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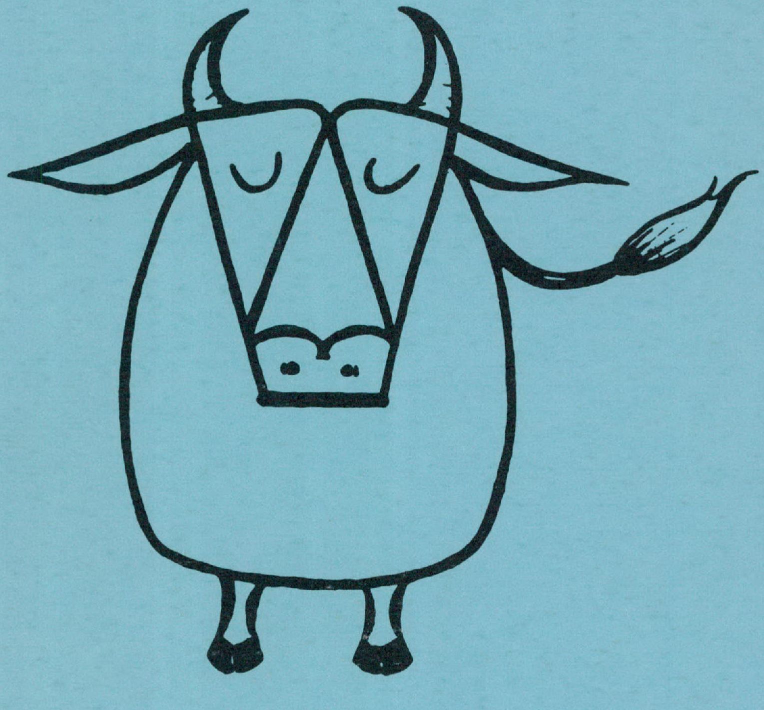
Beef Cattle Research in Texas, 1981



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Metric Units - English Equivalents

Metric Unit	*English Equivalent*
Centimeter	0.394 inch
Hectare	2.47 acres
Kilogram	2.205 pounds
Kilogram per hectare	0.893 pounds per acre
Kilometer	0.62 statute mile
Kilometer per hour	0.62 miles per hour
Liter	0.264 gallons
Meter	3.28 feet
Square meter	10.758 square feet
(Degrees centigrade $\times 1.8 + 32$)	Degrees fahrenheit

The Texas Agricultural Experiment Station has many of the physical plant components required to support a research program of excellence in beef cattle production, processing, and distribution. It also has a staff of dedicated research scientists with competence in the disciplines required for a comprehensive research program in this field. The research program is under effective scientific leadership and competent research management and reflects wise investment of public resources with a generally well-balanced program. The Research-Extension Centers, located among the land resource areas of the State (see map), provide an unusual opportunity for a truly comprehensive beef cattle research program for Texas with the efforts at each Center focusing on developing the technology needed to alleviate the most limiting constraints in the area it serves while contributing to the statewide program.

Texas unquestionably holds a position of major influence and responsibility in the beef industry. It has ranked first among all states in fed cattle production since 1972 and has always ranked first in beef cow and total cattle numbers. Texas became the leading cattle slaughter state in 1975.

Despite the magnitude of the industry, there are major constraints to development of its full potential. To realize its potential, new technology for an increasingly efficient as well as now "socially acceptable" beef industry must be continuously developed and disseminated to all segments. This can be accomplished only through sound and vigorous research and education programs. A comprehensive beef cattle research program oriented toward developing technology to alleviate these constraints is clearly in the public interest and is consistent with the missions and goals of The Texas Agricultural Experiment Station.

A 10-year plan for the research program was prepared a decade ago, and implementation was begun in 1972. The plan was updated in 1979, and recommendations were provided for a comprehensive program for the period 1978 to 1988. From this a Five-Year Plan was prepared as part of the overall TAES plan. The Five-Year Beef Cattle Research Plan included nine Research Need Statements. These were

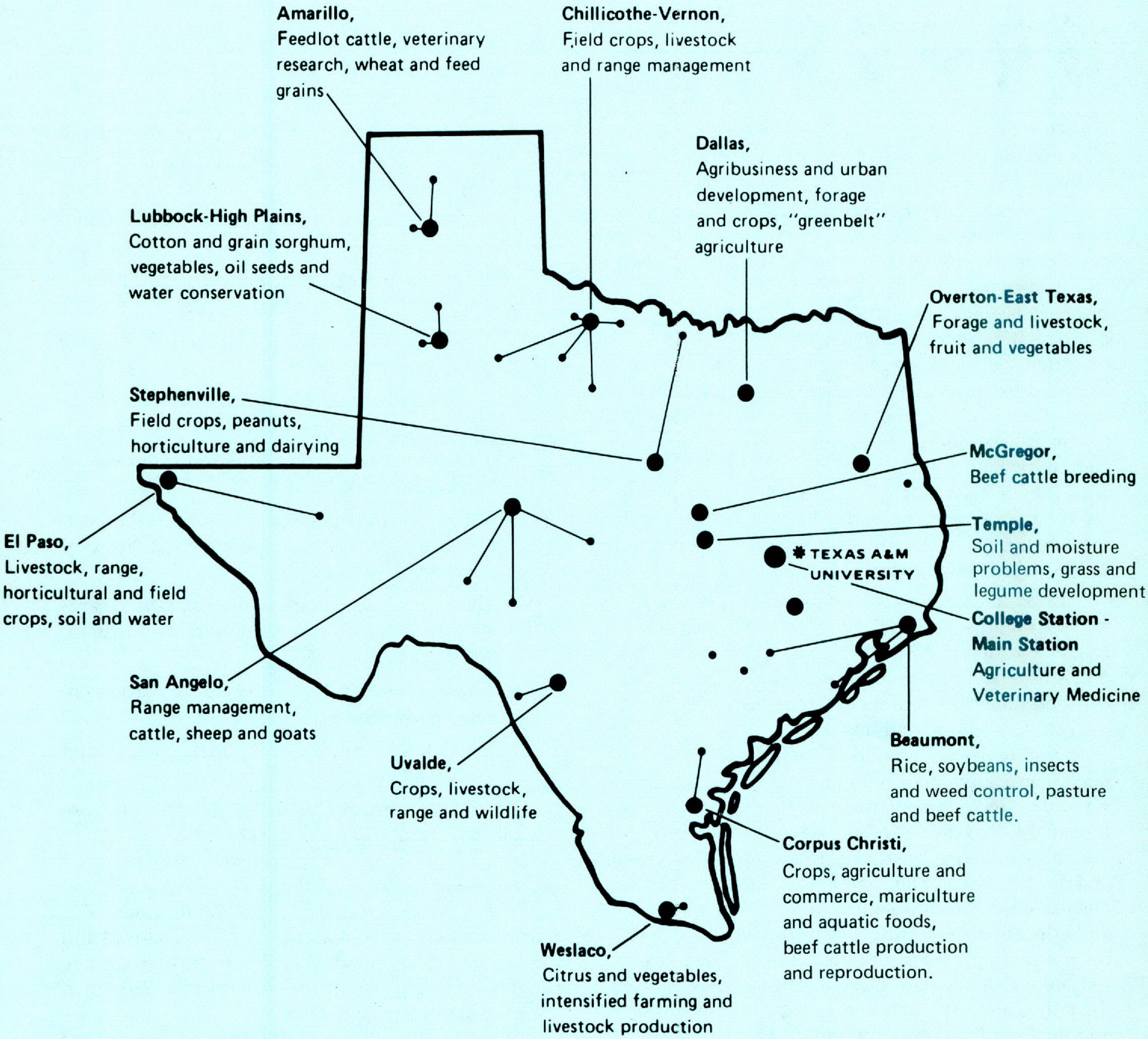
1. Improve biological efficiency of beef production
2. Improve energy efficiency for producing, processing, and distributing beef
3. Develop management systems to increase profit and reduce risk
4. Develop alternative markets and market options for live cattle and beef cattle products
5. Develop more efficient land and water use by the beef industry
6. Determine the effects of governmental regulations on efficiency of operations in the beef industry
7. Develop more complete information regarding the effects of beef in human nutrition, health, and food safety
8. Improve beef industry through environmental consciousness
9. Prevent and control beef cattle diseases and parasites.

Progress reports of beef cattle research work consolidated under the title "Beef Cattle Research in Texas" were first published in 1965. The idea soon became popular in other disciplines. The beef cattle report was issued annually from 1965 through 1973, then combined for 1974 and 1975 when financial and physical problems of producing it necessitated some change. Similar problems prevailed until 1980 when annual publication was resumed.

While earlier editions were devoted primarily to reports of animal science origin, the interdisciplinary nature of research related to the field of beef production, processing, and distribution is clearly reflected in later editions.

J. K. Riggs

THE TEXAS A&M UNIVERSITY SYSTEM
RESEARCH AND EXTENSION CENTERS



Beef Cattle Research in Texas, 1981

Forage Management and Utilization

Beef cattle provide the largest source of cash agricultural income to Texas at almost $5 billion per year. The major source of nutrients to sustain beef cattle production is derived from a forage base including rangelands, forest and cultivated pastures. These resources must be efficiently utilized and managed to maintain an economically viable and competitive industry. The major nutrient requirements of beef cattle have been defined for some time but numerous gaps still exist in our knowledge. More fundamental information is needed to understand factors controlling forage intake and rate of passage upon site and extent of digestion for cattle. These concepts may then serve as the bases for development of production and management systems of direct benefit to producers. Texas Agricultural Experiment Station staff have recognized this need and some of their current efforts are reflected in the following progress reports.

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PR-3758

Effect of Frequency and Duration of Grazing Annual Ryegrass on Diet Composition and Its Intake and Digestibility

J.P. TELFORD AND W.C. ELLIS

Summary

Frequency and duration of grazing are factors that appear to alter both the composition of forage on offer and that consumed. The results of these studies suggest that for cool season forages, quantity of forage available and its digestibility are dominant factors influencing the voluntary intake of the grazing animal. These factors appear to be altered by both frequency and duration of grazing.

Introduction

The majority of beef cattle produced today derive a substantial amount of their protein and energy requirements from forages. The major factor limiting animal performance of the foraging animal is variability in quantity and quality of consumed forage. A large number of foraging animals are wintered on cool season annuals in the South where animal productivity has been acceptable, yet variable. Therefore, this study was conducted to determine the effect of frequency and duration of grazing annual ryegrass (*Lolium multiflorum*) pasture by steers on the composition of diets selected and its effect on intake and digestibility.

Experimental Procedure

Four hectares (ha) of prepared seedbed were fertilized and seeded with annual ryegrass on September 15 and allowed to grow undisturbed until the project commenced in January. An experimental design was developed with five series of six plots per series each separated by electrical fence to contain 0.10, 0.0151, 0.0201, 0.0401, and 0.0803 ha per plot. A combination of three animals (A, B, C) grazed 2 days in each plot as successive first (A), second (B), and third (C) grazers so that the effect of duration of grazing could be observed. Forage was allowed to accumulate in plot series for different periods of time to give different forage maturities, but each set of plots varied in size so that reductions in plot sizes were accompanied by increasing regrowth periods to obtain similar forage availabilities. At least two collections were made for each set of plot series.

Ten bi-fistulated (esophageal and ruminal) Angus steers, ranging in weight from 290 to 415 kilograms (kg) were used to collect samples representative of consumed forage. Esophageal samples of consumed forage were collected on a daily basis in collection plots on three successive afternoons between 3 and 5 p.m. Each collector animal sampled the available forage upon a) entering each new collection plot beginning day one, b) 24 hours later at the beginning of day two and c) ending of day two prior to exiting the particular collection plot. Therefore, each animal spent a total time of 2 days in each of three collection plots so there was a total of 6 days' collections. Additional regulator animals were used to maintain regrowth of the frequently grazed plot series to as near targeted standing crops as possible. Standing crop measurements of available forage were obtained from each collection plot on the same days that consumed forage samples were collected. Available forage samples were clipped to 2.54 centimeters (cm) above ground level within a 0.61 square meter (m^2) quadrad. Standing crop measures were calculated from these yield samples. In addition, a minimum of 25 individual tillers were collected (hand plucked) for leaf and stem separation. All available, esophageal-consumed, and hand-plucked samples were analyzed for dry matter, ash, crude protein (CP), neutral detergent fiber (NDF), indigestible neutral detergent fiber (INDF), and *in vitro* dry matter digestibility (IVDDM). Fecal output and, subsequently, voluntary intake estimates were determined by external marker technique using chromium oxide impregnated paper, or continuous infusion of CrEDTA. All data were analyzed statistically, and differences between means were evaluated by Duncan's multiple range test.

Results and Discussion

Means of initial plant height, standing crop, and grazing pressure with their respective collection dates and regrowth periods are presented in Tables 1 and 2. Estimates of standing crop ranged from 1,581 to 5,119 kg DM/ha in trial 1 and 1,678 to 6,604 kg DM/ha in trial 2. Grazing pressure expressed as kg DM per plot per 100 kg body weight ranged from 7.9 to 47.4 in trial 1 and 9.7 to 63.8 in trial 3. Less time was required to obtain equal amounts of forage in cycle II than in cycle I, suggesting more favorable growth with changing environmental conditions.

The mean composition of IVDDM, CP, and NDF of available, consumed, and hand-plucked leaf and stem are summarized in Table 2. The mean values of IVDDM, CP were greater while NDF was lower in cycle I than in cycle II, while the observed differences between available and consumed forage chemical composition was less in trial I than trial II. The reported mean values of analysis for IVDDM, CP, and NDF suggest that leaves were more digestible and contained more crude protein and less fiber (NDF). The greater difference in composition between these plant parts in cycle II than cycle I could possibly explain the differences incurred between consumed and available forage composition.

The mean values across cycles I and II for *in vivo* dry matter digestibility (DDM), fecal output (FO) and voluntary intake (VI) are summarized in Table 4. Estimates of DDM and VI tended to decrease with grazer progression (A, B, C) and between cycles (I and II), while FO tended to increase with grazer progression (A, B, C) and between cycles (I, II). The average DDM values were higher in cycle I than in cycle II and are in agreement but higher than IVDDM estimates. These differences are a consequence of the dynamic continuous digestive processes of rates of passage (Kp) and digestion (Kd) occurring in the grazing animal while the IVDDM estimates are more a function of Kd. There were small but not always significant increases in FO between cycle I and cycle II (.80 vs. .82) and between grazers in cycle I (.78, .81, .82) and cycle II (.80, .83, .84). These data indicate that with decreasing digestibility, a small increase (5 percent) in fecal output of undigested dry matter residues might be observed.

Mean voluntary intake estimates were greater in cycle I than cycle II (2.90 vs. 2.74). There was a tendency for reduced voluntary intake between B and C grazers but not between A and B grazers. These differences occurred as a consequence of lowered digestibility and greater fecal outputs. The inability of animals to process the greater fecal residues necessary to maintain equal voluntary intake suggests a limitation of either handling total tract residues or their processing rates.

Summaries of simple and multiple regression analysis for some components of the forage animal relationship are presented in Table 5. These results indicate that in cycle I, 43 percent of the variation in consumed forage was accounted for by estimates of available forage, while in cycle II 70 percent of the variation was accounted for by available forage. The higher value in cycle II could be attributed to a greater range of sample data points from which these data were fitted. A combination of both cycle I and II give

TABLE 1. COLLECTION DATES, REGROWTH DAYS, AND PLANT HEIGHT ASSOCIATED WITH RYEGRASS STUDY

	Cycle I			Cycle II		
Plot series	Collection[a] date	Regrowth days	Plant[c] height(cm)	Collection date	Regrowth days	Plant height (cm)
1	3-18	6	14.4	4-8	4	18.5
2	3-25	18	28.7	4-14	8	26.2
3	3-31	24	32.0	4-20	14	35.6
4	4-6	30	40.6	4-24	21	37.3
5	2-6	Initial[b]	36.3	4-20	50	43.2

[a]Initial date of 6-day collection period.

[b]Initial, primary growth from seedling not having been previously grazed.

[c]Mean height measured from ground level, N=25.

TABLE 2. ESTIMATES OF STANDING CROP AND GRAZING PRESSURE ASSOCIATED WITH RYEGRASS STUDY

		Cycle I		Cycle II	
Plot series	Grazer	Standing crop	Grazing[a] pressure	Standing crop	Grazing pressure
		kg DM/ha	kg DM/plot/100 kg BW	kg DM/ha	kg DM/plot/100 kg BW
1	A	1581	42.8	2140	40.3
	B	1742	48.1	2280	63.8
	C	1775	47.4	2183	55.1
2	A	2237	26.5	2366	31.5
	B	2334	27.5	2000	25.6
	C	2118	26.3	1678	19.1
3	A	3625	24.5	4130	26.7
	B	2796	19.3	3334	15.3
	C	2097	14.0	2474	14.8
4	A	5119	22.9	5238	22.3
	B	3894	17.2	3871	16.0
	C	2915	13.6	2990	13.4
5	A	4421	12.3	6604	18.6
	B	2420	7.9	4453	15.2
	C	-	-	3270	9.7

[a]Grazing pressure based on kg DM per plot adjusted for plot size and animals' body weight (kg).

TABLE 3. MEAN AND STANDARD DEVIATIONS FOR *IN VITRO* DRY MATTER DIGESTIBILITY (IVDDM), CRUDE PROTEIN (CP), NEUTRAL DETERGENT FIBER (NDF) OF AVAILABLE, CONSUMED, AND HAND-PLUCKED LEAF AND STEM PARTS FOR RYEGRASS STUDY

	Cycle I				Cycle II			
Item	A	B	C	$\bar{X}$	A	B	C	$\bar{X}$
	----------	----------	----------	---------- % DM	----------	----------	----------	----------
IVDDM								
AVAIL[1]	73.41[a]	71.56[b]	70.56[b]	71.89	64.86[a]	62.63[b]	60.89[c]	62.79
CONS[1]	72.93[a]	71.38[b]	70.65[b]	71.64	70.70[a]	68.15[b]	66.40[c]	68.42
LEAF[2]	74.60				73.52			
STEM[2]	71.79				67.46			
CP								
AVAIL	20.04[a]	18.36[b]	17.93[b]	18.76	15.36[a]	13.60[b]	13.02[b]	14.03
CONS	20.80[a]	19.03[b]	18.72[b]	19.34	19.16[a]	16.25[b]	14.76[c]	16.77
LEAF	23.48				20.35			
STEM	18.65				13.92			
NDF								
AVAIL	51.83[c]	53.94[b]	55.72[a]	53.38	61.31[c]	63.08[b]	63.89[a]	62.64
CONS	51.29[c]	52.40[b]	55.41[a]	52.39	58.72[c]	60.37[a]	59.81[ab]	59.65
LEAF	51.86				57.11			
STEM	56.85				68.93			

[abc]Means in rows with different superscripts are significantly different ($P<.05$).

[1]Means of available consumed forage across plot series by grazer, N=45.

[2]Mean of leaf and stem from hand-plucked samples of individual tillers, N=15.

TABLE 4. MEAN VALUES OF *IN VIVO* DRY MATTER DIGESTIBILITY (DDM), FECAL OUTPUT (FO), AND VOLUNTARY INTAKE (VI), FROM RYEGRASS STUDY

	Cycle I				Cycle II			
Item	A	B	C	$\bar{X}$	A	B	C	$\bar{X}$
DDM (%)	73.46^{a}	72.57^{a}	71.66^{b}	72.45	71.58^{a}	70.52^{b}	68.13^{c}	70.08
FO (kg/100 kg BW)	0.78^{b}	0.81^{a}	0.82^{a}	0.80	0.80^{b}	0.83^{a}	0.84^{a}	0.82
VI (kg/100 kg BW)	2.94^{ab}	2.95^{a}	2.89^{b}	2.90	2.82^{a}	2.82^{a}	2.64^{b}	2.74

^{abc}Means with different superscripts are different (P<.05).

TABLE 5. RELATIONSHIPS BETWEEN PARAMETERS ESTIMATED FROM THE FORAGE-ANIMAL COMPLEX OF RYEGRASS STUDY

Cycle	Simple Relation	R^2	CV
Cycle I	$DOM_c = 38.93 + 0.45\ DOM_a$	.43	2.60
Cycle II	$DOM_c = 31.45 + 0.59\ DOM_a$	.70	3.13
Cycle I & II	$DOM_c = 39.66 + 0.45\ DOM_a$	.65	3.12
Cycle I	$DOM_c = 53.61 + 0.04\ (DOM_a) + .0029\ (DOM_a)^2$	.43	2.61
Cycle II	$DOM_c = 39.96 + 0.61\ (DOM_a) - .0001\ (DOM_a)^2$	.70	3.23
Cycle I & II	$DOM_c = 6.98 + 1.47\ (DOM_a) - .0078\ (DOM_a)^2$	.67	3.07
Cycle I & II	INTAKE = 23.29 + 0.014 (kg DM/100 kg BW)	.59	6.64
Cycle I & II	INTAKE = 7.54 + 0.289 (DOM_a)	.46	7.71
	Multiple Relation		
Cycle I & II	INTAKE = 12.03 + 0.18 (DOM_a) + 0.0011 (kg DM/100 kg BW)	.74	5.34

an intermediate value (65 percent). Second order polynomials gave only slightly better fits than did simpler linear regression equations, but the intercept was more biologically sound with only slightly lower coefficients of variation. Combinations of various relationships of parameters of the forage animal complex with voluntary intake indicate that forage quantity and its digestibility accounted for 59 and 40 percent of the variation in intake, and when combined in multiple regression equations accounted for 74 percent of the variation in intake.

The results of these studies suggest that for cool season forage, the quantity of forage available and its digestibility are dominant factors affecting the voluntary intake of the grazing animal. Specific factors relating to plant parts, rates of digestion and passage are not available for these data but appear as factors in altering intake and digestibility of forages. Relatively constant fecal outputs would suggest that there are inherent limits in processing undigested forage residues. Management schemes that allow for maximal forage yields, not at the expense of leafy materials, appear to result in the greatest nutrient intake per unit body weight. The frequency and duration of grazing appear to give results that are important considerations for obtaining acceptable intake, hence, gains.

PR-3759

Effects of Monensin on Utilization of Grazed Ryegrass

K. R. Pond, J. P. Telford, and W. C. Ellis

Summary

Measurements of forage utilization and rates of passage were determined for Brahman x Jersey cows and heifers grazing ryegrass supplemented with 0 and 200 milligrams (mg) of monensin. Monensin-supplemented animals had increased digestibility of organic matter and neutral detergent fiber with reduced rates of passage.

Introduction

Previous work with cattle supplemented monensin while grazing Coastal bermudagrass indicated monensin increases digestibility of forage organic matter and decreases rate of passage. Little information, however, is available concerning the action and response when monensin is supplemented to cattle grazing cool-season annuals such as ryegrass. With so many cattle utilizing cool-season grasses, information is needed on the effects of monensin on intake, digestibility, and the digestive process. The purpose of this study was to determine the influence of monensin on the intake, digestibility, gastrointestinal fill, and flow of ingesta in cattle grazing ryegrass.

Experimental Procedure

Eight Brahman x Jersey cows and heifers fitted with rumen and esophageal cannulae were placed by pairs in four separate pastures in early May. After a 3-week pasture adjustment period, animals were twice daily (7 a.m. and 5 p.m.) dosed via rumen cannulae with 4 grams (g) chromic oxide-impregnated paper to serve as a fecal output indicator. One animal in each pasture also received, via rumen cannulae, a gelatin capsule containing 0.87 g rumensin premix to supply 200 mg monensin, while the other animal received a 0.87-g cottonseed meal placebo. After 5 days of adaptation to monensin, esophageal samples were taken each day during the 6 days of collection. At the beginning of collection day 1, each animal was dosed with 50 g of dried ingested forage, obtained via esophageal cannulae, labeled with 171μCi of $^{169}YbCl_3$. Grab samples of feces were taken per rectum at 0, 6, 12, 16, 20, 24, 28, 36, 44, 48, 52, 60, 66, 72, 84, 90, 96, 108, 120, 132, and 144 hours post dosing. Samples of available forage were taken during days 2 and 6 of the collection period.

Sample Analysis and Calculations

Forage and fecal samples were dried at 55° C in forced draft oven. Esophageal samples were frozen and subsequently freeze dried. All samples were ground through a Wiley Mill fitted with a 2-millimeter (mm) screen, placed in glass bottles, and dried in a vacuum oven at 50° C for 8 hours before chemical analysis. Available forage and esophageal samples were analyzed for crude protein (CP) and neutral detergent fiber (NDF). Esophageal samples were also analyzed for the internal marker, indigestible neutral detergent fiber (INDF). Fecal samples were analyzed for both fecal NDF and INDF.

An analysis of variance indicated no difference (P<.1) in the composition of the esophageal NDF or INDF due to day collected. Therefore, the mean of four esophageal samples per animal was used to represent the NDF and INDF composition of the daily intake for each of the 6 days of fecal collection. INDF was determined for 12 of the fecal samples per animal and NDF was determined on four samples spaced equally through the collection. Using mean values for esophageal samples, it was possible to compute four estimates of digestibility of fiber and 12 estimates of digestibility of organic matter (DOM) for each animal:

$$\text{DOM, \%} = \left(1 - \frac{\text{mean \% INDF esophageal O.M.}}{\text{\% INDF fecal O.M.}}\right) \times 100$$

$$\text{Dig. Fiber, \%} = \left(1 - \left(\frac{\text{mean \% INDF esophageal O.M.}}{\text{\% INDF fecal O.M.}} \times \frac{\text{\% NDF fecal O.M.}}{\text{mean \% NDF esophageal O.M.}}\right)\right) \times 100$$

Concentration of Chromium (Cr) in the fecal samples was determined by atomic absorption. Since a constant amount of Cr was administered each day, the fecal output of undigested organic matter was determined from the ratio of Cr administered daily to the concentration of Cr in the fecal organic matter. Analysis for Cr included 12 samples per animal so that 12 individual fecal output determinations were made per animal. Forage intake was then computed (12 observations/animal):

$$\text{Fecal Output O.M., Kg/day} = \frac{\text{Cr administered, g/day}}{\text{Cr in feces, g/Kg fecal O.M.}}$$

$$\text{Forage Intake O.M., Kg/day} = \frac{\text{Fecal output, Kg/day}}{(100 - \text{DOM})/100}$$

The fecal samples were processed for radioactive analysis and analyzed by a pulse height analyzer equipped with a sodium iodide scintillation detector. All counts were adjusted for decay, daily background variation, and sample weight.

The fecal ^{169}Yb concentration (CPM/g) *vs.* time post dose curve was fitted to a two compartment, time dependent, time delay model (1) and rate of passage was expressed as the slower turnover rate in this model. Fecal output and rate of passage measurements were combined for undigested organic matter fill determinations:

$$\text{UDOMF, Kg} = \frac{\text{Fecal output O.M., Kg/day}}{\text{Rate of passage} \times 24\text{ h, fraction/day}}$$

Results and Discussion

Chemical composition of available and consumed (esophageal) forage is presented in Table 1. All animals regardless of treatment selected forage of higher (P<.05) protein and lower (P>.05) NDF than in available forage. However, there was no difference in selection due to monensin supplementation for any of the chemical components analyzed.

Treatment means for the effect of monensin on digestibility, fecal output, forage intake, digestible forage intake, rate of passage, and GIT fill are presented in Table 2. It should be noted that 12 and four separate estimates per animal were used for determining DOM and DNDF for each animal. This number of observations per animal and the use of INDF as the internal indigestibility marker resulted in a high ability to detect relatively small differences in digestibilities. Animals receiving monensin, as compared to controls, exhibited higher (P<.05) DOM (70.3 *vs.* 67.6) and higher (P<.05) DNDF (60.9 *vs.* 58.8). These increases of 4.0 percent DOM and 3.6 percent DNDF are in general agreement with those reported for cattle grazing Coastal bermudagrass pasture.

Animals administered monensin had reduced (P<.1) fecal outputs per 100 kilograms (Kg) body weight. This 10.0 percent reduction in fecal output due to monensin is larger than reported for Coastal bermuda. With reduced fecal outputs and increased DOM, animals administered monensin had organic matter intakes 2.0 percent less than those of the controls.

Digestible organic matter intakes can be com-

TABLE 1. CHEMICAL ANALYSIS OF AVAILABLE AND CONSUMED FORAGE

Item	Available		Consumed			
			Monensin		Control	
	Mean	SE	Mean	SE	Mean	SE
Crude Protein	11.63[a]	.24	14.06[b]	.74	14.40[b]	.38
NDF	64.82[a]	.33	54.27[b]	1.09	56.07[b]	.25
INDF			13.55[b]	.68	13.54[b]	.67

[a,b]Means in same row with different superscripts are different ($P<.05$).

TABLE 2. MEAN[a] EFFECTS OF MONENSIN ON THE DIGESTIVE UTILIZATION OF GRAZED RYEGRASS

Item	Control	Monensin	% Change[b]
DOM (%)	67.6	70.3	4.0*
DNDF (%)	58.8	60.9	3.6†
Fecal Output[c] (Kg)	1.40	1.26	−10.0†
Forage Intake[c] (Kg)	4.38	4.31	−1.6
DOM Intake[c] (Kg)	2.98	3.04	2.0
Rate of Passage (%/hr)	8.57	6.50	−24.2*
GIT Fill[c,d] (Kg)	.74	.92	+24.3

[a]N = 4 animals/treatment.

[b]Change from control is different *($P<.05$), †($P<.1$).

[c]Per 100 Kg BW.

[d]Gastrointestinal tract fill.

puted from the product of DOM and forage intake. The increase in DOM associated with monensin compensated for the reduced forage intake and intake of digestible organic matter was slightly higher in animals supplemented monensin.

Rates of passage determined from ^{169}Yb concentration in fecal samples were reduced ($P<.05$) from 9.82 to 6.50 percent per hour with monensin supplementation. In contrast, mean treatment gastrointestinal tract fill was numerically higher for monensin-supplemented animals. The reduction in rate of passage is in agreement with results for cattle grazing Coastal bermudagrass where reductions of 5 to 20 percent per hour due to monensin were reported.

With a reduction in the rate of passage and an increased time of exposure to the digestive processes, the observed increase in digestibility would be expected. Specifically, if monensin did not affect the rate of digestion, the digestibility of the more slowly digested components (fiber) would expectedly be increased. The method of reducing the rate of passage is unclear. It is possible, though, that the reduction in rate of passage may alter other digestive patterns than digestibility.

