in production animal medicine.

Nonsteroidal anti-inflammatory drugs (NSAIDs) have been widely used in veterinary medicine to reduce the effects of inflammatory mediators produced during bacterial infection (Higgins et al., 1986, Balmer et al., 1997, Bottoms et al., 1981, Selman et al., 1986, and Vernimb et al., 1977). Their mode of action involves the inhibition of cyclo-oxygenase, as well as prostaglandins and thromboxane B_2 (Anderson et al., 1990) These products of inflammation are presumed to be responsible for much of the lung damage seen with BRD (Mosier, 1997). Flunixin meglumine is a NSAID that has been approved for use in beef cattle. The purpose of this study was to examine flunixin meglumine as adjunct therapy for BRD in stressed stocker cattle.

Experimental Procedures

Ninety-six stocker calves (bulls and steers, 396 to 526 lb) were purchased from several salebarns in central Arkansas and delivered as a group to the University of Arkansas Beef Cattle Research Facility at Savoy. Initial processing was done within 24 h of arrival. This included vaccination with a modified-live viral vaccine (Infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza – 3, bovine respiratory syncytial virus), a killed multivalent clostridial vaccine and

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a killed *Pasteurella* spp. vaccine. The cattle were treated for external and internal parasites with a pour-on endectocide. The calves were revaccinated with the same products 2 wk after arrival. In addition, bulls were castrated using a banding method, given a vaccination for tetanus and horns were tipped.

The calves were blocked by weight (bulls were stratified through treatment groups) and randomly assigned to one of 16 grass lots (1.1 acres), with six calves per lot. The calves were offered 2 lb per head/d 16% protein supplement. This was gradually increased to 4 lb per head/d for the remainder of the study (35 d). Grass hay was supplemented as necessary.

Calves with clinical signs of BRD (Table 1) were removed from their home lots and treated according to one of two treatment protocols. Group 1 calves were treated with flunixin meglumine at 2.2 mg/kg BW IV and tilmicosin phosphate at 10 mg/kg SC. Group 2 calves were treated with tilmicosin phosphate at 10 mg/kg SC. Calves were examined 48 h after treatment to assess treatment success. Treatment success was characterized by an abatement of clinical signs accompanied by reduction in body temperature ≤103ºF. No improvement in clinical signs and no reduction in body temperature within 48 h post-treatment were considered to be a treatment failure. An animal that had been initially treated, successfully, was sent home, and began showing signs of BRD again was considered to have relapsed. Personnel evaluating animals for clinical signs of BRD were blinded to treatment group assignment.

The parameters recorded were proportion of treatment successes and treatment failures, proportion of BRD relapses, average medication costs, ADG (lb per head/d), and cost of gain per pound (includes cost of feed, medication, processing, and chute charges). The parametric data were analyzed using analysis of variance for medication costs, ADG, and cost of gain per pound. Analysis of nonparametric outcomes (treatment successes, treatment failures, and percent of BRD relapses) was done with the Goodness of Fit Test using the chi-squared distribution.

Results and Discussion

The number of calves noted with clinical signs of BRD was the same for each treatment group (Table 2). The number of treatment successes was greater for group 1 (antibiotic plus NSAID) than for group 2 (antibiotic alone) (88% vs. 61%, $P = 0.06$).

The combined number of treatment failures and BRD relapses was less for group 1 than for group 2 (5% vs. 38%, $P < 0.05$). Total medication cost per head for group 1 was less than for group 2 ($14.66 vs. $18.10, $P = 0.10$). Average daily gain over the 35-d feeding period was not different between groups (2.2 vs. 2.4 lb per head/d, $P = 0.51$). Cost of gain per pound was the same for both groups ($0.37). There was no reduction in cost of gain with the use of flunixin meglumine. This reflects the similar ADG between treatment groups.

Implications

Flunixin meglumine in conjunction with tilmicosin phosphate for the treatment of BRD resulted in a reduced percentage of treatment failures and BRD relapses. This represents an advantage in terms of reduced labor for treating these animals and reduced medication costs. In addition, antibiotic use would be reduced if the animals had fewer relapses. Although we did not see an advantage in ADG and cost of gain in this 35-d trial, one might expect a long-term advantage in growth performance from quicker recoveries from BRD.

Acknowledgments

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Table 1. Criteria for evaluation of bovine respiratory disease.

Clinical signs	Depression
	Purulent ocular/nasal discharge
	Difficult breathing
	Coughing
Rectal temperature	≥ 104ºF

Table 2. Percentage of treatment success, failure, and relapse, medication cost, ADG and cost per pound of gain in calves treated for bovine respiratory disease (BRD).

	Treatment		
Item	Tilmicosin + flunixin meglumine	Tilmicosin alone	P value
Treatment success, %	88 (23/26)	61 (16/26)	0.06
Treatment failure and BRD relapses, %	11 (3/26)	38 (10/26)	< 0.05
Average medication cost per head, $	14.66	18.10	0.10
ADG, lb per head/d	2.2	2.4	0.51
Cost per pound of gain, $	0.37	0.37	NS

Serum Acute-Phase Inflammation Proteins as a Means of Assessing Effectiveness of Flunixin Meglumine Therapy for Bovine Respiratory Disease

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Story in Brief

Serum acute-phase protein levels in cattle treated for bovine respiratory disease (BRD) were used to assess the effectiveness of treatment with antibiotics and flunixin meglumine. Ninety-six stocker calves were purchased from several sale barns in Central Arkansas and delivered as a group to the University of Arkansas Beef Cattle Research Facility in Savoy. Processing was done within 24 h of arrival, blood was collected, and serum harvested for baseline determination of α-glycoprotein (AGP) and haptoglobin (HPT). The calves were blocked by weight and sex, then randomly assigned to one of 16 1.1–acre lots with six calves per lot. Calves from group 1 with clinical signs of BRD were treated with flunixin meglumine at 2.2 mg/kg BW intravenously and tilmicosin phosphate at 10 mg/kg subcutaneously. Calves with clinical signs of BRD from group 2 were treated with tilmicosin phosphate at 10 mg/kg BW subcutaneously. Blood was collected each time an animal was treated for BRD, as well as 48 h after treatment. Serum AGP and HPT were determined using commercially available agar gel immunodiffussion (AGID) assay kits. There was large variation in the AGID results. Neither serum AGP nor HPT levels were correlated with response to BRD therapy as measured by reduction in body temperature and abatement of clinical signs.

Introduction

The economic consequences of bovine respiratory disease (BRD) in weaned calves and stocker cattle are considerable in terms of loss from death, decreased growth performance, increased medication costs, and labor. It is a complex disease involving both viruses and bacteria. The inflammation that accompanies BRD can result in permanent lung damage. The goals of therapeutic treatment for BRD are to reduce or resolve the lung damage. It is often difficult to determine whether this has actually been accomplished. Treatment success is often evaluated by the abatement of clinical signs and reduction in body temperature. In some cases, subclinical inflammation may persist, resulting in permanent lung damage.

Acute-phase proteins, such as α-glycoprotein (AGP) and haptoglobin (HPT), are elevated during acute or chronic periods of inflammation associated with infectious disease. The plasma concentration of these proteins can change up to 1,000-fold during disease episodes (Eckersall and Conner, 1988). Alsemgeest et al. (1994) reported on the value of measuring serum AGP and HPT in cattle to distinguish between acute, subacute and chronic inflammatory disease. They found that these values could be used to distinguish healthy animals from those with inflammation.

Flunixin meglumine (Banamine, Schering-Plough Animal Health Corp., Union, NJ) is a nonsteroidal anti-inflammatory drug (NSAID) that has been widely used as a therapeutic agent in horses (Bottoms et al., 1981). It has recently been approved for use in conjunction with antibiotics for the treatment of BRD. Its primary mode of action is to inhibit inflammatory mediators such as cyclo-oxygenase and prostaglandins (Anderson et al., 1990). The effect of flunixin meglumine on serum AGP and HPT has not been reported.

The purpose of this study was to determine the potential value of serum AGP and HPT levels to assess the therapeutic effectiveness of treating BRD with antibiotics and flunixin meglumine.

Experimental Procedures

Ninety-six stocker calves (steers and bulls, 396 to 26 lb BW) were purchased from several sale barns in central Arkansas and delivered as a group to the University of Arkansas Beef Cattle Research Facility at Savoy. Initial processing was done within 24 h of arrival. This included vaccination with a modified-live viral vaccine (Infectious bovine rhinotracheitis virus, bovine viral diarrhea virus, parainfluenza – 3 virus, bovine respiratory syncytial virus), a killed multivalent clostridial vaccine and a killed *Pasteurella spp*. vaccine. The cattle were re-vaccinated 2 wk post-arrival with the same vaccines given initially. In addition,

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bulls were castrated using a banding method and given a vaccination for tetanus, and their horns were tipped.

The calves were blocked by weight (bulls were stratified through treatment groups) and randomly assigned to one of 16 grass lots (1.1 acres), with six calves per lot. The calves were offered 2 lb per head/d of a 16% protein supplement. This was gradually increased to 4 lb/head/d for the remainder of the 35-d study. Grass hay was supplemented as necessary.

Calves with clinical signs of BRD (Table 1) were removed from their home lots and treated according to one of two treatment protocols. Group 1 calves were treated with flunixin meglumine at 2.2 mg/kg BW intravenously and tilmicosin phosphate (Micotil, Elanco Animal Health, Indianapolis, IN) at 10 mg/kg BW subcutaneously (SC). Group 2 calves were treated with tilmicosin phosphate at 10 mg/kg BW SC. Calves were examined 48 h after treatment to assess treatment success. Blood was collected from the jugular vein each time an animal was treated for BRD, as well as 48 h after treatment. Serum was harvested to be used in commercially available agar gel immunodiffussion (AGID) tests for AGP and HPT (bovine serum haptoglobin and α_1–acid glycoprotein measurement kits, Cardiotech Services, Inc., Louisville, KY). Treatment success was characterized by an abatement of clinical signs accompanied by body temperature reduction to ≤ 103ºF. Treatment failure was defined as no improvement in clinical signs and no body temperature reduction within 48 h post-treatment. Animals that had been initially treated successfully, were sent home, and began showing signs of BRD again were considered to have relapsed. Personnel evaluating animals for clinical signs of BRD and those running the serum AGID tests were blinded to treatment group assignment.

Results and Discussion

Neither serum AGP nor HPT levels were correlated with response to BRD therapy as measured by reduction in body temperature and abatement of clinical signs (Table 1). Serum HPT and AGP were variable within treatment groups, having both increased and decreased 48 h after treatment for BRD. Furthermore, serum AGP and HPT levels remained elevated in some of the animals that had recovered clinically. Patterns of serum AGP and HPT change were not correlated with clinical recovery or body temperature reduction. In addition, there were no differences between treatment groups with regard to changes in AGP and HPT 48 h after treatment (Table 2). Similar variability was reported by Young et al. (1996) with regard to using serum HPT levels as a diagnostic tool for clinical respiratory tract disease in feedlot cattle. In the present study, there was no predictable effect on AGP or HPT associated with flunixin meglumine or antibiotic treatment (Table 1). Forty-eight hours may not have been enough time for detectable changes in serum AGP and HPT levels after treatment for BRD. It is also possible that flunixin meglumine or antibiotic treatment does not have an effect on the two acute-phase proteins examined.

Implications

Current methods of evaluating treatment success for BRD, with the exception of rectal temperature, are mostly subjective. Experienced producers and feedlot personnel are forced to rely on subjective criteria for disease detection, since no reliable, objective predictors of BRD are available. Results of this study imply that variability of serum acute-phase proteins within a population may preclude their value as predictors of BRD or treatment response. Further investigations are required to determine whether optimum timing of sample collection would enhance usefulness of these tests under field conditions.

Acknowledgments

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Table 1. Criteria for evaluation of bovine respiratory disease.

Clinical signs	Depression
	Purulent ocular/nasal discharge
	Difficult breathing
	Coughing
Rectal temperature	≥ 104ºF

Table 2. Serum α-glycoprotein (AGP) and haptoglobin (HPT) (mg/ml) at time of treatment for bovine respiratory disease and 48 h after treatment.

	Treatment		
Item	Tilmicosin + flunixin meglumine	Tilmicosin alone	P value
HPT at treatment	784	950	0.35
HPT 48 h post-treatment	638	743	0.48
Change in HPT from treatment to 48 h	–208	–147	0.74
AGP at treatment	853	868	0.95
AGP 48 h post-treatment	1055	1142	0.75
Change in AGP from treatment to 48 h	187	290	0.72

Growth Performance and Serum Prolactin Concentrations of Stocker Steers Implanted with Trenbolone Acetate While Grazing Endophyte-Infected Fescue in the Spring

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Story in Brief

A 64-d grazing study was conducted to evaluate the impact of implant treatment on growth performance, hair score, and serum prolactin level of steers grazing high- (HE) or low- (LE) endophyte-infected tall fescue pastures. Mixed-breed steers (n = 130; 542 ± 7.7 lb) were allocated randomly to one of three 10-acre HE or one of four 10-acre LE pastures beginning April 13. Within each replication, half of the steers were implanted with trenbolone acetate (40 mg) and estradiol (8 mg), and half were not implanted. No implant treatment by endophyte level interactions were detected (P > 0.10). Overall BW gains were greater (P < 0.05) in the implanted groups than in the nonimplanted groups, but serum prolactin concentrations and hair scores did not differ (P > 0.10) between groups on either day 36 or 64. Steers grazing HE pastures had lower (P < 0.01) total BW gain, inferior (P < 0.05) hair scores, and lower (P < 0.01) serum prolactin concentrations on day 64 than those grazing LE pastures. Across forage and implant treatments, overall animal BW gains were negatively correlated with hair scores measured on day 64 (r = –0.28; P < 0.01), and positively correlated with serum prolactin levels measured on days 36 and 64 (r = 0.33 and 0.43, respectively; P < 0.01). Therefore, fescue toxicity symptoms were manifested in HE steers, and implanting with trenbolone acetate and estradiol improved grazing BW gain, but implanting steers with trenbolone acetate and estradiol did not offset the toxic effects of grazing infected fescue.

Introduction

Reductions in animal BW gain due to the presence of infection of tall fescue with *Neotyphodium coenophialum* are well documented (Coffey et al., 1990; Hoveland et al., 1980; 1983; Fribourg et al., 1991; McMurphy et al., 1990). Many products or compounds have been tried in an attempt to reduce the impact of tall fescue toxicity, but most have been unsuccessful or impractical. However, in a fall-grazing study, steers implanted with zeranol (Ralgro, 36 mg) gained 36% faster than nonimplanted steers when grazing high-endophyte (HE) tall fescue, but they gained only 12% faster than nonimplanted steers when grazing low-endophyte (LE) tall fescue (Brazle and Coffey, 1991). Therefore, zeranol actually offset some of the toxic effects of infected fescue in grazing steers. Other estrogenic implants have not shown similar benefits when steers grazed HE fescue (Coffey et al., 1992; Davenport et al., 1993; Beconi et al., 1995). The benefits of implanting steers grazing HE fescue with a combination of an androgenic (trenbolone acetate) and an estrogenic (estradiol) implant have not been determined. The objective of this study was to compare the effects of an androgenic-estrogenic implant combination on growth performance of steers grazing LE- or HE-infected fescue in the spring.

Experimental Procedures

A total of 130 mixed-breed steers (542 ± 7.7 lb) were weighed without prior removal from pasture and water on April 13 and allocated randomly into one of seven groups that were then allocated randomly to either one of four LE-infected or one of three HE-infected fescue pastures. Pastures varied slightly in their acreage and were stocked at two steers per acre. Within each pasture group, half of the cattle were implanted with a combination of 40 mg trenbolone acetate and 8 mg estradiol (Revalor G; Hoescht-Roussel Agri-Vet., Co., Overland Park, KS) and half were not implanted. Calves had ad libitum access to a commercial mineral supplement and were fed no other supplemental feed.

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Calves were weighed on May 19 (day 36) and June 16 (day 64) without prior removal from pasture or water to determine an intermediate and final weight. Groups of calves were comingled prior to weighing and were weighed in random order. A hair score based on a five-point scale (Table 1) was assigned to the calves on day 36 and day 64. Blood samples were collected via jugular venipuncture on those days, and serum prolactin levels were determined.

Pastures were fertilized with 50 lb nitrogen/acre on February 19, and phosphorus and potassium fertilization was applied in the fall. Hand-plucked pasture samples were gathered from multiple random locations within each pasture for ergovaline analysis on day 36. These samples were immediately stored on ice in plastic bags, transported to an ultra-low freezer (–75ºC), and then freeze-dried. Available forage was appraised visually at the beginning of the experiment and on days 36 and 64. Height of leaf canopy and a visual appraisal of forage density were used to estimate available forage on June 16.

Data were analyzed using SAS (SAS Inst., Inc., Cary, NC) procedures for a 2 x 2 factorial arrangement of a split-plot design experiment using initial weight as a covariate. The model included effects of endophyte level, replicate (endophyte level), implant, and the implant x endophyte level interaction. Animal was considered the experimental unit for the implant treatment, and group of animals was considered the experimental unit for endophyte level.

Results and Discussion

The implant treatment x endophyte level interaction was not significant ($P > 0.10$) for any of the measurements evaluated in this experiment. Overall gain by steers grazing LE-infected pastures averaged 34.5 lb (0.54 lb/d) greater ($P < 0.01$) than that by calves grazing HE-infected pastures (Table 2). The majority (64%) of this weight differential occurred between days 36 and 64. During the period from day 0 until day 36, steers grazing LE-infected pastures gained 0.35 lb/d more than those grazing HE-infected pastures, whereas from day 36 until day 64, steers grazing LE-infected pastures gained 0.79 lb/d more than those grazing HE-infected pastures. Others (Crawford et al, 1989; Chestnut et al., 1991; Thompson et al., 1993) have reported seasonal differences in response to the endophytic toxins.

Hair scores did not differ between steers grazing LE- and HE-infected pastures on day 36. However, by day 64, calves grazing LE pastures had lower ($P < 0.05$) hair scores than those grazing HE pastures. Although hair-score data were not analyzed across dates, the apparent difference in scores came from a decrease in those from calves grazing LE pastures. Those calves had almost one full hair score change during the 28-d period between May 19 and June 16, whereas calves grazing HE pastures did not demonstrate a change in hair score during that same period.

Implanted calves gained 0.2 lb/d more ($P < 0.05$) during the 64-d study than nonimplanted calves. Much of this gain differential was accounted for during the first 36-d period; implanted calves gained 0.25 lb/d more ($P < 0.01$) than nonimplanted calves during this period, but gained only 0.13 lb/d more ($P = 0.29$) than nonimplanted calves during the last 28 d. Hair scores did not differ ($P > 0.10$) between implant treatments.

Implant treatment had no effect on serum prolactin concentration. Calves grazing HE-infected pastures had lower serum prolactin levels than those grazing LE-infected pastures.

Implications

Many products have been tried in an attempt to offset the effects of consuming tall fescue toxins; most have met with limited success. Other implants have shown promise in directly reducing some of these toxic effects in the fall, but the combination of trenbolone acetate and estradiol apparently does not offset these toxic effects in the spring. However, in order to improve performance by calves consuming infected fescue, a combination of growth-promoting products will probably have to be used, even though these products do not directly affect the toxic effects of tall fescue. Therefore, in a grazing program with stocker cattle, implanting calves with trenbolone acetate and estradiol could be used to improve weight gains.

Acknowledgments

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Table 1. Hair score scale.

1	Smooth, short (<1/4 in) hair over entire body.
2	Rough hair over 25% of body.
3	Rough hair over 50% of body.
4	Rough hair over 75% of body.
5	Rough hair over entire body.

Table 2. Gain, hair score, and serum prolactin levels of steers grazing high- and low-endophyte tall fescue and implanted with a combination of trenbolone acetate and estradiol.

	Implant effects				Endophyte effects			
	I	NI	SE	P value	HE	LE	SE	P value
Weight day 36,lb	605	596	3.1	0.01	594	607	3.9	0.04
Weight day 64, lb	642	629	4.4	0.01	618	652	6.3	0.01
Gain day 0–36, lb	63	54	3.1	0.01	52	65	3.9	0.04
Gain day 37–64, lb	36	33	3.1	0.29	24	46	6.6	0.04
ADG day 0–36, lb	1.75	1.50	0.085	0.01	1.45	1.80	0.109	0.04
ADG day 37–64, lb	1.30	1.17	0.112	0.30	0.84	1.63	0.234	0.04
Total gain, lb	99	87	4.4	0.01	76	110	6.3	0.01
Daily gain, lb	1.55	1.35	0.068	0.01	1.18	1.72	0.098	0.01
Hair score day 36	3.6	3.4	0.16	0.25	3.3	3.7	0.26	0.24
Hair score day 64	3.2	3.0	0.15	0.36	3.4	2.8	0.16	0.02
Hair change	0.4	0.3	0.14	0.74	–0.1	0.9	0.16	0.01
Prolactin day 36, ng/ml	76	70	13.2	0.70	14	132	13.8	0.01
Prolactin day 64, ng/ml	205	208	36.2	0.95	9	404	37.0	0.01

Means presented are least-squares means.

See Table 1 for description of hair score.

HE = high-endophyte-infected pastures; I = implanted with trenbolone acetate (40 mg) and estradiol (8 mg); LE = low-endophyte-infected pastures; NI = not implanted.

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Effect of Dietary Chromium-L-Methionine on Glucose Metabolism of Beef Calves

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Story in Brief

Thirty-six crossbred steers (635 ± 8.2 lb initial BW) were used to determine the effect of chromium (Cr), as chromium-L-methionine, on glucose tolerance and insulin sensitivity in beef calves. Calves were fed a control diet (55% corn, 38% cottonseed hulls, 5% soybean meal) or the control diet supplemented with 400 or 800 ppb Cr as chromium-L-methionine. On days 21, 22, and 23, four calves per dietary treatment were fitted with an indwelling jugular catheter. Approximately 24 h after catheterization, an intravenous glucose tolerance test (500 mg glucose/kg BW) followed 5 h later by an intravenous insulin challenge test (0.1 IU insulin/kg BW) was conducted. There was no effect ($P > 0.10$) of dietary treatment on ADG or feed intake. During the glucose tolerance test, serum insulin concentrations were increased by supplemental chromium-L-methionine (linear effect of Cr, $P < 0.05$). Supplemental chromium-L-methionine increased the glucose clearance rate from 0 to 10 min after the insulin challenge test (linear effect of Cr, $P < 0.05$). Glucose half-life from 0 to 15 min after the insulin infusion was also decreased by supplemental chromium-L-methionine (linear effect of Cr, $P < 0.03$). These data indicate that supplemental Cr as chromium-L-methionine increased the glucose clearance rate after an insulin infusion and increased the insulin response to an intravenous glucose challenge in growing calves.