It is clear that monensin has dramatic effects on the dynamics of the digestive process. Although this study utilized only a few animals, treatment differences were evident. Similar studies with more animals are currently in progress to quantify intake, rate of passage, and GIT fill in cattle supplemented monensin.

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PR-3760

Digestibility and Selective Intake of Ryegrass and Sorghum Silages by Yearling Steers

H. LIPPKE

Summary

Ryegrass and sorghum silages were offered in various proportions to 14 yearling steers to determine intake and digestibility of diets selected. Intake and digestibility increased as the proportion of ryegrass in the diet increased and reached a maximum when intake was 2.8 percent of body weight and digestible organic matter was about 65 percent.

Introduction

Increased digestibility is one objective of current breeding programs for improved forage species. While there is considerable room for improvement in digestibility of many warm-season perennial species, the cool-season annuals (small grains) apparently exceed the level of digestibility needed by yearling steers during much of the growing season. Research with mixed diets (1) has shown that as digestibility increases beyond 65 percent, intake decreases so as to maintain a relatively constant energy intake.

This experiment was conducted to determine whether a similar situation exists for forage diets and to provide possible guidelines to plant breeders in their quest for forages of higher digestibility.

Experimental Procedure

An intermediate-type forage sorghum was harvested in the soft-dough stage and stored in a 32-foot x 84-foot bunker silo. Moisture content at feeding averaged 69 percent.

Gulf ryegrass was harvested in early February and ensiled in two 6-foot x 12-foot silos. A mixture of formic acid and formaldehyde was added at the blower at the rate of 1.5 percent and 1.2 percent of forage dry matter, respectively. Extensive drainage occurred during the ensiling process, resulting in a slightly lower moisture content at feeding (81 percent) than at harvest (82 percent).

Fourteen yearling steers, ¾ Hereford-¼ Angus, were each placed in a 6-foot x 16-foot concrete-floored pen which extended 4 feet beyond the eve of the feeding barn. Welded rod panels were used in pen construction to allow maximum visibility among animals, thereby stimulating feeding activity. All animals had free access to water and salt.

During the 15-day intake trial, silages needed for each day's feeding were taken from the silos once daily. Amounts that would be consumed within 3 hours were fed immediately. The remainder was placed in plastic bags (15 pounds/bag), successively evacuated and gassed with carbon dioxide twice to inhibit spoilage, and fed as needed. Once daily, orts were removed, weighed, and sampled for dry matter and chemical analyses. Silages were sampled as they were weighed.

Eight of the 14 steers were retained for the digestion trial. Feeding management was the same as for the intake trial except that each animal was restricted to 90 percent of the amounts consumed during the intake trial. Fecal collection began on the third day of the trial and continued for 7 days. Samples of feed and feces were frozen when collected and analyzed without drying.

Results and Discussion

Results of analyses shown in Table 2 indicate that ryegrass silage was superior to sorghum silage. This is confirmed by the intake and digestibility data shown in Table 3. Because intake for one animal on treatment 1 was abnormally low, data for that animal was not used.

TABLE 1. TREATMENTS FOR INTAKE TRIAL

		Amounts Offered	
Trt	No. of steers	Ryegrass silage	Sorghum silage
1	2	none	ad lib.
2	2	.3 × main.[1]	ad lib.
3	1	.6 × main.[2]	ad lib.
4	1	ad lib.	.6 × main.[2]
5	2	ad lib.	.3 × main.[1]
6	4	ad lib.	ad lib.
7	2	ad lib.	none

[1]An amount anticipated to supply .3 × maintenance energy requirements.
[2]An amount anticipated to supply .6 × maintenance energy requirements.

TABLE 2. COMPONENTS OF RYEGRASS AND SORGHUM SILAGES

	Organic Matter	Protein	Fiber[1]
	%		
Ryegrass	86.8	22.3	43.5
Sorghum	94.5	5.0	51.7

[1]Neutral detergent fiber.

TABLE 3. INTAKE AND DIGESTIBILITY

	Dry Matter Intake		Digestibility	
Trt	Ryegrass	Sorghum	Organic Matter	Fiber[1]
	% of BW		%	
1	--	1.82	60.0	49.9
2	0.38	1.60	61.9	52.0
3	0.74	1.55	63.1	53.2
4	1.87	0.89	64.5	57.0
5	1.95	0.45	66.4	61.7
6	2.49	0.35	66.2[2]	--
7	2.35	--	68.9	63.7

[1]Neutral detergent fiber.
[2]Calculated value.

Obviously, intake and digestibility increased with increasing proportion of ryegrass in the diet. All animals on treatments 4 and 6 appeared to reach a maximum energy intake, which was enough to allow 2.7 pounds daily gain by animals of this size. Note that animals in treatments 4 and 5 effectively had the same opportunity for selection as those in treatment 6. They chose, however, to consume larger amounts of sorghum silage, almost all that was offered, and lesser amounts of ryegrass silage than those in treatment 6, where there was free access to both silages. Visual observations during the trial, together with intake comparisons among treatments, indicate that cattle are subject to a 'shortage philosophy' wherein they tend to wait for the arrival of a feedstuff perceived to be in short supply rather than consume the feedstuff at hand. Whether this was also the cause for lower intake by steers in treatment 7 is not clear. The net result was that animals in treatments 5 and 7 had reduced intakes of digestible energy and potential gain.

These data agree with experiments using mixed diets (1) that indicate producing cattle reach a maximum intake level at about 65 percent organic matter digestibility. These data further show that cattle do not voluntarily select a diet of higher digestibility than that needed to provide moderately high levels of production.

The interaction of feeding management and animal behavior apparently acts to reduce intake in subtle ways. Such observations are frequently made but are only now beginning to be investigated experimentally.

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PR-3761

Effect of Monensin on Performance of Calves Grazing Bermudagrass

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Summary

Two trials were conducted to determine the influence of monensin on live weight gain and efficiency of forage utilization of calves grazing bermudagrass. In Trial 1, 32 calves, weaned at an average age of 238 days and 250 kilograms (kg), were grazed on 'Coastcross I' bermudagrass from July 20 to October 13. Eight steers and eight heifers were randomly placed into each of two treatments receiving either 200 milligrams per head per day (mg/hd/da) monensin or 0 mg/hd/da monensin in a .91 kg/hd/da ration of pelletized 14 percent protein feed. Both groups were stocked at 15.3 hd/ha. Monensin-fed calves gained .52 kg/hd/da, whereas, the control-fed calves gained .42 kg/hd/da ($P<.10$). Average daily gains (ADG) of steers at .54 kg were greater ($P<.05$) than those of heifers at .40 kg. Forage:gain ratio estimates were 15:1 and 19:1, respectively, for calves on monensin and control paddocks.

In Trial 2, 48 steer calves with an average age of 265 days and an average weight of 260 kg were randomly assigned to each of two replicates of the following grazing treatments: common bermudagrass only (P); bermudagrass + .91 kg/hd/da 14 percent protein feed (PF); or bermudagrass + .91 kg/hd/da feed + 200 mg/hd/da monensin (PFM). Steer ADG were .45, .47, and .68 kg, respectively, for P, PF, and PFM. The monensin-fed calves showed a 45-percent improvement ($P<.05$) in ADG. Estimated forage:gain ratios for calves on P, PF, and PFM were 20.5:1, 19:1, and 13:1, respectively.

The use of 200 mg/hd/da monensin improved calf gains 23 to 45 percent and increased estimated feed efficiencies 21 to 36 percent on bermudagrass pastures. The increased gain response of heifers to monensin was 28.6 percent, whereas, steer gains improved 18.4 percent when fed monensin.

Introduction

The concept of continuous ownership from birth to slaughter provides certain economic incentives which, in turn, challenge management expertise for maximum utilization of forage crops. Improvements in live weight gains and concomitant improvements in forage:gain efficiencies from high fiber-containing forage would be a significant advancement over current management practices. With the introduction of improved grass species adapted to the region, and improved soil fertility practices (2), acceptable beef production management systems have been made available (3). However, warm-season perennial grasses, the basic forage unit of the eastern one-third of Texas and for most of the humid south, possess the lowest nutrient value per unit dry matter of any class of forage. Therefore, improvements in forage:gain efficiencies may be directed toward techniques that either increase nutritive value via plant breeding or selection, promote animal gains via external chemical additives, and/or substitute energy sources via external feed nutrients.

Monensin, a biologically active, non-hormone compound which has been shown to alter rumen fermentation patterns in cattle (8), is one of several external chemical additives currently used to promote animal performance. Many researchers have shown that monensin increases feed efficiency (6,7) and weight gains (5, 9) for both mature and growing cattle. The purpose of this study was to measure weanling calf performance from fall-born calves grazing bermudagrass with and without the addition of dietary monensin.

Experimental Procedure

Trial 1

Thirty-two half-sibling calves (½ Simmental x ¼ Brahman x ¼ Hereford) were assigned to a 2x2 factorial arrangement of treatments (sex x feed). Equal numbers of steers and heifers, weighing approximately 250 kg at weaning, were evenly stratified by weight and pre-weaning treatments into the post-weaning treatment groups. Steers and heifers receiving the same feed treatment were placed in the same paddock on July 20. Feed treatments consisted of 200 mg monensin and 0 mg monensin fed daily in .91 kg of a 14 percent protein (commercial, all plant protein) creep pellet. Both groups of calves were weighed and placed on 1.1-hectare (ha) paddocks of a mixed sward of Coastcross I and common bermudagrass. Calves were reweighed after 7 days and at 21-day intervals thereafter. Each paddock received 112 kg/ha nitrogen on July 6 and again on August 30. Calves grazed the same paddock continuously during the entire test period at a stocking rate of 15.3 animals/ha.

Forage from each paddock was sampled at 14-day intervals for both dry matter availability and nutritive value. Chemical analyses consisted of (a) neutral detergent fiber (NDF) (11); (b) *in vitro* digestion of NDF (IVNDF) (10); and (c) crude protein via micro-Kjeldahl.

Forage dry matter production was estimated by hand clipping bermudagrass to ground level at 14-day intervals by the cage-difference technique (1). Forage disappearance was also estimated by cage difference and included that quantity of bermudagrass which was consumed, trampled, or lost due to other factors. Forage:gain ratios were calculated for each paddock and compared among treatments.

Trial 2

Forty-eight weanling steer calves with an average weight of 260 kg, an average age of 265 days, and from a herd of F-1 (Brahman x Hereford) cows and either a Charolais or Brangus bull were evenly stratified by weight, breed, and pre-weaning treatment into six groups. Three ½ Charolais and five ½ Brangus steers were randomly assigned to each of two replicates of the following treatments: (a) pasture only; (b) pasture + .91 kg/hd/da of a 14-percent protein pelletized feed; and (c) pasture + .91 kg/hd/da feed + 200 mg/hd/da monensin. Each eight-animal group was placed on a 1.1 ha common bermudagrass paddock at initiation of the trial, July 18, weighed after a 7-day adjustment period, and weighed thereafter on 21-day intervals. On each weigh day, all groups were rotated to a different paddock in an attempt to equalize forage availability across treatments. The stocking rate on each paddock was 7.3 animals/ha. All paddocks received 112-112-112 kg/ha N-P_2O_5-K_2O two weeks prior to initiation of grazing and 112 kg/ha nitrogen at the mid-point of the trial.

Forage sampled for chemical analyses and the analyses of NDF, IVNDF, and protein were conducted identical to those in Trial 1. Forage dry matter production and disappearance was also estimated via the cage difference technique as used in Trial 1. However, a rotary mower was used to cut the bermudagrass to a 5-cm height. Forage:gain ratios were calculated for each paddock.

Results and Discussion

Trial 1

The influence of monensin and sex of animal on average daily live weight gain (ADG) is shown in Table 1. Both heifers and steers showed approximately .10 kg increase in ADG as a result of the addition of 200 mg monensin to the ration ($P<.10$). Although there was a similarity in the absolute ADG increase, the improvement due to monensin was 28.6 percent for heifers and 18.4 percent for steers. Weight gain comparisons due to sex of calf showed a significant ($P<.05$) advantage in favor of the steers. It was of particular interest that the inclusion of monensin in the ration accelerated the heifer gains to nearly those of the control steer gains. Live weight gains/ha were 546 and 663 kg, respectively, for control feed and monensin-supplemented feed. Steer and heifer gains/ha were 702 and 520 kg, respectively. Steers which received monensin in their diet exhibited gains of 754 kg/ha compared with 637 kg/ha in control-fed steers.

Approximately half of the total forage production of bermudagrass occurs during May to July and half from August to October. By waiting until mid-summer (July 20) to accommodate the overall objectives of maximum forage input on fall-born calves, only about one-half of the animal gain capabilities of this forage have been utilized. Therefore, by initiating the grazing-feeding trial at an earlier date (May 1), steer gains which approach 1400 kg/ha appear to be well within the range of biological possibilities from the high-quality warm-season grasses.

Forage availability was not significantly different between the control and monensin paddocks throughout the sampling period (Table 2). Therefore, any animal performance differences that occurred were not confounded with grazing pressure or stocking rate. And, since there was approximately 4000 kg/ha dry matter available thoughout the trial, individual animal performance was not restricted by grazing pressure. Forage production and disappearance estimates for the monensin paddock were 12,463 and 10,151 kg/ha respectively, whereas, the control paddock estimates were 12,589 and 10,384 kg/ha, respectively. By using the live weight gains of 663 and 546 kg/ha, respective forage:gain ratios were 15:1 and 19:1 for cattle on monensin and control paddocks. The difference in these estimates of forage: gain represents a 20-percent improvement in feed efficiency from the monensin-fed calves. Others have shown that monensin may improve feed/gain ratio under various feeding and /or grazing conditions (4, 5, 6, 7, 9).

The nutritive value of the forage was similar for both treatment groups thoughout the sampling period (Figures 1 and 2). The marked improvement in percent protein and *in vitro* digestion of neutral deter-

TABLE 1. PERFORMANCE OF STEERS AND HEIFERS GRAZING 'COASTCROSS I' BERMUDAGRASS AND RECEIVING SUPPLEMENTAL FEED

	July 20 to October 13 Average Daily Gain					
	Heifers		Steers			
Paddock	kg	Gain/ha	kg	Gain/ha	Avg (kg)	Gain/ha
Control[a]	.35	455	.49	637	.42[e]	546
Monensin[b]	.45	585	.58	754	.52[f]	663
Avg	.40[c]	520	.54[d]	702		

[a]Calves received 0 mg/hd/da monensin.

[b]Calves received 200 mg/hd/da monensin.

[cd]Significant ($P<.05$) effect due to sex of calf.

[ef]Significant ($P<.10$) effect due to monensin.

TABLE 2. FORAGE AVAILABILITY IN 'COASTCROSS I' BERMUDAGRASS PADDOCKS

	Paddocks		
Date	Monensin[a]	Conrol[b]	Avg
	(kg dry matter/ha)		
7-20	4333	3812	4073
8-3	4126	4090	4108
8-17	4322	3703	4013
9-2	4158	4962	4560
9-17	4247	4761	4504
10-1	3994	4858	4426
10-20	2312	2205	2259
Avg	3927	4056	

[a]Cattle received 200 mg/hd/da monensin.

[b]Cattle received 0 mg/hd/da monensin.

gent fiber at the mid-point of the trial was a result of the frequent occurrences of rainfall and a nitrogen fertilizer application.

Trial 2

The influence of .91 kg/ha/da of a supplemental feed and 200 mg/hd/da monensin over that of non-fed, pasture-only steers is shown in Table 3. Gains from steers which received approximately .35 percent of their body weight in feed were not different from the gains from steers receiving pasture only. Thus, the .91 kg/hd/da was used in a substitutive manner rather than an additive manner. A feed level greater than .35 percent of body weight is therefore needed to significantly enhance the gain of steers on warm-season grasses. Monensin was primarily responsible for the additional .21 kg/hd/da steer gain ($P<.05$).

TABLE 3. PERFORMANCE OF STEERS GRAZING COMMON BERMUDAGRASS AND RECEIVING SUPPLEMENTAL FEED

Paddock	July 25 to September 26 Daily gain
	(kg)
Pasture only	.45[a]
Pasture + feed	.47[a]
Pasture + feed + monensin	.68[b]

[ab]Means with different superscripts are significantly different ($P<.05$).

This represented a 45-percent improvement in animal performance. Although the monensin-fed steers in Trial 2 exceeded the similar group in Trial 1, steer ADG from pasture plus supplemental feed was nearly identical in both trials.

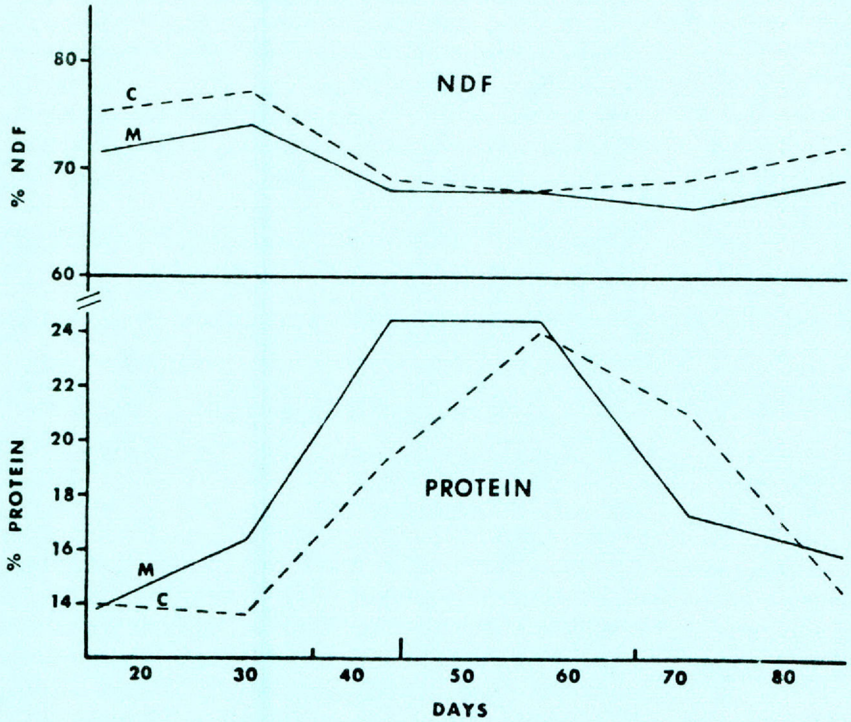

Figure 1. Neutral detergent fiber (NDF) and percent protein of forage sampled from control (C) and monensin (M) paddocks.

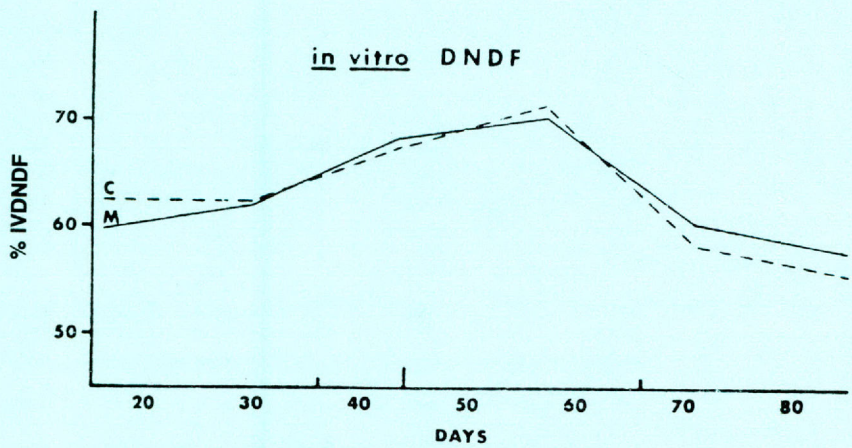

Figure 2. *In vitro* digestibility of neutral detergent fiber (IVDNDF) of forage sampled from control (C) and monensin (M) paddocks.

The similarity of forage availability that was present at any one date is shown in Table 4. Differences between the quantity of forage available in Trial 1 and Trial 2 were due primarily to sampling procedure. It was concluded that forage quantity available for consumption did not restrict steer performance. Estimated forage:gain ratios for pasture only, pasture + creep, and pasture + creep + monensin were 20.5:1, 19:1, and 13:1, respectively. As reported in the previous trial, there appears to be a substantial improvement in forage:gain efficiency from monensin.

TABLE 4. FORAGE DRY MATTER AVAILABLE ABOVE A 5-CM HEIGHT IN BERMUDAGRASS PADDOCKS

Date	Pasture only	Pasture + feed	Pasture + feed + monensin	Average
		(kg/ha)		
July 25	1703	1324	1525	1517
Aug 15	1502	1725	1026	1418
Sept 5	985	821	450	752
Sept 26	573	334	844	584
Avg	1191	1051	961	

Nutritive parameters from the treatment paddocks are shown in Table 5. Although seasonal trends of the bermudagrass forage were evident, there was close agreement among treatment paddocks for any one sampling date. Animal performance differences which occurred could not be attributed to variations in quality of forage, but rather were a result of the addition of monensin to the diet.

Based on the data from these two trials, incorporation of monensin into the rumen appears to have a biological advantage for cattle grazing relatively low energy-containing forages such as bermudagrasses. The magnitude of the biological gain advantage was modified by sex of the animals. Monensin increased ADG and efficiency of utilization of bermudagrass. Results of these trials suggest that carrying capacities may possibly be increased via improved forage utilization. The economic feasibility of this program, however, is based largely on the structure of the cattle market and cost of supplemental feed used as a carrier for monensin rather than costs attributed to monensin alone.

TABLE 5. PERCENT PROTEIN, NEUTRAL DETERGENT FIBER (NDF), AND *IN VITRO* DIGESTION OF NDF (IVDNDF) OF FORAGE IN BERMUDAGRASS PADDOCKS

	Protein				NDF				IVDNDF			
	(%)				(%)				(%)			
Date	P[a]	PF[b]	PFM[c]	Average	P	PF	PFM	Average	P	PF	PFM	Average
Jul 25	12.0	12.8	12.0	12.3	70.4	70.1	70.7	70.4	54.4	50.5	51.1	52.0
Aug 15	14.3	14.8	14.4	14.5	71.4	70.4	69.0	70.3	51.5	54.6	54.3	53.5
Sept 5	18.1	17.3	16.2	17.2	68.6	68.1	69.3	68.7	57.4	57.8	55.2	56.8
Sept 26	17.1	17.2	16.7	17.0	66.4	69.9	69.6	68.6	57.0	57.0	54.0	56.0
Avg	15.4	15.5	14.8		69.2	69.6	69.7		55.1	55.0	53.7	

[a]Pasture only.
[b]Pasture + feed.
[c]Pasture + feed + monensin.

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PR-3762

Effect of Monensin on Rate-of-Gain in Stocker Calves Grazing Dormant, Native Rangeland in West-Central Texas

J.E. HUSTON AND DON SPILLER

Summary

A study was conducted to determine the effects of supplemental feed on rate-of-gain of calves [460 pounds (lb)] grazing dormant, native rangeland. Treatments included: (1) control (mineral supplement only), (2) supplemental feed [3 pounds per head per day (lb/hd/day)], (3) supplemental feed plus low monensin 100 milligrams (mg)/hd/day, and (4) supplemental feed plus high monensin (200 mg/hd/day). Rates of gain during the 100-day study were: 0.56, 1.06, 1.01, and 0.86 lb/hd/day for the four treatments, respectively. The low rate-of-gain of the control group indicated that the nutrient composition of diet selected from dormant range forage limited growth of stocker calves. Supplemental feed at 3 lb/hd/day increased growth rate to approximately twice the rate of control calves. Monensin at 100 mg/hd/day did not significantly affect growth rate but at 200 mg/hd/day significantly depressed growth rate ($P<.10$). These results suggest that under the conditions of this study, monensin at 100 mg/hd/day and above will not increase growth rate and may have an adverse effect. Studies with monensin at levels below 100 mg/hd/day are needed to determine the optimum level for growth rate in calves grazing poor quality vegetation.

Introduction

Monensin is a feed additive which improves feed efficiency in feedlot cattle with little, if any, effect on daily gain (5,8). Cattle fed monensin at 50 to 200 mg/hd/day have a lower proportion of acetic acid, compared with propionic acid in the rumen (7), and a lower dry matter intake (4), compared with cattle fed control diets.

Studies with pasture cattle under good grazing conditions indicate that monensin up to 200 mg/hd/day may increase rate-of-gain (3,6). However, under a poor dietary situation on poor quality vegetation, gain was not increased by feeding monensin at 200 mg/hd/day (1). Lemenager *et al.* (2) reported that monensin reduced voluntary intake and slowed rumen turnover in cattle fed harvested range grass. A study was conducted to determine the effects of supplemental feed and two levels of monensin (100 and 200 mg/hd/day) on gain of stocker calves grazing poor quality winter forage.

Experimental Procedure

Seventy-six Hereford x Brangus calves averaging 459 pounds were assigned randomly to four treatment groups of 19 calves per group. The calves were grazed in four experimental pastures of approximately uniform size and vegetative type. Experimental feeds (Table 1) were fed during a 100-day treatment period beginning December 20, 1978. Group 1 received a mineral supplement free choice, which provided for phosphorous intake equal to that supplied by the other feed supplements. Groups 2, 3, and 4 were fed an equivalent of 3 lb/hd/day in three equal amounts per week. The groups were rotated among pastures at 25-day intervals to remove pasture effects. Weights were taken at the beginning and at termination of the trial.

Results and Discussion

Range conditions during the trial appeared normal for the area. Dormant vegetation was plentiful but low in quality. Texas wintergrass and some forbs and browse provided a limited amount of live vegetation for diet selection. In previous studies under similar conditions, cattle diets selected from the available vegetation contained approximately 6, 45, and 0.10 percent crude protein, digestible organic matter and phosphorus, respectively.

Overall results of the study reflect dietary conditions (Table 2). The low gains of cattle in group 1 were the result of inadequate protein and energy intake. The supplemental protein and energy provided to group 2 significantly increased gain to approximately twice the level of group 1. Monensin at 100 mg/hd/day did not further increase gain, and at 200 mg/hd/day significantly depressed gain ($P<.10$), compared with group 2.

These results confirm those of a previous study (1) which suggested that monensin at 200 mg/hd/day could reduce gain in calves grazing low quality for-

TABLE 1. COMPOSITION OF FEED SUPPLEMENTS IN A STUDY TO DETERMINE THE EFFECT OF MONENSIN ON RATE-OF-GAIN IN STOCKER CALVES, %

	Supplement[1]			
Ingredient	1	2	3	4
Cottonseed meal	5	70	70	70
Sorghum grain	-	28	28	28
Dicalcium phosphate	50	-	-	-
Salt (NaCl)	45	-	-	-
Molasses	-	2	2	2
Monensin	-	-	(+)[2]	(+)[3]
	100	100	100	100

[1]Supplement 1 fed to group 1, free choice. Supplements 2, 3 and 4 fed to groups 2, 3, and 4, respectively, at the equivalent of 3 lb/hd/day.

[2]Monensin included at a level of 67 g/ton to provide 100 mg in 3 lb of supplement.

[3]Monensin included at a level of 133 g/ton to provide 200 mg in 3 lb of supplement.

TABLE 2. EFFECTS OF SUPPLEMENTAL FEED AND MONENSIN AT TWO LEVELS ON RATE-OF-GAIN OF CALVES GRAZING DORMANT, NATIVE RANGELAND

Item	Treatment			
	1 Phosphorus only	2 Concentrate only	3 Concentrate plus 100 mg monensin	4 Concentrate plus 200 mg monensin
Number of calves	19	19	19	19
Body weights (lb)				
Initial	454.3	463.0	449.9	468.2
Final	510.8	569.4	551.3	554.7
Gain	56.5	106.4	101.4	86.5
Avg. daily gain (lb)	0.56^a	1.06^b	1.01^b	0.86^c

[a,b,c]Gains which do not share a common superscript are significantly different (P<.10).

age. Although the cause of the adverse effect of monensin under conditions of this study is not clear, it is probably mediated through the demonstrated effects of slowed rumen turnover (2) and reduced voluntary intake (4). Monensin at lower levels (below 100 mg/hd/day) may increase gains but additional studies with lower levels of monensin are required to identify the optimum for these range conditions.

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PR-3763

Probabilistic Determination of Kleingrass Growth and Consequent Performance of Grazing Steers

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Summary

A mathematical simulation model that probabilistically determines climatological input to a soil moisture model and ultimately a Kleingrass growth model illustrates how various management decisions concerning the grazing of steers may be evaluated given uncertainty of weather. Annual precipitation resulted in an unsatisfactory prediction of annual cumulative forage growth. Differences in the use of British standards and U.S. standards in the calculation of animal performance were apparent, although not statistically different (P<.05). Heavier stocking rates yielded greater production (P<.05) per hectare than lighter stocking rates; however, variability was much greater. Steers at lighter stocking rates achieved heavier weights (P<.05). Four management schemes were analyzed and the alternative that introduced steers when sufficient forage was available but removed them immediately upon the depletion of forage resulted in greater steer gains.

Introduction

Weather is perhaps one of the greatest risk factors that confront the cattle producer. Average precipitation and temperature may have little meaning to the cattle producer because of the great variability of the weather. Systems analysis and simulation are methods by which mathematical forms and computer technology may be utilized to study and analyze complex production or biological systems. The Texas A&M University beef cattle production model (8) determines cattle production given genetically diverse cattle under a variety of given feed inputs.

However, given the great variability in weather and, consequently, forage growth, a mathematical model that probabilistically determines forage growth would be of value to the producer because risk factors could then be assigned to the various management and stocking rate decisions that daily confront cattlemen. The purpose of this research was to probabilistically determine the growth and consumption of Kleingrass (*Panicum coloratum* L.) by growing beef steers without *a priori* knowledge of temperatures, precipitation and forage growth.

Experimental Procedure

For a 20-year period (1957-1976) temperature and rainfall data were obtained from Beeville and their frequencies determined (5). Correlations between temperature and rainfall were established, and monthly data determined by a computer random number generator. Moisture retention curves were fitted to data previously obtained in soil samples from the Texas A&M University Agricultural Research Station at Beeville (E. C. Holt, unpublished data). A water-balance model based upon previous work (7) was used to calculate the amount of available water in the soil profile at any given time.