Introduction

Chromium (Cr) was first shown to be an essential nutrient for normal glucose metabolism in 1959 in the rat. Chromium is a component of a glucose tolerance factor that potentiates the action of insulin. The bioavailability of Cr sources has been determined on the basis of their ability to alter glucose metabolism. Limited research has investigated the effect of supplemental Cr in cattle diets on glucose metabolism. Supplemental Cr, as chromium picolinate, increased glucose clearance rate and decreased glucose half-life and area under the curve in calves fed corn-cottonseed hull-based diets. In calves fed milk replacer, supplemental Cr, as a chromium-nicotinic acid complex, slowed the return to the basal glucose concentration after an insulin infusion (NRC, 1997). The objective of this experiment was to assess the effect of 400 or 800 ppb supplemental Cr, as chromium-L-methionine, on glucose tolerance and insulin sensitivity of beef calves.

Materials and Methods

Thirty-six crossbred steers initially weighing 635 ± 8 lb were blocked by weight (two blocks) and randomly assigned to pens (three pens per block, six steers per pen). Pens within a block were randomly assigned to a treatment. Steers were kept in drylots and had ad libitum access to water. Twice daily, at 0730 and 1430, calves were moved to a feeding barn containing 36 locking feeding gates, where they were individually offered feed.

Three dietary treatments included either a control diet or the control diet supplemented with 400 or 800 ppb Cr as chromium-L-methionine (Zinpro Corp., Eden Prairie, MN). The diets were formulated to meet or exceed, NRC (1996) recommendations (Table 1). Calves were offered an amount of feed greater than most had consumed on the previous day.

Calves were fed their respective diets for 22, 23, or 24 d. On days 21, 22, and 23, four calves per dietary treatment were fitted with an indwelling jugular catheter. Calves were weighed before the morning feeding on day 21, 22, or 23. The next day, 2 h after being offered the morning feeding, steers were infused intravenously with 0.5 g glucose/kg BW (IVGTT). Five hours later, steers were infused intravenously with 0.1 IU insulin/kg BW (IVICT). Blood samples were obtained immediately before (–10 and 0) and 5, 10, 15, 30, 45, 60, 90, 120, and 150 min after each infusion.

The plasma glucose and serum insulin concentrations after each infusion were analyzed using the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). A spatial structure was used as the covariance structure. The model

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included dietary treatment, block, time, and the time by dietary treatment interaction. The glucose and insulin kinetic data and the growth performance data were analyzed using the GLM procedure of SAS. The model included block and dietary treatment. Individual animal was used as the experimental unit. Least-squares means were reported.

Results and Discussion

There was no effect ($P > 0.10$) of Cr supple-mentation on ADG, DM intake, or feed-to-gain ratio during the 21- to 23-d feeding period (Table 2). Supplemental Cr has increased ADG of calves in some studies; however, in other experiments, it has not affected ADG (NRC, 1997). These variable results may reflect differences in Cr status of the calves, the amount of stress to which the calves had been exposed, the amount and bioavailablity of Cr in the basal diet, or the bioavailablity of the supplemental Cr source.

Intravenous Glucose Tolerance Test. There was a significant time by dietary treatment interaction ($P < 0.05$) on plasma glucose concentrations after the glucose infusion (Figure 1). Plasma glucose concentrations of calves fed 800 ppb supplemental Cr were greater than controls immediately after the glucose infusion, but by 30 min after infusion, those calves had plasma glucose concentrations that were lower than calves fed the control diet. Glucose clearance rates and glucose half-lives after the intravenous glucose tolerance test (Table 2) were not affected ($P > 0.10$) by dietary treatment.

There was a linear effect ($P < 0.05$) of supplemental chromium-L-methionine on serum insulin concentrations after the glucose infusion (Figure 2). Calves fed increasing concentrations of chromium-L-methionine had greater insulin responses than control calves after the glucose infusion. Area under the insulin curve between 0 and 60 min after IVGTT was greater ($P < 0.05$; linear effect of Cr supplementation) for calves supplemented with chromium-L-methionine (Table 2).

Intravenous Insulin Challenge Test. There was a linear effect of supplemental dietary chromium-L-methionine on glucose clearance rates (Table 2) when measured between 0 to 10 min ($P < 0.05$), 5 to 10 min ($P < 0.02$), and 0 to 15 min ($P < 0.07$) after infusion. Steers fed 800 ppb Cr had the greatest glucose clearance rates, whereas steers fed 400 ppb Cr had intermediate rates of glucose clearance. Glucose half-lives were decreased in a linear manner by supplemental Cr from 0 to 10 min ($P < 0.03$), 5 to 10 min ($P < 0.08$), 0 to 15 min ($P < 0.04$), and 0 to 30 min ($P < 0.06$) after infusion.

There was not a time x treatment interaction ($P > 0.10$) on plasma glucose concentrations after the IVICT. There was, however, a linear effect of supplemental chromium-L-methionine ($P < 0.05$) on plasma glucose concentrations after the insulin challenge test (Figure 3). Calves fed increasing concentrations of chromium-L-methionine had reduced concentrations of plasma glucose after the insulin infusion.

There was a time x dietary treatment interaction ($P < 0.01$) on serum insulin concentrations after the insulin infusion (Figure 4). There were also overall linear ($P < 0.04$) and quadratic ($P < 0.04$) effects of supplemental chromium-L-methionine on insulin concentrations after the insulin infusion. Steers fed 800 ppb Cr as chromium-L-methionine had the greatest serum insulin concentrations after the insulin infusion.

Implications

Currently, chromium is not approved for addition to cattle diets. Chromium-L-methionine was a bioavailable source of chromium, altering glucose and insulin metabolism in growing beef calves. More research must be done to determine the impact of this supplemental chromium source on immune function, body composition, and growth performance.

Acknowledgments

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The authors express their appreciation to Pete Hornsby, Gordon Carte, and John Silgar of the Stocker-Receiving Facility in Savoy for the management and care of the experimental animals. Gratitude is extended to J.W. Spears, North Carolina State University, for chromium analysis of the basal diet; to M.T. Socha, Zinpro Corp. for assistance with diet formulation; and to Zelpha Johnson, University of Arkansas, for her assistance with statistical analysis of the data.

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Table 1. Composition of basal diet (as fed basis).[a]

Ingredient	%
Cottonseed hulls	38.3
Corn, cracked	54.8
Soybean meal	5.2
Limestone	0.92
Salt, white	0.17
Urea	0.81
Vitamin premix[b]	+
Trace mineral premix[c]	+

[a] Diet analyzed 88.9% DM, and 11.8% CP, 45.9% neutral detergent fiber, 31.1% acid detergent fiber, 3% ash, and 0.2 ppm chronium (DM basis).

[b] Vitamin premix supplied 1,136 IU of vitamin A, 227 IU of vitamin D, and 0.14 IU of vitamin E/lb of diet.

[c] Trace mineral premix supplied 5 ppm copper as copper sulfate, 20 ppm zinc as zinc sulfate, 0.1 ppm cobalt as cobalt carbonate, 0.5 ppm iodine as calcium iodate, and 0.1 ppm selenium as sodium selenite.

Table 2. Effects of dietary chromium-L-methionine on growth performance, and glucose and insulin kinetics.

	Supplemental chronium, ppb			
	0	400	800	SE
Growth performance				
Initial wt, lb	635	635	635	8.2
Final wt, lb	688	688	686	10.8
ADG, lb	2.38	2.38	2.31	0.324
DM intake, lb/d	14.02	14.22	13.85	0.300
After the intravenous glucose tolerance test				
Glucose clearance rate, %/min				
15 to 30 min	1.53	1.57	1.70	0.125
Area under the insulin curve, μIU of serum insulin/(mL • min)				
0 to 60 min[a]	3571	5205	6604	1000
After the intravenous insulin infusion				
Glucose clearance rate, %/min				
0 to 10 min[a]	1.31	1.64	1.66	0.120
5 to 10 min[a]	2.18	2.73	2.82	0.181
0 to 15 min[b]	1.64	1.99	1.96	0.120
Glucose half-life, min				
0 to 10 min[a]	64.4	43.8	45.1	5.95
5 to 10 min[b]	36.8	26.2	27.0	3.89
0 to 15 min[a]	50.0	35.5	36.9	4.22
0 to 30 min[b]	42.4	33.5	33.0	3.41

[a] Linear effect of Cr supplementation ($P < 0.05$).

[b] Linear effect of Cr supplementation ($P < 0.10$).

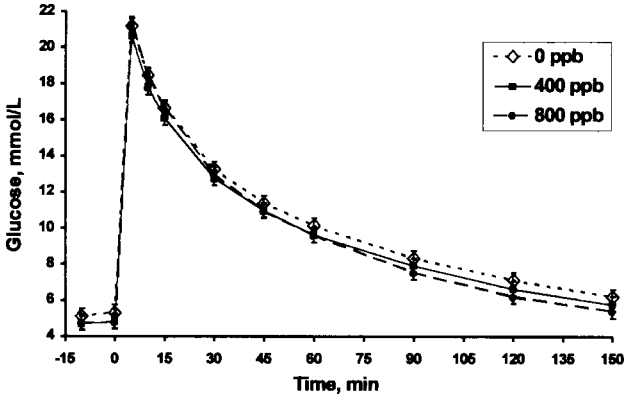

Figure 1. Effect of chromium-L-methionine on plasma glucose concentrations after an intravenous glucose tolerance test. Significant time x dietary treatment interaction (P < 0.05).

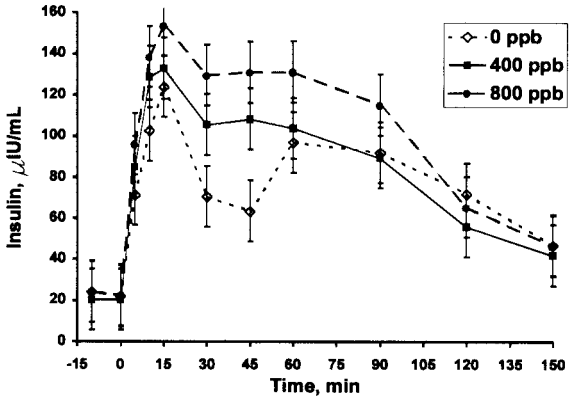

Figure 2. Effect of chromium-L-methionine on serum insulin concentrations after an intravenous glucose tolerance test. Linear effect (P < 0.05) of supplemental chromium-L-methionine.

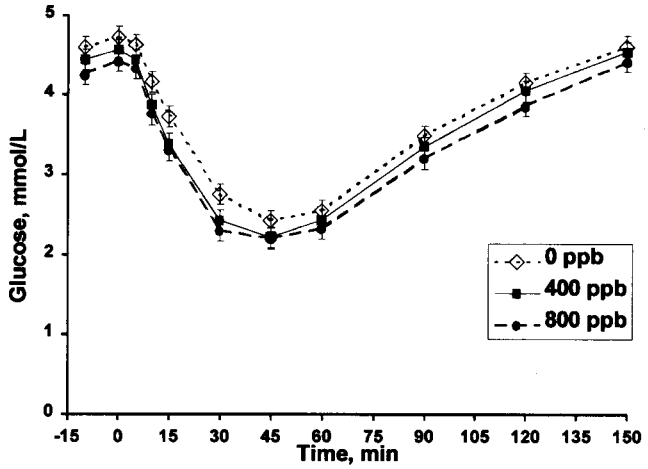

Figure 3. Effect of chromium-L-methionine on plasma glucose concentrations after an intravenous insulin infusion. Linear effect (P < 0.05) of supplemental chromium-L-methionine.

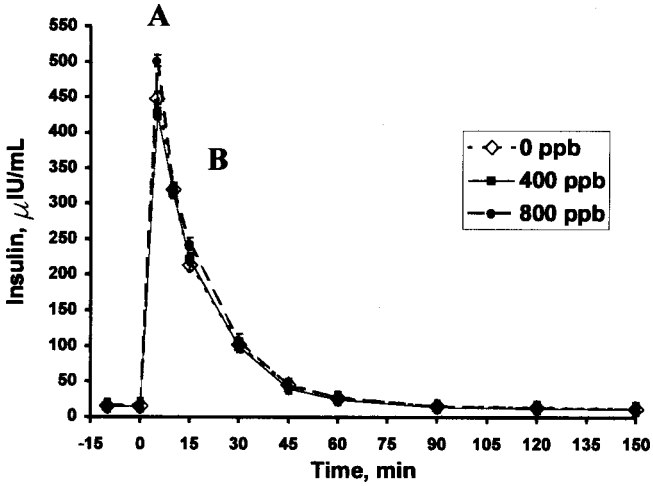

Figure 4. Effect of chromium-L-methionine on serum insulin concentrations after an intravenous infusion. Significant time x dietary treatment interaction (P < 0.01). A = 800 ppb greater (P < 0.01) than 0 and 400 ppb. B = 800 ppb greater (P < 0.05) than 0 ppb.

Interaction of Amprolium and Supplemental Dietary Thiamin on Thiamin Status and Growth Performance of Stressed Calves

S.A. Silzell, E.B. Kegley, K.P. Coffey, and L.B. Daniels[1]

Story in Brief

Ninety-six mixed-breed steers were used for a 35-d trial to determine the effects of amprolium (a coccidiostat) and supplemental thiamin (vitamin B_1) on thiamin status and growth performance of stressed calves. Treatments were 1) no supplemental thiamin and no amprolium, 2) amprolium, 3) supplemental thiamin (147 ppm), and 4) supplemental thiamin (147 ppm) plus amprolium. Amprolium was top-dressed at a rate of 2.3 mg/lb BW for the first 21 d of the study. Calves fed amprolium had increased ($P < 0.01$) ADG from day 0 to 7. Supplemental thiamin tended to increase ADG from day 0 to 21 ($P < 0.10$). Blood thiamin monophosphate concentrations (TMP; day x thiamin interaction) were increased ($P < 0.001$) by supplemental thiamin on every sampling date; however, the magnitude of increase was not as great on day 35 ($P = 0.08$). A day by amprolium interaction was detected on blood TMP ($P < 0.05$) and blood thiamin pyrophosphate (TPP; $P < 0.05$) concentrations. Blood TMP and TPP concentrations were decreased on days 14, 21, and 28 ($P < 0.05$) in the calves fed amprolium, but amprolium did not affect TMP and TPP concentrations on days 7 and 35. Thiamin supplementation had no effect on the number of coccidial oocysts in feces, but calves fed amprolium had reduced numbers of oocysts ($P < 0.05$). Supplemental thiamin and amprolium did not improve overall ADG, ADFI, or feed/gain for the 35-d trial.

Introduction

Loss of body condition, poor gains, and mortality are effects of acute coccidiosis in cattle. The cost of coccidiosis to the cattle producer was estimated to be $54.25 per animal (Fox, 1983). Amprolium is an effective anticoccidial that may be fed to cattle. Amprolium kills coccidia by preventing thiamin uptake and utilization by the protozoa (Coombs et al., 1997). High concentrations of amprolium have also been used to experimentally induce animals to become thiamin deficient (Rammel and Hill, 1986). Therefore, when administering amprolium at a therapeutic level, there is the possibility for alteration of thiamin status in stressed calves. The purpose of this study was to determine the effects of amprolium and supplemental thiamin on thiamin status, growth performance, and coccidial oocyst numbers in stressed calves.

Materials and Methods

Forty-five steers and 51 bulls (465 ± 3.3 lb initial BW) were purchased at sale barns and delivered to the Stocker Research Facility in Savoy. Upon arrival, calves were branded with an electric iron, any horns were tipped, and calves were dewormed (Ivomec, Merial Limited, Iselin, NJ), and ear tagged. Calves were vaccinated against bovine respiratory syncytial virus, infectious bovine rhinotracheitis virus, bovine viral diarrhea, and parainfluenza –3 (BRSV – Vac 4, Bayer Corp., Shawnee Mission, KS). All calves were given a vaccine containing *Pasteurella haemolytica, Pasteurella multocida, Haemophilus somnus,* and *Salmonella typhimurium* (Poly-Bac-HS, Texas Veterinary Labs, San Angelo, TX) and a clostridial toxoid injection (Vision 7 and Vision CD-T, Bayer Corp.). All bulls were castrated by banding (Callicrate Bander, St. Francis, KS). Calves were weighed upon arrival, blocked by weight, stratified by castration and horn tipping, and assigned randomly to pens within a block (four pens/block). Calves were housed in 16 drylot pens with six calves/pen and were given ad libitum access to water. Calves were fed a complete ration (Table 1) once a day. Daily feed intake and any refusals were recorded. Calves were offered a small amount of long hay in addition to the complete ration for the first 5 d of the study. Treatments were 1) no supplemental thiamin and no amprolium, 2) amprolium, 3) supplemental thiamin, and 4) supplemental thiamin plus amprolium. Supplemental thiamin was provided as thiamin mononitrate (Nutra Blend Corp., Neosho, MO) at a rate of 147 ppm. The amprolium (Amprolium 1.25% Cattle Pellets, Nutra Blend Corp.) was top-dressed at a rate of 2.3 mg/lb initial BW for 21 d. Calves were observed daily for signs of morbidity. Any calves observed to be depressed were pulled and rectal temperature was measured. Calves with a rectal temperature greater than 104ºF were treated with antibiotics according to a preplanned antibiotic regimen.

[1] All authors are associated with the Department of Animal Science, Fayetteville.

Two consecutive weights were measured at the beginning and end of the study, and interim body weights were obtained on days 7, 14, 21, and 28. Fecal samples were obtained on days 1, 7, 14, 21, 28, and 35 for coccidia oocyst counts. Blood samples were obtained via jugular venipuncture on days 1, 7, 14, 21, 28, and 35 for blood thiamin monophosphate (TMP) and thiamin pyrophosphate (TPP) concentrations.

Weights, ADG, ADFI, feed/gain, initial concentrations of blood TMP and TPP, incidence of morbidity, medication costs, and number of antibiotic treatments were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Blood TMP and TPP concentrations were analyzed using the MIXED procedure of SAS with day 0 as a covariant. The model included block, thiamin, amprolium, the thiamin x amprolium interaction, day, the day x thiamin interaction, the day x amprolium interaction, the day x thiamin by amprolium interaction and initial concentration as a covariant. The natural log of the coccidia oocyst counts were analyzed using the MIXED procedure of SAS.

Results and Discussion

Average daily gain for the 35-d study (Table 2) was not affected ($P > 0.10$) by dietary supplementation of thiamin or amprolium. Gains during the period from day 0 to 14 were greater in thiamin supplemented calves ($P < 0.05$) compared with those fed no supplemental thiamin. Calves fed amprolium had increased ADG from day 0 to 7 ($P < 0.01$). There was no ($P > 0.10$) thiamin x amprolium interaction on ADG.

The ADFI (Table 2) for day 0 to 35 was not different ($P > 0.10$) among treatments. Average daily feed intake from day 0 to 28 had a tendency for a thiamin by amprolium interaction ($P = 0.10$). Amprolium decreased ($P < 0.05$) ADFI among calves fed no supplemental thiamin, but ADFI did not differ among other treatment combinations. The feed/gain from day 0 to 21 tended to improve as a result of thiamin supplementation ($P = 0.08$). There were no differences in the feed/gain over the entire 35-d study because of supplemental thiamin or amprolium.

Zinn et al. (1987) reported that feeding two levels of supplemental thiamin (20 or 200 mg thiamin/d) to stressed calves reduced morbidity the first 10 d of a 56-d study. In the present study, there were no differences ($P > 0.10$) due to supplemental thiamin or amprolium on morbidity rates, or medication costs (data not shown).

There was a day x thiamin interaction on TMP concentrations ($P < 0.001$; Figure 1). Thiamin monophosphate concentrations were increased by supplemental thiamin ($P < 0.001$) on days 7, 14, 21, and 28; however, the magnitude of increase was not as great on day 35 ($P = 0.08$). A thiamin x day interaction ($P < 0.01$) was detected on TPP concentrations, with an increase in TPP concentrations on days 7, 14, and 21 ($P < 0.001$) due to thiamin supplementation. A day x amprolium interaction was detected on TMP ($P < 0.05$) and TPP ($P < 0.05$) concentrations. Thiamin monophosphate and TPP concentrations were decreased on days 14, 21, and 28 ($P < 0.05$) in the calves fed amprolium, but were not different on day 7 and 35.

Coccidial oocyst counts (Table 2) decreased ($P < 0.05$) when amprolium was fed. There was also an effect of day on number of oocysts present ($P < 0.001$), with the greatest numbers observed on day 1 ($P < 0.001$). Numbers of oocysts and incidence of oocyst presence were greater on days 28 and 35 than on day 14 ($P < 0.05$). Cattle fed amprolium also had lower incidence of coccidial oocyst presence ($P < 0.05$). There was no thiamin x amprolium interaction detected on fecal oocyst numbers or the incidence of oocyst presence. Supplementation of thiamin did not interfere with the efficacy of the amprolium.

Implications

Amprolium reduced thiamin status compared to controls in stressed receiving cattle; however, there were no clinical incidences of thiamin deficiency (polioencepholomacia), and no detrimental effects on growth performance as a result of using amprolium for 21 d as a coccidiostat. Dietary thiamin supplementation did increase thiamin concentrations in blood and did not interfere with the efficacy of amprolium.

Acknowledgment

The authors acknowledge T.A. Yazwinski and C. Tucker for their expertise and assistance with the Coccidia data collection; K. Beers for HPLC analysis; Z. B. Johnson for assistance with statistical analysis; and J.A. Hornsby, G. Carte, and J. Silgar for the management and care of the experimental animals.

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Table 1. Ingredient and chemical composition of basal diets, DM basis.[a]

Ingredient	%
Corn, cracked	52.25
Cottonseed hulls	30.05
Fat	1.13
Soybean meal	11.23
Molasses, mixture of cane and beet	3.41
Dicalcium phosphate	0.44
Limestone	1.31
Salt, white	0.16
Vitamin A, D, E premix[b]	0.01
Trace mineral premix[c]	0.01

[a] Diets contained 0 or 147 ppm of thiamin as thiamin mononitrate. Diets analyzed to contain 87% DM, 12% CP, 24.4% acid detergent fiber, 39.5% neutral detergent fiber, and 4.65% ash.

[b] Vitamin A, D, E premix added to provide 2,000 IU vitamin A, 400 IU vitamin D, and 5.3 IU vitamin E/lb diet.

[c] Trace minerals added to provide 26 ppm zinc as zinc sulfate, and 0.1 ppm selenium as sodium selenite.

Table 2. Effect of amprolium and supplemental thiamin on growth performance, number of oocysts, and incidence of coccidial oocyst presence of stressed calves.

	Control		Thiamin[a]			
	No amprolium[b]	Amprolium	No amprolium	Amprolium	SE	Significance
ADG, lb						
Day 0 to 7	1.8	2.9	2.4	3.3	0.26	T†, A**
Day 0 to 14	1.2	1.4	1.9	2.2	0.32	T*
Day 0 to 21	2.0	1.8	2.4	2.4	0.27	T†
Day 0 to 28	2.8	2.4	2.9	2.7	0.21	
Day 0 to 35	2.3	2.3	2.6	2.6	0.24	
Day 21 to 35	2.9	3.0	3.0	2.8	0.38	
ADFI, lb						
Day 0 to 7	8.1	8.0	8.1	8.7	0.25	
Day 0 to 14	9.4^{x,y}	8.4^{y}	9.0^{x,y}	9.7^{x}	0.37	T x A†
Day 0 to 21	10.6^{x,y}	9.2^{y}	10.4^{x,y}	10.7^{x}	0.46	T x A†
Day 0 to 28	11.9^{x,y}	10.3^{z}	11.7^{y}	11.8^{y}	0.45	T x A†
Day 0 to 35	12.7	11.3	12.7	12.7	0.42	
Day 21 to 35	15.9	14.6	16.2	15.7	0.50	A†
Feed/gain						
Day 0 to 7	5.6	2.9	9.4	2.7	3.12	
Day 0 to 14	9.7	8.3	5.0	4.7	1.56	T*
Day 0 to 21	5.7	5.3	4.3	4.5	0.48	T†
Day 0 to 28	4.3	4.2	4.0	4.4	0.22	
Day 0 to 35	5.7	5.0	4.9	5.0	0.41	
Day 21 to 35	6.2	4.8	5.7	5.9	0.84	
Oocysts, No./g of feces (geometric mean)[c]						A*, D***
Day 0	52.9	46.5	53.6	53.3	0.31	
Day 7	4.3	0.3	1.6	0.6	0.31	
Day 14	0.6	0.4	0.7	0.01	0.31	
Day 21	1.3	0.2	1.3	1.2	0.31	
Day 28	1.7	0.1	4.2	1.5	0.31	
Day 35	0.5	0.8	4.4	2.2	0.31	
Incidence of oocyst presence, %						A*, D***
Day 0	96	92	92	96	7.4	
Day 7	49	25	33	29	7.4	
Day 14	25	21	29	4	7.4	
Day 21	29	17	33	25	7.4	
Day 28	42	12	46	38	7.4	
Day 35	25	33	42	38	7.4	

Means within the same row lacking common superscripts differ (P < 0.05).

A = effect of amprolium; T = effect of supplemental thiamin; T x A = thiamin by amprolium interaction;

D = effect of day.

[a] Thiamin supplemented to provide 147 ppm thiamin.

[b] With or without amprolium (2.3 mg/lb initial BW) from day 1 to 21.

[c] Counts were log-transformed for statistical analysis and geometric means are shown.

† P < 0.10. *P < 0.05. **P < 0.01. ***P < 0.001.

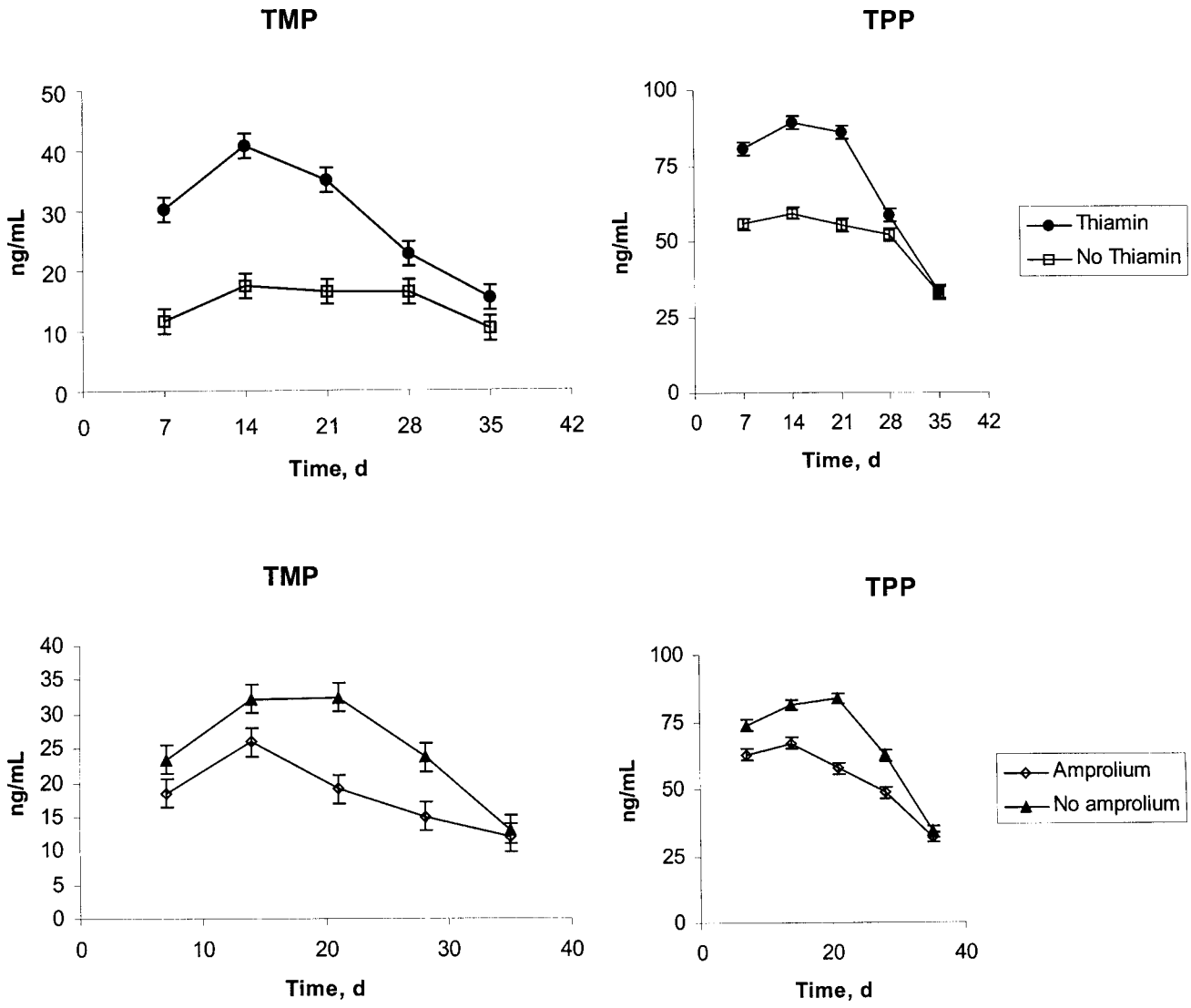

Figure 1. Main effects of supplemental thiamin and amprolium on blood thiamin monophosphate (TMP) and thiamin pyrophosphate (TPP) concentrations.

Prediction of Mature Weight and Maturing Rate From Body Measurements Taken on Angus and Charolais Calves at Birth

Z.B. Johnson, A.H. Brown, Jr., C.F. Rosenkrans, Jr., and J.A. Hornsby[1]

Story in Brief

The objective of this study was to use body measurements taken at birth to predict mature weight and maturing rate of mature cows. Body measurements for length of rear leg from hook to dewclaw (LL), circumference of forearm (FA), heart girth circumference (HG), body length from point of shoulder to pin bone (BL), width at loin (WL), width at hip (WH), and depth at chest (DC) were taken within 24 h of birth on 131 purebred Angus and 39 Charolais female calves in 1992, 1993, and 1994. Fifty-four Angus and 20 Charolais remained in the herd long enough to obtain estimates of mature weight (A) and maturing rate (k) using Brody's model. Stepwise regression procedures were used to determine which traits would be predictors of A and k. Stepwise regression including the seven body measurements gave the following equation for A: A = –507.32 + 126.20 (LL) + 91.70 (FA) + 6.25 (BL) + 171.41 (WL) – 121.27 (DC). The R^2 value was 0.46. For k the equation was 0.10018 – 0.00096 (BL) with an R^2 value of 0.29. Including early weights and gains in models for A did not give higher R^2 values. Including early gains in the model for k gave the equation: k = 0.08135 – 0.00091 (BL) + 0.01510 (ADG from 240 to 360 d) with an R^2 of 0.32. Results of this study indicate that body measurements taken at birth may be useful in predicting mature weight and maturing rate of cows. Higher R^2 values were obtained for A than for k; however, more traits were retained in the model.

Introduction

Growth curves generated from weight-age data have been used by many workers to describe growth and development of cattle. Two parameters of these curves have biological meaning: a size parameter, usually evaluated as weight at maturity (A), and growth rate relative to body size, commonly referred to as maturing rate (k). Fitzhugh and Taylor (1971) suggested that individual differences in rate of maturing are likely to be associated with differences in production efficiency. Also rate of maturing and mature weight have been found to be related to lifetime production characters of the cow.

The parameters A and k can be obtained only in retrospect from mature animals, after growth is completed. They need to be predictable early in the life of the animal to be useful in selection programs. It has been suggested by some researchers (Beltran et al., 1992) that the inclusion of some measurement of skeletal size could improve the accuracy of equations for estimating mature weight and maturing rate. The objective of this study was to examine the feasibility of using body measurements taken at birth to predict growth curve parameters of mature cows.

Materials and Methods

Animals used were female Angus and Charolais calves born in the respective University of Arkansas purebred herds in 1992, 1993, and 1994. Body measurements for length of rear leg from hook to dewclaw (LL), circumference of forearm (FA), heart girth circumference (HG), body length from point of shoulder to pin bone (BL), width at loin (WL), width at hip (WH), and depth at chest (DC) were taken within 24 h of birth on 131 purebred Angus and 39 Charolais female calves.

Fifty-four Angus and 20 Charolais remained in the herd long enough to obtain estimates of A and k using Brody's model which is as follows: $W_t = A - B\ e^{(-kt)}$ where A, B, and k are parameters to be estimated, t is age measured in months, and W_t is body weight at time t. The parameter B is a constant of integration necessary for accurate curve fit, especially at early ages, and e is the base of natural logarithms.

Correlation and stepwise regression procedures were used to determine which traits would be predictors of A and k. Early weights and ADG (up to 1 yr of age) were also included in some models. Three models were examined by stepwise regression in an attempt to predict A and k. The

[1] All authors are associated with the Department of Animal Science, Fayetteville.

first model included only body measurements taken at birth; the second included the body measurements and early weights. The third included the body measurements and early ADG. Traits were retained if the regression coefficients were significant at the $P < 0.15$ level.

Results and Discussion

Means for body measurements, weights, and ADG for the 131 Angus and 39 Charolais calves that were measured are presented in Table 1, and corresponding means for the 54 Angus and 20 Charolais calves that remained long enough to have growth curves generated, as well as mean growth curve parameters for this group, are presented in Table 2. Measurements were larger for Charolais than for Angus and, in general, only slightly different between the two groups of animals within breed. As would be expected, Charolais were heavier than Angus at all times, with the group of cattle kept long enough to generate growth curves being slightly heavier than the group of all cattle measured up to 205 d of age. There did not appear to be much difference in ADG between the two groups within a breed. Charolais gained faster than Angus at earlier intervals, and Angus gained faster than Charolais at later intervals. Angus matured faster ($k = 0.0584$ vs. 0.0502) but to a smaller size than Charolais ($A = 1154$ vs. 1404 lb).

All body measurements were correlated with A (Table 3; $P < 0.01$). Body length ($r = –0.54$; $P < 0.01$), forearm circumference ($r = –0.20$; $P < 0.10$), and width of loin ($r = –0.20$; $P < 0.10$) were correlated with k. All measurements were positively correlated with A and negatively correlated with k. All early weights were positively correlated with A ($P < 0.01$) but showed no relationship to k. Early ADG values (that is for intervals that begin with birth weight) were correlated with A ($P < 0.05$), while the opposite was true for k. The ADG traits ending at 360 d of age (specifically ADG from 120 to 360 d, ADG from 205 to 360 d, and ADG from 240 to 360 d) were correlated with k ($P < 0.05$).

Results for the stepwise regression analyses for A using three different models are presented in Table 4. The highest R^2 (0.46) was found with Model 1 (using body measurements only) where five of the seven body measurements were kept in the model. Including early weights (Model 2) gave a model that dropped three measurements and kept weight at 240 d of age. The R^2 was slightly smaller (0.42), but fewer traits were kept. Including ADG rather than weights in Model 3 gave an R^2 of 0.44. Body length and width at loin were kept in all three models.

Model 1 and Model 2 gave the same results for k (Table 4), where only body length was kept in the model with an R^2 of 0.29. Adding ADG traits in Model 3 increased the R^2 slightly to 0.32 and added the trait ADG from 205 to 360 d of age.

Previous investigators at Arkansas (Johnson, 1990) used birth and 360-d weights to predict A and k. Values of R^2 were 0.05 and 0.19 for A and k, respectively. Adding birth and 360-d weight of the dam increased R^2 values slightly to 0.06 and 0.20. Furthermore, adding various combinations of birth and 360-d weights of sire, maternal and paternal grandsires, and granddams increased R^2 values, but the number of observations became so low that the model was not significant in most cases.

Results of this study indicate that body measurements taken at birth may be useful in predicting mature weight and maturing rate of cows. Higher R^2 values were obtained for A than for k; however, more traits were retained in the model. Body length, in particular, seemed to be related to both parameters A and k. Width at loin was important for A but not k.

Implications

Early prediction of mature weight and maturing rate would allow producers the opportunity to identify a mature size range for their production resources, and once mature size is established, then to select for early maturing cattle to that particular mature size. As long as selection is in the linear phase of growth, selection for ADG would be similar to selection for maturing rate. Some breed associations are already using genetic prediction for mature weight, and the inclusion of maturing rate in genetic prediction would aid producers in the correct match of cattle to production resources. Additional research is needed to further characterize biological types and to determine the biological type that matches each production resource.

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Table 1. Means for body measurements taken at birth and early weights and gains by breed for female Angus and Charolais calves.

	Angus			Charolais		
Trait	n	Mean	SD	n	Mean	SD
Body measurement, in						
Leg length	131	9.75	0.72	39	11.16	0.53
Forearm circumference	129	6.84	0.49	39	7.72	0.52
Heart girth circumference	129	26.85	1.71	39	28.63	1.60
Body length	128	42.11	12.73	39	47.57	12.88
Width at loin	131	4.17	0.40	39	4.64	0.44
Width at hip	131	7.09	0.49	39	8.19	0.55
Depth at chest	131	10.15	0.71	39	10.83	0.59
Weight, lb						
Birth weight	131	69.21	11.86	39	89.72	12.31
Weight at 120 d of age	125	263.06	50.28	35	318.46	56.79
Weight at 205 d of age	102	382.60	51.44	28	470.36	67.02
Weight at 240 d of age	88	423.84	51.23	26	495.96	57.89
Weight at 360 d of age	85	566.73	62.00	26	629.65	80.73
ADG, lb						
Birth to 120 d of age	125	1.61	0.36	35	1.91	0.43
Birth to 205 d of age	102	1.52	0.23	28	1.84	0.30
Birth to 240 d of age	88	1.46	0.19	26	1.67	0.22
Birth to 360 d of age	85	1.37	0.16	26	1.49	0.22
120 to 205 d of age	101	1.28	0.24	26	1.62	0.29
120 to 240 d of age	87	1.19	0.21	24	1.28	0.24
120 to 360 d of age	84	1.19	0.17	24	1.19	0.25
205 to 240 d of age	88	0.91	0.71	26	0.48	0.59
205 to 360 d of age	85	1.13	0.26	26	0.97	0.32
240 to 360 d of age	85	1.21	0.32	26	1.11	0.42

Table 2. Means for body measurements taken at birth, early weights, and gains and growth parameters by breed for female Angus and Charolais calves.

	Angus (n = 54)		Charolais (n = 20)	
Trait	Mean	SD	Mean	SD
Body measurement, in				
Leg length	10.00	0.54	11.31	0.47
Forearm circumference	7.01	0.48	7.91	0.52
Heart girth circumference	27.68	1.29	29.20	1.49
Body length	45.28	11.92	46.60	14.04
Width at loin	4.30	0.38	4.75	0.34
Width at hip	7.30	0.44	8.30	0.56
Depth at chest	10.46	0.63	11.07	0.59
Weight, lb				
Birth weight	74.19	9.86	94.15	11.43
Weight at 120 d of age	281.81	37.42	347.50	46.27
Weight at 205 d of age	390.00	43.86	486.60	59.54
Weight at 240 d of age	425.13	51.70	500.20	62.32
Weight at 360 d of age	573.54	61.67	624.35	70.60
ADG, lb				
Birth to 120 d of age	1.73	0.28	2.11	0.34
Birth to 205 d of age	1.54	0.20	1.91	0.27
Birth to 240 d of age	1.46	0.20	1.69	0.23
Birth to 360 d of age	1.39	0.16	1.47	0.18
120 to 205 d of age	1.27	0.19	1.64	0.29
120 to 240 d of age	1.19	0.21	1.27	0.26
120 to 360 d of age	1.21	0.17	1.15	0.16
205 to 240 d of age	1.00	0.67	0.39	0.55
205 to 360 d of age	1.18	0.24	0.89	0.16
240 to 360 d of age	1.24	0.31	1.03	0.21
Growth parameters[a]				
A, lb	1153.82	223.19	1403.73	219.34
B, lb	1085.83	183.46	1289.40	187.26
k, rate/mo	0.0584	0.0242	0.0502	0.0143

[a] A estimated from model: $W_t = A - B\ e^{(-kt)}$ where A, B, and k are parameters to be estimated, t is age measured in months, and W_t is body weight at time t. The parameter B is a constant of integration necessary for accurate curve fit, especially at early ages, and e is the base of natural logarithms.

Table 3. Correlations of body measurements taken at birth and early weights and gains with growth parameters A and k.

Trait	Correlation with: A	k
Body measurement, in		
Length leg	0.51**	–0.14
Forearm circumference	0.50**	–0.20+
Heart girth circumference	0.48**	–0.10
Body length	0.32**	–0.54**
Width at loin	0.51**	–0.20†
Width at hip	0.54**	–0.18
Depth at chest	0.35**	–0.13
Weights, lb		
Birth weight	0.50**	–0.17
Weight at 120 d of age	0.45**	–0.05
Weight at 205 d of age	0.45**	–0.01
Weight at 240 d of age	0.47**	0.01
Weight at 360 d of age	0.39**	0.13
ADG, lb		
Birth to120 d of age	0.39*	–0.01
Birth to 205 d of age	0.40**	0.04
Birth to 240 d of age	0.42**	0.04
Birth to 360 d of age	0.33**	0.19
120 to 205 d of age	0.30**	0.09
120 to 240 d of age	0.27*	0.09
120 to 360 d of age	0.11	0.28*
205 to 240 d of age	0.01	0.01
205 to 360 d of age	–0.07	0.23*
240 to 360 d of age	–0.09	0.25*

† $P < 0.10$.

* $P < 0.05$.

** $P < 0.01$.

Table 4. Results of stepwise regression[a] using body measurements at birth to predict growth parameters, A and k.

Trait	A	k
Model 1[b]		
Intercept	–507.32	0.10018
Length of leg	126.20	
Forearm circumference	91.70	
Body length	6.25	–0.00096
Width at loin	171.41	
Depth at chest	–121.27	
R^2	0.46	0.29
Model 2		
Intercept	–457.66	0.10018
Body length	6.31	–0.00096
Width at loin	182.09	
Weight at 240 d of age	1.31	
R^2	.42	0.29
Model 3		
Intercept	–668.70	0.08135
Body length	6.43	–0.00091
Width at loin	131.07	
Width at hips	95.19	
ADG 120 to 205 d of age	215.24	
ADG 205 to 360 d of age		0.01510
R^2	0.44	0.32

[a] Regression coefficients for variables retained in stepwise regression are shown. All variables left in the model are significant at the 0.15 level.

[b] Model 1 included measurement traits only, Model 2 included measurement traits and early weights, and Model 3 included measurement traits and early ADG traits.

Heritability of Lactate Dehydrogenase Activity in Replacement Beef Heifers

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Story in Brief

Beef heifers (n = 193) from 26 sires representing Angus, Charolais, Hereford, and Red Poll breeds were used to estimate coefficients of heritability for lactate dehydrogenase (LDH) activity. After weaning, heifers were developed as contemporaries on mixed-grass pasture with grain supplement (0.37% $BW^{.75}$). Blood samples were drawn and serum harvested from heifers at weaning (7 to 8 mo of age), yearling (11 to 12 mo of age), and prebreeding (13 to 14 mo of age). Colorimetric assays were used to determine LDH activity and protein concentration of frozen/thawed serum samples for each heifer at each time point. Activity of LDH was corrected for protein concentration and was expressed as international units per milligram of protein at each collection time (LDHW, LDWY, and LDHPB, respectively). Heritabilities were calculated using an animal model and derivative-free restricted maximum likelihood methodology. Heritabilities for LDH at weaning, yearling, and prebreeding were 0.22, 0.32, and 0.13, respectively. These data suggest that LDH at the yearling stage would be useful in artificial selection and may be useful as a tool for selecting replacement beef heifers.

Introduction

Improvement of growth, as indicated by live weight, is an objective of most modern breeding programs. This is due to the fact that rate of growth affects efficiency of production. Generally, growth can be defined as the directive coordination of all physiological processes until maturity is reached. Physiological markers may serve as useful tools for selecting animals, provided the marker is moderately to highly heritable. Lactate dehydrogenase (LDH) activity may have potential for use as a physiological marker (Paria et al., 1997; Rosenkrans et al., 1998). Activity of LDH is representative of anaerobic glycolytic metabolism in the cell and is associated with growth and maturation in mice (Markert and Ursprung, 1962; Markert et al., 1975), cattle (Kaneko, 1989; Renand et al., 1995 ; Paria et al., 1997), and swine (Larzul et al., 1997). Based on these findings, our objective was to estimate heritabilites for serum LDH activity in replacement heifers at weaning, yearling, and prebreeding stages.