Temperature, stocking rate, and available soil moisture were the variables that affected forage growth. Constant soil fertility due to fertilization was assumed. Monthly forage growth, adjusted downward for the effects of trampling, was then determined (2).

In order to determine the performance of grazing animals in relation to grazing pressure, data from B. E. Conrad (unpublished data) were obtained and fitted into the equation:

$$1)\ G = \frac{\kappa}{1-\lambda}\left(M^{1-\lambda} - M_0^{\,1-\lambda}\right)$$

where G = average daily gain, kg/day

M = grazing pressure, kg forage/(100 kg body wt./ha/day)

M_0 = grazing pressure at maintenance

and κ, λ = shape parameters.

Many authors (4) have concluded that animal performance and intake are highly correlated (r = 1); equation 1 could then be adjusted to determine intake of forage:

$$2)\ IN = \frac{\kappa}{1-\lambda}\left[(M+X_0)^{1-\lambda} - M_0^{\,1-\lambda}\right] + I_0$$

IN = intake as a percent of body weight

X_0 = a shift along the X-axis

I_0 = a shift along the Y-axis.

Two energy systems were analyzed for the purpose of determining cattle performance from given feed inputs (1, 6), and data were obtained concerning the *in vitro* digestibility of Kleingrass over time (E. C. Holt, unpublished data). Given forage availability and forage quality, two separate estimates of intake were determined. The minimum value of intake was chosen since either availability or quality could be a limiting factor controlling intake. One of these two intake estimates was used to determine animal performance. Three stocking rates were used: 2.47 head/ha, 4.32 head/ha, and 6.1 head/ha. Steer calves entered each grazing system weighing 250 kilograms. Four management schemes were evaluated:

A) Calves are contracted to be on the pasture April 1. If at any time forage becomes unavailable, animals lose weight to 200 kg, or gain weight to 365 kg, then animals are automatically withdrawn from the paddock.

B) At least 750, 1,250 or 1,650 kg of forage/ha must be available at the light, medium and heavy stocking rates, respectively, before animals are introduced onto the paddock. Animals are withdrawn as in A.

C) This scheme is similar to A except that if forage becomes unavailable animals are kept on the paddock until the end of the current month. The next month a decision based upon the occurrence of any new forage growth is made as to whether the calves should remain on the paddock or not.

D) This scheme is similar to B with the exception of withdrawal to animals. D altered B in the same manner that C altered A.

Results and Discussion

Forage production and, consequently, animal production were based upon random (probabilistic) weather variables. Means between monthly mean maximum temperature, mean maximum temperature and annual precipitation were similar ($P<.05$) for the simulated data and the historical climatological data from Beeville. For light, medium and heavy stocking, the mean and standard deviation for cumulative growth of Kleingrass was $\bar{X}$ = 3820.07, S.D. = 2504.20, $\bar{X}$ = 5309.26, S.D. = 3163.48, and $\bar{X}$ = 5717.88, S.D. = 3329.85 kg/ha, respectively.

A representation of how equation 1 was utilized for what was classified as high quality forage is given in Figure 1; how a curve for gain may be used to calculate forage intake is represented in Figure 2. Weight gains over time at a light stocking rate using the N.R.C. system are given in Figure 3; and the same are presented using the A.R.C. system in Figure 4. During periods of high quality forage the A.R.C. system predicted higher gains than the N.R.C. system and during periods of low quality forage the A.R.C. system predicted lower gains than the N.R.C.

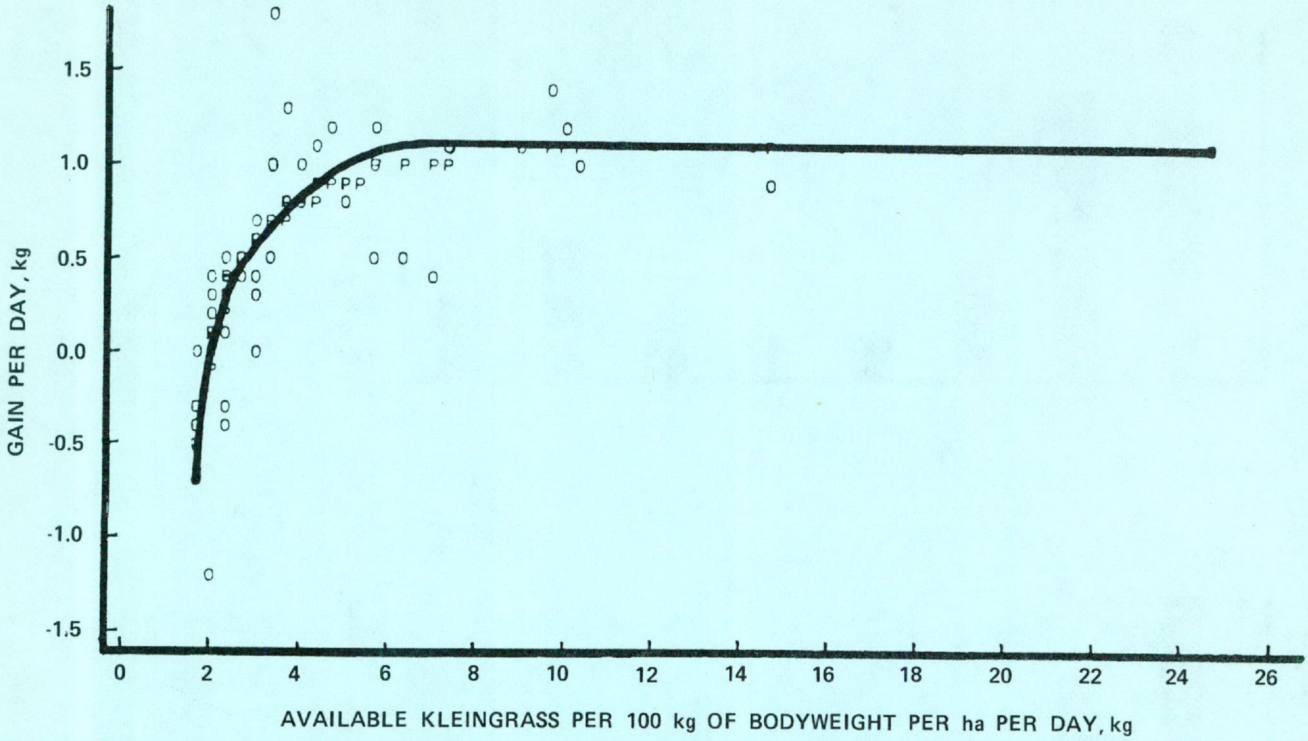

Figure 1. Steer performance on high quality forage [0 = actual gains on kleingrass (Conrad, unpublished data), P = predicted gains from grazing pressure using equation 1].

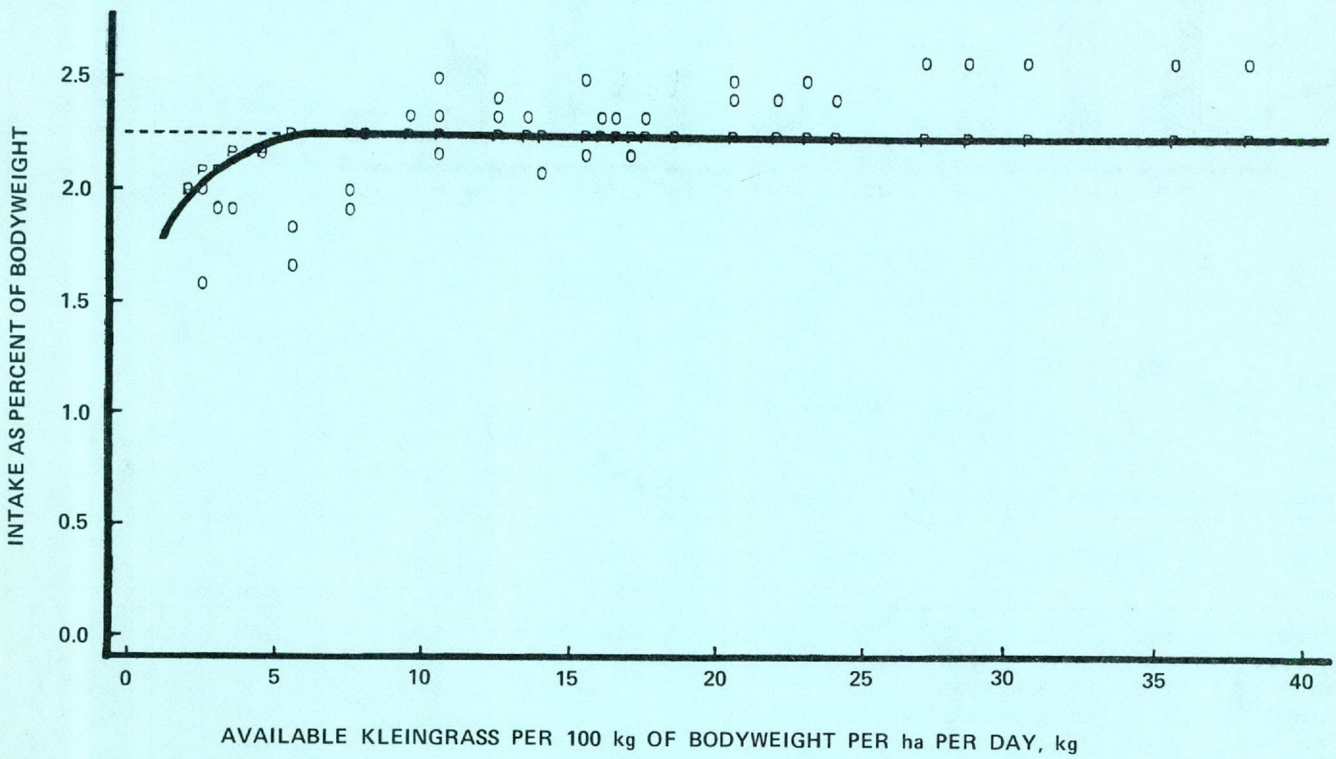

Figure 2. Axis shift for low quality forage (0 = estimated intake based on forage quality, P = intake based on shifting axes from weight gain data.)

system, although differences were not statistically different (P<.05).

An example of model output is presented in Tables 1 and 2 under scheme A, a light stocking rate, and the N.R.C. system. Twenty-four different combinations of schemes, stocking rates and energy systems were analyzed. Cumulative weight gain/ha was higher (P<.05) for the heavier stocking rate than for the medium and lighter stocking rates, but was much more variable. However, steers at lighter stocking rates were withdrawn from the paddock at heavier weights (P<.05).

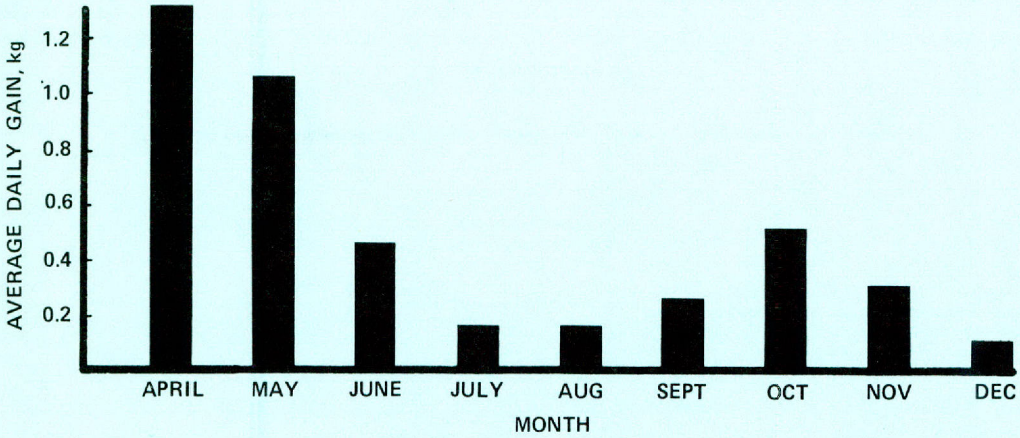

Figure 3. National Research Council's (N.R.C.) predicted gains for grazing seasons.

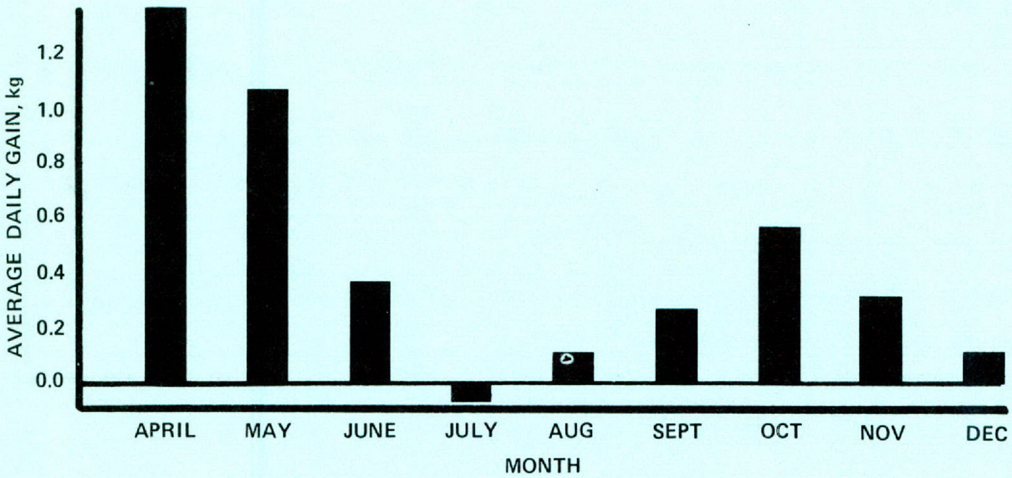

Figure 4. Agricultural Research Council's (A.R.C.) predicted gains for grazing seasons.

TABLE 1. SAMPLE MODEL OUTPUT WITH LIGHT STOCKING RATE[a]

Month	Temperature, C°			Rain, cm[b]			Evapotranspiration, cm	Soil moisture, cm	Kleingrass growth, kg of dry matter/ha
	Min.	Max.	Mean	Total	Runoff	Effective			
January	8.61	19.72	14.17	5.66	.81	4.84	2.82	14.73	.00
February	8.61	19.72	14.17	11.16	.18	10.98	2.73	16.08	.00
March	11.39	25.28	18.33	1.24	.00	.64	5.86	11.47	975.00
April	14.17	25.28	19.72	.64	.00	.64	7.23	4.87	1,921.00
May	19.72	30.83	25.28	15.58	5.31	10.27	14.04	4.21	270.42
June	22.50	33.61	28.06	3.82	.00	3.82	17.95	.00	.00
July	22.50	33.61	28.06	7.89	.57	7.32	18.26	.00	10.21
August	22.50	36.39	29.44	4.02	.00	4.02	19.59	.00	.00
September	22.50	33.61	28.06	17.57	1.69	15.88	15.78	2.17	1,385.21
October	14.17	28.06	21.11	10.93	.16	10.78	7.77	5.70	761.11
November	11.39	25.28	18.33	1.76	.00	1.76	5.12	3.13	.00
December	5.83	19.72	12.78	1.33	.00	1.33	2.19	2.98	.00

[a]Management option A with N.R.C. energy system.
[b]Effective rainfall = Total-runoff.

TABLE 2. SAMPLE OF MODEL OUTPUT WITH LIGHT STOCKING RATE[a]

Month	Kleingrass, kg Available[b]	Kleingrass, kg Consumed[c]	Weight of steer, kg	Steer gain per ha, kg	Daily steer gain, kg
January	.00	.00	250.00	.00	.00
February	.00	.00	250.00	.00	.00
March	926.00	.00	250.00	.00	.00
April	2,169.04	632.07	288.76	95.76	1.29
May	1,685.58	665.58	325.91	91.81	1.24
June	1,137.57	547.61	337.22	27.93	.38
July	679.39	425.03	337.33	.28	.00
August	252.89	410.36	335.75	−3.89	−.05
September	1,017.04	602.08	351.80	39.64	.53
October	1,237.38	469.49	365.48	33.81	.46
November	1,191.60	.00	365.48	.00	.00
December	1,147.80	.00	365.48	.00	.00

[a]Management option A with N.R.C.

[b]Standing forage at the end of the month.

[c]Monthly forage consumption.

Annual rainfall and total cumulative forage production are not highly correlated, which agrees with previous work (3). Post precipitation runoff, rainfall distribution and the importance of winter rainfall help to explain the reason that annual precipitation is not a good predictor of total forage yield. Soil moisture seems to be a better estimator of growth than rainfall. Waiting for sufficient forage to be on the ground and then withdrawing animals as soon as forage becomes nonexistent appears to be the best management scheme of those analyzed.

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PR-3764

Interaction Between Levels of Monensin and Dietary Protein on Grazed Forage Utilization

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Summary

The effects of dietary supplementation of monensin [0,100 or 200 milligrams per head per day (mg/head/day)] and crude protein [210 grams (gm)/head/day] on intake and fiber digestibility were determined for 30 Angus or Hereford heifers grazing winter dormant common bermudagrass. Both protein alone and monensin alone increased ($P<.05$) digestibility of neutral detergent fiber. Monensin significantly ($P<.05$) decreased intake at both levels of supplementation.

Introduction

Crude protein content is frequently a limiting factor in the intake and utilization of poor quality forages by grazing animals. This limitation may be due to decreases in cellulytic bacterial growth (accompanied by lower concentrations of their cellulytic enzyme) which results from low dietary protein levels. Since a major factor governing forage intake is the rate of ruminal fiber digestion and passage (2), any increase in bacterial growth rate should also increase digestibility and intake. Previous studies (5) have shown monensin to increase the digestibility of fiber by cattle grazing low quality forages. These increases in digestibility have been accompanied by decreases in intake and rates of passage. It is theorized this increase in digestibility may be due to a slower rate of passage which increases the exposure time of dietary fiber to microbial enzyme attack. The purpose of this experiment was to determine what effects and interactions monensin and crude protein supplementation might have on intake and digestibility of low quality forage by heifers.

Experimental Procedure

In December, 1979, 30 Angus or Hereford heifers were placed on trial in a 13-hectare, winter dormant, common bermudagrass pasture. Heifers were randomly assigned to two groups of 15 animals each to receive 454 gm of grain sorghum (12 percent crude protein) or cottonseed meal (46 percent crude protein). Groups were further divided into three subgroups of five animals each to receive 0, 100 or 200 mg monensin/head/day. Animals were penned daily and fed their respective supplement. After a 6-day adjustment period, 9 gm of $YbNO_3$ was pulse dosed (0 hr) each animal via the supplement. Fecal grab samples were taken at 6, 12, 18, 24, 30, 36, 42, 48, 60, 72, 84, 96, 108, 120 and 132 hours post dosing.

Eight esophageal-cannulated Brahman X Jersey steers and heifers were divided into two groups of four each to receive 0 or 300 mg monensin/head/day. Animals were fitted with nylon mesh collection bags and allowed to graze. Esophageal extrusa collected from these animals was considered to represent the diet for all animals within that treatment group.

Sample Analysis and Calculations

Esophageal, fecal and forage samples were immediately frozen following collection. As lab time became available forage and fecal samples were dried at 55° C in a forced draft oven, ground through a Willey Mill fitted with a 2-millimeter screen and placed in glass sample bottles and redried. Esophageal samples were freeze-dried, ground and placed in sample bottles. All samples were analyzed for crude protein (CP), neutral detergent fiber (NDF) and indigestible neutral detergent fiber (INDF) (4). Rare earth (Ytterbium) determination was conducted by taking a 1 gm subsample of the feces, ashing, and digesting this ash in 20 milliliters (ml) of acid (3 N HCL and 3 N HNO_3). Concentration [parts per million (ppm)] of the marker was then read via atomic absorption spectrophotometry (1). The reduction in marker concentration with time was fit to a two-compartment, time delay model (3) for estimation of fecal organic matter output and fractional turnover. Digestibility of organic matter (DOM) was determined by use of a ratio technique utilizing INDF as the internal indigestible marker.

Where:

$$\text{DOM} = 100 - \left(\frac{\text{INDF in Esophageal Extrusa, \% of OM}}{\text{INDF in Feces, \% of OM}} \times 100\right)$$

By determining NDF content in the feces and in the esophageal sample the digestibility of neutral detergent fiber was determined.

Where:

$$\text{DNDF} = 100 - \left(\frac{\text{INDF in Esophageal Extrusa, \% of OM}}{\text{INDF in Feces, \% of OM}}\right) \times \left(\frac{\text{NDF in Feces, \% of OM}}{\text{NDF in Esophageal Extrusa, \% of OM}}\right) \times 100$$

By calculating the fecal output [kilograms (kg)] of the animal, together with the percent of the forage that goes undigested (100 − DOM), forage organic matter intake was computed.

Where:

$$\text{IOM, kg/day} \times \frac{\text{Fecal Output, kg OM/day}}{(100 - \text{DOM})/100}$$

Results and Discussion

Both INDF and NDF percentages were lower for the esophageal extrusa than for the standing crop (Table 1). Crude protein content was slightly higher. This indicates animals were selective in their grazing habits and some winter grasses (rescue grass, Texas wintergrass, etc.) may have been eaten.

Digestibility of organic matter (DOM) and fiber (DNDF) are presented in Table 2. Only those animals receiving 0 mg monensin + protein had significantly higher digestibility than the controls. However, DOM was numerically increased for all treatment groups except 200 mg monensin alone. Thus it appears protein alone or monensin alone will increase DOM although the upper level of monensin (200 mg) appeared to have a depressing effect unless accompanied by protein. DNDF was significantly increased ($P<.05$) for all treatment groups compared to controls. No difference or interaction was found to exist between monensin and protein.

Monensin (100 and 200 mg/hd/day) significantly decreased fecal output, intake and digestible intake.

TABLE 1. COMPOSITION OF ESOPHAGEAL EXTRUSA AND STANDING CROP, TREATMENT MEANS

Sample	Treatment[c]	NDF	INDF	CP	OM
	mg/hd/day	-- % of OM --		-- % of DM --	
Esophageal[a]	0	69.87	42.18	7.15	92.26
Esophageal[a]	300	67.95	46.29	6.52	91.00
Standing Crop[b]	--	76.89	52.09	6.29	95.70
Kg DM/Hectare		1355			

[a]Mean of four animals per treatment, four to five samples per animal.
[b]Mean of 10 samples.
[c]No significant differences were found due to treatment or day ($P<.1$).

TABLE 2. INTAKE AND UTILIZATION OF FORAGE, TREATMENT MEANS[a]

Item	Monensin level, mg/hd/day					
	0	0+P[b]	100	100+P[b]	200	200+P[b]
DOM %	40.71[c]	43.31[d]	41.41[cd]	41.99[cd]	40.43[c]	41.48[cd]
Change, %	--	+6.00	+1.93	+3.05	--	+1.86
DNDF, %	31.71[c]	33.32[d]	33.06[d]	32.62[d]	32.91[d]	33.06[d]
Change, %	---	+7.83	−7.11	+5.59	+6.68	+7.11
Fecal Output KgOM/100 KgBW	1.29[c]	1.15[cd]	.93[d]	.97[d]	.92[d]	.88[d]
Change, %	--	−10.85	−27.91	−24.80	−28.68	−31.78
Intake, KgOM/100 KgBW	2.18[c]	2.02[cd]	1.60[d]	1.66[d]	1.35[d]	1.50[d]
Change, %	--	−7.34	−26.61	−23.85	−28.90	−31.19
Digestible Intake, KgOM/100 KgBW	.89[c]	.87[cd]	.66[de]	.70[cde]	.63[cde]	.62[e]
Change, %	--	−2.24	225.84	−21.35	−29.21	−30.34
Monensin mg/hd/day (assay)	0	0	84	83	177	183
Monensin, ppm	0	0	14.26	11.53	32.13	33.39

[a] Five animals per treatment.
[b] Animals supplemented with 210 gm crude protein (454 gm cottonseed meal).
[cde] Treatment means in a row with different subscripts differ ($P<.05$).
-- Changes of less than 1% are not given.
Change = change from 0 mg/hd/day.

Reductions in digestible intake were slightly smaller than reductions in intake or fecal output (excepting the 200 mg without CP treatment) due to monensin-related increases in digestibility.

No significant differences were found in animal weight change due to treatment, although all animals lost weight during the trial. Thus, the lower intakes and higher fiber digestibilities realized with monensin supplementation would appear to increase efficiency of maintenance. In addition, crude protein supplementation alone, while having little effect on intake, would appear to increase forage utilization by increasing digestibility of both organic matter and fiber.

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PR-3765

Effect of Monensin on Digestibility of Grazed Coastal Bermudagrass

K. R. Pond and W. C. Ellis

Summary

Feeding monensin at levels of 200 milligrams per head per day (mg/hd/day) consistently increased digestibility of grazed Coastal bermudagrass organic matter (mean increase of 5 percent) and neutral detergent fiber (mean increase of 6 percent).

Introduction

Monensin increases feed efficiency by reducing feed intake without affecting the gain of cattle fed highly digestible rations. In contrast, only increased weight gains have been reported when monensin is supplemented to cattle fed less digestible forage rations or to cattle grazing pasture. Such increases in gain could be due to positive effects on digestibility, intake and/or metabolic efficiency. The present report summarizes the results of five experiments designed to measure the effects of monensin on the digestibility of grazed Coastal bermudagrass at different times during the growing season.

Experimental Procedure

Brahman × Jersey heifers (Table 1) were randomly allotted to groups to receive 0 or 200 milli-

TABLE 1. EXPERIMENTAL DETAILS

Trial	Date	Cattle Control	Monensin	Mean wt.	Bermudagrass description
		Number		(kg)	
1	9/77	6	5	328	drouth dormant
2	10/77	6	6	329	regrowth after N and H_20
3	12/77	8	8	335	frosted residues
4	8/78	10	9	367	regrowth with continuous grazing
5	10/78	10	9	373	fall dormant residues

grams (mg) monensin each day while grazing Coastal bermudagrass at different intervals of two grazing seasons at College Station. Trial 1 in late September utilized a 12.4 acre pasture which had previously been continuously grazed by the experimental animals and was in a state of drouth-induced dormancy. Trial 2, in late October, utilized a portion of the same pasture after clipping, irrigation, and a 6-week regrowth period. Trial 3, in early December, utilized the same pasture after continued grazing and a killing frost November 20. Trials 4 and 5, in August and October of 1978, utilized the same Coastal bermuda pasture as the previous year.

Animals were individually penned twice daily (8 a.m. and 4 p.m.) and fed their respective supplements. A one-half-pound grain mixture containing 12 percent crude protein was fed in trials 1 and 2 and 1 pound of cottonseed meal containing 43 percent crude protein was fed twice daily in trials 3, 4, and 5. The supplement for the monensin-fed animals contained 200 mg monensin fed in the morning feeding in trial 1 and 100 mg monensin fed twice daily in trials 2, 3, 4, and 5.

Four animals fitted with ruminal and esophageal cannulae (two for each monensin level) were fed with the intact animals except during 6 days when they were tethered via 6 meter (m) cables to facilitate collection of esophageal forage samples in the pasture at three different sites, for 2 days each. After 7 days of treatment adjustment before each trial, grab samples of feces were taken per rectum at each feeding for 8 consecutive days. Esophageal collections began 1 day prior to the fecal collections and continued for 5 days.

Fecal samples were dried at 55° C in a forced-draft oven. Esophageal samples were frozen and subsequently freeze dried. All samples were then ground through a Wiley Mill fitted with a 2 millimeter (mm) screen, placed in glass bottles, and dried in a vacuum oven at 50° C for 8 hours before chemical analysis.

Aliquots of eight esophageal samples per trial were analyzed for crude protein (CP). Aliquots of all esophageal samples together with two fecal samples per animal for each day were analyzed for indigestible neutral detergent fiber (INDF) (1). Aliquots of all esophageal samples plus six fecal samples per animal for each trial were analyzed for neutral detergent fiber (NDF).

Percent INDF organic matter was calculated:

$$\% \text{ INDF} = \frac{\text{(dried filtered sample wt.) - (ashed filtered sample wt.)}}{\text{initial sample weight}} \times 100$$

Using the INDF values for the esophageal samples and INDF values for the feces, the digestibility of organic matter was computed by the ratio technique.

$$\text{Digestibility } (\%) = 100 - [\frac{\text{INDF esophageal}}{\text{INDF feces}} \times 100]$$

Together with the NDF values of esophageal and feces, the digestibility of fiber was computed.

$$\text{Digestibility of fiber} = 100 - [\frac{\text{INDF esoph}}{\text{INDF feces}} \times \frac{\text{NDF feces}}{\text{NDF esoph}} \times 100]$$

Results and Discussion

The chemical composition of consumed forage for each trial is presented in Table 2. There was no difference in composition of consumed forage in any trial due to monensin supplementation for any of the components analyzed. There was also no differences due to pasture site of collection or collection day. Therefore, the mean values for each of the components analyed was used to represent the quality of the forage consumed by all animals in each trial.

The frost-damaged forage consumed in trial 3 was the poorest quality with the lowest crude protein 3.5 percent, highest NDF 77.88 percent, and highest INDF 49.16 percent. The regrowth forage of trial 2 was the highest quality forage with 8.5 percent crude protein, 71.35 percent NDF and 31.12 percent INDF. The August forage of trial 4 was next best in quality, with trials 1 and 5 completing the range.

Digestibility of organic matter (DOM) and fiber (DNDF) are presented in Table 3. Animals receiving monensin had consistently higher DOM. Increased DOM ranged from 2.8 percent in trial 4 (51.9 vs. 50.5 percent) to 8.2 percent in trial 2 (55.6 vs. 51.4 percent). The DOM in trial 3 of 35.6 for control and 38.5

TABLE 2. MEAN COMPOSITION OF CONSUMED FORAGE

Trial	Crude protein		Neutral detergent fiber		Indigestible neutral detergent fiber	
	Control	Monensin	Control	Monensin	Control	Monensin
1	6.17	6.24	73.52	73.54	32.57	29.15
2	8.56	8.35	72.37	70.32	30.14	31.10
3	3.47	3.48	78.83	76.92	47.72	50.60
4	8.18	7.58	75.94	75.53	35.79	36.06
5	5.36	5.47	74.65	75.83	32.25	32.49

TABLE 3. DIGESTIBILITY OF FORAGE ORGANIC MATTER AND FIBER

Trial	Digestibility of organic matter			Digestibility of fiber		
	Control	Monensin	Change, %	Control	Monensin	Change, %
1	51.6	53.4	3.5**	48.6	49.4	1.6
2	51.4	55.6	8.2**	43.7	48.0	9.8*
3	36.6	38.5	5.2†	30.4	33.3	9.5*
4	50.5	51.9	2.8*	49.0	50.4	2.9**
5	46.1	48.4	5.0†	48.3	50.9	5.4*

[a]Change is different: †(P<.1), *(P<.05), **(P<.01).

for monensin-fed animals, although improved with monensin supplementation, is very low and lower than physiologically expected. DNDF was also higher for animals receiving monensin. DNDF was approximately 50 percent for animals receiving monensin and 43-49 percent for control animals except in trial 3. Trial 3 which had the highest percent NDF and percent INDF had the lowest DOM and DNDF but nearly the largest change due to monensin. Animals supplemented with monensin in trial 3 had increased DNDF of 9.5 percent (33.3 vs. 30.4). Animals supplemented with monensin while consuming the highest quality forage (trial 2) also had increased DNDF of 9.8 percent (48.0 vs. 43.7). DOM and DNDF were increased with monensin supplementation regardless of quality of forage. A portion of the positive gain response with monensin could be attributed to this increased digestibility of forage.

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PR-3766

Effects of Monensin on Fecal Output and Voluntary Intake of Grazed Coastal Bermudagrass

K.R. Pond and W.C. Ellis

Summary

Feeding monensin at levels of 200 milligrams/head/day (mg/hd/day) to cattle grazing Coastal bermudagrass numerically increased intake of digestible organic matter in four trials and reduced (P<.1) the digestible organic matter intake of the low quality forage of trial 3. It appears that in the medium range of digestibility (45-55 percent DOM), part of the increased performance associated with monensin may be due to increased digestible organic matter intake.

Introduction

Several workers have reported reduced forage intake with monensin supplementation with no alteration in cattle performance. Others reported that monensin-fed gestating cows fed hay outgained controls and achieved these gains more efficiently.

If monensin reduces feed intake and maintains or increases body weight, herd size or stocking rates could be increased to utilize the additional forage. With low quality forages that do not meet the energy requirements, an increased energy utilization could reduce the need for supplementation. Many other speculative benefits of monensin supplementation have been postulated. These, however, will remain speculations until further knowledge of the effects and mode of action of monensin is acquired.

The growing number of monensin-supplemented pasture-grazing cattle emphasizes the importance of understanding monensin's effects on grazed forage intake. The purpose of this study was to determine the effects of monensin on fecal output and, hence, intake of organic matter by cattle grazing Coastal bermudagrass pasture.

Experimental Procedure

Experimental details are presented in PR-3765 (1). All animals received erbium chloride ($ErCl_3$) in their supplement to serve as a fecal output marker. The $ErCl_3$ was dissolved in water to a concentration of

200 milligrams per liter (mg/l) and mixed with the supplement in a horizontal ribbon mixer to supply the animals with 1,200 mg Er/day. After 5 days of adjustment, 10 days of fecal collections followed with grab samples of feces taken per rectum at each feeding. Fecal samples were then dried at 55° C in a forced-draft oven and ground through a Wiley Mill fitted with a 2-millimeter (mm) screen. Er concentration in fecal samples was determined via atomic absorption spectrophotometry. Since a constant amount of Er was fed each day, the organic matter fecal output can be computed by the ratio of marker consumed to the marker concentration in the fecal organic matter. Using the calculated fecal outputs (FO) and the digestibility (DOM) values from PR-3765 (1), the forage organic matter intake (FOMI) was calculated:

$$\text{Forage Organic Matter Intake} = \frac{\text{fecal output}}{(100\text{-digestibility})/100}$$

Results and Discussion

Treatment means of the effects of monensin on fecal output, forage intake, and digestible intake for each trial are presented in Table 1.

Fecal outputs were numerically higher for monensin-fed cattle in each trial except trials 2 and 3. Consuming the poorest quality forage in trial 3, monensin-fed animals had a 16.0-percent reduction ($P<.1$) in fecal output compared to the controls. Forage organic matter intake was numerically higher (4.9 - 15.4 percent) for monensin-fed animals in all trials except trial 3. Again, consuming poor quality forage in trial 3, the monensin-fed animals had reduced ($P<.1$) forage intakes. It appears that in the medium range of digestibility (45 - 55 percent) monensin tended to increase forage intake. However, with poorly digested forages, monensin may have an effect of depressing forage intake.

TABLE 1. EFFECTS OF MONENSIN ON FECAL OUTPUT, FORAGE ORGANIC MATTER INTAKE, AND DIGESTIBLE ORGANIC MATTER INTAKE

	Trials				
Item	1	2	3	4	5
Fecal output[a]					
control	1.16	.93	.81	1.16	1.12
monensin	1.29	.90	.68	1.25	1.15
change, %	1.2	−3.2	−16.0[b]	7.8	2.7
Forage organic matter intake[a]					
control	2.40	1.84	1.25	2.35	2.13
monensin	2.77	1.93	1.09	2.60	2.26
change, %	15.4	4.9	−12.8[b]	10.6	6.1
Digestible organic matter intake[a]					
control	1.26	.90	.47	1.19	1.01
monensin	1.50	1.04	.43	1.35	1.11
change, %	19.0	15.6	−8.5	13.4	9.9

[a]Expressed as Kg per 100 Kg body weight.
[b]Change from control is different ($P<.1$).

Digestible organic matter intake can be computed from the product of forage intake and digestibility. The increased digestibility partially compensated for the reduced forage intake in that digestible intake for trial 3 was only reduced by 8.5 percent with monensin. In all other trials, monensin-fed animals had increased mean digestible forage intake ranging from improvements of 9.9 to 19.0 percent. Although statistically nonsignificant, it appears that part of the increased performance associated with monensin may be due to an increased digestible organic matter intake.

Table 2 presents the quantity of monensin supplemented and the concentration of monensin in the total intake. The differences associated with trial 3 compared to other trials may have been due to an excessive concentration of monensin. Monensin was supplemented at 200 mg/hd/day in each trial. With the low voluntary intake of the poorly digested forage in trial 3, the concentration of monensin in the intake was nearly twice the concentration of monensin in the other trials (56.46 *vs.* 22.35 - 30.45 parts per million). Possibly the levels of monensin supplementation should be varied according to expected forage intake rather than simply set at 200 mg/hd/day.

TABLE 2. QUANTITY OF MONENSIN SUPPLEMENTED AND THE CONCENTRATION OF MONENSIN IN TOTAL DIET

Trial	Monensin supplemented	Concentration in total diet
	----mg/hd/day----	--ppm--
1	200	25.21
2	200	30.45
3	200	56.46
4	200	22.35
5	200	25.57

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PR-3767

Effect of Monensin on Gastrointestinal Fill and Turnover of Undigested Forage Residues in Animals Grazing Coastal Bermuda

W.C. Ellis, J.H. Matis, and K.R. Pond

Summary

When supplemented to cattle grazing Coastal bermuda of 46-52 percent digestible organic matter, monensin at levels of 14-30 parts per million (ppm) resulted in increased mean fill of undigested dry

matter by 16 percent and reduced its turnover rate by 10 percent. When the same cattle were grazing very poor quality Coastal bermuda (36.6 percent digestible organic matter), monensin at 56 ppm of the diet also depressed turnover (by 15.5 percent) but had negligible effects on fill. These effects on fill and turnover appear to provide a physiological explanation for the observed effects of monensin on intake, digestibility, and fecal output of grazed Coastal bermudagrass.

Introduction

Previous reports (PR-3765 and PR-3766) demonstrated that monensin consistently increased digestibility of organic matter and fiber and increased fecal output and forage intake by cattle grazing Coastal bermudagrass. It has been postulated that effects such as these could be explained in terms of the capacity of the animals' gastrointestinal tract (fill) and its rate of turnover (1). Therefore, these measurements were made on the animals involved in the previous two reports.

Experimental Procedure

Animals were treated as previously described (PR-3765 and PR-3766). During the digestion trial, one-half a single meal was offered which contained the additional marker $Yb(NO_3)_3$ to supply approximately 9 grams (gm) of Yb/animal. Animals were allowed 30 minutes to consume the one-half meal (227 or 454 gm) and then given the remaining one-half meal to encourage complete consumption of the marker dose. Grab samples of feces were collected at 0, 8, 24, 32, 48, 56, 72, 80, 92, 100, 112, 120, 128, 140, 148, 160, and 168 hours post-dose of the marker, dried, and analyzed for Yb.

Turnover of undigested matter (fecal matter) was assumed to be the slower turnover rate constant of a two-compartment, time-dependent model with time delay (2). Fill of undigested dry matter (MGIF) was estimated as fecal output measured by the continuous dose Er marker (as described in previous papers) divided by the turnover rate expressed on a daily basis. In experiments 4 and 5, particles of masticated forage were obtained via esophageal cannulae and labelled with $^{141}Ce(NO_3)_3$. This was then fed with the one-half meal of Yb-labelled grain or cottonseed to determine more specifically the turnover of forage residues. Turnover of ^{141}Ce was then computed as described for Yb.

Results and Discussion

Results are summarized in Table 1. Monensin consistently reduced turnover rate (kp) and had the greatest effect on forage residues (trial 4F *vs.* 4G and 5F *vs.* 5G). This suggests that the turnover of forage residues in trials 1, 2, and 3 was probably larger than that measured for labelled residues derived from the grain or cottonseed oil meal. Consequently, the monensin effects on increased MGIF for these three trials may have been even greater than those computed from the turnover of the supplement's labelled residues. This would be the case since the method used to compute fill assumed the turnover of the labelled residues derived from the supplement represented the turnover of all material contributing to the total fecal output. The MGIF in trials 4 and 5 is also computed, assuming the turnover of residues derived from the labelled forage (4F and 5F) represented turnover of all material contributing to the total fecal output. Monensin effects on MGIF computed from kp of forage were greater than when computed from grain and are thought to be more rational estimates. Regardless of the uncertainties of magnitude, it is clear monensin did increase fill in all trials with the exception of trial 3 which is estimated from turnover of grain residues and hence may be less representative of the total dietary residues of forage.

These observations offer an explanation for the previously reported effects of monensin on digestibility and intake. The increased digestibility of organic matter (DOM) could be accounted for by the increased digestibility of fiber (DNDF) due to its slower turnover and hence longer retention time in the rumen. In trials 1, 2, 4, and 5 the control forage had a

TABLE 1. MEAN GASTROINTESTINAL FILL OF UNDIGESTED DRY MATTER (MGIF) AND ITS TURNOVER (KP) WHEN GRAIN (G) OR FORAGE (F) WAS LABELLED

	Trial/labelled particle						
	1	2	3	4		5	
Measurement	G	G	G	G	F	G	F
MGIF, Kg/100 Kg							
Control (C)	.98	.67	.60	.88	1.00	.71	.69
Monensin (M)	1.20	.82	.60	.96	1.32	.77	.92
$[(M-C)/(C)] \times 100$	22.5	23.1	nil	9.3	31.8	9.3	31.9
Kp, %/hr.							
Control (C)	4.91	5.80	5.62	5.52	4.81	6.65	6.72
Monensin (M)	4.46	4.56	4.75	5.44	3.95	6.20	4.96
$[(M-C)/(C)] \times 100$	−9.2	−21.4	−15.5	−1.4	−17.9	−6.1	−26.2

TABLE 2. SUMMARY OF MONENSIN RESPONSES REPORTED FOR COASTAL BERMUDAGRASS[a]

Trial	DOM	DNDF	MGIF[b]	KP[b]	FO	FOMI	DOMI
	%	[(Monensin-Control)/(Control)] × 100					
3	36	10	nil	−16	−16	−13	− 9
1	52	3.5	23	− 9	2	15	19
2	51	8.2	23	−21	− 4	5	16
4	51	3.0	9	− 1	8	11	13
5	46	5.0	9	− 6	3	6	10

[a]Where: DOM = Digestibility of OM, DNDF = digestibility of fiber, MGIF = mean gastrointestinal fill, Kp = rate of passage, FO = fecal output, FOMI = forage OM intake and DOMI = digestible OM intake.

[b]Computed from Kp of grain residues.

DOM in the order of 50, and monensin increased MGIF more than it reduced kp; hence, fecal output and feed intake were increased. This, coupled with the increased DOM, resulted in nutritionally significant increases in daily intake of DOM (DOMI). This increase is sufficient to account for the increased liveweight gains promoted by monensin by calves grazing Coastal bermuda pastures (3 and 4).

The failure of monensin to increase MGIF in trial 3 in the face of the observed marked reduction in its turnover (Table 1) would have led to the observed reduction in fecal output and forage intake previously reported. It may be that ingested forage residues from the poorly digested forage (36.6 percent DOM) completely occupied all available space within the rumen and therefore limited a monensin effect on further increasing fill. A summary of these data supporting this generalization is presented in Table 2.

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PR-3768

Comparison of Fecal Output as Estimated by Two Marker Methods

D. S. DeLaney, K. R. Pond, C. E. Lascano, and W. C. Ellis

Summary

Quantification of fecal output using indigestible markers with continuous and single dose techniques with 120 cattle are summarized. Either technique can be used for effectively estimating fecal output.

Introduction

Quantifying forage intake by cattle on pasture is critical in grazing studies and important in adjusting stocking rates or density. Sampling the available forage has been used as an indirect measurement of forage intake, but this offers only a crude estimate of forage disappearance (trampling, consumption of forage by non-domestic animals and differing forage yields by site all add variables to the measurements). A more accurate measurement of intake involves measuring the animals' total fecal output. Combining this output with *in vivo* or *in vitro* determinations of digestibility allows estimation of forage intake by the grazing animal.

$$\text{Forage Intake} = \frac{\text{Fecal Output}}{1 - \text{Digestibility}}$$

Although total collection of feces is practical in pen studies, the labor, time, and apparatus required make this method unsatisfactory in grazing studies. Fecal output can be computed without total collection with the use of indigestible markers. Daily dosing of a known amount of indigestible marker followed by periodic sampling of feces, allows for determination of the dilution of the marker in the total tract of the animal. Typically, the marker is given in a daily or twice-daily dose for 3-4 days to achieve equilibrium and the grab samples of feces are collected (per rectum) over a 3- to 7-day period to obtain estimates of mean marker concentration in the feces. This procedure has the disadvantage of labor required for the daily dosing and also presents problems in maintaining a constant marker consumption. Alternatively, fecal output can be estimated from the changes in marker concentrations with time following a larger pulse (single) dose of the marker.

This report summarizes fecal output values from five trials utilizing Angus, Hereford, and Brahman x Jersey heifers where both continuous and pulse dose techniques were used.

Experimental Procedure

Thirty Angus or Hereford heifers and 8-12 Brahman x Jersey heifers or steers were used over different stages of the grazing season (Table 1) to compare fecal organic matter output (FO) estimates by two different methods. In all trials, animals were individually penned daily and fed approximately 5.5 grams (g) of Erbium Nitrate ($ErNO_3$) contained in a supplement. On day 1 of each trial animals were pulse dosed with 14 g of Ytterbium Nitrate ($YbNO_3$) which had been added to the supplement. Grab samples of feces were taken every 6 hours for 48 hours and then every 12 hours for 96 hours. All fecal samples were immediately frozen and stored. Prior to lab analysis fecal samples were dried at 55° C in a forced-air convection oven and ground through a Wiley Mill fitted with a 2-millimeter (mm) screen. Samples were then placed in glass bottles and re-dried. A 1-g subsample was ashed and digested in 20 milliliters (ml) of an acid solution (3N HCL + 3N HNO_3). The concentration of the rare earths (Yb and Er) were then assayed via atomic absorption spectrophotometry (1).

Collections began when equilibrium of the continuous (Er) marker was considered to be reached. Marker concentration in the feces after saturation *vs.* day collected is presented in Figure 1. Mean marker concentration was then computed. By dividing the daily marker dose by the mean marker concentration in the feces, average daily FO was determined as

$$\text{FO, Kg/day} = \frac{\text{Marker Dosed, Kg/day}}{\text{Marker in Feces, g/Kg}}$$

The justification of a pulse dose is presented in Figures 1 and 2. After dosing, the marker concentrations in the feces increase and then decrease with time. Figure 2 presents the plot of the natural logarithm of marker concentration *vs.* time. Note the inclining and declining portion of the excretion curve. Typical data fit a two-compartment, time-dependent delay model (2). Parameters estimated in this model involve the concentration of the marker (λ_o) had it been instantaneously mixed (Figure 2) and its fractional turnover by passage to the feces (λ_2) expressed on a daily basis (λ_2^{-day}). The fecal output was then determined by

$$\text{FO, Kg/day} = \frac{\text{Marker Dosed, Kg/day}}{\lambda_o\text{, gm/Kg}} \times \lambda_2^{-day}$$

TABLE 1. EXPERIMENTAL DETAILS

Trial	Trial dates	Description of forage[a]
1	7/23/79-8/3/79	Summer growth, common bermudagrass, ~ 55% digestible
2	11/24/79-12/1/79	Winter dormant, common bermudagrass, ~ 41% digestible
3	12/13/79-12/18/79	Winter dormant, common bermudagrass, ~ 48% digestible
4	4/18/80-4/25/80	Mature ryegrass and oats, ~ 61% digestible
5	5/2/80-5/6/80	Mature ryegrass, ~ 63% digestible

[a]Digestibility determined *in vivo* with indigestible fiber as internal indicator.

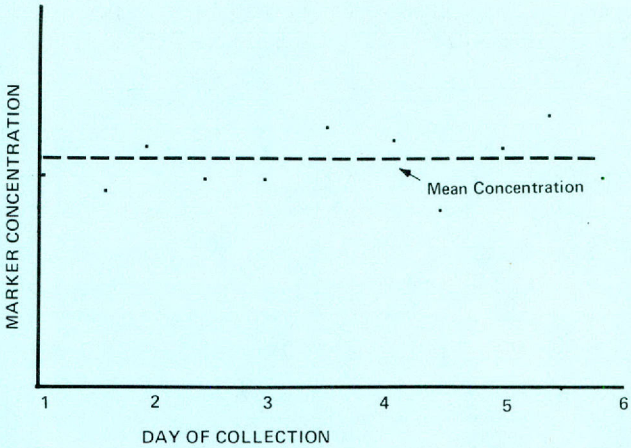

Figure 1. Marker concentration *vs.* time (continuous dose).

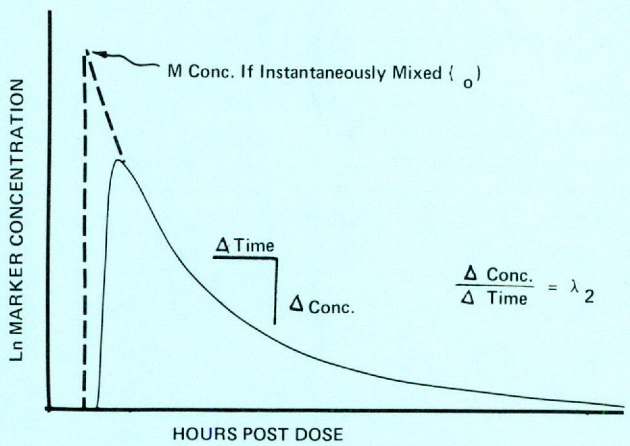

Figure 2. Ln of marker conentration *vs.* time (pulse dose).

Results and Discussion

Fecal outputs determined by the continuous dose and pulse dose methods are presented in Table 2. In no trial did the estimate of FO change more than 10 percent due to method used. Although trial means were very similar, this may be misleading since variation by method among individual animals ranged from 0-50 percent. The pulse dose model seemed to fit best in situations where more than 1 point was observed in the inclining segment of the curve. When there were observations in the inclining segment, fecal outputs determined by both techniques were similar.

Sources of variation in both methods included spillage of the marked supplement by animals, inconsistent intake of the marker, and poor mixing of marker with the supplement. Despite large individu-

TABLE 2. COMPARISON OF CONTINUOUS (Er) AND PULSE (Yb) DOSE MARKERS FOR DETERMINATION OF FECAL OUTPUT

Trial	Number Cattle	Continuous dose[ab] Er	Pulse dose[b] Yb
		Kg OM/100 Kg BW	
1	30	.79 ± .20	.75 ± .08
2	30	1.08 ± .09	1.02 ± .22
3	12	1.22 ± .24	1.28 ± .17
4	30	.64 ± .09	.70 ± .10
5	8	1.04 ± .22	1.03 ± .33

[a]Mean Er concentration a result of eight observations/animal (trials 1, 2 and 5), four observations/animal (trial 3) and 15 observations/animal (trial 4).
[b]Trial mean ± SD.

al animal variations, the pulse dose method appears adequate in determining average daily fecal output. This method has the advantage of less labor (single dose) and, in addition, rate of passage through the gastrointestinal tract and total tract fill can be estimated. Continuous dosing with multiple sampling offers the advantage that an estimate of FO can be computed from each sample taken. Hence, several estimates of FO can be determined for each animal and measurements of individual animal variation in FO determined.

Both techniques provided similar estimates of fecal output. Each method, with proper marker administration and fecal collection, can effectively and accurately be used for FO estimation.

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PR-3769

Effect of Pasture Application of Tebuthiuron (Graslan®) Upon Forage Composition, Production, and Disappearance During Grazing

W.C. Ellis and John Snell

Summary

Application of the herbicide Tebuthiuron (trade name Graslan) had no significant effect on disappearance of Coastal bermudagrass when grazing animals were either restricted to the treated plots or had access to both treated and untreated plots. This suggests the herbicide treatment does not result in preferred or increased consumption of Coastal bermudagrass as has been suggested for other grasses.

Introduction

The herbicide Tebuthiuron (trade name Graslan) has been demonstrated effective in removal of woody species from pastures. A number of observations have suggested a marked preference by cattle for forage subsequently grown on sites treated with this herbicide. This study was conducted to determine the relationship between preference for or consumption of Coastal bermudagrass and rate of Tebuthiuron application.

Experimental Procedure

Forage Plots

A 3.137-acre area of established Coastal bermuda was divided into three blocks of 83 x 549 feet identified as A, B, and C. Each block was further subdivided into three areas each of 183 x 83 feet and treated with either 0, 0.75 or 1.5 pounds of active Tebuthiuron per acre. Fencing was installed such that within each block three 183 x 48-foot plots were formed to localize grazing (L grazing method) to the individual Tebuthiuron application level and one 35 x 549-foot plot to allow common grazing (C grazing method) across all Tebuthiuron application levels.

Tebuthiuron was applied as a spray in 5.0 gallons of water to each plot on April 13, 1979.

Grazing

The grazing procedure involved allocation of equal body weights of cattle to the localized treatment plots of block A when sufficient forage was available for grazing. When it was observed that any one plot was grazed out, the animals were then moved to the treatment-common plot of that block. When any one area within this treatment-common plot was visually grazed out, all animals were moved to the localized treatment plots of block B and block C. This grazing sequence was repeated across blocks A, B, and C a second time and is considered as a second replication.

Before grazing, the blocks were successively clipped in order to sequence a 7-day interval in regrowth initiation for blocks A, B, and C. Animal numbers were varied within block-treatment-grazing method to achieve graze out within 5-7 days to maintain this sequence interval.

Measurements

Animals were weighed before placement on the first plot and after removal from each plot. A forage strip 22 inches wide and of sufficient length to yield approximately 25 pounds fresh weight was harvested at three locations within each plot prior to entry and subsequent to vacancy by the cattle. These three harvests were made at the three treatment sites within the treatment-common plot. Harvest was made with a rotary lawnmower adjusted to a height of approximately 2 inches above mean ground level.

Mean forage disappearance from a plot was measured as the difference in forage/acre before entry and after removal from that plot. Mean forage appearance in a plot was measured as the difference in forage/acre after removal and before subsequent reentry on that same plot.

Results and Discussion

Tebuthiuron severely retarded the growth of bermuda such that clipping and initiation of the trial had to be delayed for fear of further damaging stand. Blocks were clipped beginning day 190 and grazing began day 212.

Results for mean daily forage disappearance are summarized in Table 1. Greater forage disappearance occurred from treatment-common pastures (C) than from treatment-localized pastures. An explanation for this is beyond the scope of this project. However, it should be noted there was no significant treatment grazing method interaction. Thus Tebuthiuron had no effect upon forage disappearance by either grazing method. This is particularly significant since prior observations have been interpreted to suggest a preference by cattle for Tebuthiuron-treated plots as opposed to non-treated plots, conditions similar to that tested by the treatment-common grazing method.

It should be noted that the grazing procedure used resulted in extensive utilization of the existing forage. Such an extensive utilization may have minimized any preference effects especially in the localized grazing method. However,it would have accentuated treatment effects in the treatment-common grazing method. Since no treatment effects were significant for the treatment-common grazing method and no treatment by grazing method interaction was significant, the extensive utilization appears not to have masked any treatment effects upon forage intake.

Mean daily dry matter appearance is summarized by treatment in Table 2. Analysis of variance indicated no significant effect attributable to any variable measured. There was a trend for the higher application level of Tebuthiuron to depress mean daily dry matter appearance.

Tebuthiuron significantly increased forage crude protein (Table 3) and decreased forage neutral detergent fiber (Table 4) content.

TABLE 1. MEAN DAILY DRY MATTER DISAPPEARANCE OF BERMUDAGRASS DURING GRAZING OF CONTROL AND TEBUTHIURON-TREATED PLOTS

		Tebuthiuron, lb/acre		
Replication	Grazing method[a]	0.0	0.75	1.5
		--------lb. DM/day/acre--------		
1	L	192	194	227
	C	548	357	598
2	L	368	374	377
	C	618	709	505

[a]L = grazing localized to individual treated plot.
C = grazing common to all treated plots.

TABLE 2. MEAN DAILY DRY MATTER APPEARANCE AS AFFECTED BY TEBUTHIURON APPLICATION AND PRIOR GRAZING METHOD

	Tebuthiuron, lb/acre		
Grazing method[a]	0.0	0.75	1.5
	-----------------lb. DM/day/acre-----------------		
L	94	90	40
C	110	91	82
L&C	104	91	61

[a]L = grazing localized to individual treated plot.
C = grazing common to all treated plots.

TABLE 3. PROTEIN CONTENT AS AFFECTED BY TEBUTHIURON APPLICATION

	Tebuthiuron, lb/acre		
Replication	0.0	0.75	1.5
	-------------------% of DM-------------------		
1	9.32	10.45	10.55
2	8.84	8.62	9.28

TABLE 4. NEUTRAL DETERGENT FIBER CONTENT AS AFFECTED BY TEBUTHIURON APPLICATION

	Tebuthiuron, lb/acre		
Replication	0.0	0.75	1.5
	-------------------% of DM-------------------		
1	80.9	76.2	75.1
2	80.8	79.8	77.7

Although Tebuthiuron did not significantly affect forage growth rate as measured by mean daily dry matter appearance, all the other observations reported here suggest that in this trial forage growth rate was reduced, resulting in lowered animal gain due to decreased quantity of forage and higher-protein-lower-neutral detergent fiber associated with the resulting less mature forage.

Acknowledgments

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PR-3770

Effect of Heavy Stocking Rates on Cow-Calf Performance

A.B. Johnson, R.K. Heitschmidt, J.R. Frasure and D.L. Price

Summary

Increasing rates of stocking with yearlong continuous grazing from 12.6 acres/animal unit (ac/au) to 8.5 ac/au tended to decrease cow weight and calf weaning weight. Although no differences were noted the first year, by the end of the second year cow weights averaged 1024, 1011 and 988 pounds for the 12.6, 10.5, and 8.5 ac/au stocking rates, respectively. Conception rate was 100 percent for both the 12.6 and 10.5 rate but only 76 percent for the 8.5 ac/au rate at the end of the second year. Average age of fetus was 149, 151, and 123 days for the respective treatments. Calf weaning weight did not differ by treatment the first year but averaged 496, 461, and 440 pounds for the 12.6, 10.5, and 8.5 ac/au treatments at the end of the second year.

Introduction

Optimal stocking rate varies by year. However, during past years the Texas Experimental Ranch has held its heaviest stocking rate at 12.5 ac/au. With the new interest in rotational, short-duration grazing systems at doubled stocking rate, it became necessary to re-evaluate maximum rate of stocking at the ranch. The objective of this experiment was to determine the effects of extremely heavy stocking rates on cow-calf performance.

Experimental Procedure

One hundred-seventy-four mature Hereford cows were allocated to one of three treatments in October 1978. The treatments were increasing levels of stocking and included 12.6, 10.5, and 8.5 ac/au (Table 1). All cows had been bred to Hereford bulls and were due to calve in October and November (1978). The cows received no winter supplement for the winter of 1978-79. Cows and calves were weighed in February, April, and at weaning in June (1979).

In October 1979, one replication of both the 10.5 ac/au and the 8.5 ac/au were eliminated to reduce anticipated financial loss from light weaning weights and reduced conception rate. At this time all cows in the remaining replications that had been palpated open in August were culled and replaced with bred cows for the same treatment of the eliminated replication. All cows had been bred to Angus bulls and were due to calve in December, January, and February.

TABLE 1. STOCKING RATE TREATMENT

	Stocking rate (ac/au)		
	12.6	10.5	8.5
Rep. I, No. of animals	25	26	38
Rep. II, No. of animals	23	27	34
Total, No. of animals	48	54	72

Cows were fed 2 pounds/day of a 20-percent crude protein range cube in December 1979 and 3 pounds /day of the cube in January and February 1980 as range and cow condition declined. Cows were weighed in November, January, and February to estimate rate of weight decline throughout the winter months. Cows and calves were weighed in April, June and at weaning in August (1980).

At weaning in August 1980, all cows were palpated and age of fetus estimated. In order to ensure a fair estimation, a blind study was conducted. Cows from one 12.6 ac/au replication were mixed with cows from the remaining replication of the 8.5 ac/au treatment. The same was done for the 10.5 ac/au treatment. Cows were identified by ear tag number or tattoo. Minimum age of fetus calculated from bull removal was withheld from the person estimating age of the fetus. All cows and calves were removed from the treatments in August 1980. Only cows which remained in their original treatment and raised a calf both years were considered.

Results and Discussion

Average initial weight of the cows as they entered the treatments in October 1978 was 1,084 pounds (Table 2). They lost an average of 20 percent of their October weight by February. This included losses due to calving. The cows reached their yearly low weight in February of 868 pounds with no difference noted between the treatments. By September they had regained all weight lost and averaged 1076 pounds. Therefore no effect of stocking rate could be seen on cow condition at the end of the first year. It should be noted that pasture condition was extremely good at the initiation of the trial.