Materials and Methods

Data were obtained from replacement heifers in the registered Angus, Charolais, Hereford, and Red Poll herds of the University of Arkansas Agricultural Experiment Station near Savoy. Heifers were spring-born and weaned in the fall. After weaning, heifers were developed as contemporaries on common bermudagrass *(Cynodon dactylon*) and tall fescue (*Festuca arundinacea*) pastures, which were overseeded with winter annuals of wheat (*Triticum acstiuum*), ryegrass (*Lolium multiforum*), and the cool-season perennial red clover (*Trifolium pratence*). In addition, heifers received a daily supplement consisting of cracked corn, soybean meal, vitamins A, D, and E, limestone, and molasses. Average daily supplement on pasture from weaning (7 mo of age) to breeding (13 to 14 mo of age) was 0.37% $BW^{.75}$. Stocking rate on pasture was one heifer/acre, and daily feed was provided when all heifers were present at the feed bunk. Each heifer had 24 in of linear bunk space, which was adequate for each heifer to have received feed.

Most heifers weaned in the herd started the developmental process. There were two primary reasons for heifers being culled. First, heifers were culled at weaning, yearling, and prebreeding stages based on frame score, BW gain, and structural incorrectness. Second, heifers were culled if they did not conceive during the breeding period or if they did not wean a calf in their first parity. Most of the heifers that were culled failed to conceive at 14 to 15 mo of age. This made annual average heifer replacement about 20% in each breed group.

Blood samples were collected by jugular venipuncture at weaning (7 to 8 mo of age), yearling (11 to 12 mo of age), and prebreeding (13 to14 mo of age). Samples were allowed to clot overnight at 5ºC, then centrifuged at 2,300 x *g* for 30 min.

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Serum was decanted and stored at –20ºC until assayed for LDH activity and protein concentration. Serum samples drawn from heifers that experienced chronic illness and (or) extreme injury were not assayed. A distribution of serum samples that were assayed are shown by breed and year in Table 1.

Lactate dehydrogenase activity in each serum sample was evaluated using a quantitative, colorimetric assay kit from Sigma Diagnostics (St. Louis, MO), and values were adjusted for protein concentration. Total protein concentrations were determined using the Biuret method (Oser, 1965). Lactate dehydrogenase activity was expressed as international units per milligram of protein at weaning (LDHW), yearling (LDHY), and prebreeding (LDHPB).

Data were analyzed by restricted maximum likelihood (REML) methodology. Variance components for LDHW, LDHY, and LDHPB were estimated using an animal model with the multiple-trait derivative-free maximum likelihood (MTDFREML) program (Boldman et al., 1993). Included in the model were the fixed effects of year and breed, age as a covariate, and random animal effects. A three-generation pedigree was available for each animal, and relationships were included in the analysis. Heritabilities were calculated as the additive genetic variance divided by the total variance for each trait.

Results and Discussion

Table 2 presents the estimates of heritabilities for LDHW, LDHY, and LDHPB. The heritability for LDHY was higher than that for LDHW and LDHPB. The heifers had a more uniform environment during the postweaning phase of development, which could account for the higher heritability of LDHY.

The heritability of LDHPB was less than that of LDHW and LDHY. Perhaps the lesser heritability of LDHPB resulted from less phenotypic resemblance among relatives due to different states of metabolism associated with different rates of maturing among heifers (Brown and Stallcup, 1968; Prasse, 1969). Mean maturity rate differences for Angus, Charolais, Hereford, and Red Poll breed groups represented by heifers in this study are discussed by Brown et al. (1991).

In these data, mean LDH activity increased from 6.13 IU/mg protein at weaning to 7.67 IU/mg protein at yearling and then decreased to 7.45 IU/mg protein at prebreeding. Decreases in mean LDH activity with the progression of maturity corresponds with the general concept that the lower inflection point on the growth curve is the point at which the impetus for lean growth declines and the impetus for fattening begins. This concept is supported by Goodhart and Shils (1980) and Renand et al. (1995), who reported that LDH activity is related to the proportion of BW that is in lean muscle mass. Lactate dehydrogenase activity was correlated (r = 0.25) with protein and DNA content in homogenized bovine muscle tissue (Jurie et al., 1995). Cellular restructuring is another factor that might account for changes in serum total LDH activity (Prasse, 1969 and Lauerman et al., 1982). Total LDH should not, however, reflect cell restructuring because the observations for heifers that had chronic illness or extreme injury were deleted.

In our study, heritabilities for serum LDHW, LDHY, and LDHPB estimated with the animal model were moderate (0.22 and 0.32), and low (0.13), respectively (Table 3). Our estimates of heritability for serum LDHW and LDHPB were lower than the estimate (0.31) for muscle tissue LDH in Limousin cattle reported by Renand et al. (1995) and lower than the estimate (0.27) of plasma LDH in lactating dairy cattle reported by Torekhanov (1993), but our estimate of heritability of serum LDHY was greater than estimates reported by these scientists. Our heritability of LDHY was greater than the estimate of 0.31 for LDH activity in blood plasma, heart, and muscle tissue in mice reported by Major and Tawfik (1981). Our findings, and the findings of others, suggest a larger additive genetic effect and a lesser environmental effect for LDH activity. An exception was Maier et al. (1983) who reported a high environmental effect for LDH activity in Goltingen miniature pigs.

Estimates of heritability may be biased by selection if one sire's progeny is culled more frequently than progeny of other sires or if animals of one breed are culled more severely than those of other breeds in the sample. A small number of heifers were culled during the developmental process based on poor performance; this should not have been an important source of bias in these data, because the culling rate was about equally distributed across sires and breeds so no one sire's progeny or no one breed was discriminated against more than others.

Other researchers have recognized the potential for using blood and tissue enzyme activity as selection traits in cattle, pigs, and mice. Green et al. (1990) and Salak et al. (1990) reported coefficients of heritability for selected measures of immune response in cattle and pigs, respectively. Torekhanov (1993) reported that blood metabolites could be used in selection because they are heritable and related to milking capacity in dairy cattle. Renand et al. (1995) reported that metabolic enzyme activity in muscle tissue of cattle is moderately heritable. Larzul et al. (1997) estimated the heritability of metabolic enzymes in pig skeletal muscle. Maier et al. (1993) calculated coefficients of heritability of metabolic enzymes in miniature pigs. Major and Tawfik (1981) stated that heritability coefficients showed a high additive genetic effect on enzyme activity in blood plasma, heart, and muscle tissue in mice.

Implications

These data suggest that total serum LDH in yearling beef heifer, as an indicator of growth and composition, could be used as a selection trait. They suggest that LDH may be a physiological marker useful in selection.

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Table 1. Distribution of serum samples at weaning, yearling, and prebreeding stages by breed and year.

	Serum samples			
Breed	Weaning	Yearling	Prebreeding	Total
Angus	91	90	88	269
Charolais	27	26	26	79
Hereford	52	48	51	151
Red Poll	28	28	28	84
Total	198	192	193	583
Year	Weaning	Yearling	Prebreeding	Total
1991	69	68	69	206
1992	62	57	60	179
1993	67	67	64	198
Total	198	192	193	583

Table 2. Heritability estimates for LDHW, LDHY, and LDHPB activity.[a]

Trait[b]	Heritability estimate
LDHW	0.22
LDHY	0.32
LDHPB	0.13

[a] LDHW = lactate dehydrogenase activity at weaning (7 mo of age); LDHY = lactate dehydrogenase activity at yearling stage (11 to 12 mo of age); LDHPB = lactate dehydrogenase activity at prebreeding stage (13 to 14 mo of age).

[b] IU/mg protein = adjusted for total protein concentration.

Reduction of Microbial Pathogens in Ground Beef Utilizing Hurdle Technology and a Novel Ozone Generator

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Story in Brief

The objective of this study was to utilize multiple antimicrobial interventions (hurdle technology) to reduce the microbial load in ground beef. To do this, frozen beef trim was thawed to 4ºC and inoculated with a mixture of *Escherichia coli* (ATCC #11775; EC) and *Salmonella typhimurium* (1769NR; ST). Next, antimicrobial treatments were applied in combinations as follows: 1) 1% ozonated water (15 min) and 5% acetic acid (OA), 2) 1% ozonated water (15 min) and 0.5% cetylpyridinium chloride (OC), 3) 200 ppm chlorine dioxide and 10% trisodium phosphate (CT), or 4) an untreated control (C). Trim was ground twice, placed in overwrapped trays, and stored under simulated retail conditions. Packages were evaluated on days 0, 1, 2, 3, and 7 of display for aerobic plate count, coliform, EC, ST, instrumental color, and sensory color and odor characteristics. Both OA and OC treatments were effective ($P < 0.05$) for controlling all microorganisms monitored, and ground beef from these treatments was lighter in color through display than beef in the C or CT treatments. The CT treatment was effective ($P < 0.05$) for reducing all monitored microorganisms except ST, and ground beef from this treatment maintained a redder and darker color ($P < 0.05$) than beef from all other treatments by day 7 of display. Sensory panelists did not detect ($P < 0.05$) odor differences between OC, CT, and C treatments. Also, sensory panelists indicated ($P < 0.05$) that ground beef from the CT treatment was brighter red in overall color and worst point color and had less surface discoloration than ground beef from the control. Therefore, it is possible to control microbial growth in ground beef by using multiple interventions while maintaining or improving color and odor characteristics.

Introduction

Although ground beef is a staple commodity, there has been limited research evaluating methods for improving its safety. In the past, the majority of meat safety research has focused on carcass microbial decontamination. Although such technologies as carcass washes and pasteurization have addressed slaughter contamination, these methods offer little protection during further processing.

Compounds such as trisodium phosphate, cetylpyridinium chloride, chlorine dioxide, and ozone have all been effective for reducing *Escherichia coli* O157:H7 and *Salmonella typhimurium* on poultry and beef carcasses (Dickson et al., 1992; Kim et al., 1996); however, it would be advantageous for these technologies to be applied closer to the finished product to protect against processing contamination. In addition to single-intervention technologies previously described, it would be beneficial to use hurdles to attack individual microorganism species weaknesses and supply an added degree of protection should a single intervention fail (Graves-Demore et al., 1998). Therefore, the objective of this research was to determine whether the use of multiple antimicrobial interventions on beef trimmings prior to grinding could reduce the microbial load and improve the safety of ground beef, while maintaining color and odor quality.

Experimental Procedures

Boneless, frozen (–20ºC) cow beef trimmings were thawed to 4 ºC and inoculated with *E. coli* (ATCC #11775) and a nalidixic acid resistant strain of *S. typhimurium* (ATCC #1769NR). Inoculums were prepared from frozen (–80ºC) stock cultures that were maintained by brain heart infusion (BHI) broth with glycerol (20%). Frozen cultures of *S. typhimurium* and *E. coli* were thawed, and 0.1 ml of each culture was inoculated into separate 40-ml aliquots of BHI broth and incubated for 18 h at 37ºC. Bacteria were harvested by centrifugation (3460 x *g* for 20 min at 37ºC); resuspended in the same volume of 0.1% peptone water, and then pooled together (1600 ml of *E. coli* and 1600 ml of *S. typhimurium*) to make a bacterial cocktail. The cocktail (3200 ml; log 10^7/ml *E. coli* and log 10^7/ml *Salmonella typhimurium*) was cooled to 4ºC and poured into a container with the meat (24 lb) and

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allowed to attach for 1 h. The meat was then drained and separated into 6-lb sub-batches and placed in a 4ºC cooler for 12 to 14 h to allow further microbial attachment.

The 6-lb meat batches were then treated with one of the following: 1) 1% ozonated water bath for 15 min followed by mixing with 400 ml of 5% acetic acid (OA); 2) 1% ozonated water bath for 15 min followed by mixing with 400 ml of 0.5% cetylpyridinium chloride (OC); 3) mixing with 400 ml of 200 ppm chlorine dioxide followed by mixing with 400 ml of 10% trisodium phosphate (CT); or 4) left untreated (control; C). With the exception of the OA treatment, which was placed in a stainless steel vessel continuously replenished with ozonated water, each batch was placed in a meat tumbler along with the selected antimicrobial treatment and tumbled for 3 min. After tumbling, meat was removed from the tumbler and ground twice through a 1/8-in grinder plate. Samples were then packaged (l lb per package) on an absorbent diaper in oxygen-permeable, overwrap trays made of Styrofoam, and stored under deluxe warm white fluorescent lighting at 4ºC to simulate retail display. On days 0, 1, 2, 3, and 7 of simulated retail display, 25-g ground beef samples were placed into whirlpack bags with 225 ml of 0.1% buffered peptone water and buffered to a pH of 7 with sodium hydroxide. Serial dilutions and subsequent platings were made on *Salmonella Shigella* agar containing nalidixic acid, Petrifilm (3M Co.) aerobic plate count (APC) plates, and Petrifilm (3M) *E. coli*/coliform plate count plates. Plates were then incubated at 37ºC in an aerobic incubation chamber. Aerobic plate count plates and *Salmonella Shigella* agar plates were read at 48 h, and *E. coli*/coliform plates were read at 24 h. Counts were recorded as colony-forming units per gram (CFU/g), then transformed to log counts prior to data analysis. Instrumental color was measured using a HunterLab Miniscan colorimeter, and a trained sensory panel was used to evaluate overall color, worst point color, percentage discoloration, beef odor, and off odor characteristics on days 0, 1, 2, 3, and 7 of display.

This experiment was replicated three times. The randomized complete-block factorial experiment was analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). For those variables confounded by interactions, interaction means were generated, separated using the PDIFF option of PROC GLM of SAS, then plotted. Least-squares means for all other variables were generated and separated using the PDIFF option of PROC GLM of SAS.

Results and Discussion

Table 1 shows the reduction of log (CFU/g) *E. coli,* coliform, *S. typhimurium* and APC using OC, OA, or CT treatments in ground beef through simulated retail display. With regard to the treatments, *E. coli* was reduced ($P < 0.05$; 1.68, 1.42 and 0.61 log CFU/g by OC, OA, and CT treatments, respectively) by all treatments evaluated compared to the control. Cutter et al. (1994) found that the use of 5% acetic acid on carcasses could reduce *E. coli* O157:H7 counts by 2 log CFU/cm^2. Likewise, Dorsa et al. (1998) found that using 2% acetic acid or 12% trisodium phosphate on beef trimmings destined for ground beef could reduce *E. coli* O157:H7 (1.8 and 1.5 log CFU/g, respectively) and *S. typhimurium* (2.7 to 3.5 log CFU/g and 2.2 log CFU/g respectively) through 7 d of display. Dickson et al. (1994), using sliced beef tissue inoculated with *E. coli* O157:H7, *Listeria monocytogenes,* and *S. typhimurium*, then treated with either 8 or 12% trisodium phosphate for up to 3 min, found that trisodium phosphate reduced bacterial numbers on the tissues by 1.0 to 2.5 log CFU/cm^2. Other coliforms were also reduced ($P < 0.05$; 1.88, 1.84 and 0.40 log CFU/g by OC, OA, and CT treatments, respectively) by all treatments evaluated compared to the control. However, *S. typhimurium* was reduced ($P < 0.05$; 1.77 and 1.66 log CFU/g, respectively) by the OC and OA treatments, but not by the CT treatment ($P > 0.05$) when compared to the control. All treatments were effective ($P < 0.05$) for reducing aerobic plate counts (1.50, 1.27, and 0.30 log CFU/g by OC, OA, and CT treatments, respectively) against the control. Gorman et al. (1995) used combinations of 12% trisodium phosphate and water, 0.5% ozone and water, and 2% acetic acid and water to reduce *E. coli* on adipose tissue of beef carcass brisket by 2.70, 1.38, and 1.74 log CFU/cm^2, respectively. Using other multiple interventions, Phebus et al. (1997) found that a combination of water and steamwashing could reduce *E. coli* O157:H7 and *S. typhimurium* by 3.5 to 5.3 log CFU/cm^2 on beef carcasses. Therefore, the use of multiple interventions, or "hurdle technology," in ground beef production systems proved to be an effective method for decreasing the amount of microbial contamination in ground beef through simulated retail display. Regarding instrumentally evaluated color and sensory odor, the OC and OA treated ground beef was lighter (L*; $P < 0.05$) than the control; however, the CT treated beef was darker (L*; $P < 0.05$) than the control (Table 1). Sensory panelists indicated no difference ($P > 0.05$) in beef odor or off odor intensities among the control, OC, and CT treatments. However, the OA treatment had less ($P < 0.05$) beef odor and less off odor intensities than the control, OC, or CT treatments.

By day 1 of display, the control was redder ($P < 0.05$; a*) than the OC, OA, and CT treatments (Figure 1A). However, the CT treatment was more red (a*; $P < 0.05$) and the OC and OA treatments were less red (a*; $P < 0.05$) by day 7 of simulated retail display than the control. Likewise, the OA treatment was the only treatment that reduced ($P < 0.05$) product redness (a*) compared to the control throughout the duration of simulated retail display. Although the CT treatment was less ($P < 0.05$) yellow (b*) on day 0 of display than the control, no difference ($P > 0.05$) was observed in yellowness (b*) between the control and the OC or OA treatments by day 1 of display (Figure 1B). Throughout display, the OA treatment tended to be less yellow (b*) than the control treatment. However, there were no differences ($P > 0.05$) in yellowness (b*) between the OC treatment and the control by day 7 of display. Likewise, there was no difference ($P > 0.05$) in orangeness (hue angle) initially (day

0) between the control and any of the treatments (Figure 1C). Also, there were no differences ($P > 0.05$) in color (hue angle) among the control, OC, or CT treatments from days 1 to 3 of display. However, by day 1, and throughout the duration of display, the OA treatment had a greater ($P < 0.05$) hue angle, indicating a different color or hue, than the control. Although there were no differences in saturation index (vividness of color) among the control, OC, and OA treatments on day 0 of display, the CT treatment had a lower ($P < 0.05$) saturation index (less vivid color) than any other treatment by day 1 of display (Figure 1D). In contrast, there were no differences ($P > 0.05$) in vividness of color (saturation index) among the control, OC, or CT treatments from day 1 through the duration of display.

Sensory panelists indicated that the CT treatment maintained ($P < 0.05$) a brighter purple-red overall (Figure 2A) and worst point color (Figure 2B) than the control, OC, or OA treatments by the end of display (day 7). Likewise, sensory panelists found the CT treatment to have a lower ($P < 0.05$) percentage of discoloration than any of the other treatments by day 7 of display (Figure 2C). And in general, sensory panelists found the CT treatment tended to maintain a brighter purplish red overall and worst point color and less surface discoloration than the control, OC, or OA treatments throughout the duration of display. However, sensory panelists indicated that the OA treatment was ($P < 0.05$) more brown in overall and worst point color than the control throughout display, and it had a higher ($P < 0.05$) percentage of discoloration by day 1 of display than any other treatment. Bell et al. (1986) found that dipping meat pieces in acetic acid (2.4%) for 10 min resulted in moderately discolored beef when compared to a control, which was moderately bright red.

Implications

The use of hurdle technology closer to the packaging stage was effective in reducing microbial numbers while maintaining odor or improving ground beef color characteristics. This technology, if approved, adopted, and used correctly, could become part of a Hazard Analysis Critical Control Point program for processors, ensuring an increased level of safety of meat products.

Acknowledgments

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Table 1. Effect of multiple antimicrobial treatments[a] applied to beef trimmings on least-squares means (± SE) log CFU/g *E. coli*, coliform, *S. typhimurium*, aerobic plate count and CIE L*[b] value, beef odor,[c] and off odor[d] intensities of ground beef through simulated retail display.

	Treatment				
	Control	OC	OA	CT	SE
Microorganism					
E. coli	6.77^{z}	5.09^{w}	5.35^{x}	6.16^{y}	0.09
Coliform	6.02^{y}	4.14^{w}	4.18^{w}	5.65^{w}	0.10
S. typhimurium	5.81^{x}	4.04^{w}	4.15^{w}	5.52^{x}	0.11
Aerobic plate count	7.06^{y}	5.56^{w}	5.79^{w}	6.76^{x}	0.09
Instrumental color					
CIE L*	48.35^{x}	52.30^{z}	49.87^{y}	43.80^{w}	0.31
Sensory odor					
Beef odor	6.44^{x}	6.37^{x}	3.98^{w}	6.51^{x}	0.14
Off odor	4.55^{x}	4.36^{x}	2.54^{w}	4.60^{x}	0.09

Least-squares means within a row with different letters are different ($P < 0.05$).

[a] OC = 15 minute ozonated water bath (1%; 45ºC) and 0.5% cetylpyridinium chloride; OA = 15 minute ozonated water bath (1%; 45ºC) and 5% acetic acid; CT = 200 ppm chlorine dioxide and 10% trisodium phosphate.

[b] 0 = black and 100 = white.

[c] Beef odor score: 1 = extremely non-beef-like and 8 = extremely beef-like.

[d] Off odor score: 1 = extreme off odor and 5 = no off odor.

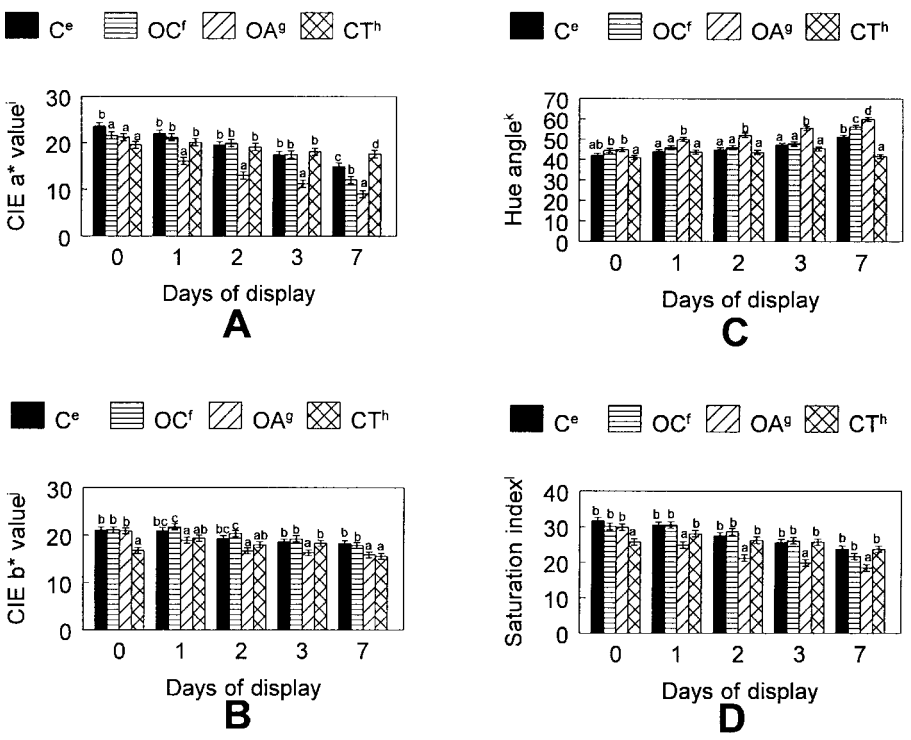

Figure 1. Day of display by antimicrobial treatment interaction effect on the least-squares mean (± SE) CIE (A) a* and (B) b* values, (C) hue angle, and (D) saturation index of ground beef through simulated display. [abcd]Least-squares means within a day with different superscripts are different ($P < 0.05$). [e]C = control; [f]OC = 15 min ozonated water bath (1%; 45ºC) and 0.5% cetylpyridinium chloride; [g]OA = 15 min ozonated water bath (1%; 45ºC) and 5% acetic acid; and [h]CT = 200 ppm chlorine dioxide and 10% trisodium phosphate. [i]a*: –60 = green and +60 = red. [j]b*: –60 = green and +60 = yellow. [k]Calculated as $\tan^{-1}(b^*/a^*)$. [l]Calculated as $(a^{*2} + b^{*2})^{0.5}$.