The cows entered the winter calving season of 1979-80 averaging 1,176 pounds (Table 3). By Feb-

TABLE 2. COW WEIGHTS — 1979 (POUNDS)

	Stocking rate (ac/au)		
	12.6	10.5	8.5
October 1978	1072	1070	1089
February 1978	866	871	868
Average weight loss	206	219	222
Weight loss of Oct. wt., %	19.2	20.1	20.4
September 1979	1077	1057	1095

TABLE 3. COW WEIGHTS — 1980 (POUNDS)

	Stocking rate (ac/au)		
	12.6	10.5	8.5
November 1979	1188	1171	1168
February 1980	970	903	907
Average wt. loss	260	268	261
Weight loss of Nov. wt., %	21.9	22.9	22.4

ruary all treatments lost an average of 22 percent of the November weight. However, due to the declining conditions of the pastures and lack of rainfall, the cow weight continued to decline though April 1980. By August 1980 differences in weight with the 12.6, 10.5, and 8.5 ac/au treatments averaged 1024, 1011 and 988 pounds, respectively (Table 3).

A comparison of September 1979 cow weights with August 1980 cow weights by treatment showed a difference of 4.9, 4.3, and 9.7 percent weight loss for the 12.6, 10.5, and 8.5 ac/au treatments, respectively (Table 4). However, a calendar year comparison may not be valid because of different weaning dates between the 2 years. A comparison of cow weights at weaning in June 1979 with cow weights at weaning in August 1980 showed differences of −.3, +1.0, and −6.0 percent in the 12.6, 10.5, and 8.5 ac/au treatments, respectively.

Calf weaning weights are shown in Table 5. Comparison between years may not be valid because breed of bull differed and time of year at weaning differed. Nevertheless, 1979 weaning weights averaged 414 pounds with no differences between any of the stocking rates. Weaning weights in 1980 averaged 496, 461, and 440 pounds for the 12.6, 10.5 and 8.5 ac/au treatments which indicated the stocking rate was beginning to have effect on calf weaning weight.

Conception rate by palpation in August 1980 was 100 percent for both the 12.6 and 10.5 ac/au treatments and 76 percent for the 8.5 ac/au stocking rate (Table 6). Based on this information and other circumstances, the trial was terminated. Average age of fetus and range within a treatment are shown in Table 6. A range of 90 days is observed for the 8.5 ac/au treatment compared to a range of 55 and 40 days for the 12.6 and 10.5 ac/au treatment, respectively.

These results may be interpreted to mean that current rate of stocking (1) may be correct for this region of Texas if a sustained yield is to be realized. Heavier rates of stocking can be utilized over a short-term basis, but the decline in cow-calf performance with increasing stocking rate over the 2-year period indicates that exceeding the 12.5 ac/au rate may not be economically justifiable. Furthermore, long-term data from the ranch (2) indicate that economic risk dramatically increases at stocking rates near 12.0 ac/au compared to a more moderate rate of 14 ac/au.

TABLE 4. WEIGHT COMPARISON OF COWS ON A CALENDAR YEAR BASIS AND A CALF YEAR BASIS

	Stocking rate (ac/au)		
	12.6	10.5	8.5
Calendar year			
September 1979	1077	1057	1095
August 1980	1024	1011	988
Weight change, %	−4.9	−4.3	−9.7
Calf year			
June 1979	1027	1000	1051
August 1980	1024	1011	988
Weight change, %	− .3	+1.0	−6.0

TABLE 5. CALF WEANING WEIGHTS

	Stocking rate (ac/au)		
	12.6	10.5	8.5
June 1979			
Average weight (lb)	415	415	414
Calf production (lb/acre)	33.2	39.1	48.75
August 1980			
Average weight (lb)	496	461	440
Calf production (lb/acre)	39.6	43.5	51.7

TABLE 6. CONCEPTION RATE AND AGE OF FETUS

	Stocking rate (ac/au)		
	12.6	10.5	8.5
Conception rate, %	100	100	76
Average age of fetus	149	151	124
Range of age, minimum	110	120	75
maximum	165	160	165

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PR-3771

Effect of Different Stocking Rates and Grazing Systems on Cow-Calf Performance at the Texas Experimental Ranch

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Summary

The various grazing management studies under continued evaluation on the Texas Experimental Ranch showed that within any single year a heavier stocked system offered the greatest production potential. However, across years this may not be true. Pounds of calf produced per acre for the 1979-80 season were greatest for the heavy stocking treatment, with the moderate rate and the deferred-rotation grazing treatment averaging 5 pounds per acre (lb/ac) less. Pounds of calf produced per cow for the deferred rotation and moderately stocked treatment averaged 75 lb more than the heavily stocked treatment.

Introduction

Evaluation of various grazing management systems is feasible only over a long-term basis. Evaluation of three different grazing studies has been conducted on the Texas Experimental Ranch since 1960. The objective was to study the effect of various grazing treatments on cow-calf performance.

Experimental Procedure

The three different grazing treatments involved were a heavily stocked year-long grazing treatment [12.5 acres per animal unit (ac/au)], a moderately stocked year-long grazing treatment (16.5 ac/au) and a four-pasture, three-herd deferred rotation (14.5 ac/au). Hereford/Angus cows had been bred to Charolais bulls and were due to calve in December, January, and February 1980. A pre-supplementation and pre-calving weight was taken in November 1979. Cow and calf weights were taken in February, April, June, and at weaning in August 1980. There were two replications of 50 cows/herd in the heavily stocked treatment, two replications of 37 cows/herd in the moderately stocked treatment, and 24 cows/herd in the three herds of the deferred rotation. Both herds of heavy-grazing treatment received 2 lb/day of a 20-percent crude protein (CP) range cube, while only one herd of the moderate treatment was supplemented with 2 lb/day of the same cube. Two herds of the deferred rotation were supplemented with 2 lb/day of the 20 percent CP cube, while one herd was not supplemented. Cows were fed winter supplement for 90 days beginning in December.

Calves were paired, tagged, and branded, and bulls were castrated in late February. Calves were weaned in August 1980, and conception rate was determined by palpation.

Results and Discussion

Cow weight changes for the winter supplementation period are shown in Table 1. These weight changes include losses due to calving. On a percentage weight loss basis the deferred-rotation cows only lost 18 percent of the November weight as contrasted to a 22-percent weight loss for the other two treatments. It must be noted again that not all treatments were supplemented alike but evaluating the effects of grazing treatments is possible because at least one herd in each treatment was supplemented. This analysis used only these herds in each treatment that received supplementation.

TABLE 1. WINTER COW WEIGHT CHANGE, POUNDS

	Treatments		
Item	Heavy 12.5 ac/au	Moderate 16.5 ac/au	Deferred rotation 14.5 ac/au
November, 1979	1102	1163	1134
February, 1980	846	902	926
Weight loss, %	23	22	18

The effect of supplement is shown in Table 2. No beneficial effect to supplementation for the 90-day winter feeding period of 1979-80 was noted. Cow weight change for the remaining period reveals that the cows continued to lose weight through the April weighing period (Table 3). This was due to a lack of rainfall for adequate forage production. An average weight of 1203 lb for the deferred rotation and a 972-lb average for the other two treatments at weaning in August was observed. Similar results are reported in an 18 year summary of the ranch's systems (1). Conception rate, as determined by palpation in August, averaged 96 percent for all grazing treatments.

It was observed that the ranking of treatments by calf weights remained the same at all weighing periods (Table 4). At weaning in August an average of 578, 562 and 528 lb for the deferred rotation, moderately and heavily stocked treatments, respectively, was observed.

Evaluation of treatment production as pounds of calf produced per cow, yields averages of 433, 507 and 508 lb for the heavy, moderate and deferred rotation treatments, respectively. Evaluations of the treatments using pounds of calf per acre as the criterion shows 37, 31 and 33 lb for the heavy, moderate

TABLE 2. EFFECT OF SUPPLEMENTATION ON COW WEIGHT, POUNDS

	Treatments			
	Moderate 16.5 ac/au		Deferred Rotation 14.5 ac/au	
Item	0 Supp.	2#/day Supplement	0 Supp.	2#/day Supplement
November, 1979	1138	1187	1146	1128
February, 1980	866	939	944	917
Weight loss, %	24	21	18	19

TABLE 3. COW WEIGHT CHANGE FROM APRIL TO AUGUST, POUNDS

	Treatments		
Item	Heavy 12.5 ac/au	Moderate 16.5 ac/au	Deferred rotation 14.5 ac/au
April	791	880	1083
June	862	995	1224
August	960	983	1203

TABLE 4. CALF WEIGHTS, POUNDS

	Treatments		
Item	Heavy 12.5 ac/au	Moderate 16.5 ac/au	Deferred rotation 14.5 ac/au
April	241	263	274
June	421	444	454
August	528	562	578

and deferred rotation treatments, respectively. These production estimates by treatment are very similar to those in an 18-year summary of the various grazing management studies on the Ranch. However caution must be exercised noting that over the years variation of production increases greatly as one approaches the heavier stocking rate (1). In any one year the heavier stocked pasture may provide the greatest production but over a period of years, variation and risk in production increases as one approaches the heavier stocking rates. This is due to the variation in forage production based on different climatic conditions from year to year.

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PR-3772

Evaluation of Effect of Winter Hay Feeding Practices and Calving Season on East Texas Herds

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Summary

The effects of two management practices, amount of hay feeding and calving season, on productivity were predicted for East Texas cow-calf herds. The Texas A&M University Cattle Production Systems Model was used to simulate a self-contained farm where all hay fed in the winter was farm-harvested and all sales were weaning calves and cull cows. Forage and cattle data from the Research and Extension Center at Overton were used to establish base production levels. Forage production was assumed to be that produced on well-fertilized, intensively managed Coastal Bermudagrass pastures and hay fields. Cattle were assumed to be Hereford-Brahman crossbred types. The effects of winter hay feeding from November 15 through April 15 fed at unlimited *(ad libitum)*, 80 percent, 60 percent and 40 percent *ad lib.* levels were simulated for fall-calving and spring-calving herds.

Overall herd productivity for a given acreage increased as level of winter feeding increased. Higher levels of hay feeding resulted in fewer cattle per acre but higher production per breeding cow. Herd size increased 2.9 percent, 11.9 percent and 32.5 percent as winter hay levels were reduced from *ad lib.* to 80 percent, 60 percent, and 40 percent of *ad lib.*, respectively, under spring-calving management. Herd productivity , measured as total liveweight sold per herd, declined 2.2 percent, 9.4 percent and 10.3 percent for the same respective feed levels. Spring-calving herds produced 3.2 percent more calves than fall-calving herds but fall-calving herds produced an average of 3.6 percent more liveweight sales because calves were carried to heavier weights. The relatively well-fed herds had fewer cows, more and heavier calves, and were more profitable.

Introduction

A cattle producer is faced with many management practice alternatives that affect production efficiency, but may find it often difficult to accurately predict the effect of implementing a specific practice on productivity and profit. Time and cost of experimentally testing all possible practices for all areas are prohibitive. Also, accurate evaluation requires that not only each separate practice, such as level of winter hay feeding, be tested but that each combination, such as level of hay feeding for spring calving and for fall calving, must be tested. Further, the effect of one combination of practices versus another can be adequately evaluated only if all of the inputs and outputs of the entire production system, including costs and sales of cull cows and replacements as well as calves, are included. The use of a simulation model permits relatively inexpensive examination of different treatments in a short time. To be effective, simulations must be based on sound experimental data and be validated against production parameters taken from actual animals in an environment similar to that simulated.

The objective of this research was to evaluate the relative production efficiencies of feeding several different levels of hay during the winter and of fall and spring calving for the Northeast area of Texas. Data collected at the Research and Extension Center and Overton were utilized as the base for evaluating these practices by use of simulation or systems analysis techniques.

Experimental Procedure

The Texas A&M University Cattle Production Systems Model, developed for simulating cattle production in a wide variety of environments, was utilized for the systems analyses (3,4). Growth and reproduction parameters simulated for classes of animals are calculated monthly based on animal nutritive requirements and total digestible nutrients (TDN) available. Animal requirements are determined by current age, reproduction and lactation status, and weight and body condition. These current requirements are considered in a background of genetic potentials for growth rate, maturing rate, mature weight, and milk production of the breedtype being simulated. Nutrient intake of each animal is determined by its requirements and quantity and quality of feed available. The model calculates, on a monthly basis, nutrient consumption, weights, reproductive status, body condition, and dynamics such as births, deaths, and sales. The result is a simulated reaction of all individuals in a herd to a specific nutritional (CP and TDN) and management environment.

Production conditions for this study were those of Northeast Texas, an area where beef cattle are the major source of agricultural income and production systems are based on forages. Forage and cattle performance data were collected for the area at the Overton Research and Extension Center (2). Forage production was based on intensively managed Coastal Bermudagrass pastures and hay fields similar to those prevalent in the area. Yields, total digestible nutrients (TDN), and crude protein (CP) are given in Table 1. Crude protein was never estimated to be below 8.3 percent on this well-managed, heavily fertilized forage, therefore protein level independent of TDN was not considered to be a limiting factor in animal performance; that is, TDN was limiting before CP. Annual fertilization rates were 200 pounds nitrogen, 100 lb phosphorus, and 100 lb potassium per acre. Animal performance data that coincided with the plant data were based on Brahman-Hereford type cattle. The average weight of dry, open mature cows consisting of 25 percent body fat was estimated as 1,058 pounds. This same type mature cow on an adequate diet was estimated to have a potential lactation peak of 22 pounds per day. Forage and animal data used in this analysis were based on stocking rates of approximately 1.7 breeding cows per acre per 12-month period established at the Overton Center.

In order to simplify the comparisons, management practices were set to be constant across all simulations. The entire herd grazed from April 15 through November 15 and was fed hay from November 16 through April 14 without grazing available. Hay fed during the winter period was that harvested during May, June, July and August of the previous grazing period. Hay was harvested from reserved hay fields and as excess from grazed pastures. Hay qualilty was based on forage quality during the four harvest months and then discounted 10 percent for storage loss. The net TDN value was approximately 50 percent.

Heifers were bred to calve first at 2 years of age and were kept to a maximum age of 11 years. Any cow going 2 consecutive years without a calf was culled. About 2 percent of each age class of cows was culled each year to account for injury or disease problems. Bulls were not considered either for nutritional consumption or cull weight.

In the baseline run, all animals were fed unlimited hay *(ad lib.)* throughout the winter period. Subsequent simulations were run with 80 percent, 60 percent and 40 percent of the *ad lib* consumption.

In the spring-calving option, calves were born from January 15 through April 15 and weaned at 7 months of age in August, September and October. In the fall-calving option, for which a separate baseline was established, calves were born from September 15 through November 15. Calves born in the first 2 months of the calving season were weaned on June 15 at 8 and 9 months of age, respectively; and the calves born later were weaned on July 15 at 8 months of age. In each simulation, all steers and excess heifers were sold at weaning.

TABLE 1. FORAGE GROWTH, TOTAL DIGESTIBLE NUTRIENTS (TDN) AND CRUDE PROTEIN (CP) FOR COASTAL BERMUDAGRASS AT OVERTON[a]

Month	Forage growth, lb/ha	CP,%	TDN, %
Jan, Feb, Mar	---	---	---
April	6046	24	72
May	10644	16	64
June	11197	12	55
July	10780	11	53
August	9859	13	54
September	7561	15	57
October	4209	13	55
Nov, Dec	---	---	---
TOTAL	60,296		

[a]Month represents the period from the 15th of the month until the 14th of the next month; values are on a dry matter basis.

Results

Under the stocking rates, available forage dry matter and nutritive value assumed in these simulations, cows fed higher levels of winter hay were heavier at the onset of lactation and lost less weight during the lactation period than cows fed hay at levels less than *ad lib.* Simulated fertility decreased from about 90 percent pregnancy rate for the *ad lib.* hay feeding to about 60 percent for the 40 percent *ad lib.* hay feeding. Fertility did not decrease as much when the winter hay was reduced to 80 percent of *ad lib.* as it did when hay levels were reduced from 80 percent to 60 percent or from 60 percent to 40 percent of *ad lib.* (Figure 1). Spring-calving herds had higher overall fertility levels than fall-calving herds except when winter hay was limited to 40 percent of the *ad lib.* level. For the spring-calving herds, the last 60 days of the breeding season occurred when the forage was most plentiful and highest in quality. However, at the 40 percent level, spring-calving cows were not able to gain enough during the spring period to reach the weight at which their fall-calving counterparts entered the breeding season.

Weaning weights were also affected by winter feed level (Figure 2); weaning weights decreased at an increasing rate as winter feed level became more limited. The most dramatic decrease was in fall born calves which were suckled through the winter feeding period.

An important effect of lower levels of hay feeding and the resulting reduced fertility was the increase in percentage of heifers required for replacements. The number of heifers available was reduced and more cows were culled for infertility since any cow missing two consecutive calvings was culled; therefore a larger proportion of heifers was required to replace them.

Cow productivity, measured as liveweight sold per year, followed the same pattern as that of cow fertility (Figure 1). At all winter feed levels, fall-calving cows were more productive individually than

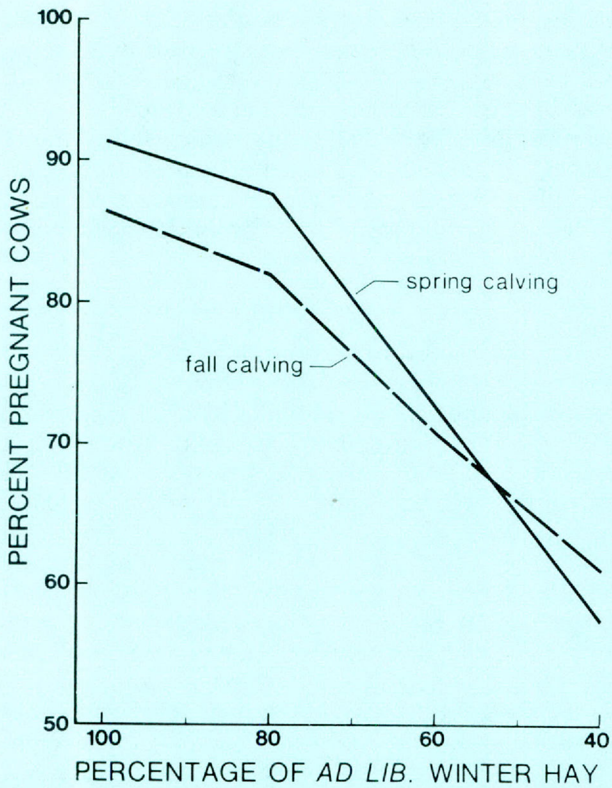

Figure 1. Overall percent cows pregnant of cows exposed for spring- and fall-calving herds fed four levels of winter hay.

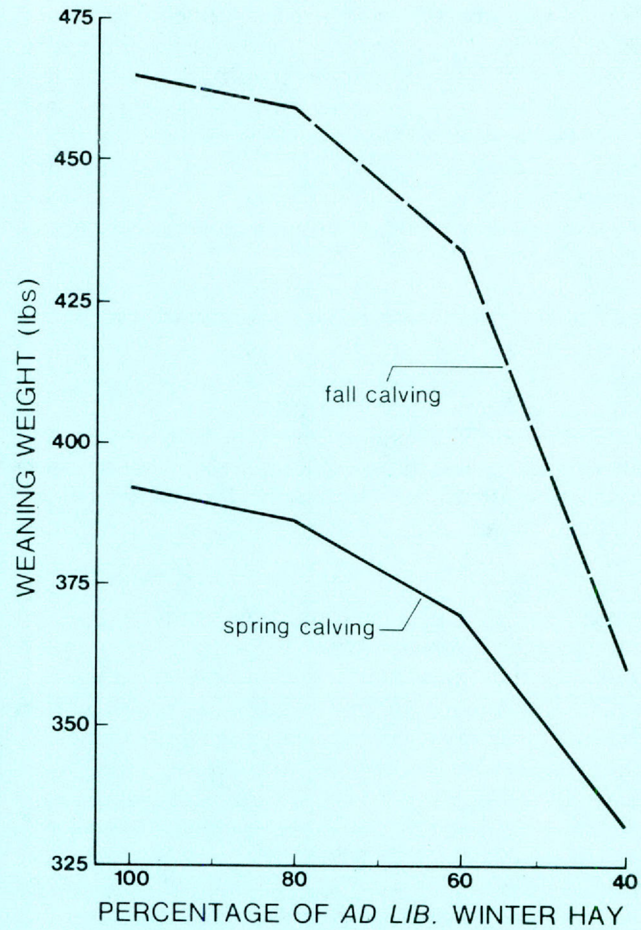

Figure 2. Mean heifer weaning weights for spring- and fall-calving herds fed four levels of winter hay.

spring-calving cows because of the older ages at weaning of the fall-born calves.

Herd productivity is a function of individual cow productivity and total number of producing cows. In this systems analysis, all hay fed during winter was assumed to have been harvested on the same farm during the previous spring and summer. Thus, as level of winter feeding increased, the amount of land required to be set aside for hay production increased and a smaller proportion of farmland was available for grazing. Within spring- or fall-calving herds, cow numbers increased as winter feed level decreased. Equal grazing pressure was maintained for all simulations.

The relatively well-fed herds, although fewer in number of breeding cows (Table 2), weaned more and heavier calves and required fewer replacements.

TABLE 2. HERD PRODUCTION OF A 248-ACRE FARM FOR EACH MANAGEMENT PRACTICE

	Spring-calving hay feeding levels,[a] %				Fall-calving hay feeding levels,[a] %			
Item	100	80	60	40	100	80	60	40
Land use,[b,c]								
grazed, acre	158	162	178	199	173	178	198	214
hay only, acre	65	60	44	24	50	44	24	8
No. breeding cows	360	371	403	477	347	359	393	462
No. calves weaned	268	265	245	206	236	233	225	225
No. replacements	56	58	65	88	63	65	73	90
No. calves sold	212	207	180	118	173	168	151	135
Livewt sales								
lb/breeding cow	389	369	314	263	417	394	343	275
lb/acre	364	353	296	179	360	346	296	214
Cow sales, lb	49531	49403	53222	81201	55595	55745	61123	73863
Total sales, lb	139916	136849	126721	125506	144780	141482	134631	126911

[a]Hay feeding is percentage of *ad lib* intake.

[b]Assumes 24-25 acres used for roads, pens, and otherwise produce no forage.

[c]Bulls were not considered either for grazing acreage, hay consumption or sales.

Herd productivity, measured as liveweight sales either per acre or per cow was greater for the higher levels of winter feeding; if hay feeding was at a higher level, fall calving was more efficient than spring calving. Also, as winter feeding levels declined, the proportion of the total liveweight made up of steers and heifers available for sale declined; as the proportion of sales made up of culled cows increased the average price per pound decreased.

A thorough economic analysis was conducted for each of the production systems employing different practices (1). The time period from which production costs and sale prices were taken included 1958 through 1977; all budgets were adjusted for inflation to 1977 levels. The higher levels of hay feeding and fall calving were more profitable as well or more productive. Herd production and profit decreased relatively small amounts as hay feeding was reduced from *ad lib.* to 80 percent *ad lib.*, suggesting that there is a range of near optimal feeding levels. It should be noted that this systems analysis study simplified some practices in order to make comparisons simpler. One was that only hay was considered to be consumed (no grazing or browsing) during the winter. The hay was only about 50 percent TDN which is not a high quality but is probably fairly representative for Coastal bermudagrass hay in the East Texas area.

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PR-3773

Cow-Calf Management Alternatives for the Texas Coastal Prairie

M. M. KOTHMANN AND G. M. SMITH

Summary

Data obtained over a 6-year period from a cooperating ranch were combined with simulation of animal production to study alternative management practices for cow-calf operations in the Coastal Prairie of Texas. Management practices evaluated with the model included different calving seasons, different weaning dates, different kinds and levels of winter supplement, and different levels of nutrition for replacement heifers. Winter calving increased death losses of calves compared to fall and spring at the base nutritional level. Fall calving increased weaning weights, whereas spring calving increased the percent calf crop. Fall calving with improved nutrition resulted in the highest production but also the highest feed expenditures.

Introduction

Range cattle production in the Coastal Prairie of Texas is characterized by high potential, but also by many difficulties. High rainfall and a long growing season result in high potential forage production, but environmental and nutritional stresses on cattle are great during winter months. Problems facing cow-calf producers include low calf crop percentages, high death losses of young calves during winter, severe weight losses by cows during winter, and low levels of digestible energy in the forage. Management practices such as dates of calving and weaning and kinds and amounts of supplements all have significant impact on the productivity of a ranch. However, it is impossible to evaluate all possible management combinations in a field research program. Simulation is a tool which makes possible the evaluation of many combinations of management practices. In order to use the TAMU Beef Cattle Production Systems Model, data on forage production and quality and on the genetic potential of a cow herd are required.

Experimental Procedure

Study Area

Livestock and forage data for the simulations were obtained from a cooperating ranch in northern Calhoun County. The average frost-free period was from mid-February to mid-December, and the average annual rainfall was about 45 inches. Native vegetation was typical of tall grass prairie but had been invaded by Macartney rose *(Rosa bracteata)*. Little bluestem *(Schizachyrium scoparium)* was the dominant grass species with yellow indiangrass *(Sorghastrum nutans)* and various species of paspalum *(Pasapalum* spp*)* as subdominants (1).

Elevation is about 20 feet above sea level and drainage is slow. Soils are heavy dark clays of the Lake Charles and Victoria series. Following heavy rains, water stands on much of the surface of the soil for several days. During January and early February there is often standing water on much of this ranch.

The ranch was operated as a cow-calf operation with calves sold or moved to other locations at weaning. The cow herd of approximately 2,000 grade Santa Gertrudis was rotated between rangeland and Coastal bermudagrass but generally spent the entire period from November to April on rangeland. Yearling replacement heifers were grazed on oat pasture from November to April, but the stocking rate has been set at levels which restrict forage availability to the point that it limits intake of the heifers. The primary winter supplement was Coastal bermudagrass hay which averaged about 6 percent crude protein (CP) and 45 percent digestible organic matter. Mineral blocks containing 12 percent P and 12 percent Ca plus trace minerals were provided free choice throughout the year.

Cattle Model

A computer model that simulates beef cattle production systems has been developed at Texas A&M University (3,4). This model is designed to allow solution of problems such as the type of cattle and management practices that can best utilize a given feed resource. The model does not assume some level of animal performance and calculate the feed required to meet this assumed performance; but rather, growth rates, condition, milk production, fertility, and deaths are simulated from the genetic potential of the cattle interacting with the quality and availability of feed resources. The model allows simulation of cattle of any breedtype for size, maturing pattern, and milk production potential in production systems varying in time and length of calving season, culling and selling policies, supplemental feeding, and forage quality and availability. In other words, the model attempts to predict what would happen if a herd of cattle were placed on a ranch under real management practices.

Forage Parameters

Nutrition programs have been simulated at two levels designated as base and improved. Base nutrition for weaned replacements consisted of range forage from weaning through October, then oat pasture from November through March, shifting to range forage in April. The oat pasture was not fertilized and was heavily stocked so that forage availability was the primary factor limiting gains. The improved nutrition consisted of increased availability of oat pasture with CP and digestibility unchanged. Improved nutrition for weaned replacements also included grazing on well-managed tame pasture from weaning through October.

On the base nutritional level, Coastal bermudagrass hay was fed during January and February to the 2-year-old replacements at the rate of 8.8 pounds per head per day with range forage providing the total diet for the remaining montns. Improved feeding of 2-year-olds consisted of increasing the level of Coastal bermudagrass hay from 8.8 to 13.2 lb/hd/day in January and February and increasing the availability of range forage to the same levels allowed for the cows on base nutrition.

Base nutrition for the cows (3 to 10 years of age) consisted of Coastal bermudagrass hay fed at the rate of 13.2 lb/head/day in January and February with grazed forage for the remainder of the year. Improved nutrition of cows consisted of feeding a sorghum hay for an additional month (January to March) at the same rate of 13.2 lb/hd/day. Digestibility of the sorghum hay was 60 percent and CP content was 10 percent. Under improved nutrition, urea-molasses was fed at the rate of 3.3 lb/hd/day to all fall-calving cows during October, November, and December and to winter-calving cows during December.

The values for availability, digestibility, and CP contents of forages were derived from published and unpublished research conducted on the ranch from 1974 to 1979 (1,2). Many of the forage values were based on clipped forage analyses with only limited data from samples collected by esophageally fistulated animals. The judgment and experience of the authors were used to extrapolate from clipped forage analyses to estimated values for consumed forage.

Cattle Parameters

Breedtype must be specified in terms of genetic potential for mature size, milk production, and maturing rate. The cattle parameters in the present study were chosen to represent a herd of grade Santa Gertrudis, but the results are directly applicable to other adapted breeds of similar size and milking ability. Mature weight of a cow in good condition was set at 1,100 pounds based on individual weights, and condition scores were taken on 200 cows in mid-April and again in mid-June, 1979. The mean weights and condition scores (scale of 1 to 9) were 820 pounds and 3.76 units in April and 968 pounds and 4.78 units in June. Milk production potential was set at 25.4 lb/day which is 15 percent higher than what has been used in previous simulations for the average of Hereford and Angus cows. This percentage increase is in line with preweaning growth rate differences of about 18 percent for Santa Gertrudis versus the average of Hereford and Angus calves at the McGregor Research Center.

In addition to the above major specifications of breedtype, three other parameters were altered from those normally used for British breedtypes to better reflect the Zebu component. The fraction of mature size at which puberty could first occur was increased from 40 to 50 percent, and the upper limit for this fraction to affect puberty was increased from 60 to 70 percent. Also, slower preweaning and postweaning maturing rate was specified.

Cattle Management Alternatives

Alternatives available to a ranch manager to help synchronize herd feed requirements with feed availability and quality include selection of calving season, weaning age, and heifer development rate. These factors interact with environmental effects, seasonal price fluctuations, and supplemental feeding practices. The cooperating ranch in this study was calving from December through March and weaning in late September or early October. Heifers were developed to calve first at 3 years of age and only limited culling of cows was practiced. Alternatives that were evaluated included winter, spring, fall, and split (spring and fall) calving seasons at both base and improved nutrition.

Results and Discussion

The percentage of cows becoming pregnant was affected more by the changing nutrition than by changing the time of calving and weaning (Figure 1). The percentage of cows pregnant with spring calving and split calving was greater than for fall or winter calving. It should be noted that fall calving was limited to a 3-month period while winter and spring calving had 4-month periods. Split calving consists of two 3-month periods with cows allowed to shift from one season to the other. In addition, spring calving cows nurse for 2 months less than fall and winter calving cows. The highest pregnancy rate was 83 percent for split calving under improved nutrition. No interaction between level of nutrition and calving season was apparent for pregnancy rate.

Level of nutrition interacted strongly with calving season with respect to calf mortality (Figure 2). Calf mortality was much greater under the base nutrition with winter calving than under any other management alternative. This high mortality rate was reduced by improving nutrition or by changing the calving season. The highest mortality rates always resulted from over-wintering young calves. There appears to be little opportunity for additional reduction of death losses by further improvement in nutrition. This information has great practical significance for ranchers in this region.

The number of calves sold per 1,000 cows was lowest for winter calving and highest for spring and split calving (Figure 3). Improved nutrition had a significant effect on calves sold from all management systems with winter calving having the greatest effect. The differences among calving and weaning alternatives were greater under base nutrition than under improved nutrition.

Level of nutrition affects weaning weights differently depending on the season of calving (Figure 4).

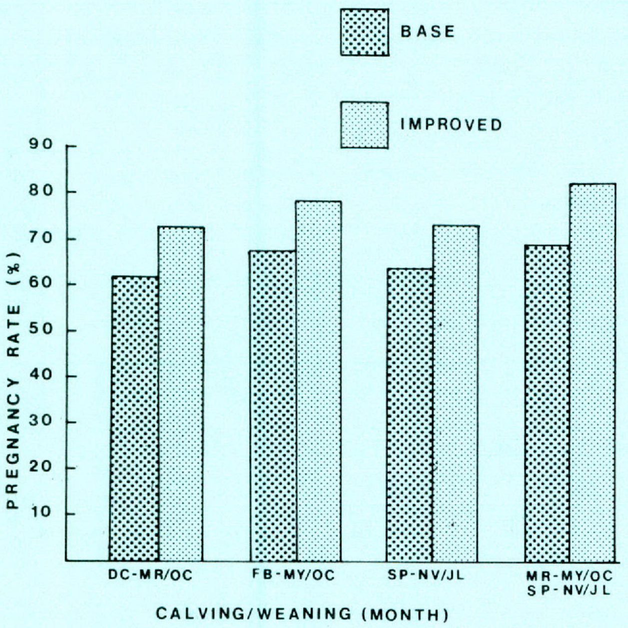

Figure 1. Pregnancy rate of cows exposed.

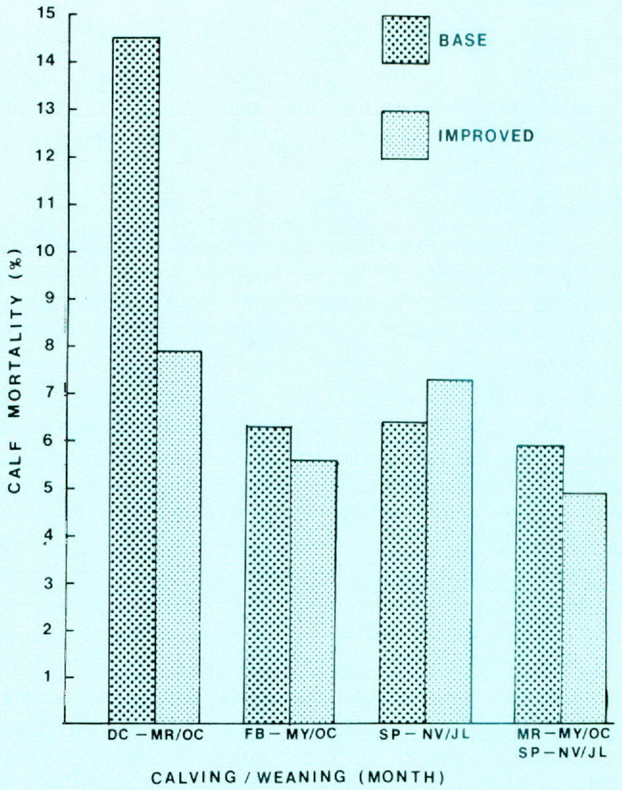

Figure 2. Calf mortality at birth and up to weaning.

The younger spring-born calves are lightest under both base and improved nutrition, and they exhibit the least spread between levels of nutrition. Fall and winter calves had comparable weaning weights on base nutrition, but with improved nutrition fall calves were heavier than winter calves. Spring calves had little opportunity to utilize the higher quality forage available during spring, whereas fall and winter calves were old enough to utilize this forage. Fall calves received the greatest benefit from improved winter nutrition because of the increased milk production of their dams.

A combined measure of production from the different management alternatives is the weight of calves and weight of cull cows sold per cow (including replacements) in the herd. The weight of cull cows sold varied little among management practices (Figure 5). However, weight of calf sold per cow differs markedly among treatments. Winter calving with base nutrition was lowest, and fall calving with improved nutrition was highest. Changing calving from winter to fall under base nutrition increased calf sold per cow by 31 pounds: under improved nutrition, the increase was 42 pounds. Improved nutrition had a greater effect on calf production than did calving season. The response to improved nutrition varied from 97 pounds under fall calving to 53 pounds under spring calving with winter and split calving being intermediate.

Based upon the simulations reported here, dif-

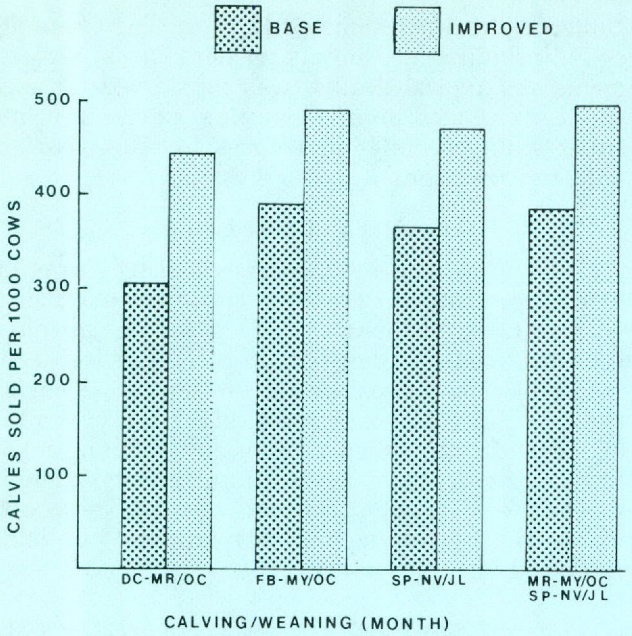

Figure 3. Number of calves sold per 1,000 cows in herd.

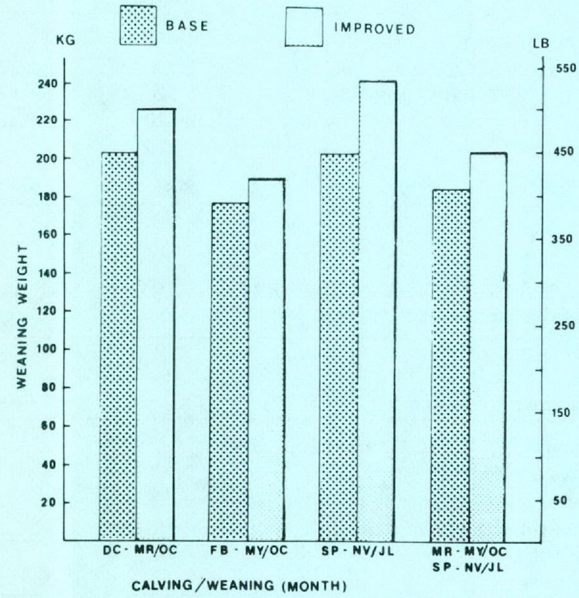

Figure 4. Average weaning weights of calves.

ferent management strategies may be formulated. For a rancher desiring the lowest cash input with a maximum number of calves produced, spring calving or split calving may be most effective; however, weaning weights would be reduced. High levels of supplements were simulated to have less effect on these management alternatives because weaning weights of spring calves showed little response to improved nutrition. For a rancher desiring to increase production, fall calving appears to offer the best opportunity, primarily because of the expected increased weaning weight of fall calves with improved nutrition.

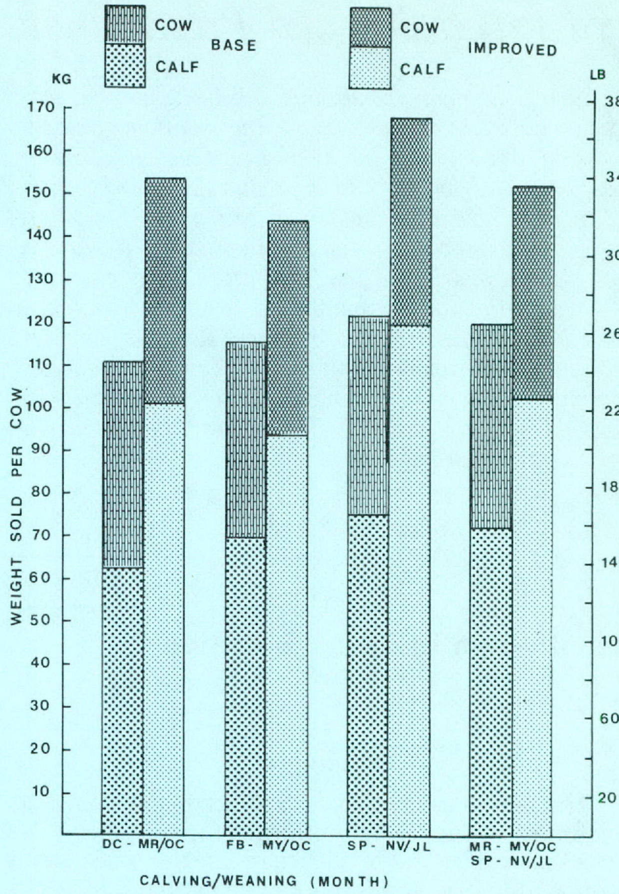

Figure 5. Weight of calves and cull cows sold per cow in herd.

However, a fall calving program will require greater expenditures for feed.

Full interpretation of these data requires that economic aspects of the practices be considered. Simulations have been run for 65 different management alternatives. Results of this more extensive study and economic analysis of all the treatments will be reported in subsequent publications.

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Feed Processing and Preservation

Current economic conditions and fuel shortages have forced producers to rethink many of the traditional feedstuff processing, preservation and distribution systems. Concentrates, harvested forages and byproduct feeds each contribute to the efficient production of beef and, in most instances, some processing and/or preservation is required before they are distributed and fed to cattle. Feed processing and preservation are accomplished to enhance nutrient availability in a cost effective manner. Renewed emphasis has been placed upon this need by Texas Agricultural Experiment Station scientists with the sorghum plant serving as the primary feedstuff. Their most recent contributions are presented here.

PR-3774

Use of Grain in Beef Production

L. M. SCHAKE

Summary

The fact that a typical U.S. feedlot steer or heifer consumes about 2,000 pounds of grain has often provoked unfavorable criticism of the U.S. cattle feeding industry, implying excessive use and inefficient production. In this study, compared to swine and broiler, beef production was intermediate in converting grain to tissue. One pound of edible carcass broiler, beef or pork required 2.44, 5.39 or 6.60 pounds of grain, respectively, when the entire production cycle was considered. Alternative systems of producing beef with less grain are possible but may not result in improved efficiency of production within current economic and industrial conditions.

Introduction

Efficient conversion of feed nutrients into beef tissues has continued as an ultimate goal of research nutritionists for well over a century. Tremendous progress has been achieved through nutrition, reproduction, genetics and other disciplines allowing typical U.S. consumers ample quantities of quality beef while spending only 2.4 percent of their disposable income (6). Most countries envy both the magnitude and efficiency of the U.S. beef industry; however, the practice of feeding concentrates to cattle has been criticized as wasteful, and the redistribution of world grain supplies for alleviation of human hunger has been strongly advocated. Within this context, animal scientists conducted research to document the relative efficiency of concentrate utilization within the U.S. livestock and poultry industries.

Experimental Procedure

Total feed intake required to sustain typical cattle, broiler and swine production systems in the United States was estimated (2, 3, 4). The entire life cycle, including feed inputs for herd (flock) replacements and typical deaths, was considered for each specie. Total feed inputs were then categorized into either grain or nongrain sources to reflect current industry conditions.

Results and Discussion

Of the total feedstuffs consumed by calves intended for slaughter (Table 1) approximately half is grain, 90 percent of which is fed during finishing. Feedstuffs consumed by parents of a calf as well as by herd replacements required to sustain the system are presented in Tables 2, 3 and 4. Eighty-six percent of all feedstuffs consumed were of nongrain origin (extensive grazing, hays, silages, supplements) while 14 percent were of grain origin (Table 5). These estimates have been independently supported by other reports (1,5).

TABLE 1. FEEDSTUFF DRY MATTER CONSUMED BY CALF FROM BIRTH TO SLAUGHTER

	Pounds of feedstuff	
Component of system	Nongrain	Grain
Nursing (245 days - 450 lbs.)	1,050	0
Postweaning (150 days - 600 lbs.)	1,950	150
Finishing (150 days - 1,000 lbs.)	1,320	1,980
Subtotals	4,320	2,130
Death loss (4%)	173	85
Totals	4,493	2,215

TABLE 2. FEEDSTUFF DRY MATTER CONSUMED BY SIRE AND DAM (PER CALF PER YEAR)

	Pounds of feedstuff	
Component of system	Nongrain	Grain
Dam of calf (245-day lactation and 120 days as dry cow)	7,000	150
Nonproductive cows (10%)	700	15
Sire of calf (1/25 of sire intake)	401	8
Subtotals	8,101	173
Death loss (1%)	81	2
Totals	8,182	175

TABLE 3. FEEDSTUFF DRY MATTER CONSUMED BY REPLACEMENT COW[a]

	Pounds of feedstuff	
Component of system	Nongrain	Grain
Heifer calf (450 lbs. - 245 days)	1,050	0
Calf postweaning (450-600 lbs. - 120 days)	1,680	150
Breeding (600-900 lbs. - 1 year)	6,470	100
Subtotals	9,200	250
Death loss (2% for 2 years)	184	5
Totals	9,384	255

[a]Only 15% of these total feedstuffs were assumed per calf per year, or 1,408 lbs. of nongrain and 38 lbs. of grain.

TABLE 4. FEEDSTUFF DRY MATTER CONSUMED BY REPLACEMENT BULL[a]

Component of system	Pounds of feedstuff	
	Nongrain	Grain
Bull calf (450 lbs. - 245 days)	1,050	0
Calf postweaning (450-800 lbs. - 1 year)	9,700	155
Breeding (800-1,300 lbs. - 1 year)	9,025	100
Subtotals	19,755	255
Death loss (2% for 2½ years)	395	5
Totals	20,170	260

[a]Only 15 % of these total feedstuffs was assumed per herd per year; each herd containing 25 calves results in 121 pounds of nongrain and 1.6 pounds of grain per year.

TABLE 5. FEEDSTUFF DRY MATTER CONSUMED TO PRODUCE BEEF

Component of system	Pounds of feedstuff	
	Nongrain	Grain
Sire and dam of calf[a]	8,182	175
Calf from birth to slaughter[b]	4,034	1,973
Replacement cow[c]	1,408	38
Replacement bull[c]	121	2
Totals	13,745	2,188
Percent	(86)	(14)

[a]Assumes a 245-day lactation and 120 days as a dry cow with 10 percent nonproductive cows. Sire assumed to have sired 25 calves per year. A 1-percent death loss per year for both cows and bulls.

[b]Assumes 65 percent steers and 35 percent heifers. Steers weaned at 245 days (450 pounds), grazed for 150 days (1 pound ADG), and fed to 1,000 pounds in 150 days. Heifers weaned at 245 days (450 pounds), grazed for 100 days (1 pound ADG), and fed to 850 pounds in 130 days. A 4-percent death loss for both steers and heifers from birth until slaughtered. Average grain content of the feedlot ration estimated at 60 percent.

[c]Annual replacement rates of 15 percent and a 1-percent annual death loss assumed for both cows and bulls.

Relative conversions of grain to animal tissue (Table 6) rank swine as least efficient, broiler as most efficient, and beef intermediate. Less grain could be used in the production of beef but relative values of pork, broiler and beef at the consumer level must also be considered. Swine and broiler production systems essentially lack this alternative. Additionally they must derive most of their feed protein from preformed sources (14 and 35 percent of rations composed of protein meals for swine and broilers, respectively), while cattle utilize various nonprotein nitrogen sources.

Many areas of the world produce beef with less grain inputs than the U.S. system and clearly the same can be accomplished in this country. However, since most grain is fed to cattle in feedlots immediately prior to slaughter, other inherent efficiencies in the U.S. system emerge. Data in Table 7 illustrate the consequences of slaughtering calves at lighter weights upon total conversion of feed energy to empty body weight. When calves are slaughtered prior to their biological optimum weight the efficiency of the production system suffers. Another alternative would be to develop cattle to their optimum slaughter

TABLE 6. COMPARISONS OF GRAIN TO MEAT CONVERSION FOR BEEF, BROILER AND SWINE PRODUCTION SYSTEMS[a,b]

Basis of comparison[c]	Pounds of grain to produce 1 pound of		
	Broiler[d]	Beef	Pork[d]
Edible carcass tissue	2.44	5.39	6.60
Carcass weight	1.83	3.79	4.60

[a]These values do not consider the meat contributed by salvage breeding stock.

[b]Total pounds of feedstuff input estimated for broilers and swine in the same manner as outlined for beef cattle.

[c]Liveweights and respective dressing percentage of each specie:

	Pounds	Percent
Broiler	4.25	73.0
Swine	200	70.0
Steers	1,000	61.5
Heifers	850	60.0

[d]Swine rations require 14 percent soybean meal or cottonseed meal and broiler rations require 35 percent soybean meal in addition to their grain intake.

TABLE 7. GROSS EFFICIENCY OF BEEF PRODUCTION WHEN CALF IS SLAUGHTERED AT VARIOUS WEIGHTS

Item	Slaughter weight, pounds		
	1,000	650	450
Dressing percent	61.2	56.0	52.0
Carcass weight, lbs.	612.0	364.0	234.0
Megcal. of total feed gross energy to produce one pound of empty body weight	23.3	28.8	58.4

weight without grains. When this system is applied cattle reach slaughter weights at advanced chronological ages which substantially increases the total maintenance cost to the system, increases seasonality of beef supplies, and reduces the cow-calf inventory and total beef supplies (assuming range resources are fixed). In general, this alternative is not compatible with the need for uniform utilization of fixed investments, especially for the slaughter, processing, distribution and marketing industries.

Obviously grain must be available in large quantities before it can be considered as feed for any specie. Feeding grain to cattle is biologically sound and economically viable for a large sector of the world's economy. Almost 80 percent of annual U.S. grain production is fed to livestock with swine consuming more than cattle (1). Therefore, the producer of grain relies upon the feeding industries to add value to his product in the free enterprise-open market system. In fact, U.S. farmers would not have emerged to their present grain production potential without this mutually supportive relationship. If other uses of grain such as direct consumption by humans, alcohol for fuel or grain exports have greater economic potential to investors, each would proportionally contribute to the value of grain by competing at the market place.

The production of beef with relatively low grain inputs (14 percent of total feed requirements) reflects the highly flexible nature of the ruminant. Feeding of grain to cattle should be based upon their relative biological efficiency, the value of beef products in the market place, and the cost and availability of feed grains within the free enterprise system.

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PR-3775

Energy Value of Forages in Grain Diets

F. M. Byers

Summary

A split phase system of feeding forage before feeding grain resulted in an 8.4-percent improvement in efficiency of feedstuff energy use when compared to a system of feeding a constant proportion of forage and grain daily throughout the total feeding period. This system could save the equivalent of ½ ton of corn silage per animal fed. Overall average daily gain was identical with either system. These data, in concert with other recent research (3), document the need to consider feeding system alternatives in scheduling the time and level of forage or grain feeding to realize the full potential of energy conversion from harvested forages (corn silage, sorghum silage) to beef.

Introduction

While it has long been an accepted practice to include forage in grain rations and *vice versa,* the question of whether or not the energy in these feedstuffs can be effectively digested and utilized when fed in combination is still controversial. Proponents of "single feed energy value" concepts suggest that feed interactions are minimal while a substantial volume of recent research from Colorado (4), Minnesota (5), Michigan (6), and Ohio (1, 2, 3), among others, documents results to the contrary. The data presented here indicate that feeding forages and grains in mixed rations results in less than optimal or expected energy utilization (Figure 1) and cattle performance.

When feeding forages, which inherently have less usable energy than grains, it is important to design feeding systems that maximize forage energy and feeding value.

Several problem areas limit this from happening in a steer feeding system. These include the effects of soluble carbohydrate (from grain) which reduces the rate of fiber digestion in the rumen, and also residence time of small forage particles in the rumen which consequently reduces starch digestion in the small intestine due in part to passage of undigested forage fiber. Feed intake can be reduced when long hay and similar forages are fed, as starch reduces the rate of digestion in the rumen. Rate of passage, rate of digestion, pH, and level of intake all have an impact on this problem. Forages with large amounts of structural carbohydrates with high potential extent but low rates of digestion are most susceptible to depression in digestion when rapidly fermentable carbohydrates are added. Increasing level of intake increases rate of passage and further restricts the extent of digestion achieved, especially with structural carbohydrates.

Obviously, this is more important for forages with larger amounts of fermentable fiber and low amounts of lignin. Forages containing very little fiber (high in solubles), fiber with fast rates of digestion, or large amounts of indigestible fiber suffer the least when grain is added. Consequently, good quality cereal grain forages (corn silage, sorghum silage) are feedstuffs susceptible to negative feed interaction effects which decrease the energy yield from the forage carbohydrates when grain is fed. Systems to circumvent these problems have to date met with only marginal, if any, success. A split-phase feeding program where mostly silage or forage is fed during the first phase of feeding and the total diet is switched to high grain during latter stages of finishing may offer the most potential.

Experimental Procedure

Fifty-six crossbred steers averaging 282 kilograms were allotted to seven groups, one for initial slaughter and six assigned to two treatments with three pens per treatment. The two feeding systems were as follows: a "constant" system involving feeding a 43 percent corn silage, 57 percent whole shelled corn and supplement ration from start until slaughter; and a two-phase system involving feeding only corn silage and a protein-mineral supplement for the first 70 days followed by a switch to a whole shelled corn and supplement diet with only a limited amount of silage. Carcass and empty body consumption and energy

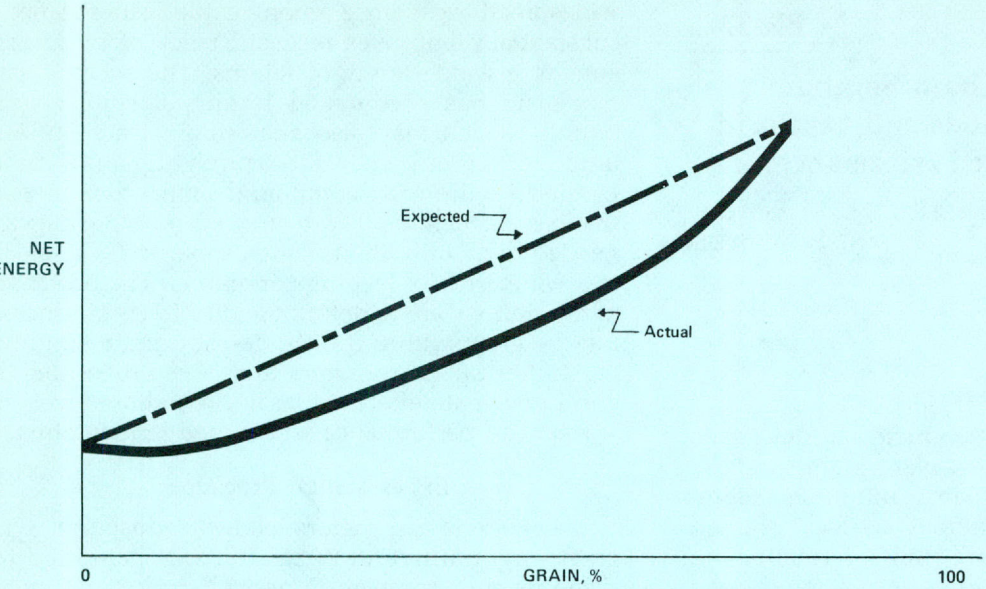

Figure 1. Energy value of mixed forage/grain diets.

were determined from carcass specific gravity measurements. Steers were fed until they were estimated to average 30 percent carcass fat.

Results and Discussion

Over the total study, diets for split-phase and constant systems averaged 54.9 and 57.1 percent grain, respectively (Table 1), indicating that the target of feeding similar proportions of silage and grain but at different times during the study was closely approximated. Rates of gain were similar for either feeding system. Feed efficiency favored the split-phase system by 3.0 percent even though a slightly lower (3 percentage units) level of grain was fed in this system over the total study. While energy retention (RE) was similar for either system, daily metabolizable energy (ME) intake was 3.0 percent higher for the constant system. As a result, the efficiency of energy storage was improved by 8.4 percent with the split-phase system as compared to the constant feeding system. These data indicate that the grain and silage fed were used more efficiently when fed during separate phases of feeding than when fed in a constant proportion throughout. With the 8.4-percent improvement in energy utilization, approximately ½ ton of corn silage or the equivalent in grain energy would be saved per animal fed by using the split forage-grain vs. the constant combination feeding system. These observations support the concept of separating forage and grain to the extent possible prior to feeding to maximize energy recovery from both feedstuffs.

TABLE 1. PERFORMANCE AND ENERGY UTILIZATION IN CATTLE FED SILAGE AND GRAIN IN SPLIT-PHASE OR CONSTANT FEEDING SYSTEMS

Item	Split-phase	Constant
Number of cattle	24	24
Initial weight, kg	281.9	281.6
Final weight, kg	542.5	540.7
Days on feed	218	216
Average daily gain, kg	1.20	1.20
Average percent grain fed	54.9	57.1
Dry matter intake per day, kg	8.10	8.36
Dry matter/gain	6.75	6.96
Metabolizable energy (ME), kcal/wt$^{.75}$/day	249	265
Retained energy (RE), kcal/wt$^{.75}$/day	58.7	59.7
Efficiency of ME use for gain, %	42.5	39.2
Improvement with split-phase, %	8.4	

Similar responses may be possible with grain sorghum. Methods for separating grain from forage in ensiled whole plant sorghum prior to feeding are currently under development to facilitate even greater utilization of the forage energy from sorghum in cattle feeding systems.

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PR-3776

Effect of Whole-Plant Grain Sorghum Silage Processing Methods and Lasalocid Sodium on Stocker Calf Performance

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Summary

Two experiments were conducted to determine the effects of processing whole-plant grain sorghum silage on stocker calf performance and *in vivo* digestibilities and to evaluate different lasalocid sodium levels on calf performance and rumen fermentation. Two silage treatments and three levels of lasalocid were compared in a growth trial. Dry matter intake and animal weight gains were greater for the whole-plant grain sorghum silage with whole grain than for grain sorghum silage with pre-ensiled rolled grain. No significant differences in rumen fermentation were found between silage treatments. Lasalocid sodium significantly depressed feed intake and improved feed efficiency at 33 parts per million (ppm). Lasalocid at 49 ppm did not improve feed conversion over that of control steers, but depressed ($P<.05$) daily gains. Lasalocid produced a shift in ruminal volatile fatty acid levels, reducing the acetate:propionate ratio. The apparent starch digestion of the post-ensiled rolled silage was greater ($P<.05$) than for the two other silage treatments. Apparent digestibility of dry matter, organic matter, crude protein, and acid detergent fiber were similar for all treatments.

Introduction

Previous research indicated that an acre of whole-plant grain sorghum harvested as silage increased liveweight gains of cattle by almost a third compared to harvesting and feeding only the grain. One problem in feeding whole-plant grain sorghum silage is the apparent indigestibility of much of the grain when fed in the whole form. This is thought to be due to a dense proteinaceous matrix in the peripheral endosperm layer of the sorghum kernel which renders starch granules inaccessible to ruminal digestion. Some attempts have been made to improve the digestibility of the grain within the silage by processing the grain before or after ensiling. Inconsistent results have been obtained, but processing the silage after ensiling has produced the most promising results.

Historically, the cattle feeding industry has utilized feed additives to improve weight gains and/or feed efficiency of cattle. Recently, a new compound, monensin sodium, was approved for feeding beef cattle. This new additive has found widespread acceptance among cattle feeders since it substantially improves feed efficiency of cattle consuming a wide variety of rations. The success with monensin has encouraged testing of similar compounds which may also alter ruminal activity and improve feed efficiency and/or weight gain of cattle. Lasalocid sodium is a compound similar to monensin that has reached the field-testing stage. More data are needed to identify the unique properties of lasalocid in a wide array of feeding conditions. The objectives of this study were to determine the effects of processing the grain within the whole-plant grain sorghum on stocker calf performance and *in vivo* digestibilities and to evaluate effects of lasalocid sodium levels on stocker calf performance and rumen fermentation.

Experimental Procedure

A commercial heteroyellow endosperm type grain sorghum hybrid,WAC 715, was harvested for silage using a combine (Massey-Ferguson 92) modified to harvest the whole plant and process the grain and stover separately. Sufficient quantities of whole-plant grain sorghum containing either whole or rolled grain were harvested and immediately ensiled in oxygen-limiting structures before being fed in growth and digestion trials.

Seventy-two crossbred Beefmaster steers were randomly allotted to twelve pens in a 2×3 factorial design with two replicates per treatment. Two silage treatments (whole grain and pre-ensiled rolled grain) and three levels of lasalocid sodium (0, 33 and 49 ppm) formed the six treatments studied in this growth trial. The rations consisted, on a dry matter basis, of 91.2 percent of each silage and 8.8 percent of a commercial protein supplement (34 percent crude protein) providing the three levels of lasalocid sodium.