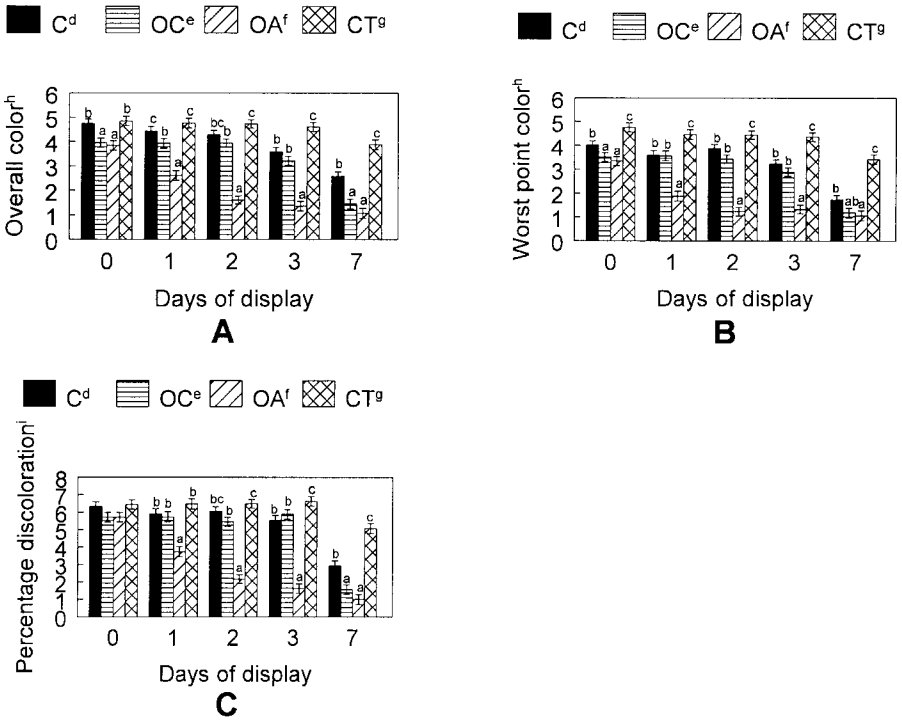

Figure 2. Day of display by antimicrobial treatment interaction effect on the least-squares mean (± SE) sensory evaluated (A) overall color, (B) worst point color, and (C) percentage discoloration, of ground beef through simulated display. [abc]Least square means within a day bearing different superscripts are different ($P < 0.05$). [d]C = control; [e]OC = 15 min ozonated water bath (1%; 45ºC) and 0.5% cetylpyridinium chloride; [f]OA = 15 min ozonated water bath (1%; 45°C) and 5% acetic acid; and [g]CT = 200 ppm chlorine dioxide and 10% trisodium phosphate. [h]Color score: 1 = brown and 5 = bright purple-red. [i]Percentage discoloration: 1 = total discoloration and 7 = no discoloration.

Effect of Oxygen Concentration During Oocyte Maturation on Subsequent Bovine Embryo Cleavage and Development In Vitro

G.F. Miller[1] and R.W. Rorie[2]

Story in Brief

The objective of this study was to determine the effect of varying the incubator oxygen atmosphere on in vitro maturation of bovine oocytes. Bovine oocytes were matured for 24 h in a gas atmosphere of 5% carbon dioxide and either 5, 10, or 20% oxygen. After maturation, oocytes were fertilized with frozen-thawed spermatozoa. Oocytes cleaving to the 2- to 4-cell stage by 45 h post-insemination were co-cultured with oviductal cells in M-199 supplemented with 20% fetal bovine serum. The atmosphere for both in vitro fertilization and embryo culture was 5% carbon dioxide in air. After 6 d of co-culture, embryos developing to the blastocyst stage were fixed, stained, and nuclei number determined. The cleavage rate of oocytes matured in an atmosphere containing 20% oxygen was higher than that for maturation in atmospheres containing either 10 (P = 0.05) or 5% oxygen (P = 0.07). In contrast, more (P = 0.07) of the cleaved embryos continued development to the blastocyst stage when oocytes were matured in a reduced (5%) oxygen atmosphere. There were no differences in mean number of cells per blastocyst among the treatments (P = 0.84). The development rate of cleaved embryos to the blastocyst stage would indicate that reducing the oxygen atmosphere to 5% during bovine oocyte maturation may enhance oocyte developmental competence.

Introduction

Usually, less than 25% of the embryos produced through in vitro maturation and fertilization procedures will reach a developmental stage (morula or blastocyst) suitable for nonsurgical transfer. Development of procedures that increase the number of viable embryos produced through in vitro techniques is essential for these procedures to be used successfully on a commercial basis. A typical atmosphere for in vitro maturation of bovine oocytes is a humidified atmosphere of 5% carbon dioxide in air (about 20% oxygen). However, the oxygen concentration within the reproductive tract is about 5 to 8%. Some researchers suggest that by reducing oxygen within the culture environment, the problems associated with free radical formation and cellular damage will be reduced. This study was conducted to determine the effect of varying the atmospheric oxygen concentration for in vitro maturation of bovine oocytes, based on cleavage rates and the developmental competence of embryos after in vitro fertilization.

Experimental Procedures

Ovaries were collected from dairy and beef cows at a local abattoir. Cumulus cell-intact oocytes were recovered by slicing through follicles on the surface of the ovaries with a razor blade. The recovered oocytes were matured for 24 h in M-199 supplemented with 20% estrous cow serum, under gas atmospheres of 5% carbon dioxide and either 5, 10, or 20% oxygen. The balance of each gas atmosphere was nitrogen. Approximately 100 oocytes were cultured per well in 4-well culture plates. Cultures were carried out in modular incubator chambers that were placed into a larger incubator maintained at 39°C. The gas atmosphere within the modular chambers was equilibrated by gassing each modular unit with the appropriate gas mixture for 15 min.

Oocytes were fertilized using heparin-capacitated, frozen-thawed spermatozoa. Motile spermatozoa were selected by glass wool column filtration. Oocytes were fertilized in drops of fertilization medium (under silicone oil) containing heparin and bovine oviductal epithelial cells. Approximately 25 oocytes and 75,000 motile spermatozoa were placed into each drop of the fertilization medium. The oocytes remained in fertilization medium until 45 h post-insemination, at which time the oocytes/embryos were removed and evaluated for cleavage.

The cleaved (2- to 4-cell) embryos in each treatment were co-cultured with bovine oviductal epithelial cells in M-199 supplemented with 20% fetal bovine serum. After 5 d, embryos were removed from culture and evaluated for development to the blastocyst stage. After evaluation, embryos developing to the blastocyst stage were fixed and

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stained to count the number of cells (nuclei). Cleavage and embryo development data were analyzed using the PROBIT procedure of SAS (SAS Inst. Inc., Cary, NC). Cell number per blastocyst was analyzed using the GLM procedure of SAS.

Results and Discussion

Results of this study are presented in Table 1. At 45 h post-insemination the cleavage rate of oocytes matured in an atmosphere containing 20% oxygen was higher than after maturation in atmospheres containing either 10 (P = 0.05) or 5% oxygen (P = 0.07). These results are in agreement with those of Pinyopummintr and Bavister (1995) who reported the highest percentage of normal fertilization when bovine oocytes matured in 20, as compared to either 5 or 10% oxygen.

Although initial cleavage was highest in the present study when oocytes were matured in 20% oxygen, subsequent development to the blastocyst stage was higher (P = 0.07) for oocytes matured in an atmosphere of 5% oxygen. These results would suggest that the initial cleavage rate may not be a reliable indicator of oocyte developmental competence. Bovine oocytes undergo nuclear maturation to metaphase II under a variety of conditions ranging from totally defined, protein-free medium to media highly supplemented with different sera and hormones. Developmental competence requires acquisition of both nuclear and cytoplasmic maturation. The results of this study illustrate the difficulty in attempting to evaluate developmental competence based on only nuclear maturation or cleavage.

It has been suggested that the detrimental effect of atmospheric oxygen concentrations (about 20%) is due to cellular damage caused by an increase in the production of oxygen free radicals (Umaoka et al., 1992). The free radicals that appear to be of major concern are the hydrogen peroxide radicals, superoxide anions, and the hydroxyl radicals. Oxygen free radicals are highly reactive and cause cellular damage through lipid peroxidation of membrane lipids, inactivation of enzymes, and DNA damage. The toxic effects of atmospheric oxygen levels can occur rapidly but may not become apparent until the latter developmental stages, i.e., the morula or blastocyst stage (Pabon et al., 1989; McKiernan and Bavister, 1990). This might explain the results observed in this study, where initial cleavage was higher when oocytes were matured under atmospheric oxygen conditions, but subsequent development was decreased.

The mean cell number per blastocyst was similar (P = 0.84) among the various maturation treatments. This suggests that the various treatments had no effect on the developmental competence of the embryos that did achieve the blastocyst stage. We conclude that 5% oxygen concentration in the gas atmosphere is superior for in vitro maturation of bovine oocytes under conditions of this study. However, it is evident that the optimum oxygen concentration for oocyte maturation, fertilization and embryo culture is dependent on many factors including oocyte concentration, type of media, medium supplementation, and the presence or absence of co-culture.

Implications

Based on development of cleaved embryos to the morula or blastocyst stage in this study, oocyte developmental competence might be improved by reducing the oxygen atmosphere to 5% during bovine oocyte maturation. However, the optimum oxygen atmosphere for oocyte maturation, fertilization, and embryo culture is likely to vary with different in vitro systems and conditions. Therefore, optimal oxygen concentration must be determined for each in vitro system or laboratory.

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Table 1. Cleavage and development of bovine oocytes/embryos after in vitro maturation different oxygen atmospheres.

Oxygen atmosphere	No. oocytes matured*	% of oocytes cleaving	% of cleaved to blastocysts	Mean cells per blastocyst§
5%	462	53.0 ± 2.4[a]	29.9 ± 0.6[d]	93.9 ± 4.7
10%	478	52.5 ± 2.3[a]	23.2 ± 0.5[c]	96.2 ± 5.3
20%	540	58.7 ± 2.2[b]	22.1 ± 0.5[c]	91.2 ± 4.8

Cleavage rates with different superscripts differ (P ≤ 0.07).

Percent blastocysts with different superscripts differ (P = 0.07).

* Data are from five replicates.

§ Mean cell number per blastocysts were similar (P = 0.84).

The Use of an Electronic Estrus Detection System to Evaluate the Effect of Embryo-Recipient Synchrony on Pregnancy Rate in Cattle

R.W. Rorie and T.D. Lester[1]

Story in Brief

When embryo recipients and donor cows are observed twice daily for estrus, a difference of several hours can occur between the actual and "detected" onset of estrus. This potential discrepancy makes it impossible to determine the exact synchrony between embryos and recipients. The use of an electronic estrus detection system to continuously monitor animals would allow for more precise timing of embryo transfers and might result in improved pregnancy rates. Therefore, the objective of this study was to use an electronic estrus detection system to evaluate the effect of embryo-recipient synchrony on transfer pregnancy rate. Also investigated was any possible effect of recipient estrus length or intensity on subsequent pregnancy rate. Multiparous, crossbred beef cows (n = 168) served as embryo recipients. At estrous synchronization treatment, HeatWatch mount transmitters were placed on the recipients. Embryo donors (n = 27) were also monitored with the HeatWatch system so that exact donor-recipient synchrony could be determined. Either fresh or frozen-thawed (frozen in glycerol or ethylene glycol) embryos were transferred approximately 7 d after detected estrus. Pregnancy was confirmed by palpation or ultrasonography at 45 to 60 d of gestation. Chi-squared was used to evaluate the effect of donor-recipient synchrony on pregnancy rate. The pregnancy rate tended ($P = 0.088$) to be higher for synchrony of ± 0 to 12 h than that of ± 12 to 24 h (60 vs. 46%, respectively). Neither estrus length nor intensity influenced subsequent pregnancy rate ($P \geq 0.278$). The results of this study suggest that continuous monitoring of embryo donors and recipients and selection of recipients with synchrony of ± 12 h can improve embryo transfer pregnancy rates.

Introduction

Embryo transfer (ET) involves the nonsurgical collection of embryos from valuable donor cows and then, transfer of recovered embryos to recipient cows for gestation. Close estrus synchrony between the embryo donor and recipient is necessary for optimum embryo survival after transfer. Synchrony is designated as zero, plus or minus, depending on whether the recipient cow comes into estrus at the same time, before or after the donor cow, respectively. Typically, embryos are transferred to recipients that are in estrus within ±24 h of the donor cow.

When embryo recipients and donor cows are observed twice daily for estrus, a difference of several hours can occur between the actual and "detected" onset of estrus. This potential discrepancy makes it impossible to determine the exact synchrony between embryo donors and recipients. The use of an electronic estrus detection system to continuously monitor animals would allow for more precise timing of embryo transfers, and might result in improved pregnancy rates. Therefore, the objective of this study was to evaluate the effect of embryo-recipient synchrony on transfer pregnancy rate, using an electronic estrus detection system. Also, length and intensity (mounting activity) of estrus were evaluated as possible indicators of embryo recipient quality.

Experimental Procedures

Multiparous, crossbred beef cows (n = 168) served as embryo recipients for this study. The recipients were synchronized either by two injections of PGF2alpha (Lutalyse) given 14 d apart, or by treatment with GnRH (Cystroelin) followed by an injection of Lutalyse 7 d later. At synchronization treatment, HeatWatch mount detection transmitters were placed on the recipients. Mount detection transmitters were also placed on the embryo donor cows (n = 27) so that the exact time of onset of estrus and thus, synchrony between donors and recipients could be determined.

The embryo donors were superovulated, using a 4-d descending dose regimen of follicle-stimulating hormone (Follitropin). Donors were inseminated at 12 and again at 24 h after the onset of estrus (day 0). Approximately 7 d later, embryos were recovered nonsurgically. Depending on availability of recipients, embryos were transferred fresh, or frozen in either glycerol or ethylene glycol and stored in liquid

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nitrogen until recipients were available. At 45 to 60 d of gestation, rectal palpation or ultrasonography was used to confirm pregnancy in recipients that did not return to estrus after embryo transfer. Data were categorized and analyzed for any effect of synchrony, length of estrus, and intensity of estrus (mounting activity) on pregnancy rate. Also, the pregnancy rate was compared for transfer of fresh vs. frozen embryos, and for embryos frozen in glycerol vs. ethylene glycerol.

Results and Discussion

There was no difference (P = 0.827) between pregnancy rates for embryos frozen in glycerol or ethylene glycol (51.5 vs. 49.1%, respectively). The pregnancy rate resulting from transfer of fresh embryos (62.2%) was similar (P = 0.279) to that for frozen-thawed embryos, so data for fresh and frozen-thawed embryos were combined for further analysis. Comparison of the various estrus synchrony categories (12-h intervals from –24 to +24 h) revealed a numeric trend for decreasing pregnancy rate with increasing asynchrony between the embryo donor and recipient (Table 1). Possibly because of the small number of embryo transfers in each category, this trend was not significant (P = 0.491). However, combining the data into two categories (± 0 to 12 h vs. ± 12 to 24 h) for comparison did reveal a tendency (P = 0.088) for increased pregnancy rates with better synchrony between embryo donors and recipients.

It is generally believed that acceptable pregnancy rates can be achieved by transferring embryos to recipients exhibiting estrus within ±24 h of the embryo donor. Without continuous monitoring of embryo donors and recipients, it is impossible to know their actual synchrony. Our results suggest that pregnancy rate can be improved by transfer of embryos to recipients with no more than 12 h asynchrony. The use of an electronic estrus detection system allows for better timing of embryo transfers.

Pregnancy rates were compared for recipients with estrus periods ranging from under 6 h to over 18 h. Typically, beef cows have estrus periods of 12 h or less. In the present study, 80% of the cows had estrus periods of 12 h or less. Abnormally long estrus periods could indicate a problem such as ovulation failure. However, there were no significant differences (P = 0.278) in pregnancy rate among recipients for any estrus length. The lowest numerical pregnancy rate occurred in recipients with long (over 18 h) estrus periods (Table 2) and would merit further study.

The Heatwatch system records every mount event during estrus and thus, makes it possible to determine if estrus intensity is related to subsequent pregnancy rates. The majority of recipients had 40 or fewer mounts during estrus. Mounting activity (Table 3) does not appear related to subsequent pregnancy after embryo transfer (P = 0.808).

Implications

The results of this study suggest that continuous monitoring of embryo donor and recipient cows and selection of recipients with synchrony of ± 12 h may improve embryo transfer pregnancy rates. Intensity of estrus (mounting activity) does not appear to be related to fertility. Further study is necessary to determine if length of estrus is related to embryo transfer pregnancy rates.

Table 1. Effect of recipient synchrony on embryo transfer pregnancy rate.

Estrus synchrony category	No. embryo transfers	Pregnancy rate (mean ± SE)
–12 to –24	21	47.6 ± 10.8
0 to –12	56	57.1 ± 6.6
0	9	66.7 ± 16.6
0 to +12	51	62.7 ± 7.0
+12 to +24	31	45.2 ± 9.0
± 0 to 12	116	60.3 ± 4.6
± 12 to 24	52	46.2 ± 6.9

Table 2. Effect of length of estrus on subsequent pregnancy rate.

Length of estrus (h)	No. embryo transfers	Pregnancy rate (mean ± SE)[a]
Under 6	44	61.5 ± 9.7
6 to 12	91	52.7 ± 5.2
12 to 18	7	63.6 ± 7.5
Over 18	23	28.6 ± 18.8

[a] Pregnancy rate was similar, regardless of estrus length (P = 0.278).

Table 3. Effect of estrus intensity on subsequent pregnancy rate.

No. mounts during estrus	No. embryo transfers	Pregnancy rate[a] (mean ± SE)
Under 20	75	54.7 ± 5.8
20 to 40	57	59.6 ± 6.6
41 to 60	19	47.4 ± 11.5
Over 60	17	58.8 ± 12.2

[a] Pregnancy rate was similar, regardless of estrus intensity (P = 0.808).

Performance of Stocker Steers and Heifers Implanted With Synovex-S and Synovex-H

S. McPeake, S. Gadberry, K. Combs, and D. Vangilder[1]

Story in Brief

A trial involving 56 steer and heifer calves was conducted to evaluate performance differences in calves that were implanted (Steers-Synovex S and Heifers-Synovex H) vs. calves that were not implanted. Steers and heifers having an average initial weight of 485 lb were randomly allocated within sex to remain either as nonimplanted controls or to receive a synovex implant. The calves were fed free choice hay plus a supplement for 100 d during the winter period (November 2, 1999, to February 10, 2000). During the 63-d spring period (February 10, 2000, to April 13, 2000), calves grazed bermudagrass pasture drilled with wheat, along with hay and supplement. During the winter period, there were no differences ($P > 0.05$) in ADG between the implanted calves and those in the control group. However, least-squares means for implanted calves vs. control calves did show a numerical difference in ADG (0.48 vs. 0.35 lb/d). During the spring period, implanted calves had greater ($P < 0.05$) ADG than control calves. Least-squares means were 1.69 lb/d for implanted calves vs. 1.26 lb/d for control calves. Average daily gain of calves over the entire trial period was 0.69 lb/d for nonimplanted calves and was improved to ($P < 0.05$) 0.96 lb/d for calves that were implanted.

Introduction

Anabolic implants have been used to increase gains of grazing cattle since the early 1950s. The products available are based on compounds that have estrogenic or estrogenic-like activity. The effectiveness of these types of implants is well documented. This trial serves to validate the effectiveness of implanting in a typical Arkansas environment.

Experimental Procedures

On November 2, 1999, 56 feeder calves, (30 heifers and 26 steers) having an average initial weight of 485 lb were randomly allocated within sex to remain as nonimplanted controls or to receive a synovex implant. The cattle were of mixed breeding containing Limousin, Simmental, and Brahman breeding and were retained by the owner.

On November 2, 1999, calves were given injectable ivomec for internal parasite control, and respiratory vaccinations (infectious bovine rhinotracheitis, bovine virus diarrhea, parainfluenza –3) and implanted. Calves were maintained during the winter period (November 2, 1999 to February 10, 2000) in a small pasture area and fed free choice hay plus 2 lb per animal per day of a supplement that was approximately 90% corn, 10% cottonseed meal, and added vitamins A, D, and E. Also a high magnesium-free choice mineral was provided.

On February 10, 2000, calves were weighed and ADG was calculated. Upon review of the gain information, some management changes were recommended. Higher quality hay was selected and recommended to be fed during the remainder of the trial. Since the calves had slowly gained weight, the supplement was increased to about 3 lb per animal per day or about 0.5% of body weight. Also, fecal samples taken at this time revealed that the calves had a parasite load. They were dewormed approximately 1 wk later with a pour-on avermectin product.

After February 10, 2000, the calves were maintained in a larger pasture area that had been drilled with wheat; however, due to low rainfall amounts, hay was still made available along with the supplement. The wheat pasture did not offer an adequate forage supply until early March. On April 13, 2000, final weights were collected.

Least-squares means for ADG and calf weights were generated using general linear model procedures of SAS (SAS Inst. Inc., Cary, NC).

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Results and Discussion

Steers and heifers gained at similar rates during the winter period, spring period, and the total trial. No interactions between sex and implant treatments were detected for ADG, indicating that both sexes tended to respond similarly to implants. Implanted heifers gained 1.66 lb/d during the spring period, while nonimplanted controls gained 1.30 lb/d (Table 1, $P < 0.05$). In addition, implanted heifers for the entire trial period (163 d) gained 0.92 lb/d vs. 0.71 lb/d for nonimplanted control heifers (Table 1, $P < 0.05$).