The steers were given routine vaccinations, were wormed, had horns tipped, and were ear tagged and implanted with 36 milligrams (mg) of zeranol at the initiation of the trial. Steers were individually weighed at the beginning, at 28-day intervals, and at the end of the trial. Steers were fed once daily at a rate consistent with free choice consumption. Weight gains, feed intake, and dry matter content were used to calculate daily gains, dry matter intake, and feed conversion. Rumen fluid samples were collected from 50 percent of the steers by stomach tube approximately mid-way through the 100-day experiment to determine the effects of lasalocid and its possible interaction with the silage treatments upon volatile fatty acid concentrations in the rumen.

A digestion trial was conducted to determine *in vivo* nutrient digestibility of three whole-plant grain sorghum silage processing methods. The first two treatments were exactly the same as outlined in the growth trial. A third treatment consisted of rolling both the grain and the stover portions of the whole-plant sorghum silage containing whole grain after being ensiled (post-ensiled rolled silage).

The silages were mixed with a 34-percent protein-mineral supplement to form the three iso-nitrogenous rations. The rations consisted, on a dry matter basis, of 91.2 percent of one of the three silages and 8.8 percent of the protein supplement. These mixtures were fed to six crossbred Beefmaster steers following a switchback design. Digestibility coefficients were determined using the external marker ytterbium nitrate at a rate of 50 micrograms (μg) of pure ytterbium per gram (g) of dry matter consumed. The marker was uniformly added to the protein supplement and then blended with each silage. The trial consisted of three periods of 14 days, 8 days to adapt the steers to the new rations followed by 6-day fecal collection periods. Fecal samples were collected twice daily in duplicate. At the end of the trial composite fecal and feed samples were analyzed.

Results and Discussion

Silage Treatments

Since statistical analysis indicated no significant interactions between silage treatments and lasalocid sodium, each will be discussed separately. Dry matter intake was higher ($P<.05$) for the whole-grain silage treatment than for pre-ensiled rolled grain silage (Table 1). This difference coincides with a higher ($P<.05$) dry matter content of the whole grain presumably due to a somewhat later harvest date. These results are in agreement with most of the previous work (4,5,6), indicating that an increase in dry matter content of silages consistently increases dry matter consumption and animal performance. No significant difference in feed conversion was found between silage processing methods — a finding supported by previous work. A 4.34-percent difference ($P=.13$) in weight gains was obtained between treatments. However, most of the weight gain difference observed may be attributed to the difference in silage dry matter intake.

TABLE 1. EFFECT OF WHOLE-PLANT GRAIN SORGHUM SILAGE PROCESSING ON STOCKER CALF PERFORMANCE

Item	Silage treatments	
	Whole grain	Pre-ensiled rolled grain
Number of steers	36	36
Number of replicates	6	6
Steers per replicate	6	6
Average initial weight, kg	216.57	216.38
Average final weight, kg†	293.58	290.05
Daily feed intake, as fed, kg	15.41	15.66
Dry matter, %*	36.48	34.01
Daily dry matter intake, kg*	5.62	5.34
Average daily gain, gm†	770.10	736.71
Feed conversion	7.30	7.26

* = ($P<.05$).
† = ($P=.13$).

The effects of processing the grain within the silage upon ruminal fermentation is shown in Table 2. No significant differences were found in acetic, propionic, iso-butyric, iso-valeric, and valeric acid levels. Butyric acid was highest ($P<.05$) in the whole-grain treatment. A reason for this observation is not indicated by these data.

Lasalocid Sodium

Lasalocid sodium depressed ($P<.05$) feed dry matter intake over that of control steers (Table 3). Lasalocid reduced feed consumption by 12.2 percent at the 33-ppm level and by 17.3 percent at 49 ppm (Table 3). The greatest reduction in feed intake occurred during the first 28 days when the steers were introduced to the antibiotic. At that time feed intake was reduced by 29 percent and 19.2 percent for 49 and 33 ppm levels, respectively. These results are in agreement with most reports (1,2,3) in which feed intake has been reduced from the initial introduction of lasalocid. No statistical difference was observed in daily gains between the control and the 33 ppm treatment but both were higher ($P<.05$) than the 49 ppm treatment. This difference in daily gain may be attributed to the low dry matter intake observed for the 49-ppm treatment. Apparently lasalocid at the 49-ppm level depressed feed intake of steers sufficiently to offset any possible improvements in nutrient utilization.

TABLE 2. EFFECT OF WHOLE-PLANT GRAIN SORGHUM SILAGE PROCESSING ON RUMEN FERMENTATION PARAMETERS

Volatile fatty acid, %	Silage treatments	
	Whole grain	Pre-ensiled rolled grain
Acetic	66.05	67.92
Propionic	19.85	20.20
Butyric*	8.06	6.95
Acetic:propionic ratio	3.21:1	3.21:1
Iso-butyric	1.54	1.36
Iso-valeric	2.51	2.18
Valeric	2.00	1.67

* = ($P<.05$).

TABLE 3. EFFECT OF LASALOCID SODIUM LEVELS ON STOCKER CALF PERFORMANCE

Item	Lasalocid levels, ppm		
	0	33	49
Number of steers	24	24	24
Number of replicates	4	4	4
Steers per replicate	6	6	6
Average initial weight, kg	216.08	216.70	216.63
Average final weight, kg	296.48^{a}	293.70^{a}	285.25^{b}
Average feed intake, kg	6.08^{a}	5.34^{b}	5.02^{c}
Average daily gain, g	803.99^{a}	769.97^{a}	686.25^{b}
Feed conversion	7.58^{d}	6.95^{e}	7.32^{d,e}

^{a,b,c}Means of the same line with unlike superscripts are different ($P<.05$).
^{d,e}Means of the same line with unlike superscripts are different ($P<.10$).

Analysis of variance for feed efficiency showed a trend ($P = .16$) between treatments. Control steers were similar to the 49-ppm level but different ($P < .10$) from the 33-ppm level. No significant difference was obtained between 49-and 33-ppm treatments. The 8.3-percent improved feed efficiency for 33 ppm over control steers supports most of the previous findings (1,2,3) indicating improvements in feed conversion when lasalocid was added to cattle diets. From these data, 33 ppm of lasalocid seems to represent a near optimum for intake, weight gain, and feed conversion of steers.

Lasalocid sodium reduced ($P < .05$) the proportion of acetic acid and increased ($P < .05$) propionic acid in the rumen (Table 4). Butyric acid was similar for control and 49-ppm treatment but different ($P < .05$) at the 33 ppm. No significant difference in acetic, propionic, and butyric acids was observed between the 49-and 33-ppm treatments. These data are in agreement with earlier research (1,3). No significant differences were observed for other volatile fatty acids studied.

Digestibility Trial

No significant differences in dry matter, organic matter, crude protein, or acid detergent fiber digestibilities were observed between silage treatments (Table 5). Even though no statistical differences were found among treatments, there was a trend toward higher coefficients for post-ensiled rolled silage with a 4.3-percentage unit improvement in organic matter digestibility, 3.9 percent improvement in dry matter digestibility, and 3.0 percent in crude protein digestibility over the other treatments. Starch digestibility was higher ($P < .05$) for the post-ensiled rolled silage than for the other treatments. No significant differences were observed for any nutrient digestibility between the whole-grain and the pre-ensiled rolled grain treatments; this result supports the absence of growth responses to silage processing in the growth trial.

TABLE 4. EFFECT OF LASALOCID SODIUM LEVELS ON RUMEN FERMENTATION

	Lasalocid levels, ppm		
Volatile fatty acid, %	0	33	49
Acetic	71.98[a]	66.12[b]	62.85[b]
Propionic	13.94[a]	22.13[b]	24.00[b]
Butyric	8.21[a]	6.83[b]	7.48[a,b]
Acetic:propionic ratio	4.75:1	2.98:1	2.61:1
Iso-butyric	1.53	1.34	1.48
Iso-valeric	2.50	2.35	2.19
Valeric	1.82	1.65	2.04

[a,b]Different superscripts on the same line indicate significant differences ($P < .05$).

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TABLE 5. EFFECT OF WHOLE-PLANT GRAIN SORGHUM SILAGE PROCESSING METHODS ON NUTRIENT DIGESTIBILITY

	Silage treatments		
Item	Whole grain	Pre-ensiled rolled grain	Post-ensiled rolled silage
Number of steers	6	6	6
Digestibility, %			
Organic matter	55.10	55.39	59.50
Dry matter	52.83	53.00	56.80
Crude protein	43.83	43.30	46.57
Starch	87.21[a]	83.97[a]	93.63[b]
Acid detergent fiber	29.81	36.57	33.98
Fecal pH	6.85	6.97	7.02

[a,b]Means in the same line with different superscripts indicate significant difference ($P < .05$).

PR-3777

Whole-Plant Grain Sorghum for Growing and Finishing Beef Cattle

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Summary

Whole-plant grain sorghum silage, sorghum grain, and two combinations were fed to 64 crossbred steers to measure growth and carcass responses. Rations with whole-plant silage increased feed dry matter intake of steers over an all-grain control. Rate of gain and feed conversions were most favorably influenced with rations containing more grain than whole-plant silage. The all-grain treatment produced steers with an average carcass dressing percentage two percentage units higher than treatments containing whole-plant silage. Steers in the whole-plant grain sorghum treatment resulted in a 28-percent increased liveweight gain per unit of land compared to the all-grain treatment.

Introduction

Texas produces about 6 million tons of grain sorghum and only 80 thousand tons of sorghum silages annually. Therefore, an enormous quantity of sorghum vegetation is not being fully utilized as a roughage source for cattle. Previous research has indicated that both the grain and stover of whole-plant sorghum silages must be processed to obtain full nutritive potential for cattle. Therefore, an experiment was designed to establish the potential of feeding processed whole-plant grain sorghum silage to beef cattle.

Experimental Procedure

Sufficient quantities of both whole-plant grain sorghum silage and grain sorghum were harvested from the same field in 1976. The whole-plant grain sorghum silage was harvested with a Massey Ferguson Super 92 combine modified to produce rolled grain and chopped stover. The grain was harvested by this same combine and rolled before being conveyed into trailing wagons. Both of these field-processed sorghums were stored in oxygen-limited storage until fed. Twice the land area for grain as whole-plant was harvested to result in 46.5 and 51 tons of dry matter, respectively. Sixty-four crossbred steers were assigned to one of four treatments as outlined in Table 1. In addition to the four combinations of sorghums fed, steers were fed 0.9 kg per head per day of a protein-mineral supplement to result in near equal intakes of protein, calcium, and phosphorus. Steers were managed in an acceptable research routine during the 112-day growth trial to obtain feed dry matter intake and growth responses. At the termination of the growth trial, all steers were slaughtered to obtain measurements of carcass value.

Results and Discussion

The grain-to-stover ratio (dry matter basis) was

TABLE 1. EXPERIMENTAL APPROACH

	Treatments			
Item	Whole plant	75-25	25-75	All grain
Whole plant, %[a]	100	75	25	0
Grain, %[a]	0	25	75	100
Total grain, %	50	57.5	87.5	100
Number of replicates	2	2	2	2
Steers per replicate	8	8	8	8

[a]As fed basis.

TABLE 2. FEEDING TRIAL RESULTS

	Treatments				
Item	Whole plant	75-25	25-75	All grain	S.D.
Initial weight (kg)	251.10	255.15	247.11	250.91	5.54
Daily dry matter intake (kg)	11.64[c]	12.60[c]	10.73[b]	7.80[a]	2.07
ADG (kg)	.93[b]	1.13[b]	1.40[a]	1.11[b]	1.18
Kg feed per kg gain (DM basis)	12.55[b]	11.14[b]	7.70[a]	7.00[a]	2.67
Percent increased liveweight per hectare over all grain	28.4	1.2	2.0		

[a,b,c](P<.05).

TABLE 3. CARCASS CHARACTERISTICS

Item	Treatments				
	Whole plant	75-25	25-75	All grain	S.D.
Warm carcass weight (kg)	208.69[b]	228.89[a]	238.37[a]	232.04[a]	12.83
Dressing percent	60.45[b]	60.80[b]	60.86[b]	62.73[a]	1.03
Ribeye area, cm^2	9.34[b]	10.95[a]	10.55[a]	10.85[a]	.74
Kidney and pelvic fat (%)	2.15[b]	2.26[a,b]	2.46[a]	2.36[a,b]	.14
Yield grade	2.10[a,b]	1.83[b]	2.40[a]	2.27[a]	.25
Marbling score[c]	3.38[b]	3.92[b]	4.71[a]	4.56[a]	.61
Fat thickness, cm	.22	.24	.32	.33	.01
Quality grade[d]	8.69[b]	9.64[b]	11.00[a]	10.94[a]	1.11

[a,b]($P<.05$).

[c]Coded: 3 = Traces; 4 = Slight; 5 = Small.

[d]Coded: 8 = High Standard; 9 = Low Good; 10 = Average good; 11 = High good.

1:1 for the field-processed whole-plant silage, thus indicating that near equal amounts of grain and stover dry matter are present in grain sorghums. When this whole-plant silage was fed to steers as the major ration ingredient, feed dry matter intake was greater ($P<.05$) than the 25 percent silage-75 percent grain combinations or the all-grain treatment (Table 2). These observations are consistent with a large body of cattle feeding research on roughage concentrate ratios. Steers fed the 25 percent silage-75 percent grain combinations gained more rapidly ($P<.05$) than those on other treatments and with a feed conversion similar to the steers fed all grain rations. Feed conversion for steers fed whole plant and 75 percent silage-25 percent grain rations was similar, but higher ($P<.05$) than for the other treatments.

Carcass weight was greater ($P<.05$) for all treatments that contained added grain compared to whole-plant silage (Table 3). However, dressing percentage was higher ($P<.05$) for the all-grain treatment compared to remaining treatments. The most likely reason for this response is the reduction of gut-fill for the steers fed all grain rations compared to rations with silage. The carcasses resulting from steers fed the 25 percent silage-75 percent grain and the all-grain ration had higher ($P<.05$) marbling scores, yield grades, and quality grades than those from remaining treatments.

Liveweight gain per hectare was increased ($P<.05$) through the use of whole-plant grain sorghum, 28.40 percent, 1.20 percent, and 2.00 percent for the whole-plant, 75 percent silage-25 percent grain, and 25 percent silage-75 percent grain treatments, respectively. However, it must be recognized that the values of resulting liveweight gains were not necessarily equivalent as indicated by differences in carcass characteristics.

PR-3778

Module Storage of Grain Sorghum Head Chop Silage for Cattle

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Summary

Grain sorghum head chop was stored either in large free standing modules or in oxygen-limited structures as field cut or recut silage. Module silage underwent dry matter losses of 36 to 47 percent compared to 12 to 18 percent for oxygen-limited storage ($P<.05$). Module-stored silage indicated a decreased nutritive potential by both chemical analyses and cattle performance. Steers fed either of the module-stored silages ate less head chop dry matter and gained less weight ($P<.01$) at a reduced feed efficiency ($P<.10$) compared to those fed oxygen-limited stored silages. Carcass characteristics were also disfavorably influenced by module-stored silages. These data suggest that intake of module-stored silage dry matter was a more limiting factor in steer performance than digestibility as estimated by the *in situ* procedure. Modules may hold potential as short-term ensiling systems.

Introduction

Previous research had indicated that grain sorghum head chop silage represented a logical method of early harvesting grain with some roughage in the form of stover for feeding cattle. Adapting field cutters to harvest the upper one-half to one-third of the grain sorghum plant was an effective way to harvest head chop, but it was not clear if additional processing of the head chop would enhance storage and/or feeding value of the crop.

Cattlemen are interested in highly flexible and inexpensive techniques of silage preservation. Throughout Texas the cotton module builder has found widespread application and was considered as a possible alternative for storing silages in free standing modules, similar to the concept of baled silage (1). Therefore, a series of silage fermentation, cattle feeding, and digestion experiments were established to investigate these concepts.

Materials and Methods

Oro-T hybrid grain sorghum was harvested by cutting the upper 56 centimeters (cm) of the plant from July 15 to 23, 1976, at 39 to 46 percent dry matter. The head chop contained 84.4 percent grain and 15.6 percent stover. Half of the head chop was introduced into storage through a Wetmore recutter-blower to reduce particle size beyond the field cut material. The remaining head chop entered storage through a Gehl tractor-powered forage blower. The field cut and recut head chop were either ensiled in oxygen-limited structures or free-standing high density modules. The hydraulically operated vertical foot of the module builder traversed the entire width and length of the module to allow uniform compaction of the head chop, resulting in 288 or 341 kilograms (kg) of silage dry matter per cubic meter (m^3) for the field cut and recut treatments, respectively. Modules were constructed on plywood pallets. A commercial preservative consisting of 67 percent propionic acid, 10 percent formaldehyde plus 23 percent inert ingredients was combined with the head chop at 1.6 percent of fresh weight as the silage entered each storage system.

Sixty-four Brahman x British cross steers were assigned to the head chop treatments from November 7, 1976, until March 19, 1977, when they were slaughtered to evaluate carcasses. The steers were fed grain sorghum head chop silage according to appetite plus .9 kg/day of a cottonseed meal-based protein and mineral and vitamin supplement. *In situ* dry matter digestibilities of these head chop silages were obtained with established procedures (2). Sampling procedures and both chemical and statistical analyses employed were accepted procedures for experiments of this nature.

Results and Discussion

Data presented in Table 1 indicate that total dry matter losses were about threefold greater for module-stored head chop silage than for that stored in oxygen-limited structures ($P<.05$). Recut head chop resulted in more dry matter weight loss than field cut silage in both storage systems.This response to particle size is not consistent with most previous research. About 4.5 percent of silage dry matter in modules was judged unfit for feeding and was discarded, representing 15 to 20 cm on the exposed surfaces of the modules. From July through March the field cut and recut modules lost 36.6 and 47.4 percent of original dry matter, apparently the result of excessive exposure to the atmosphere and heating to over 50° C. Most of the surface deterioration and fermentation losses occurred after the first 30 days of storage. Modules may hold potential as a short-term silage storage system since the initial shift in pH was not significantly different than in oxygen-limited storage, and dry matter losses were judged to be minimal for the initial month of storage.

Composition of the head chop rations fed reflect higher crude fiber ($P<.10$) and ash values for module and recut oxygen limited-stored silage but lower nitrogen-free extract values than field cut silage stored in oxygen-limited systems (Table 2). These observations plus relatively high acid detergent insoluble nitrogen values obtained from small laboratory module-stored silage in another experiment all indicate a reduced nutritive potential for module-stored silage, due largely to heating of the silage during storage.

Steers fed either module-stored head chop silage consumed less per day than those offered oxygen-limited stored silage (Table 3). Rate of gain was also depressed ($P<.01$), resulting in the least desirable ($P<.10$) feed conversion for the steers fed module-

TABLE 1. STORAGE QUALITIES OF SORGHUM HEAD CHOP SILAGE STORED IN MODULES AND OXYGEN-LIMITED STRUCTURES

	Storage treatments			
	Oxygen limited		Module	
Item	Field cut	Recut	Field cut	Recut
Head chop silage dry matter, %	51.3	51.2	50.1	50.0
Compaction pressure, kg/cm^2			.49	.49
Dry matter density, kg/m^3			277.9	340.7
Head chop silage pH	5.75	4.70	4.78	5.22
Silage dry matter discarded, %	0.00	0.00	4.5	4.4
Silage dry matter loss, %	12.5	18.0	36.6	47.4
Total silage dry matter loss, %*	12.5	18.0	41.1	51.8

*($P<.05$).

stored silages. With module storage, field cut or recut silages resulted in similar performance of steers, while recut silage improved rate of gain ($P<.01$) for steers over the field cut oxygen-limited treatment. Recut oxygen-limited silage also indicated a slight improvement in dry matter conversion over field cut oxygen-limited silage.

Carcass characteristics reflected the growth response of steers fed the four processed silages (Table 4). Carcasses from steers fed module-stored silages had lower ($P<.01$) dressing percentages and lower carcass quality and yield grades ($P<.05$) than those from steers fed silages stored in oxygen-limited systems. These data clearly indicate that module-stored silages depressed silage dry matter intake and rate of growth for steers resulting in lighter carcasses of lower quality and yield grade. *In situ* silage dry matter disappearance estimates (Table 5) also tend to support these responses, although recut module silage was more rapidly utilized ($P<.05$) at 48 and 168 hours

TABLE 2. CHEMICAL COMPOSITION OF FEED MIXTURES

	Storage treatments			
	Oxygen limited		Module	
Item[a]	Field cut	Recut	Field cut	Recut
Dry matter	48.3[x]	47.2[x]	49.4[x]	54.8[y]
Crude protein	13.5	12.5	13.2	13.9
Crude fiber	17.9[x]	13.3[x]	21.9[y]	19.9[y]
Ether extract	2.4	1.8	2.2	1.7
Ash	4.8	5.7	6.2	7.1
Nitrogen-free extract	60.5[y]	67.5[y]	56.4[x]	57.4[x]

[a]Values expressed as percent of dry matter.

[x,y]Values in same row with different superscripts differ ($P<.10$).

TABLE 3. PERFORMANCE OF STEERS FED SORGHUM HEAD CHOP STORED IN MODULES OR OXYGEN-LIMITING STRUCTURE, KG

	Storage treatments			
	Oxygen limited		Module	
Item	Field cut	Recut	Field cut	Recut
Initial weight	293.64	294.55	293.64	295.91
Final weight	406.36	415.45	378.64	380.45
Head chop dry matter intake per day	9.74	9.18	8.56	8.54
Total gain	112.72[b]	120.90[c]	85.00[a]	84.54[a]
Average daily gain	.85[b]	.92[c]	.64[a]	.64[a]
Kg of head chop dry matter per kg of gain	11.14[e]	10.01[e]	13.38[f]	18.28[f]

[a,b,c]Values on same row with different superscript differ ($P<.01$).

[e,f]Values on same row with different superscript differ ($P<.10$).

TABLE 4. CARCASS CHARACTERISTICS OF STEERS FED SORGHUM HEAD CHOP[a]

	Storage treatments			
	Oxygen limited		Module	
Item	Field cut	Recut	Field cut	Recut
Steers per treatment	16	16	16	16
Slaughter weight, kg[†]	852.25	860.94	804.06	798.13
Dressing percent[**]	60.94	61.33	59.06	58.93
Quality grade[b,*]	17	18	16	16
Yield grade[**]	2.49	2.36	1.93	1.95

[a]Characteristics evaluated according to USDA (1976).

[b]Coded: 16 = good$^-$, 17 = good$^\circ$, 18 = good$^+$.

[†]Significant treatment effect ($P<.10$).

[*]Significant treatment effect ($P<.05$).

[**]Significant treatment effect ($P<.01$).

TABLE 5. *IN SITU* DRY MATTER DISAPPEARANCE OF SORGHUM HEAD CHOP SILAGE, PERCENT

	In situ time, hrs.		
Silage treatments	48	96	168
Recut oxygen limited (control)	30.19[a]	37.88[a]	47.05[b]
Field cut module silage	25.04[b]	33.03[b]	46.00[a]
Change from control, %	−17.06	−12.80	−2.23
Recut module silage	31.24[a]	33.98[b]	51.35[b]
Change from control	+3.44	−10.30	+9.14

[a,b]Values in the same column with different superscripts differ (P<.05).

of *in situ* exposure compared to recut oxygen-limited silage. These data suggest that intake of module-stored silage dry matter was a more severe limiting factor upon steer performance than estimated digestibility.

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PR-3779

Preservation of Sorghum Plant Portions Harvested at Ten Stages of Maturity

L. M. SCHAKE, W. C. ELLIS, W. A. SUAREZ AND J. K. RIGGS

Summary

Two varieties of grain sorghum were cultured and harvested at 10 intervals from 35 to 189 days post planting. Leaf, stem, and head portions were separated before being prepared for chemical analysis or ensiled for 30 days in 1-liter silos. The taller variety (FS-lb) accumulated 60 percent more dry matter than ORO-T with advancing plant maturity while whole-plant crude protein content decreased from near 20 to less than 7 percent for both varieties. Dry matter ensiling losses (DMEL) were significantly different for each plant portion but were lower and less variable after the 77-day harvest. Immature leaves and heads resulted in the greatest DMEL of 31 and 24 percent, respectively. DMEL of leaves was influenced by a varietal x modulus of fineness interaction, while the stem exhibited an interaction with plant maturity x modulus of fineness. Modulus of fineness was not associated with levels of organic acid production in silages, but plant maturity significantly influenced acetic, propionic, and butyric acid production in heads. These data indicated that numerous combinations of silage preservation techniques affected DMEL of sorghum plant portions at different maturities.

Introduction

Nationally, Texas ranks first in grain sorghum production and third in sorghums harvested for silage. Many variables are known to influence nutrient and dry matter preservation in grain sorghum silages, including maturity of plant at time of ensiling. Additionally, plant particle size affects compaction, preservation, and seepage of silages. Preservation of sorghum silages has often been less successful than of other crops, (2,3) which accentuates the need to better understand possible relationships among the common variables associated with sorghums. Therefore, an experiment was designed to characterize the effects of sorghum plant portions and their possible interactions with varieties, stage of maturity, and fineness of chop upon silage preservation.

Experimental Procedure

Two commercial hybrid sorghum varieties, ORO-T, a tall grain sorghum and FS-lb,an intermediate forage sorghum, were cultured in 68-centimeter (cm) rows at the Texas A&M University Farm. A population of 247,000 plants per hectare (ha) was grown on Miller clay soil fertilized 4 months prior to planting with 201 kilograms (kg) each of nitrogen, phosphorus, and potassium per ha. Weeds were controlled by both mechanical and chemical methods. The crop was flood-irrigated twice.

The hybrids were hand harvested during the morning at 10 intervals (Table 1) by cutting 6 cm above the ground level before storage at 4° C. Later that same day plants were prepared for treatments (Table 2) by separation into leaf blade, stem (including leaf sheath), and head upon emergence. Each fresh plant portion was chopped to yield a coarse, intermediate, or fine particle size by chopping one, three, or five times, respectively. Immediately after chopping, samples were weighed, blended, and hand compacted in airtight glass jars of 1-liter capacity. Whole-plant sorghum was obtained only at the intermediate chop, and no plant separation was attempted for the first harvest. Duplicate samples of 300 to 700 grams (g) were ensiled for each treatment and stored for 30 days in darkness at 20° C.

Dry matter was determined on the fresh and ensiled materials. Particle size of each sample was obtained from the dried ensiled sorghums by shaking for 5 minutes over four screens of 12.7, 6.35, 4.2, and 1.19 millimeters (mm) plus pan. The particles recovered from each stratum were weighed with each weight calculated as a percent of the total. Modulus of fineness (MF) and average particle size (APS) were calculated with published equations (1,3), respectively. Volatile fatty acids were determined by gas liquid chromatography on a filtrate obtained from the ensiled silages. The least squares method of analysis of

TABLE 1. HARVEST INTERVALS

Harvest sequence	Harvest dates, 1975	Days post-planting	Physiological maturity of each variety	
			ORO-T	FS-lb
1	May 21	35	6 leaf	5 leaf
2	June 4	49	Flag	7 leaf
3	June 18	63	½ bloom	Flag
4	July 2	77	Soft dough	½ bloom
5	July 16	91	Hard dough	Soft dough
6	July 30	105	Mature	Hard dough
7	August 13	119	Fully mature	Mature
8	August 27	133	Fully mature	Fully mature
9	September 24	161	Fully mature	Fully mature
10	October 22	189	Fully mature	Fully mature

TABLE 2. TREATMENTS APPLIED TO TWO SORGHUM VARIETIES AT EACH OF 10 HARVESTS

Plant portion[a]	Physical processing[b] (chopping)
Whole	Intermediate
Leaf	Coarse
	Intermediate
	Fine
Stem	Coarse
	Intermediate
	Fine
Head	Coarse
	Intermediate
	Fine

[a]Only whole plant was ensiled at first harvest. Head portions were obtained from 77-189 days post-planting.

[b]Coarse, intermediate, and fine chop obtained by chopping one, three, or five times, respectively.

variance (4) was employed to test for homogeneity of treatment means and their first-order interactions.

Results and Discussion

Whole-plant dry matter yield per ha increased ($P<.001$) for both varieties as plant maturity advanced with FS-lb accumulating 60 percent more dry matter than ORO-T (Figure 1). Leaf, stem, and head contributions to total dry matter yield differed ($P<.05$) with variety and stage of maturity as indicated by ORO-T heads weighing more than stem and leaf at four consecutive harvests, while FS-lb head weights tended to be intermediate to stem and leaf. The stem contributed 35 and 50 percent of mean dry matter yield for ORO-T and FS-lb, respectively. The decline in dry matter yield of the head beyond 130 days post-planting was associated with large bird predation and weathering of grain.

Crude protein content of whole plant, leaf, stem, and head portions are presented in Figure 2. Crude protein content of the leaf, stem, and whole plant declined ($P<.001$) with advancing maturity for both varieties. Whole-plant crude protein was 18 and 20 percent, respectively, for ORO-T and FS-lb at first harvest but decreased to 8 and 5 percent by the tenth harvest. The crude protein content of the head remained relatively stable over the sampling intervals.

Mean dry matter ensiling losses (DMEL) were influenced by variety, ($P<.05$) while stage of maturity influenced ($P<.001$) leaf, head, and stem DMEL for both varieties (Table 3). Stem and head portions of ORO-T resulted in less ($P<.05$) average DMEL than FS-lb, while the reverse was observed for the leaves. At each harvest ORO-T was physiologically more mature than FS-lb as indicated by accumulative weight (Figure 1). DMEL for whole plant and each plant portion tended to remain relatively uniform after the 77-day harvest.

The DMEL was less for ORO-T stems ($P<.01$) and heads ($P<.05$) than for FS-lb while the reverse was true for the leaf fraction of these varieties. Leaf DMEL was also influenced ($P<.05$) by a varietal x modulus of fineness interaction (Figure 3). ORO-T leaf had the least DMEL with the intermediate chop when FS-lb exhibited the greatest loss. DMEL of stems was influenced ($P<.05$) by modulus of fineness differently ($P<.05$) at various harvests (Figure 4). The greatest DMEL of stem resulted with the intermediate chop for the second and third harvests. Fine chopping was least favorable during the next four harvests. Previous to the ninth harvest, heavy rains initiated partial ratooning of plants, reducing plant dry matter which may have further influenced these observations.