Implanted steers gained 1.71 lb/d during the spring period while nonimplanted steers gained 1.21 lb/d (Table 2, $P < 0.05$). Overall, implanted steers gained 1.00 lb/d for the entire trial period (163 day) vs. 0.68 lb/d for nonimplanted control steers (Table 2, $P < 0.05$).

Implanted calves gained 0.96 lb/d during the entire trial period (163 day) while nonimplanted calves gained 0.69 lb/d (Table 3, $P < 0.05$). However, most of the advantage in weight gain occurred during the spring period for implanted calves vs. nonimplanted controls (Table 3). During the spring period, implanted calves gained 1.69 vs. 1.26 lb/d for nonimplanted calves (Table 3, $P < 0.05$). There were no significant differences in gains between implanted calves and nonimplanted calves during the winter period. During the total trial implanted calves gained 69 more lb ($P < 0.05$) than nonimplanted calves. Most research shows that implants return $10 for each $1 invested.

It has been reported that the estrogenic implants (Synovex S, zeranol) increased the concentration of thyroxin in plasma by increasing its secretion from the thyroid gland (Gopinath and Kitts, 1982; Kahl et al., 1978) as reviewed by Gill (1985). In addition, slight increases in heart rate, fasting urinary nitrogen excretion, and fasting heat production also have been observed in cattle fed or implanted with DES and implanted with Synovex S, which suggests that the estrogenic implants slightly increase maintenance energy requirements (Rumsey et al., 1973, 1980; Tyrell et al., 1975). It is rather surprising that the implanted calves maintained their rate of gain compared to nonimplanted controls with gains being so low during the winter period.

Greathead (1984), as reviewed by Gill (1985), reviewed studies with zeranol implants and concluded that the response may be large and of short duration in rapidly growing cattle on high levels of energy intake. However, smaller improvements in growth rate, but occurring over a longer duration, are more typically observed in cattle gaining less than about 1.5 lb/d.

Implications

Animals respond better to implanting when on a higher level of nutrition than in restricted nutritional environments. Calves from this study did not have a significant response from implanting in the winter period until their nutritional environment improved in the spring. Implanting is a cost-effective way to increase ADG.

Acknowledgment

The Arkansas Beef Improvement Program would like to thank Mr. Bob McCool, Danville, AR, for his assistance in conducting this trial.

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Table 1. Least-squares means for heifer weights and weight gains (lb).

Item	Control	Synovex-H
Wt (November 2, 1999)	468	472
Wt (February 10, 2000)	500	518
Wt (April 13, 2000)	578	623
ADG, winter	0.35	0.45
ADG, spring	1.30[a]	1.66[b]
ADG, total	0.71[a]	0.92[b]

Means with different letters were different (P < 0.05).

Table 2. Least-squares means for steer weights and weight gains (lb).

Item	Control	Synovex-S
Wt (November 2, 1999)	484	524
Wt (February 10, 2000)	519	575
Wt (April 13, 2000)	559[a]	697[b]
ADG, winter	0.35	0.51
ADG, spring	1.21[a]	1.71[b]
ADG, total	0.68[a]	1.00[b]

Means with different letters were different (P < 0.05).

Table 3. Least-squares means for all calf weights and weight gains (lb).

Item	Control	Implanted
Wt (November 2, 1999)	476	498
Wt (February 10, 2000)	509	547
Wt (April 13, 2000)	569[a]	660[b]
ADG, winter	0.35	0.48
ADG, spring	1.26[a]	1.69[b]
ADG, total	0.69[a]	0.96[b]

Means with different letters were different (P < 0.05).

The Production of Stocker Cattle Supplemented With Aueromycin or Gain Pro While Grazing Fescue During the Fall and Winter

D.S. Hubbell, III,[1] L.B. Daniels,[2] K.F. Harrison,[1] and Z.B. Johnson[2]

Story in Brief

Seventy-two preconditioned, crossbred steers, averaging 500 lb BW, were randomly divided into nine groups of eight animals and assigned to nine 4-acre fescue pastures on November 9, 1999, until February 29, 2000. One-third of the steers were supplemented with 70 mg of aueromycin per animal per day, one-third supplemented with 20 mg of Gain Pro per animal per day, and one-third received no supplementation. All steers were fed 2 lb of corn per animal per day. There were no differences in ADG, total gain, or gain per acre of steers from feeding antibiotics. Numerically, steers supplemented with aueromycin had an ADG of 1.33 lb/d, Gain Pro 1.17 lb, and controls 1.11 lb. These data suggest that there is no benefit of supplementing either aueromycin or Gain Pro on growth of stocker cattle while grazing fescue in the fall and winter.

Introduction

Fescue is the predominant cool-season grass grown for forage in Arkansas. It is used as pasture for stocker cattle during the fall and winter, but cattle gains are usually small, averaging approximately 1 lb per animal per day. It is important that stocker cattle gains be as efficient and economical as possible. Therefore, feed additives are often used to promote growth, improve health, and reduce morbidity. Chlortetracycline (aueromycin) has been used for several years. Recently, bambermycin (Gain Pro) has been used as a feed additive for stocker cattle production. Rush et al. (1996) observed ADGs of stocker cattle that grazed crested wheat grass pastures were improved by 22.2% when Gain Pro was fed at 20 mg per animal per day. Therefore, it was the objective of this study to evaluate the effect of feeding aueromycin and Gain Pro to stocker cattle grazing fescue during the fall and winter.

Experimental Procedures

Seventy-two preconditioned crossbred steers, averaging 500 lb BW, were randomly divided into nine groups of eight animals and then assigned randomly to nine 4-acre fescue pastures. Calves were vaccinated with a seven-way black leg (alpha-7), tetanus, modified-live IBR-BVD-P13-BRSV (Express 4-HS) plus *Haemophilus Somnus pasturella* spp. (Pulmogard) and dewormed with injectable Ivomec. Bulls were castrated, and horns were tipped if necessary. Booster vaccines were given 17 to 21 d after initial vaccinations. Steers were implanted with Ralgro. The fescue pastures were established in 1996 and were Kentucky 31 endophyte-infected. One-third of the steers were supplemented with the feed additive aueromycin at the rate of 70 mg per animal per day, one-third with Gain Pro at the rate of 20 mg per animal per day, and one-third did not receive a feed additive. All steers were fed 2 lb of corn per animal per day, which was used as a carrier for the feed additive. The steers were preconditioned for 30 d prior to assigning them to their respective treatment. Steers were weighed initially using a nonshrunk weight and every 28 d thereafter. They received a commercial trace mineralized salt mix free choice. The data were analyzed by analysis of variance procedures of SAS (SAS Inst. Inc., Cary, NC).

Results and Discussion

The ADG, total gain (TG), and gain per acre (G/A) for steers supplemented with aueromycin and Gain Pro are given in Table 1. There were no differences in ADG, TG, or G/A as a result of feeding aueromycin or Gain Pro. These data do not agree with that of Rush et al. (1996), who reported a 22% increase in ADG of stocker steers, supplemented with 20 mg of Gain Pro per animal per day while grazing crested wheat grass. However, their study was conducted during the summer, whereas the present study was conducted during

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the fall and winter. Gains in the present study were similar to those observed by Daniels et al. (2000) in which stocker heifers grazed stockpiled endophyte-infected fescue. It appears from these data that aueromycin and Gain Pro provide no growth advantage to stocker cattle while grazing endophyte-infected fescue during the fall and winter.

Implications

There appeared to be little or no growth advantage to supplementing stocker cattle with either aueromycin or Gain Pro while grazing infected fescue during the fall and winter.

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Daniels, L.B., et al. 2000. Ark. Agri. Exp. Sta., Res. Series 470:89.

Rush, I., et al. 1996. Nebraska Beef Report. pp 69.

Table 1. ADG, total gain (TG), and gain per acre (G/A) of steers grazing fescue pasture and supplemented with aueromycin and Gain Pro.

	Treatment				
Trait	Aueromycin	Gain Pro	Control	SE	P value
ADG, lb	1.33	1.17	1.11	0.08	0.24
TG, lb	149.00	131.00	124.00	9.0	0.24
G/A, lb	299.00	251.00	248.00	20.0	0.25

Effect of Forage Environment on Milk Yield and Quality in Angus, Brahman, and Reciprocal-Cross Cows

M.A. Brown,[1] A.H. Brown, Jr.,[2] W.G. Jackson,[3] and J.R. Miesner[3]

Story in Brief

Milk yield (MY) and quality were observed on 93 Angus, Brahman, and reciprocal-cross cows over 3 yr to evaluate the interactions of direct and maternal breed effects and heterosis with forage environment. Milk quality traits were milk fat percentage (MF), milk protein percentage (PRO), and somatic cell count (SCC). Forage environments were common bermudagrass (BG), endophyte-infected tall fescue (E+), and a rotational system (ROT) of both forages where each forage (BG or E+) was grazed at appropriate times of the year. Heterosis for 24-h MY was large and similar among forages, averaging 1.09 lb ($P < 0.01$). There was little evidence of maternal effects for MY for any forage. Direct effects for MY were similar among forages and averaged 1 lb in favor of Brahman ($P < 0.10$). There was little evidence of heterosis or maternal breed effects for milk fat percentage. Direct breed effects for MF were similar across forages and averaged 0.86% greater for Brahman ($P < 0.01$). There was little evidence of direct or maternal breed effects for PRO, nor was there evidence of forage effects for this trait. Purebred cows exceeded crossbreds in PRO by 0.13% on ROT ($P < 0.10$). Crossbred cows had lower SCC than purebreds on BG ($P < 0.05$), E+ ($P < 0.01$), and ROT ($P > 0.30$). Maternal breed effects for SCC were greater for the Angus dams on ROT ($P < 0.10$) with similar nonsignificant trends on BG and E+. Direct breed effects for SCC were greater for the Brahman on ROT ($P < 0.10$) with similar trends on BG and E+. These results suggest that rotation of cows from E+ to BG in the summer can partially alleviate negative effects of E+ on MY. The results suggest direct and maternal breed effects and heterosis for MY and quality were relatively stable across the forage systems evaluated. Conclusions from the research also suggest an advantage to crossbred cows in SCC and provide evidence of both direct and maternal breed effects for this trait.

Introduction

Milk yield (MY) and quality [milk fat percentage (MF), milk protein percentage (PRO), and somatic cell count (SCC)] are important components of maternal performance of beef cows and have been shown to account for 40% of the variance in 205-d weights (Robinson et al., 1978). The effects of nutritional environment on MY and quality have been well documented and information in the literature has shown that cows grazing endophyte-infected tall fescue tend to have lower milk yield compared to cows grazing forages where the endophyte is not present or has been diluted (Brown et al., 1993, 1996). In the Mid-southern United States, common bermudagrass (BG) and endophyte-infected tall fescue (E+) are the major available warm-season and cool-season forages. Sleper and West (1996) suggested that removal of cows from E+ during the summer months is appropriate management of E+ to help alleviate problems associated with this forage. There is little documentation of interactions of genetic effects with management systems involving year-round management of BG, E+, or a system utilizing both forages during appropriate grazing seasons. Consequently, the objective of this research was to evaluate milk yield and quality of Angus, Brahman, and reciprocal-cross cows where cows were managed on BG, E+, or a combination of the two forages.

Materials and Methods

Milk yield and quality were estimated in 1995, 1996, and 1997 for 93 Angus (AA), Brahman (BB), and reciprocal-cross (AB and BA) cows born in 1988 to 1991. Cows were managed on 40-acre pastures (approximately 0.5 head/acre) of either BG or E+, with all breed types represented in each pasture. After weaning in the fall of 1994, approximately 10 cows from each breed group in each forage were randomly assigned to a new forage management treatment, i.e., E+ in the fall and spring (approximately November to May) and BG in the summer (June to October). Consequently, there

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were three 40-acre pastures of BG, three 40-acre pastures of E+, and two pairs of 40-acre BG and E+ pastures used in a rotational system (ROT). Stocking rates were about 0.5 head/acre for BG and E+ and an average of about 0.5 head/acre on ROT (approximately 1 head/acre on BG in summer and about 1 head/acre on E+ in fall and spring). Pastures were fertilized as suggested by soil tests.

Milk yield was estimated each year by milking machine using a single-cow portable machine. Milk yield was estimated in all years at an average 60, 89, 116, 145, 172, and 200 d postpartum. Dates of estimates were late April to late September. Cows and calves were separated at approximately 1700 h the evening before milking and held for approximately 14 h overnight with hay and water provided. There was no milk-out prior to separation. Ten minutes before milking, cows were sedated with 1.5 ml of acepromazine, and 1.0 ml of oxytocin (20 USP units/ml) was administered immediately before milking to induce milk let-down. After a cow was milked out, milk was weighed, and triplicate samples were taken for estimates of MF, PRO, and SCC. Milk fat, MP, and SCC were estimated by a commercial laboratory using a Milkoscan System 4000 (AOAC, 1990). Daily milk was estimated as twice the net weight of milk adjusted linearly to a 24-hour basis ([milk weight/14] • 24). Heterosis effects, maternal breed effects, and direct breed effects were calculated as ((AB + BA)/2 – (AA + BB)/2), AB – BA, and (BA + BB)/2 – (AB + AA)/2), respectively. Repeated measures analyses were conducted using least-squares mixed models procedures. The initial linear model included year, sire breed, sire nested in sire breed, dam breed, forage, age, the pooled interaction of sire nested in sire breed with fixed effects, month of lactation, and all possible interactions among fixed effects and a residual of the interactions of sire within sire breed with month effects. Sire nested in sire breed, the pooled interaction of sire nested in sire breed with fixed effects, and the residual were considered random and other effects in the model were fixed. Heterosis, maternal breed effects and direct breed effects were estimated as linear contrasts of least-squares means and tested using "t" statistics. Error terms for heterosis, direct breed effects, and maternal breed effects were constructed from combinations of appropriate random effects by PROC MIXED of SAS (SAS Inst. Inc., Cary, NC). Sample sizes for sire breed x dam breed x forage environment x month for MY and quality ranged from 6 to 12 animals in each cell.

Results and Discussion

Daily MY: Milk yield of cows on E+ was lower than for cows on BG and ROT for AA ($P < 0.01$), AB ($P < 0.10$), BA ($P < 0.01$), BB ($P < 0.10$), and averaged over breed group ($P < 0.01$) (Data not shown). Milk yield of AA on ROT was lower ($P < 0.01$) than for AA on BG, but MY was similar on BG and ROT for AB, BA, and BB cows. Rotating cows from E+ to BG was effective (compared to E+) for all breed groups ($P < 0.10$), but appeared to be most helpful in AA and BA. Heterosis for MY was similar across forages and averaged 1.09 lb ($P < 0.01$), although a trend existed for heterosis to be smallest on BG, intermediate on E+, and largest on ROT. Maternal effects for MY were not evident on any forage, while direct effects were similar across forages and averaged 1.0 lb in favor of the BB ($P < 0.10$) with a numerical trend for direct effects to be less on BG, intermediate on E+, and largest on ROT.

Milk yield for each average days of lactation is given in Figure 1. Divergence between the AA and BB increased as the summer progressed, probably reflecting the heat-tolerance of the BB. There was a trend for persistence to be less in the AA, compared to the BB or reciprocal-crosses as evidence by differences in 200-d MY vs. 60-d MY. Heterosis for 116 d was larger than for 89 d (0.93 vs. 1.35 lb, $P < 0.10$) due primarily to a larger decline by AA between 89 and 116 d of lactation compared to the reciprocal crosses (Figure 2).

Milk Fat: Milk fat percentage for cows on ROT was higher than that of cows on BG or E+ ($P < 0.10$), possibly due to a better sustained plane of nutrition for cows on ROT (Data not shown). There was little evidence of heterosis or maternal breed effects for MF, but direct breed effects averaged 0.86% in favor of BB.

Milk fat percentage for each average days of lactation is given in Figure 3. Direct breed effects were not consistent across days of lactation ($P < 0.05$) and approximated a cyclic pattern (Figure 4). Direct breed effects at 60 d were larger than at 89 d ($P < 0.11$); direct breed effects at 89 d were less than at 116 d ($P < 0.01$); direct breed effects at 116 d were larger than at 172 d ($P < 0.10$); and direct breed effects at 172 d were tended to be smaller than at 200 d ($P < 0.15$).

Milk Protein: Milk protein percentage was relatively stable across both breed group and forage with two exceptions; BA on E+ had higher PRO than contemporaries on BG and ROT ($P < 0.05$) and BB on ROT had higher protein than contemporaries on BG ($P < 0.05$) (Data not shown). Reasons for these differences are not evident nor is the practical significance of the differences. Heterosis for PRO was negative on ROT ($P < 0.10$), but there was little evidence of heterosis on BG or E+. There was also little evidence of maternal or direct breed effects for this trait. Milk protein was also stable across time (Figure 5) with the only anomaly being a small spike in PRO in BB at 116 d of lactation.

Somatic Cell Count: Angus on E+ tended to have higher SCC than AA on BG ($P < 0.11$), but there was little evidence of other forage differences in SCC (Data not shown). There was evidence of favorable heterosis BG ($P < 0.05$), E+ ($P < 0.01$), and averaged over forage ($P < 0.01$), maternal breed effects on ROT favoring AA ($P < 0.10$), and direct breed effects on ROT favoring BB ($P < 0.10$). Brown et al. (1996) reported heterosis for SCC on E+ but not BG and Brown et al. (1998) reported favorable heterosis for presence of mastitis-causing organisms in Brahman-Angus reciprocal crosses.

Average SCC for each of the days of lactation for each breed group is given in Figure 6. The SCC for crossbred cows

tended to decrease and (or) remain stable whereas purebred cows tended to cycle over time. These patterns resulted in greater heterosis for SCC for days 89 ($P < 0.05$), 116 ($P < 0.05$), 145 ($P > 0.15$), 172 ($P < 0.10$), and 200 ($P < 0.05$; Figure 7).

Implications

The negative effects of endophyte-infected tall fescue on milk production in beef cows can be partially alleviated by rotation of cows to a warm-season forage such as bermudagrass in the summer. Moreover, such a rotation may be helpful in improving milk fat content and thereby increasing energy available to the calves. Direct breed effects from Brahman can be beneficial in milk yield and milk fat, and heterosis from crossbred cows can be beneficial for milk yield and somatic cell count.

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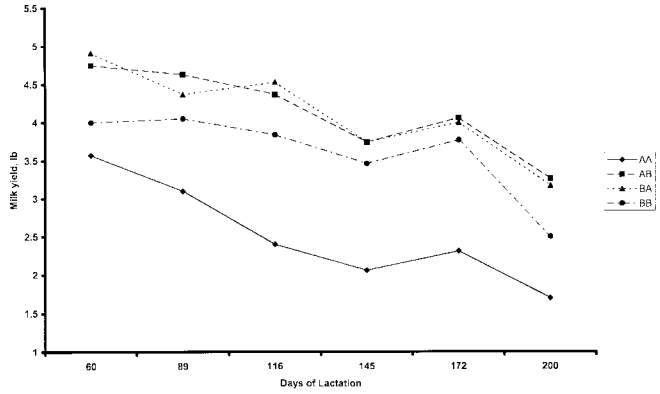

Figure 1. Twenty-four-hour milk yield for Angus (AA), Angus Brahman (AB), Braman Angus (BA), and Brahman (BB) by days of lactation.

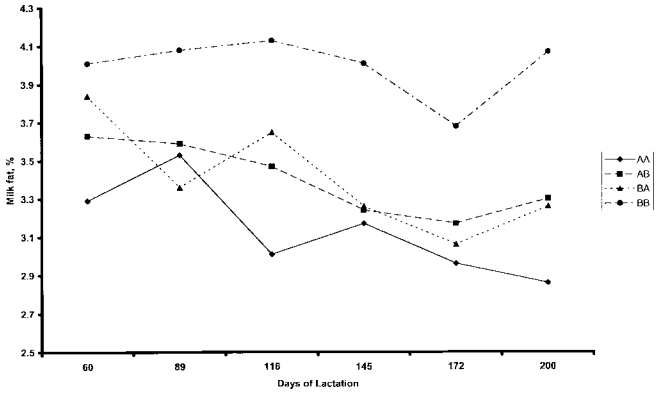

Figure 3. Milk fat percentage in 24-h milk yield of Angus (AA), Brahman (AB), Brahman Angus (BA), and Brahman (BB) cows by days of lactation.

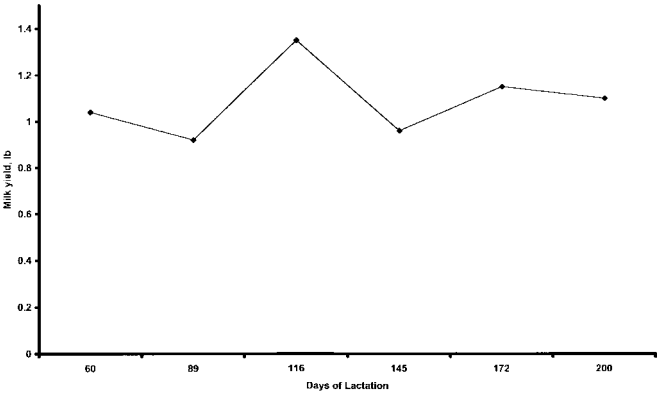

Figure 2. Heterosis for 24-h milk yield of Angus, Brahman, and reciprocal-cross cows by days of lactation.

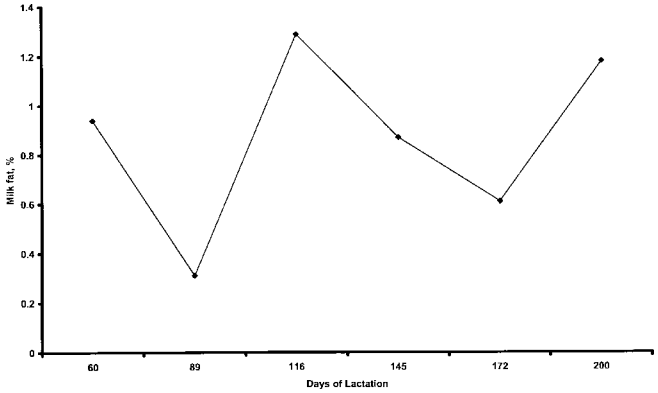

Figure 4. Direct breed effects for milk fat percentage in 24-h milk yield of Angus, Brahman, and reciprocal-cross cows by days of lactation.

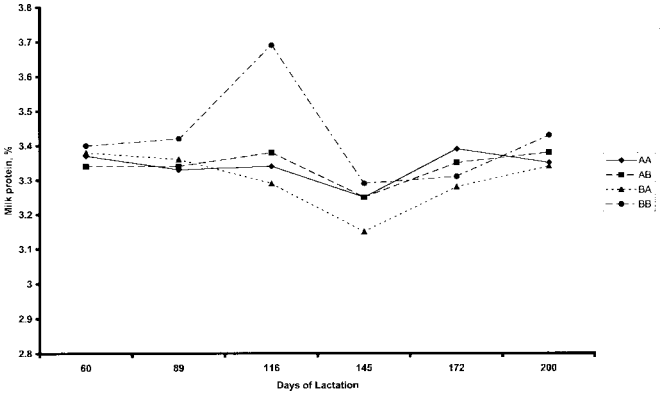

Figure 5. Milk protein percentage in 24-h milk yield of Angus (AA), Angus Brahman (AB), Brahman Angus (BA), and Brahman (BB) cows by days of lactation.

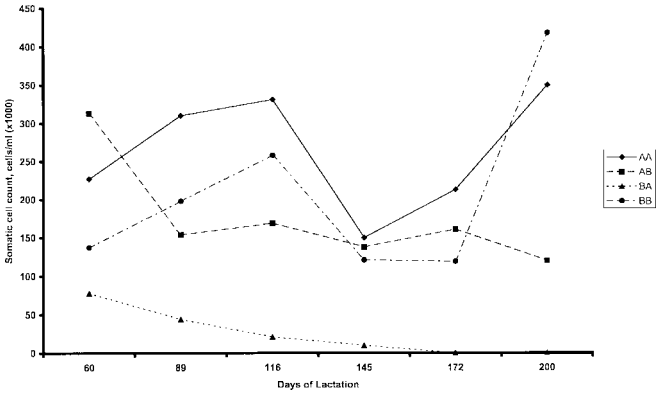

Figure 6. Somatic cell count in 24-h milk yield of Angus (AA), Angus Brahman (AB), Brahman Angus (BA), and Brahman (BB) cows by days of lactation.

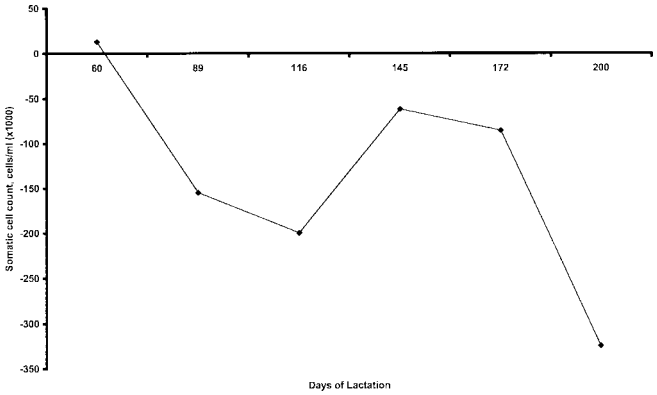

Figure 7. Heterosis for somatic cell count in 24-h milk yield of Angus, Brahman, and reciprocal-cross cows by days of lactation.

Effect of Backgrounding Diet During the Winter on Subsequent Performance of Growing Calves Grazing Tall Fescue

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Story in Brief

During the fall of 1999, 96 calves received one of four backgrounding diets in drylot for 68 d to determine the effect of diet on subsequent performance of cattle grazing cool-season pasture. Two treatment groups were fed hay and supplemented with rice bran or a self-fed molasses-based liquid supplement. Another two treatment groups were program-fed high-concentrate diets to match drylot performance of hay-fed calves with either a liquid molasses-based or an oil-seed meal based protein supplement. After the drylot phase, there were no differences ($P > 0.05$) in BW, although calves fed hay supplemented with liquid supplement had lower ($P < 0.05$) ADG than those receiving the other treatments. Drylot cost of gain was higher ($P < 0.05$) with hay-based diets or with liquid supplements. During the first 14-d grazing period, calves program-fed high-concentrate diets gained 1.61 lb/d more ($P < 0.05$) than calves fed hay. The inclusion of liquid supplements improved ($P < 0.05$) performance by 0.50 lb/d during the initial 14 d of grazing. Grazing performance after the first 14-d period was not affected ($P > 0.05$) by previous drylot diet, but profitability was improved by approximately $18.50 per animal by programmed feeding of high-concentrate diets.

Introduction

Profitability of cattle production could be improved by retaining weaned calves through subsequent stages of production. Because of a seasonal shortage of high-quality forages after weaning in the fall, calves are often backgrounded in drylot before high-quality pasture is available. The growth of stocker cattle will often "stall" for up to 30 d after being switched from drylot diets to pasture. Lippke et al. (2000) observed a negative relationship between the magnitude of change in the ruminal acetate-to-propionate ratio and ADG of calves in the first 7 d of grazing immature wheat pasture. They suggested that this decrease in the ruminal acetate-to-propionate ratio may indicate digestive upset as a cause of poor initial grazing performance (Lippke et al., 2000). Lippke and Warrington (1984) used purified diets formulated to simulate the fiber, protein, and carbohydrate fractions that are commonly found in annual ryegrass and found ruminal acidosis conditions in calves in the first 8 d of feeding. Programmed feeding is a method in which the quantities of feed offered to cattle are calculated to meet a specific rate of gain by using the net energy requirements (Galyean, 1999). Research at our facility has shown that programmed feeding of high-concentrate diets to calves is an economic alternative to feeding hay (Beck et al., 2000). Initial daily gains of growing cattle grazing either fescue or winter-annual pastures (wheat, rye, and ryegrass) were 0.6 lb/d lower ($P < 0.05$) for cattle fed hay and supplement than those of cattle that had been program-fed a high-concentrate diet. The purpose of these experiments is to evaluate the use of four drylot diets on subsequent performance of beef cattle grazing stockpiled tall fescue pasture.

Materials and Methods

On October 14, 1999, 96 weaned calves from the University of Arkansas Southwest Research and Extension Center cow herd were divided into four treatments with two replications per treatment. In order to test the effect of backgrounding diet on subsequent grazing performance, two treatment groups were fed bermudagrass hay with either a rice bran-based supplement (DRY) or a molasses-based self-fed liquid supplement (MOL). Another two treatment groups were program-fed high-concentrate diets (as described by Galyean, 1999), using net energy requirements to match performance of DRY and MOL treatments. High-concentrate diets included either a dry-protein supplement (CON) or molasses-based protein supplement (CONMOL). Adjustments were made to feeding levels of diets throughout the backgrounding period to maintain similar animal ADGs among treatments. The composition of the high-concentrate diets is shown in Table 1. Calves in the DRY treatment were fed 2.5 lb/d of rice bran, which was analyzed to contained 15.3% CP, 0.86 mega-calories (Mcal), net energy for

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[2] Quality Liquid Feeds Inc, Dodgeville, WI.

maintenance (NEm)/lb, and 0.57 Mcal net energy for gain (NEg)/lb. Rice bran normally contains around 12 to 15% fat. When program-fed calves exhibited signs of excess fat in the diet, the rice bran was analyzed for fat concentration and was found to contain 21% fat. Because of this high-fat content, the rice bran concentration was reduced in the program-fed diets from 44.9 and 36.6% to 22.5 and 18.75% for CON and CONMOL, respectively, on day 47 of drylot. Hay was analyzed and contained 11% CP, 0.44 Mcal NEm/lb and 0.20 Mcal NEg/lb. The molasses-based supplement was offered ad libitum in lick-wheel tanks, and the concentration of protein was adjusted to maintain the desired level of intake, which is from 1 to 3 lb/animal per day. The liquid supplement feeders were monitored daily and refilled as needed. The initial liquid supplement contained 18% CP, 49% TDN, 1% phosphorus, and 60% DM (as-fed basis). When excessive liquid supplement amounts were consumed, the protein concentration was increased to 26% (as-fed basis). Intake of the liquid supplement averaged 3.3 lb/animal per day over the drylot period.

One hundred acres of fall-growth tall fescue (Kentucky-31) were stockpiled from October 1 until December 21 by restricting grazing and fertilizing with 50 lb of nitrogen/acre the first week of October (Gerrish et al., 1993). During the winter grazing period, pastures consisted primarily of tall fescue (76%), cool-season annual grasses (15%), and volunteer annual ryegrass (7%). Forage availability was measured by rising plate meter in mid-January and mid-March. Average forage DM available was 2,961 lb/acre in January and 2,326 lb/acre in March.

On December 21, the calves were removed from drylot, shrunk for 16 h, weighed, and placed in the pasture. The calves were allocated to pastures by treatment, so each treatment was equally represented in each pasture. Calf weights were recorded after the first 14 d of grazing and at 28- to 35-d intervals thereafter (16-h shrink). In late January, near-record snowfall was recorded (19 in), which restricted grazing for nearly 10 d; during this time, bermudagrass hay was fed to the calves on pasture. On February 8, calves in four pastures were given access to liquid molasses-based supplements in lick-wheel-type feeders to test the effect of liquid supplements on performance of growing calves grazing spring regrowth fescue. The initial liquid supplement contained 18% CP, 49% TDN, 1% phosphorus, and 60% DM (as-fed basis). When excessive liquid supplement levels were consumed, the protein concentration was increased to 26% (as-fed basis) in order to reduce supplement consumption.

The effects of backgrounding treatment during the drylot and grazing periods were analyzed by analysis of variance using PROC GLM of SAS (SAS Inst. Inc., Cary, NC) as a completely randomized design with a 2 x 2 factorial arrangement of treatments. Drylot pens were considered the experimental unit, so the treatment effect was tested with pen within treatment as the error term. The effect of backgrounding treatments on performance during drylot and grazing were analyzed by separating least-squares means with contrasts.

Economic Analysis. Cost analysis for the backgrounding treatments, assumed $85/ton hay, which is based on the average current cost of high-quality grass hay including transportation costs of $106/ton corn, $78/ton rice bran, $200/ton liquid supplement, a $10/ton milling charge, and $0.30/animal daily charge for management, labor, and other overhead. The cost of feed ingredients was based on the 10-yr average price of corn ($2.41/bushel). The current price relationship between corn and byproduct feeds, plus a transportation cost of $10/ton and a $20/ton distributor markup, was used to estimate the cost of the byproducts used in the trials. For the economic analysis, program-fed diets were calculated at $110/ton for CON and $120/ton for CONMOL. The supplements used were assumed to cost $150 for DRY, and $200 for MOL based on retail costs of comparable supplements.

Value of gain ($79/cwt) for the stocker enterprise was determined using the 10-yr average price at Oklahoma City National Stockyards of a 400-lb steer in September ($85.86/cwt) and a 665-lb feeder steer in April ($83.12/cwt); this includes the seasonal price increase usually seen with fall-to-spring cattle ownership. The breakeven analysis and determination of enterprise profitability were calculated by subtracting the cost of gain from the $79/cwt value of gain then multiplying by the amount of gain.

Results and Discussion

The performance of calves during the drylot phase is shown in Table 2. At the end of the drylot period, calves on hay-based diets tended to be slightly lighter ($P = 0.08$) than calves on program-fed concentrated diets. There was no treatment interaction ($P = 0.17$) during the drylot period. The ADG of calves during drylot was lower for calves fed hay-based diets compared to calves program-fed concentrated diets ($P < 0.05$). This difference is the result of a tendency for lower ($P < 0.09$) performance of MOL calves compared to DRY, CON, and CONMOL. This lower performance may have been the result of the low energy content of the hay (0.44 Mcal NEm/lb) used in this trial, for which the liquid supplement could not adequately compensate at the desired level of consumption.

The performance of calves after the beginning of grazing stockpiled tall fescue is shown in Table 3. The backgrounding diet x pasture supplementation interaction was not significant ($P > 0.25$), so only the backgrounding effects will be discussed. During the first 14 d of the grazing period, calves fed hay-based diets lost ($P < 0.05$) BW. Calves from program-fed concentrated diets gained ($P < 0.05$) BW, resulting in a net increase in ADG of 1.61 lb/d ($P < 0.05$) compared to hay-fed calves. The calves fed liquid-based supplement gained 0.50 lb/d more ($P < 0.05$) than calves fed dry-protein supplements. Body weight of calves program-fed concentrated diets was higher ($P < 0.05$) than that of calves fed hay-based diets at the end of the first 14-d grazing period and tended ($P = 0.06$) to be higher at the end of the grazing

phase in April (Table 3). Drylot diets had no effect (P = 0.52) on overall pasture ADG, but program-fed calves held a numerical advantage of 0.13 lb/d over calves fed hay.

The profitability of the stocker cattle enterprise was improved (P < 0.05) by an average of $18.50/animal by programmed feeding of high-concentrate diets. The observations from this trial closely resemble those found by Beck et al. (2000), who reported that the programmed feeding of calves corn or corn gluten feed-based diets improved early-season grazing performance and overall profitability of the stocker cattle enterprise compared to backgrounding with hay-based diets.

Implications

Diets fed to calves during backgrounding in drylot before grazing does influence performance early in the grazing season. The addition of molasses to the backgrounding diets improved performance of calves during the first 14 d after the initiation of grazing by 0.50 lb/d. Program feeding concentrated diets improved performance during the same period by 1.61 lb/d. Program feeding concentrate diets to growing cattle during backgrounding improved feed efficiency and decreased feed costs.

Acknowledgments

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Table 1. Composition of program-fed diets used during drylot period.

Ingredient	CON I[a]	CON II	CONMOL I	CONMOL II
			% DM	
Rice bran	42.8	22.7	38.9	18.9
Corn	42.3	61.9	38.9	58.9
QLF 34/6[b]	-	-	9.0	9.0
Cottonseed hulls	10.0	10.0	10.0	10.0
Urea	1.3	1.8	-	-
Mineral premix	3.6	3.6	3.2	3.2
Composition				
Crude protein, %	15	15	15	14
NEm, Mcal/lb	0.80	0.81	0.79	0.83
NEg, Mcal/lb	0.52	0.53	0.51	0.54
Fat, %	12.4	8.5	10.8	7.2

[a] Diets fed before rice bran level was reduced in order to reduce fat content of diet are denoted with the Roman numeral I, and after rice bran level reduction, with Roman numeral II. CON treatment was program-fed high-concentrate diets without a molasses-based protein supplement. CONMOL treatment was program-fed high-concentrate diets including a molasses-based protein supplement.

[b] Quality Liquid Feed 34/6—contains 34% CP (with 6% from natural protein sources), 0.51 mcal NEm/lb, 0.36 mcal NEg/lb, and 60% DM.

Table 2. Effect of drylot diet on performance and cost of backgrounding calves.[a]

	Treatment[b]			
Item	DRY	MOL	CON	CONMOL
Body weight, lb				
10/14/1999	466	466	466	463
12/21/1999	551	535	553	552
ADG, lb/d[c]	1.20	1.01	1.28	1.30
Feed:gain, lb feed/lb gain[c]	12.7	15.9	11.8	11.8
Drylot cost, $/animal[cde]	$74	$74	$71	$76

[a] Least-squares means.

[b] Drylot treatments: Calves were fed bermudagrass hay with either a rice bran-based supplement (DRY) or a molasses-based self-fed liquid supplement (MOL) or were program-fed a high-concentrate diet with either a dry-protein supplement (CON) or a molasses-based protein supplement (CONMOL).

[c] Contrast—hay-based diets vs. program-fed ($P < 0.05$).

[d] Contrast—dry diets vs. liquid supplemented diets ($P < 0.05$).

[e] Contrast—dry/liquid vs. hay/program-fed interaction ($P < 0.05$).

Table 3. Effect of drylot diet on subsequent performance of calves grazing stockpiled tall fescue.[a]

	Treatment[b]			
Item	DRY	MOL	CON	CONMOL
Body weight, lb				
12/21/1999	551	535	553	552
1/5/2000[c]	527	521	555	561
4/4/2000	659	648	676	679
Pasture ADG				
Period 1 – 12/21 to 1/5[cd]	–1.47	–.97	.14	.64
Overall pasture ADG	1.05	1.08	1.17	1.22
Overall cost of gain, $/cwt[cd]	$65	$71	$61	$63
Gross margin,[e] $/animal[c]	$34	$21	$46	$46

[a] Least-squares means.

[b] Drylot treatments: Calves were fed bermudagrass hay with either a rice bran-based supplement (DRY) or a molasses-based self-fed liquid supplement (MOL) or were program-fed a high-concentrate diet with either a dry-protein supplement (CON) or a molasses-based protein supplement (CONMOL).

[c] Contrast—hay-based diets vs. program-fed ($P < 0.05$).

[d] Contrast—dry diets vs. liquid supplemented diets ($P < 0.05$).

[e] Calculated by subtracting cost of gain from a $79 /cwt value of gain then multiplying the amount of gain. Value of gain was determined using the 10-yr average price at Oklahoma City National Stockyards of 400-lb steers in September ($85.86/cwt) and 665-lb feeder steers in April ($83.12/cwt).

Influence of Grazing System and Stocking Rate on Performance of Stocker Calves

K. Cassida, B. Stewart, S. Gunter, and P. Beck[1]

Story in Brief

Interest in rotational grazing is increasing because of perceived benefits in animal performance, forage yield, and forage utilization compared to continuous grazing. We compared stocker calf performance and net return of rotationally and continuously stocked winter annual or bermudagrass pastures at three stocking rates in Southwestern Arkansas. At four calves/acre on winter annual pasture, rotational stocking improved gain/acre and ADG ($P < 0.05$) compared to continuous stocking, but the two systems did not differ at lower stocking rates. Calf performance did not differ between systems on bermudagrass pasture at any stocking rate. Gain/acre and ADG were higher for continuously than rotationally stocked pastures ($P < 0.05$) during the forage transition phase in 1999. In 1999, more hay was fed on continuously grazed pastures, but more hay was harvested from rotated pastures ($P < 0.05$). Benefits for rotational stocking vs. continuous stocking were seen only when stocking rates were pushed to high levels on winter annual pastures.

Introduction

Interest in rotational grazing methods is increasing because of perceived benefits to cattle ADGs, stocking rates, gain/acre, forage production, and control of forage utilization. However, it has proved difficult to demonstrate these effects in controlled research trials, especially on warm-season forages. One reason may be that most experiments comparing grazing systems are conducted using the put-and-take method, in which standing forage supply and quality are equalized across systems by frequent adjustments to the number of animals grazing. This eliminates one of the benefits cited for rotational grazing—that it allows better control of forage supply and quality than continuous stocking. It also does not reflect realistic production practices, because most producers deal with excess forage by haying it.

We are conducting a 6-yr trial to compare continuously and rotationally managed pastures at three fixed stocking rates. Fixed stocking rates are used to create pasture conditions of understocking, ideal stocking, and overstocking, and each pasture is managed for maximum productivity within the stocking rate restriction. Excess forage is harvested as hay. Calf performance for the pilot year and first full year are reported in this paper.

Experimental Procedures

Our farm system is defined as a stocker calf operation in which calves are purchased at weights near 450 lb, preconditioned, and grazed on winter annuals followed by warm-season grass pastures until they reach sale weight (approximately 750 lb), forage is exhausted, or winter annual planting time arrives (~ October 1). Excess forage is harvested as hay both during the grazing season and before winter annual planting. The trial is being conducted at the Southwest Research and Extension Center in Hope using 12 2-acre pastures in a completely randomized design with two replications and a 2 x 3 factorial treatment arrangement. There are two grazing systems: continuous stocking (C) and a six-paddock rotational system (R); and three fixed stocking rates (SRs) designed to produce understocked (LOW), ideal (MED), and overstocked (HIGH) pasture conditions. The trial began in 1998 and will continue through 2003. Several management factors were changed between 1998 and 1999 to improve the study, so 1998 is considered a pilot year and the 2 yr cannot be statistically compared.

In 1998, SRs were 1.5, 2.5, and 3.5 calves/acre. In 1999, SRs were increased to 2, 3, and 4 calves/acre because overgrazing was not achieved at the highest 1998 SR. In 1998,

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calves were Limousin-cross heifers (average weight at turnout 500 lb), and in 1999 Angus-cross steers and heifers (average weight 521 lb; 58 steers, 16 heifers) were used. Calves were no more than 25% Brahman breeding and were vaccinated, dewormed, and dehorned if necessary prior to being blocked by weight and gender and turned out on pasture. Calves were grazed from May 15 to October 3 in 1998 and from February16 to August 18 in 1999. The late turnout date in 1998 was a result of pasture availability, and pastures had been uniformly grazed on a continuously stocked mineral supplementation study prior to initiation of this trial. The pulloff date in 1999 was early because cattle had reached their target sale weight of 750 lb. In 1999, calves were dewormed a second time with ivermectin in June. In 1998, calves did not receive growth promotant implants, at the owner's request. In 1999, steers and heifers were implanted with the appropriate Component S product for their gender just prior to turnout and again in June. Calves were shrunk overnight and weighed at the beginning and end of the grazing season. Interim weights (not shrunk) were obtained every 2 mo in 1998 and monthly in 1999. Calves were fed 1 lb/animal per day of a corn-based supplement containing monensin and a mineral premix. Supplement was fed three times per week. All cattle had water and shade available at all times. In 1998, all R pastures were moved on the same day regardless of paddock condition. In 1999, each pasture was managed independently of the others, with cattle moved to new paddocks whenever they had consumed approximately half of the available forage. Cattle on C pastures were fed hay whenever pasture forage biomass was less than 1000 lb/acre, and weights of hay fed were recorded. When cattle on R pastures had less than one day's worth of grazing in any paddock, they were fed hay in a sacrifice paddock until rotation could be resumed.

Winter annuals were drilled into short-grazed or mowed sods in October. There was no winter annual grazing period in 1998 because warm-season grass was already the primary sward component when cattle were turned out. 'Hickory' wheat and 'Marshall' ryegrass were a minor component of swards in mid-May 1998. In 1999, winter annuals were wheat (variety not stated, 90 lb/acre), Marshall ryegrass (20 lb/acre), crimson clover ('Dixie', 15 lb/acre), and ladino white clover ('Osceola', 3 lb/acre). Pastures were not grazed between annual planting in October 1998 and calf turnout in February 1999. The summer component of pastures was mixed common bermudagrass, Coastal bermudagrass, dallisgrass, and crabgrass. Nitrogen (30 to 50 lb/acre) was applied to annual stands near November, February, and April each year, and to warm-season grass stands in June, July, and August. Potash (total 110 lb/acre per year) was applied to warm-season grass stands in April and June 1999.

This trial is designed to study the total stocker cattle per forage production system. Data were also collected on forage biomass availability, growth rates, forage quality, forage utilization, botanical composition changes over seasons and years, weather conditions, costs of production, value of production, and mapped soil fertility gradients in the pastures. These data are not presented here because of space constraints.

Data were analyzed using analysis of variance, with initial animal weight as a covariate (SAS Inst. Inc., Cary, NC). In 1999, animal gender was also included in the model. Pasture was the experimental unit. Stocking rate effects were analyzed as linear and quadratic polynomial contrasts. Animal performance data are reported as least-squares means. Years were analyzed separately. In 1999, the grazing season was divided into three periods with different forage types. Periods were February to April (winter annual period), May to June (transition period), and July to September (warm-season-grass period).

Results and Discussion

In 1998, when calves were not turned out until warm-season grass was already the primary pasture component, the grazing system had no impact on performance at any date (Table 1). Other researchers have also reported no benefit to rotational grazing when cattle graze bermudagrass-based pastures (Aiken, 1998; DeRouen et al., 1999; Kee et al., 1991). Tharel (1989) reported improved gain/acre with rotational grazing on bermudagrass in Booneville, Arkansas. Gain/acre increased linearly ($P < 0.05$) with increasing SR, while ADG, final calf weight, and gain/calf decreased linearly ($P < 0.01$) with increasing SR. Hay feeding was not required in 1998. There were no treatment differences ($P > 0.05$) for hay harvested prior to winter annual establishment.

In 1999, the effects of grazing system and SR were not the same in each forage period (Table 2). More than 50% of the total season gain/acre was produced in the winter annual phase for all treatments except C-HIGH. When calves grazed winter annuals, grazing system interacted with SR for ADG ($P < 0.08$) and gain/acre ($P < 0.05$) such that these variables did not differ between C and R at LOW or MED SRs. However, at HIGH SR, ADG was 0.80 lb/d higher and gain/acre was 256 lb/acre higher for R than for C pastures ($P < 0.05$). Within grazing systems, ADG decreased linearly with SR on C pastures ($P < 0.10$). Gain/acre tended toward a quadratic relationship with SR ($P < 0.14$), with the highest gains at the MED rate. This suggests that we were successful in achieving an overstocked condition on the C-HIGH treatment. On R pastures, ADG was not affected by SR ($P > 0.05$), and gain/acre increased linearly with SR ($P < 0.05$). The lack of difference in ADG at different SRs indicates that animal performance was not being limited by forage availability or quality on R winter annual pastures.

During the transition period in 1999, ADG, gain/calf, and gain/acre were all higher ($P < 0.05$) for C than for R pastures. In the transition period, SRs did not affect ADG or gain/calf ($P > 0.05$), and gain/acre increased linearly with increasing SRs ($P < 0.01$). Forage quality samples are currently being analyzed to see whether diet quality was a factor in these differences. The R pastures had more available

forage than C pastures during the transition period (biomass data not shown), but forage quality was likely lower on the R pastures because R calves were grazing mature headed ryegrass, while C calves were grazing immature lush bermudagrass and dallisgrass (botanical composition data not shown). This occurred because C calves grazed out their winter annual forages early in the season, while rotational stocking maintained this forage component well into June. Weather also contributed to accumulation of over-mature forage by delaying harvest of excess hay from spring pastures until the end of May.

During the 1999 warm-season grass period, grazing system did not affect any aspect of calf performance ($P > 0.05$). Gain/acre increased as the SR increased ($P < 0.06$), but ADG was not affected by SR ($P < 0.05$).

For 1999 as a whole, treatment differences generally reflected those found during the winter annual period. Grazing system and SRs interacted ($P < 0.01$). There was no difference between C and R systems until the HIGH SR was reached, where ADG and gain/acre were higher on R than C pastures ($P < 0.05$). The relationship between SR and gain/acre tended to be quadratic within both C ($P < 0.15$) and R ($P < 0.01$), with numerical peaks reached at C-MED and R-HIGH within systems. On R pastures, season ADG was not affected by SR ($P > 0.05$), while ADG tended to decrease linearly with increasing SR on C pastures ($P < 0.12$)

There was a grazing system x SR interaction for hay fed in 1999 ($P < 0.05$). Hay feeding was required on C-MED and C-HIGH pastures in spring and for C-HIGH pastures in August, while R-HIGH pastures required only a small amount of hay feeding in spring. Hay was harvested from all LOW SR pastures and from R-MED pastures in spring, and from all pastures except C-HIGH just prior to winter annual planting. The total hay yield decreased as the SR increased ($P < 0.05$), and more hay was harvested from R pastures than from C pastures overall ($P < 0.05$). More hay was harvested than was fed for all R pastures and C-LOW pastures, while C-MED and C-HIGH pastures harvested less hay than was fed.

Implications

At high stocking rates on winter annual pasture, rotational stocking increased stocker calf ADG, gain/acre, and hay yield over continuous stocking and decreased the amount of hay fed. At lower stocking rates on winter annuals and on bermudagrass at all stocking rates, there was no advantage to either grazing system.

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Table 1. Calf performance when rotationally or continuously grazed at 1.5, 2.5, or 3.5 calves/acre (low, medium, high) stocking rates from May to October 1998.

	Continuous system			Rotational system			Statistical
Item	Low	Medium	High	Low	Medium	High	significance[a]
Body weight, lb	644	596	583	653	586	571	SR linear**
ADG, lb/day	1.22	0.89	0.80	1.29	0.82	0.71	SR linear**
Gain, lb/calf	175	127	114	184	116	102	SR linear**
Gain, lb/acre	260	302	396	275	290	365	SR linear**
Hay fed, lb DM/acre	0	0	0	0	0	0	NS[1]
Hay baled, lb DM/acre	2825	875	0	2600	1950	2650	NS

[a] ** Effects were different ($P < 0.01$) level of probability.

[1] NS = not significantly different.

SR = stocking rate, DM = dry matter.

Table 2. Calf performance when rotationally or continuously grazed at 2, 3, or 4 calves/acre (low, medium, high) stocking rates from February to August 1999.

	Continuous system			Rotational system			Statistical
	Low	Medium	High	Low	Medium	High	significance[a]
Winter annual period (February to April)							
Body weight, lb	743	714	658	728	736	690	Interaction*
ADG,[1] lb/d	3.06	2.37	1.42	2.83	2.73	2.22	System,† SR linear***
Gain, lb/calf	257	199	119	238	230	186	System,† SR[1] linear***
Gain, lb/acre	510	600	486	474	686	742	Interaction*
Forage transition period (May to June)							
Body weight, lb	830	794	735	776	780	751	Interaction**
ADG, lb/d	1.52	1.40	1.38	0.83	0.94	1.08	System**
Gain, lb/calf	87	80	78	47	54	62	System**
Gain, lb/acre	174	240	310	95	163	247	System*, SR linear**
Warm-season grass period (July to August)							
Body weight, lb	906	857	769	858	866	810	SR linear***
ADG, lb/d	1.26	1.54	1.44	1.75	1.57	1.24	NS[1]
Gain, lb/calf	54	66	62	75	68	53	NS
Gain, lb/acre	106	200	254	150	199	213	SR linear*
Year (February to August)[2]							
Body weight, lb	822	784	726	769	760	746	SR linear***
ADG, lb/d	1.90	1.56	1.12	1.54	1.56	1.40	Interaction**
Gain, lb/calf	349	286	207	283	286	257	Interaction**
Gain, lb/acre	696	863	828	565	860	1022	Interaction**
Hay fed, lb DM/acre	0	1426	2504	0	0	532	Interaction*
Hay baled, lb DM/acre	5771	540	0	5548	3393	2766	System,† SR linear*

SR = stocking rate.

[a] †,*, **, *** Effects were significantly different at the 0.10, 0.05, 0.01, and 0.001 levels of probability, respectively.

[1] NS = not significantly different.

[2] Weights for full-year data are based on shrunk weights; interim period weights are not shrunk.

Growth Performance by Stocker Steers Grazing Bermudagrass Pastures and Fed Soybean Hulls, Grain Sorghum, or a Combination of Soybean Hulls and Grain Sorghum

K. Coffey,[1] G. Montgomery,[2] and W. Coblentz[1]

Story in Brief

A 107-d grazing study was conducted to evaluate the effect of feeding soybean hulls, grain sorghum, or a 50:50 mixture of the two on growth performance by stocker cattle grazing bermudagrass in the summer. A total of 72 mixed-breed stocker steers (550 ± 8.3 lb) were allocated randomly by weight into nine groups and grazed bermudagrass pastures from May 27 until September 11, 1999. Steers were fed 4.2 lb/d Monday through Friday of either soybean hulls, grain sorghum, or a 50:50 mixture of soybean hulls and grain sorghum. All steers were fed 0.5 lb/d Monday through Friday of a soybean meal-based supplement containing salt, trace minerals, and bambermicin. Weight gains did not differ (P > 0.10) among steers fed the various supplements. Therefore, when available and prices are favorable, soybean hulls can be substituted successfully for grain sorghum in supplements for stocker cattle grazing bermudagrass pastures.

Introduction

Numerous feedstuffs that are a byproduct from another process are available for feeding to ruminant animals. Soybean hulls are the external seed coat from soybeans and are a byproduct of processing of soybeans for oil and meal. Soybean hulls are high in fiber (66% neutral detergent fiber) but low in lignin (3%; NRC, 1996) and therefore are highly digestible. In previous studies, no differences in gain were observed in cattle fed either soybean hulls or corn while grazing smooth bromegrass (Anderson et al., 1988) or native grass pastures (Hibbert et al., 1987). The objective of this study was to compare growth performance by stocker cattle grazing bermudagrass and fed soybean hulls, grain sorghum, or a 50:50 mixture of soybean hulls and grain sorghum.

Experimental Procedures

Seventy-two mixed-breed steers were received at the University of Arkansas Southeast Research and Extension Center in Monticello on April 16, 1999, and had received respiratory and clostridial vaccinations and a growth-promoting implant prior to arrival at the station. Steers initially grazed late-season rye, wheat, and ryegrass that had been overseeded into bermudagrass pastures the previous fall. Steers were weighed on May 27 following a 12-h shrink, stratified by weight, and allocated randomly to one of nine groups. The groups were then allocated randomly to receive 4.2 lb/d Monday through Friday of soybean hulls, grain sorghum, or a 50:50 mixture of soybean hulls and grain sorghum. All steers were fed 0.5 lb/d (Monday through Friday) of a 48% soybean meal-based supplement containing salt, trace minerals, and bambermicin (Table 1). Groups of steers were then allocated randomly to one of nine bermudagrass pastures for a 107-d study. Pastures were fertilized with a complete commercial fertilizer to provide 50 lb/acre of each of nitrogen, phosphate, and potash in late May and 50 lb/acre nitrogen in early July.

Steers were weighed on July 15 and September 11 without prior removal from pasture and water. A 4% pencil shrink was applied to weights on September 11 to serve as a final weight. Data were analyzed statistically using SAS (SAS Inst., Inc., Cary, NC.) procedures for a completely randomized design.

Results and Discussion

Weight and gain did not differ (P > 0.10) among treatments. There was a slight numerical tendency for a reduction in gain (0.14 lb/d; P = 0.35) from steers fed soybean hulls compared with those fed the other treatments. Hibbert et al. (1987) also observed a slight but nonsignificant reduction in gain (0.08 lb/d) by heifers grazing native grass and supplemented with soybean hulls compared with those supplemented with corn. Anderson et al. (1988) reported no difference in gain by stocker steers grazing smooth

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bromegrass and fed soybean hulls or corn (2.11 vs. 2.08 lb/d for soybean hulls vs. corn, respectively). Anderson et al. (1988) also reported a 0.15 lb/d increase in gain by heifers grazing corn stalks and fed soybean hulls compared with corn. Therefore, gain by stocker calves should differ minimally when fed the same level of grain sorghum or soybean hulls.

Implications

Prices for feed commodities vary with season, year, and location. Often, surplus supplies of one feed commodity lead to a reduction in price relative to other commodities. Based on the results from this study and others, we conclude that price or convenience should be used to make decisions whether to feed soybean hulls or grain sorghum as an energy supplement for stocker calves grazing bermudagrass pastures. Relative differences in animal gain are not sufficient to warrant feeding one over the other based on expected differential in animal growth.

Acknowledgments

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Table 1. Composition of supplements fed to steers grazing bermudagrass pastures during the summer.

Item	% of supplement
Soybean meal	91.41
White salt	5.89
Liquid molasses	2.15
GainPro – 10	0.42
Trace mineral mix[a]	0.13

[a] Contains copper sulfate, zinc sulfate, 1% selenium premix, and calcium iodide.

Table 2. Growth performance by stocker steers grazing bermudagrass pastures and fed soybean hulls, grain sorghum, or a 50:50 mixture of soybean hulls and grain sorghum.[a]

	Grain sorghum	50:50 mix	Soybean hulls	SE
Initial weight, lb	550	550	550	0.2
Weight - day 49, lb	631	630	627	4.1
Final weight, lb	717	717	701	7.9
Total gain, lb	166	166	151	7.8
Daily gain, lb	1.55	1.55	1.41	0.073

[a] No significant differences were detected (P > 0.10).

Effects of Supplementation and Nitrogen Fertilization on Performance of Stocker Cattle Grazing Warm-Season Perennials

J. Weyers, S. Gunter, P. Beck, and K. Cassida[1]

Story in Brief

Seventy-six steers (average BW = 575 lb) were randomly assigned to 12 pastures, which were stocked at normal (2.5 and 3.5 steers/acre) and increased (3.0 and 4.0 steers/acre) rates. Six pastures were assigned to a low rate of nitrogen (N; 100 lb of N/acre) and six pastures were assigned to a high rate of N (166 lb of N/acre) along with three supplementation treatments. The supplement treatments (Farmland Beef Grow-Gest) were fed at 0.65% of BW and treatments within each N fertilization rate consisted of 1) nonsupplemented at normal stocking rates, 2) supplemented at normal stocking rates, or 3) supplemented at increased stocking rates. Across fertilization rates, supplementation fully compensated for the increased stocking rates. Across supplementation and stocking rates, the high rate of N fertilization did not provide the essential forage mass necessary to maintain adequate animal performance of the additional steer/acre. The high rate of N fertilization showed an increased gain/acre, but it was the result of the additional stocking rate and not increased individual animal performance. The low supplemental feed-to-added gain ratios suggest that supplementation is beneficial and economical at the lower N fertilization rate. However, the high supplemental feed-to-added gain ratios at the higher N fertilization rate indicates that forage probably was limiting.

Introduction

Supplementation has provided producers an option for manipulating the performance of pastures and cattle. Depending on management decisions, supplementation can extend the grazing season by conserving forage mass. Prior research has shown that if supplementation is provided at amounts greater than 0.45% of BW, a significant reduction in forage intake will be observed (Pordomingo et al., 1991; Mieres, 1992). If forage intake is reduced and nitrogen (N) fertilizer is applied, it should be possible to increase carrying capacity of the pasture, which would possibly enhance economic performance. Supplementation may also affect ADG and increase the performance of grazing stocker cattle. Research at the Southwest Research and Extension Center, Hope (Gunter et al., 1998) has shown that the most profitable stocking rates for stocker cattle grazing dallisgrass pastures are between 2.46 and 3.20 steers/acre, depending on the amount of N fertilizer applied. Utilization of both supplementation and a high rate of N fertilization to increase forage availability may allow for the addition of an extra animal per acre.

Therefore, this research was conducted to evaluate the effects of high-energy supplementation, N fertilization, and stocking rate on the performance of stocker cattle grazing warm season perennial pastures.

Experimental Procedures

This experiment was conducted at the Southwest Research and Extension Center on 24 acres divided into 12 2-acre pastures. The soil type was an Una silty clay loam, which consists of deep, poorly drained, level soils (slopes, 0 to 1%) located on a floodplain. This soil type has a seasonally high water table in the winter and spring and is predicted to produce approximately 7.5 animal-unit-mo/acre per year. These swards are primarily dallisgrass (39%), common bermudagrass (34%), and tall fescue (20%), but also contain other grasses and forbs.

Animals and Treatments. Seventy-six steer calves (initial shrunk BW = 575 lb) were obtained through local salebarns. After a 16-h shrink, the cattle were weighed, ear-tagged, implanted (Component-ES; Ivy Laboratories, Inc., Overland Park, KS), dewormed (Cydectin; Fort Dodge Animal Health, Inc., Overland Park, KS), and randomly assigned to one of the 12 pastures. The cattle had previously been vaccinated for infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza-3, and bovine respiratory syncytial virus plus *Haemophilus somnus*, and seven strains of *Clostridium* before arrival at the Research Center. Pastures were assigned one of to two rates of N fertilization (100 or 166 lb/acre) and one of three supplementation treatments.

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The supplement (Farmland Beef Grow-Gest; 15% CP) was fed at 0.65% of BW, adjusted at each weighing day. Treatments within each N fertilization rate consisted of 1) nonsupplemented (NS) at normal stocking rates (2.5 or 3.5 steers/acre for 100 or 166 lb N/acre, respectively), 2) supplemented (S) at normal stocking rates, or 3) S at an increased rate (3.0 or 4.0 steers/acre for 100 or 166 lb of N/acre, respectively). The cattle were allowed ad libitum access to water and a free-choice mineral supplement (Farmland B-1440), which provided 200 mg/d of lasalocid. Because of drought conditions (precipitation was 21% of normal), the planned 150-d grazing period was restricted to 104-d (May 13 to August 24). Steers were weighed unshrunk at 35-d intervals during the grazing period, and on day 70, they were reimplanted (Component-ES).

Pasture Management. Upon initiation of this trial, soil concentrations of phosphorus and potassium were increased to recommended levels according to the Arkansas Cooperative Extension Service for high production. Pastures were also fertilized with equal amounts of N in the form of ammonium nitrate during this time and at subsequent 50-d interval to total the specified rate of nitrogen.

Statistical Analysis. Dependent variables were analyzed as a 2 x 3 factorial arrangement in a completely random design with initial BW as a covariate. Because pasture was the experimental unit, pasture within treatment was the error term. Data were analyzed by analysis of variance, and least-squares means were separated using contrasts: 1) NS steers vs. S steers at the normal stocking rate; 2) S steers at normal stocking rate vs. S steers at the increased stocking rate; 3) NS steers vs. S steers at the increased stocking rate; and 4) 100 lb of N/acre vs. 166 lb of N/acre.

Results and Discussion

The effects of supplementation and N fertilization rate did not interact ($P > 0.15$) for the response variables of BW, ADG, or gain/acre (Table 1). At the normal stocking rate, ADG and gain/acre were less ($P < 0.05$) for the NS (1.23 and 1,035 lb, respectively) than for S steers (1.94 and 1,509 lb, respectively) across fertilizer rates, and ADG and gain/acre were greater ($P < 0.05$) for the S steers at the normal stocking rate than for the S steers at the increased stocking rate (1.65 and 1,332 lb, respectively). Supplemented steers at the increased stocking rate had a greater ($P < 0.05$) ADG and gain/acre than NS steers. These data suggest that supplementation of steers grazing at the increased stocking rate was sufficient to provide enough residual forage for the additional steer compared to NS steers.

Steers grazing pastures fertilized with the low rate of N had a greater ($P < 0.05$) ADG (1.72 lb) than steers grazing pastures fertilized at the high rate of N (1.48 lb), while the gain/acre was greater ($P < 0.05$) for high N pastures (1,383 lb) compared to that for steers grazing low N pastures (1,200 lb). The lower ADG for the high level of N fertilization is probably the result of a lack of rainfall during the trial, which decreased forage availability. The increased gain/acre for the high rate of N fertilization was expected because of the increased stocking rate but did not result from increased individual animal performance.

The ratios of supplemental DM to added gain interacted between S steers and N fertilization rate ($P < 0.05$; Table 1). The ratios of supplemental DM to added gain at the low N level were similar for both stocking levels (5.6 vs. 6.7 lb). On high N pastures, the ratio of supplemental DM to added gain was larger ($P < 0.05$) for the high stocking rate (6.6 vs. 16.5 lb for stocking rates of 3.5 and 4.0, respectively). The low rate of N fertilization coupled with a supplementation program provided adequate forage availability and supplemental nutrients for these animals to maintain and gain considerable amounts of BW. Also, the level of supplementation provided at 0.65% of BW did prove to be enough to suppress forage intake at the lower rate of N fertilization.

Implications

Supplementing grazing cattle, while applying N fertilizer at 100 lb/acre, seems to be a practical management decision. The low supplemental feed-to-added gain ratios obtained with this management technique would indeed be beneficial to a producer who is looking to increase the overall economical status of their pastures. In a year with adequate rainfall, the higher level of N fertilizer may produce a more economical gain, but this hypotheses needs to be tested.

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Table 1. Effects of supplementation, nitrogen fertilization, and stocking rate on stocker cattle grazing dallisgrass pasture.

Fertilizer rate	100 lb nitrogen/acre			166 lb nitrogen/acre			
Stocking rate, animals/ac	2.5	2.5	3.0	3.5	3.5	4.0	
Supplementation	No	Yes	Yes	No	Yes	Yes	SE[a]
Initial BW, lb	575	575	575	575	575	575	—-
Day 34[bcd]	656	689	660	639	674	635	4.3
Day 69[bcd]	699	742	727	687	730	681	5.1
Day 104[bcde]	705	787	769	699	766	724	13.3
Period 1 ADG, lb[bcd]	2.39	3.34	2.50	1.89	2.91	1.76	0.13
Period 2 ADG, lb	1.22	1.52	1.89	1.42	1.60	1.31	0.24
Period 3 ADG, lb[be]	0.17	1.30	1.21	0.32	1.02	1.25	0.31
Overall ADG, lb[bcde]	1.25	2.04	1.87	1.19	1.84	1.44	0.06
Gain per acre, lb[bcde]	856	1,458	1,288	1,213	1,559	1,376	26.0
Supplemental DM/added gain, lb:lb[cdf]	—	5.6	6.7	—	6.6	16.5	0.8

[a] n = 2.

[b] Contrast of nonsupplemented steers vs. supplemented steers at normal stocking rates (P < 0.05).

[c] Contrast of supplemented steers at normal stocking rates vs. supplemented steers at the increased stocking rates (P < 0.05).

[d] Contrast of fertilizer rates, 100 vs. 166 lb/acre of nitrogen (P < 0.05).

[e] Contrast of nonsupplemented steers vs. supplemented steers at the increased stocking rates (P < 0.05).

[f] Contrast of interaction fertilizer rate by stocking rate (P < 0.05).