Production of acetic, propionic, and butyric acids during ensiling was influenced ($P<.05$) by plant maturity for each plant portion (Tables 4,5 and 6). A decline ($P<.001$) in the production of acetic and propionic acids with advancing harvests is apparent for the head. Leaf and stem portions indicated the same trend but with much less consistency. Butyric acid production increased ($P<.001$) with advancing harvests for leaf and stem while the head portion was not affected. Modulus of fineness influenced organic acid production to a limited extent. Leaves produced more ($P<.05$) acetic acid at the intermediate than fine or coarse modulus of fineness, while propionic acid production was increased ($P<.01$) only in the head as modulus of fineness increased.

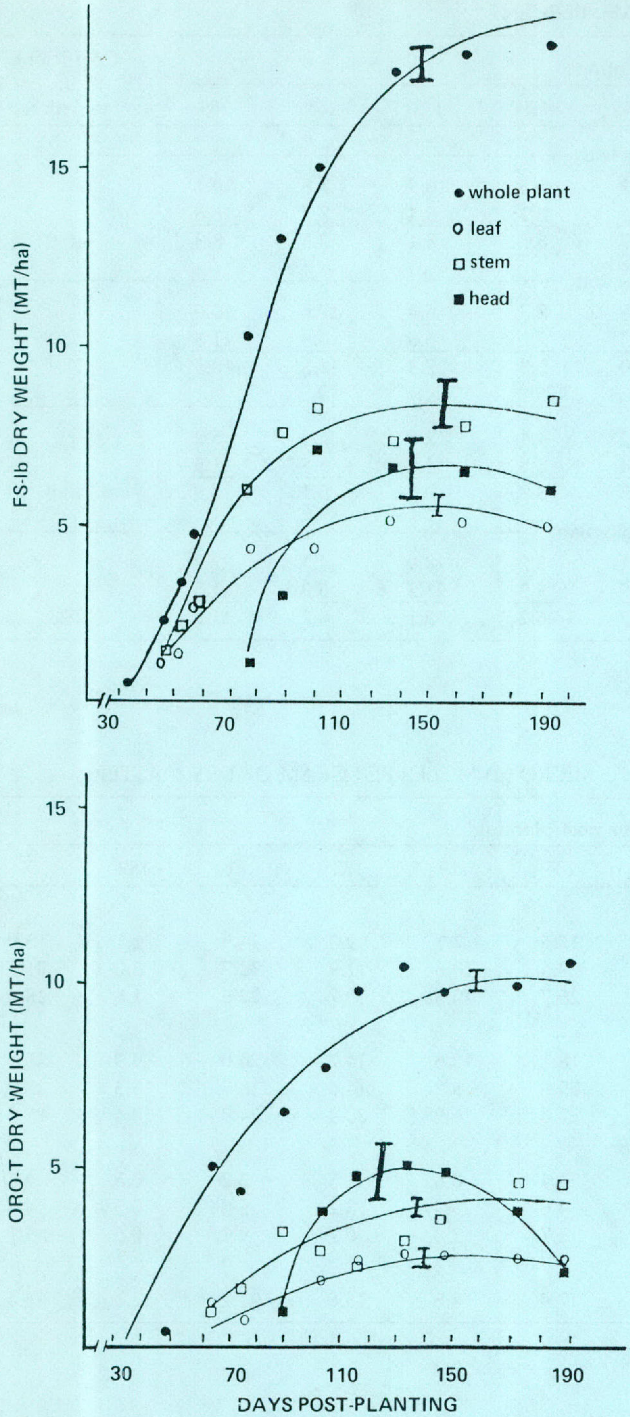

Figure 1. Dry weight yield per hectare at 10 harvests.

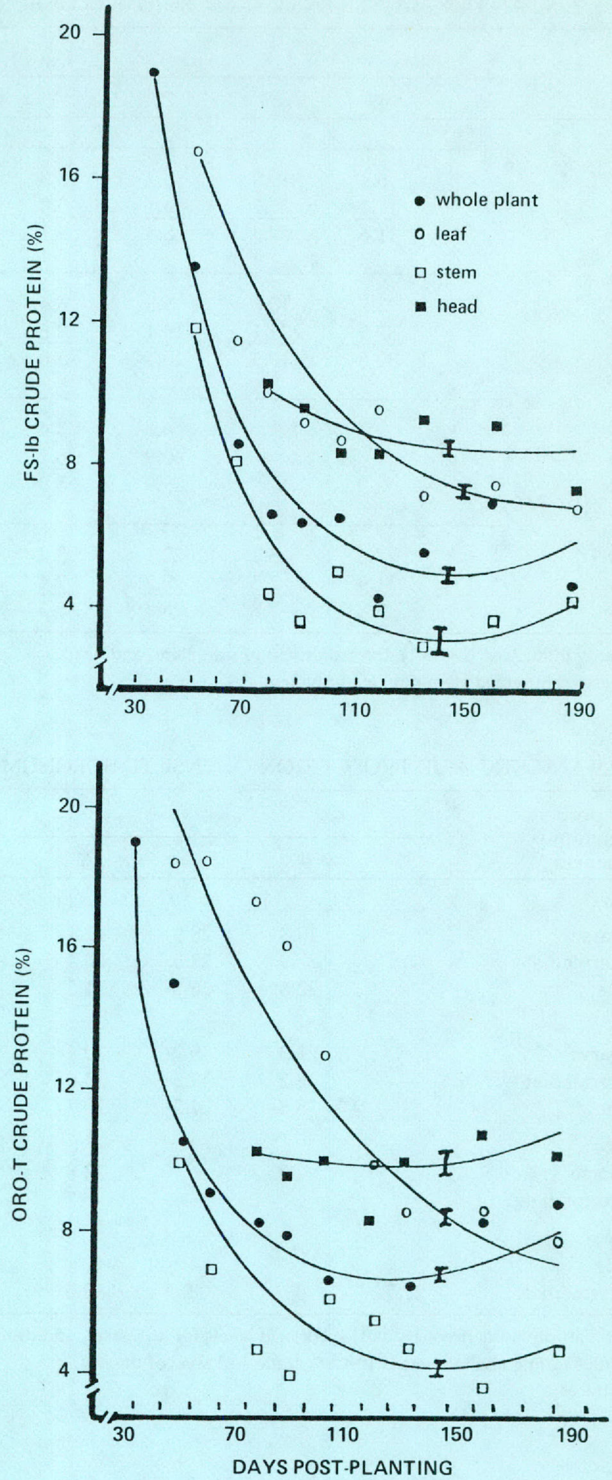

Figure 2. Crude protein content at 10 harvests.

TABLE 3. MEAN DRY MATTER ENSILING LOSS (DMEL) OF SORGHUMS, PERCENT

Variety	Days post-planting[1]										Coefficient of variation
	35	49	63	77	91	105	119	133	161	189	
						leaf					
ORO-T		6.1	18.9	6.7	13.3	12.1	8.5	10.9	7.8	10.1	
FS-lb		17.1	15.7	4.1	5.0	3.3	8.1	5.4	7.2	6.6	
Mean		11.6	17.3	5.4	9.1	7.7	8.3	8.1	7.5	8.3	40.0
						stem					
ORO-T		23.7	10.6	5.8	6.4	6.6	7.3	8.4	17.6	10.0	
FS-lb		37.5	24.1	15.1	9.6	13.3	3.2	6.0	6.8	11.8	
Mean		30.6	17.3	10.4	8.0	10.0	5.3	7.2	12.2	10.5	31.4
						head					
ORO-T				6.9	3.4	4.2	4.1	2.5	6.4	5.2	
FS-lb				40.9	6.7	6.4	3.8	3.8	3.8	2.5	
Mean				23.9	5.0	5.3	3.9	3.1	5.1	3.9	48.8
						whole plant[2]					
ORO-T	7.9	7.6	8.1	22.5	3.2	2.1	3.2	8.9	4.1	22.0	
FS-lb	5.0	11.9	7.5	30.7	7.4	7.3	9.3	21.3	5.3	1.5	
Mean	6.5	9.8	7.8	26.6	5.3	4.7	6.2	15.1	4.7	11.8	28.2

[1]Maturity influenced (P<.001) dry matter loss of leaf, stem, and head.

[2]Represents intermediate modulus of fineness.

TABLE 4. ACETIC ACID PRODUCTION OF ENSILED SORGHUM PLANT, MICRO (μ) MOLES PER GRAM OF DRY MATTER

Plant portion and modulus of fineness	Days post-planting[1]										
	35	49	63	77	91	105	119	133	161	189	$\overline{X}$
Leaf[2]											
Coarse		19.3	28.9	22.1	15.6	17.5	7.1	9.8	14.9	1.1	15.0
Intermediate		27.9	23.5	20.4	34.5	29.6	10.6	11.9	32.7	3.0	21.5
Fine		22.6	26.3	21.5	24.8	26.7	10.8	10.7	22.6	1.8	18.6
Stem											
Coarse		21.3	15.2	10.6	22.9	18.1	10.6	14.7	20.0	9.9	15.9
Intermediate		18.2	19.3	13.8	33.7	25.8	8.2	14.6	18.1	16.3	18.7
Fine		30.5	21.3	20.7	22.0	27.8	16.9	20.4	24.0	10.4	21.6
Head											
Coarse				12.8	5.9	4.4	0.6	1.5	3.2	0.5	4.1
Intermediate				9.7	10.1	4.6	0.9	3.2	5.0	0.5	4.8
Fine				11.1	14.7	2.7	1.0	0.7	9.1	0.5	5.7
Whole											
Intermediate	22.7	T	T	38.6	21.1	17.4	4.6	16.0	21.2	12.4	15.4

[1]Plant maturity influenced (P<.001) acetic acid levels for leaf, stem, and head.

[2]Modulus of fineness influenced (P<.05) acetic acid level of the leaf.

T = (traces).

TABLE 5. PROPIONIC ACID PRODUCTION OF ENSILED SORGHUM PLANT, (μ) MOLES PER GRAM OF DRY MATTER

Plant portion and modulus of fineness	Days post-planting[1]									
	35	49	63	77	91	105	119	133	161	189	$\overline{X}$
Leaf											
Coarse		24.2	28.0	30.0	29.0	15.5	12.4	17.0	40.2	9.9	22.9
Intermediate		27.2	15.5	29.0	38.8	21.3	15.3	15.4	30.6	11.3	22.7
Fine		16.2	30.0	24.8	29.5	17.5	15.9	16.9	32.6	11.4	21.6
Stem											
Coarse		31.7	61.0	45.9	28.3	34.0	22.1	17.6	41.0	24.1	33.6
Intermediate		57.8	53.7	44.5	41.1	32.1	20.9	18.8	25.3	26.5	35.6
Fine		20.6	44.5	40.6	39.1	21.6	33.1	22.3	39.1	24.0	31.7
Head[2]											
Coarse				23.7	12.8	8.4	4.0	3.9	8.1	6.4	9.6
Intermediate				39.8	13.1	10.4	4.3	4.5	10.0	6.9	12.7
Fine				39.5	18.7	7.0	6.1	5.0	10.9	6.7	13.4
Whole											
Intermediate	T	0.1	1.2	T	1.5	T	0.1	1.9	1.4	T	0.6

[1]Plant maturity influence leaf, head (P<.001), and stem (P<.05) production of propionic acid.
[2]Modulus of fineness influenced (P<.01) propionic acid production of head.
T = (traces).

TABLE 6. BUTYRIC ACID PRODUCTION OF ENSILED SORGHUM PLANT, (μ) MOLES PER GRAM OF DRY MATTER

Plant portion and modulus of fineness	Days post-planting[1]									
	35	49	63	77	91	105	119	133	161	189	$\overline{X}$
Leaf [1]											
Coarse		0.4	5.7	14.1	5.6	1.6	1.9	3.2	9.6	3.4	5.1
Intermediate		T	10.5	3.7	20.9	5.0	7.1	6.9	10.9	4.4	7.7
Fine		T	7.2	1.4	13.2	2.3	4.0	5.9	22.9	4.4	6.8
Stem[1]											
Coarse		T	T	0.5	3.7	0.2	1.4	3.8	9.1	18.1	4.1
Intermediate		T	T	T	0.9	T	4.9	4.4	10.6	9.1	3.3
Fine		T	T	0.5	21.9	T	6.1	5.4	4.6	21.1	6.6
Head											
Coarse				0.7	0.1	T	T	0.1	T	T	0.1
Intermediate				0.4	0.2	T	T	T	T	T	0.1
Fine				0.2	T	0.1	T	T	T	T	0.0
Whole											
Intermediate	T	T	T	0.5	0.6	T	1.6	T	T	T	0.3

[1]Plant maturity influenced (P<.001) butyric acid production in the leaf and stem.
T = (traces).

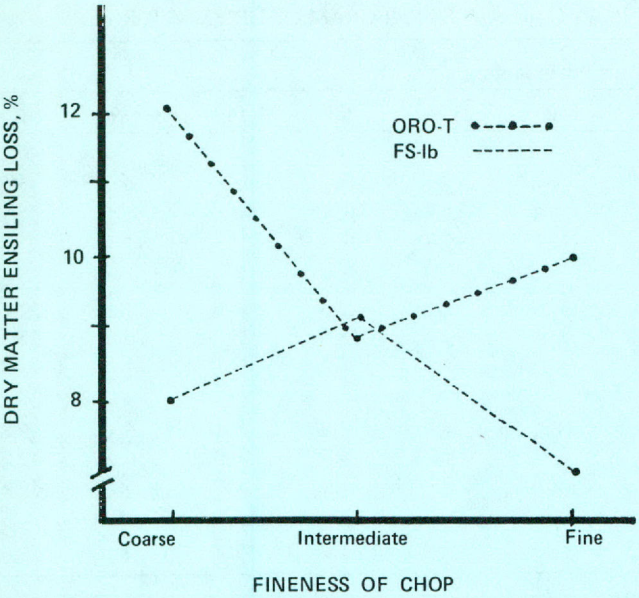

Figure 3. Interaction of variety × modulus of fineness upon leaf dry matter ensiling loss.

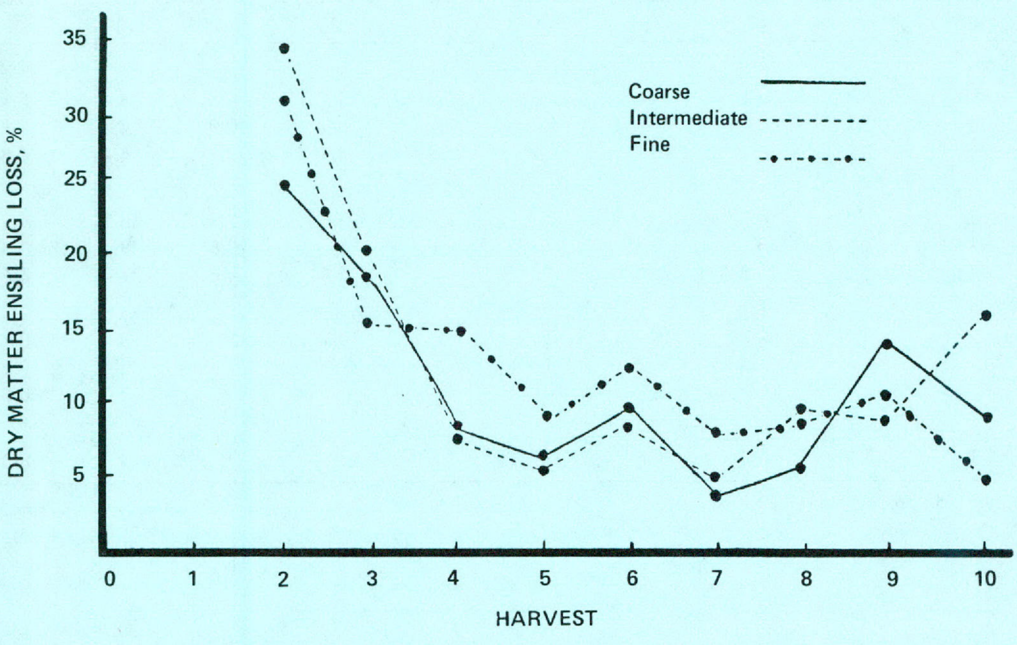

Figure 4. Interaction of modulus of fineness × harvest interval for stem.

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Reproduction and Breeding

Low reproductive rates in cattle present a challenge to producers and researchers alike. The need to approach this challenge on an interdisciplinary basis has been recognized and is reflected in the following reports from several Texas Agricultural Experiment Station Research Centers. Data on fundamental concepts and their application under ranch conditions are reported for both cows and bulls to assist in elevating the ceiling on reproductive rate in beef cattle.

PR-3780

Using Short-Term Calf Removal and Flushing to Improve Pregnancy Rate

K. J. NIX, SPENCER ROBERTS, AND J. N. WILTBANK

Summary

Cows from two ranches were used to determine the effect of calf removal and flushing on pregnancy rate. Cows suckling their first calf showed a marked improvement over controls in pregnancy rate after 21 days of breeding (28 to 57 percent), when cows were flushed and calves removed for 48 hours. However, flushing or calf removal alone showed no benefit. At the second ranch, response obtained from flushing and calf removal was shown to depend on calving time and body condition of the cow. However, in thin cows no improvement was noted.

Introduction

Most beef cows in South Texas which do not become pregnant have not shown heat. Methods for increasing the number of cows showing heat should improve calf crop. Methods of reducing or removing the suckling stimulus have been shown to effectively increase the number of cows showing heat. However, cows in thin body condition may not respond to reduced suckling or short-term calf removal, and early weaning of the calf may be necessary to effectively increase the number of cows in heat. Another alternative may be to feed a high energy ration (flushing) for a short period of time prior to calf removal. Two South Texas ranchers in cooperation with the Beevile Experiment Station conducted several flushing and calf removal trials to determine if these methods were beneficial.

Experimental Procedure

Cows on two ranches were used in these studies. In one study, 81 crossbred Brahman type cows suckling their first calf at Howell's in Premont, Texas were used. Cows were thin (body condition score 3 or 4) and were divided into four groups: control, flushed (FL), calf removal (CR) and flushed plus calf removal (FL + CR). All cows grazed on Coastal pasture and were supplied limited amounts of hay. Cows calved in Februrary and March, and were bred April 26 through June 27. Cows in the control group received only pasture and hay. Cows in the flushed group recieved 10 pounds of concentrate ration containing 10 percent protein for 2 weeks prior to breeding and for the first 3 weeks of breeding season plus grass or hay. Calves in calf removal group were removed for 48 hours just prior to breeding. Cows in FL + CR group received flushing treatment of FL group and calves were removed as in CR group.

The second ranch (Tom O'Connor, Victoria, Texas) used 105 Hereford cows the first year. Cows were either thin (body condition score 2 to 4) or moderate (body condition score 5 or 6). Cows were on native pasture and during months of December and January received limited amounts of hay. Cows began calving in November and were bred starting the first week of February. All cows received 10 pounds of corn and cob meal the first week of January until the end of February. Calves were removed from early calving cows (those calving prior to the first week in January) for 48 hours just prior to the start of the breeding season. Late calving cows (cows calving after the first week of January) were fed from March 23 to April 26, and calves were removed for 48 hours starting April 5.

In the second year at O'Connor's, 61 Hereford cows calving from the first of November until the first week of January were used in a study to determine the value of calf removal and flushing on pregnancy rate. Most cows were thin and scored 3 or less. They were again fed 10 pounds of corn and cob meal from the first week of January until the end of February. Cows were bred for 90 days beginning the first week of February.

Results and Discussion

At the Howell ranch, pregnancy was increased rather markedly in the flushing and calf removal group over that noted in the controls. There was a 29-percent increase in pregnancy after 21 days of breeding, a 16-percent increase after 42 days of breeding and a 14-percent increase after 63 days of breeding. Pregnancy rates were either lower or similar in both the flushed group and calf removal group to that noted in the controls.

TABLE 1. FLUSHING AND CALF REMOVAL AT HOWELL'S

	Control	FL	CR	FL + CR
Number cows	18	21	21	21
Pregnant (%)				
21 days	28	14	38	57
42 days	56	52	62	72
63 days	72	76	62	86

Data from the O'Connor ranch points out two things. Flushing and calf removal was not very effective in late calving cows: only 65 percent were pregnant after 84 days of breeding (Table 2). Even in early calving cows only 54 percent were pregnant after 21 days of breeding. However, 80 percent of the early calving cows in moderate condition that were flushed and had calves removed were pregnant after 21 days of breeding (Table 3). Most of these cows (87 percent) were pregnant after 42 days of breeding. These pregnancy rates were comparable to the 72 percent and 85 percent noted in dry cows (Table 4). It would appear high pregnancy rates early in the breeding season can be achieved in cows suckling calves. The criteria used to achieve this should be tested on a larger number of cows.

Pregnancy rate the second year at O'Connor's was increased in cows that were flushed and had calves removed for 48 hours from 17 percent after 21 days of breeding to 28 percent after 63 days of breeding (Table 5). Pregnancy rate after 90 days of breeding was 95 percent. However, pregnancy rate early in the breeding season was only 31 percent. These cows were thin at calving which may explain why pregnancy rate early in the breeding season was so low. Thus calf removal and flushing is not a cure-all but it appears to work well when cows have calves 30 days prior to breeding and are in moderate body condition.

TABLE 2. EARLY CALVING AT O'CONNOR's

Calving	No. cows	Percent pregnant (days after breeding) 21	42	63	84
Early	50	54	74	78	88
Late	55	18	38	56	65

TABLE 3. BODY CONDITION OF EARLY CALVING COWS AT O'CONNOR's

Early calving	No. cows	Percent pregnant (days after breeding) 21	42	63	84
Thin	35	43	68	74	86
Moderate	15	80	87	87	93

TABLE 4. MODERATE CONDITION VERSUS DRY COWS AT O'CONNOR's

Early calving	No. cows	Percent pregnant (days after breeding) 21	42	63	84
Moderate	15	80	87	87	93
Dry cows	34	72	85	85	90

TABLE 5. PREGNANCY IN COWS AT O'CONNOR'S IN 1980

	Flushed and 48-hour calf removal	Control	Difference
No. cows	32	29	
Pregnant after breeding (%)			
21 days	31	14	17
42 days	50	31	19
63 days	66	38	28
90 days	95	73	22

PR-3781

Endogenous Luteinizing Hormone (LH) and Prolactin (PRL) Release After Calf Removal in the Postpartum Cow

M. S. Amoss, K. J. Nix,
P. G. Harms, and J. N. Wiltbank

Summary

While removal of the suckling stimulus for 48 hours will induce heat in cows in good condition, little is known about the hormone pattern that causes a cow to start to cycle following calf removal. This experiment was designed to determine the changes in hormones that cause the increase in reproductive activity. This could provide a basis for future methods of inducing heat in cows after calving. Blood samples were taken from five crossbred cows in good condition, 30 days after calving. Samples were taken every 15 minutes for 3 hours immediately after calf removal, and for 3-hour periods beginning at 12, 24, 36, 48, 72, 96 hours after calf removal. Calves were returned to their dams 99 hours after removal. Cows were again bled every 15 minutes for 3 hours immediately after the return of the calf and 24 hours after calf return. Levels of luteinizing hormone (LH), prolactin (PRL), estrogen, progesterone, and cortisol in the blood were determined. Two general hormone patterns were seen: (a) LH levels remained at basal levels when prolactin and cortisol levels were high and (b) LH levels increased to surge levels 24-48 hours post calf removal when prolactin and cortisol levels were low.

Introduction

Removal of a calf for 48 hours has proven effective in shortening the interval to first heat after calving. However; the changes in hormones that occur following calf removal are not completely understood. Prolactin (PRL) is released from the pituitary when the calf suckles and has been reported to affect the levels of the ovarian-stimulating hormone LH. Also high cortisol levels have been reported to de-

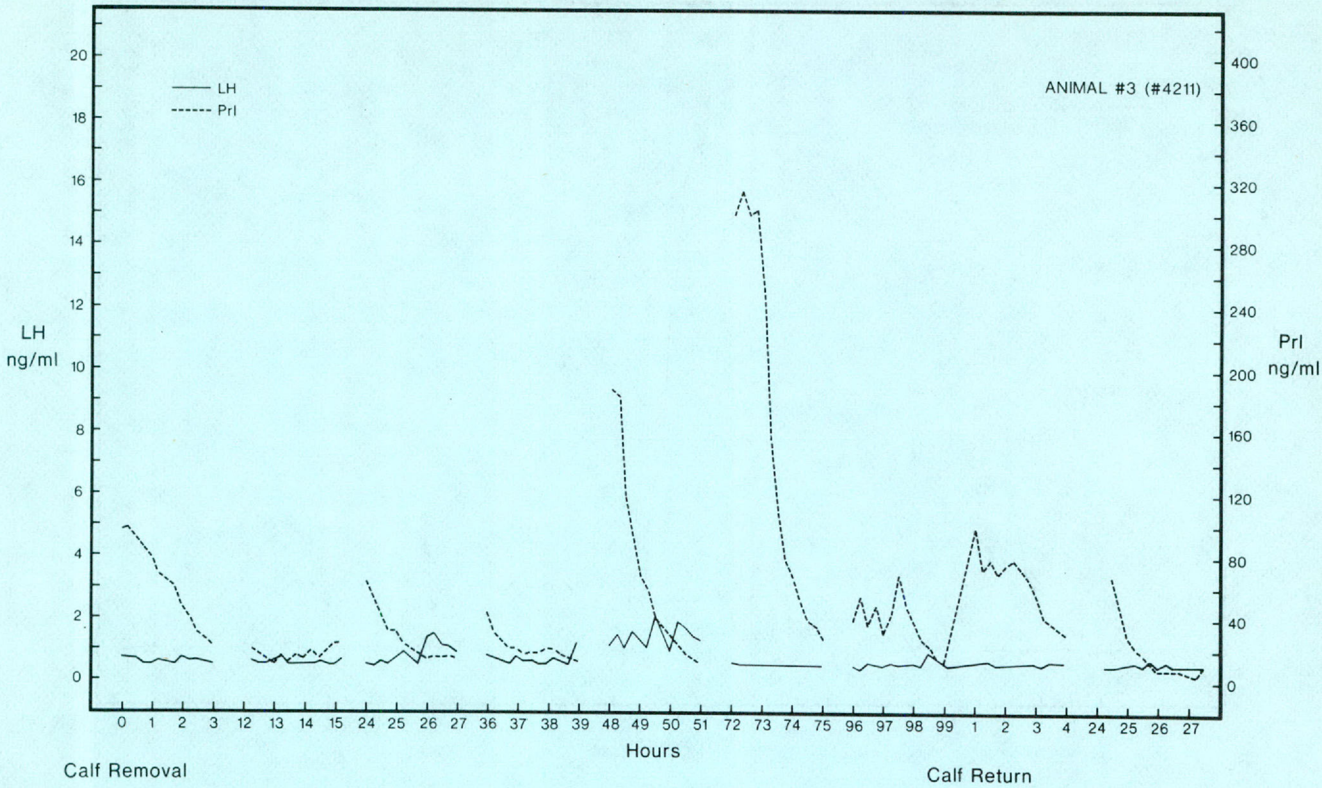

Figure 1. Examples of LH and PRL in cows of general hormone pattern 1.

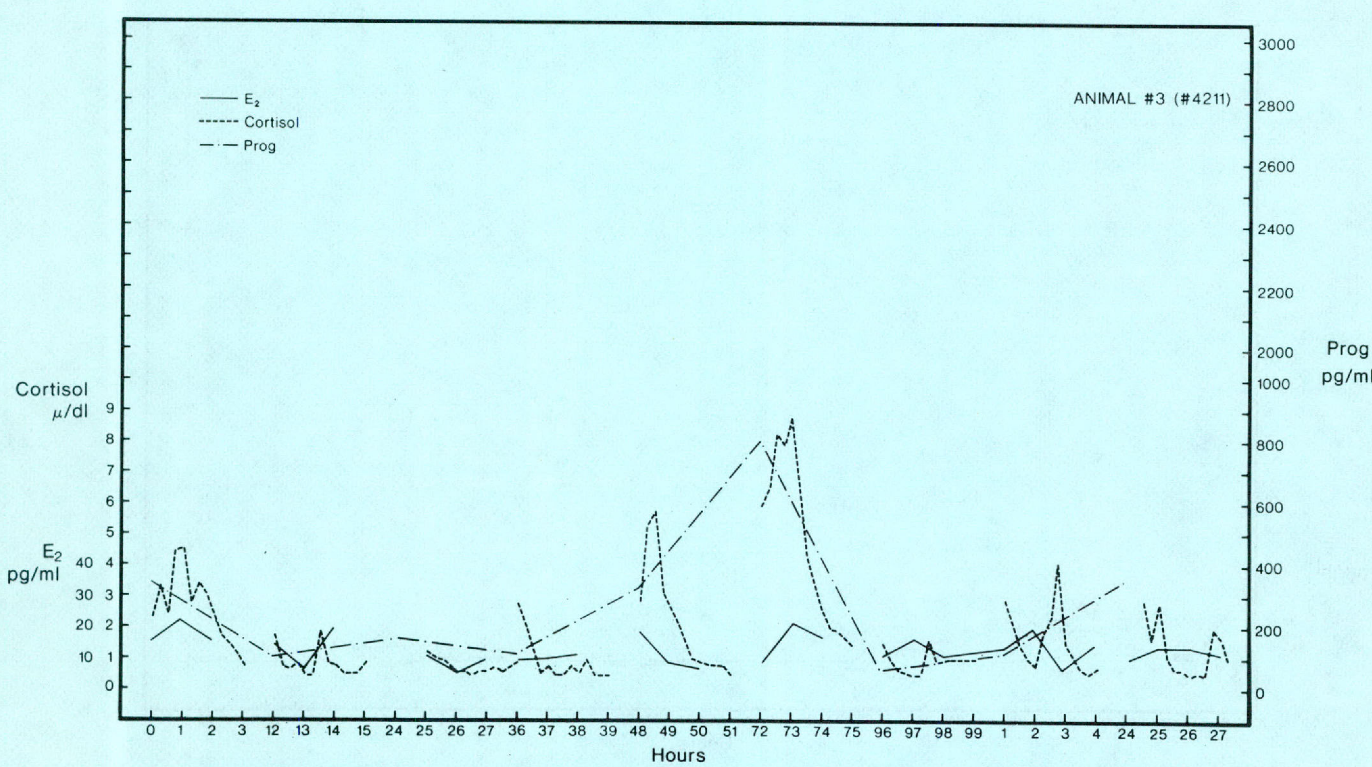

Figure 2. Examples of estradiol, cortisol and progesterone in cows in general hormone pattern 1.

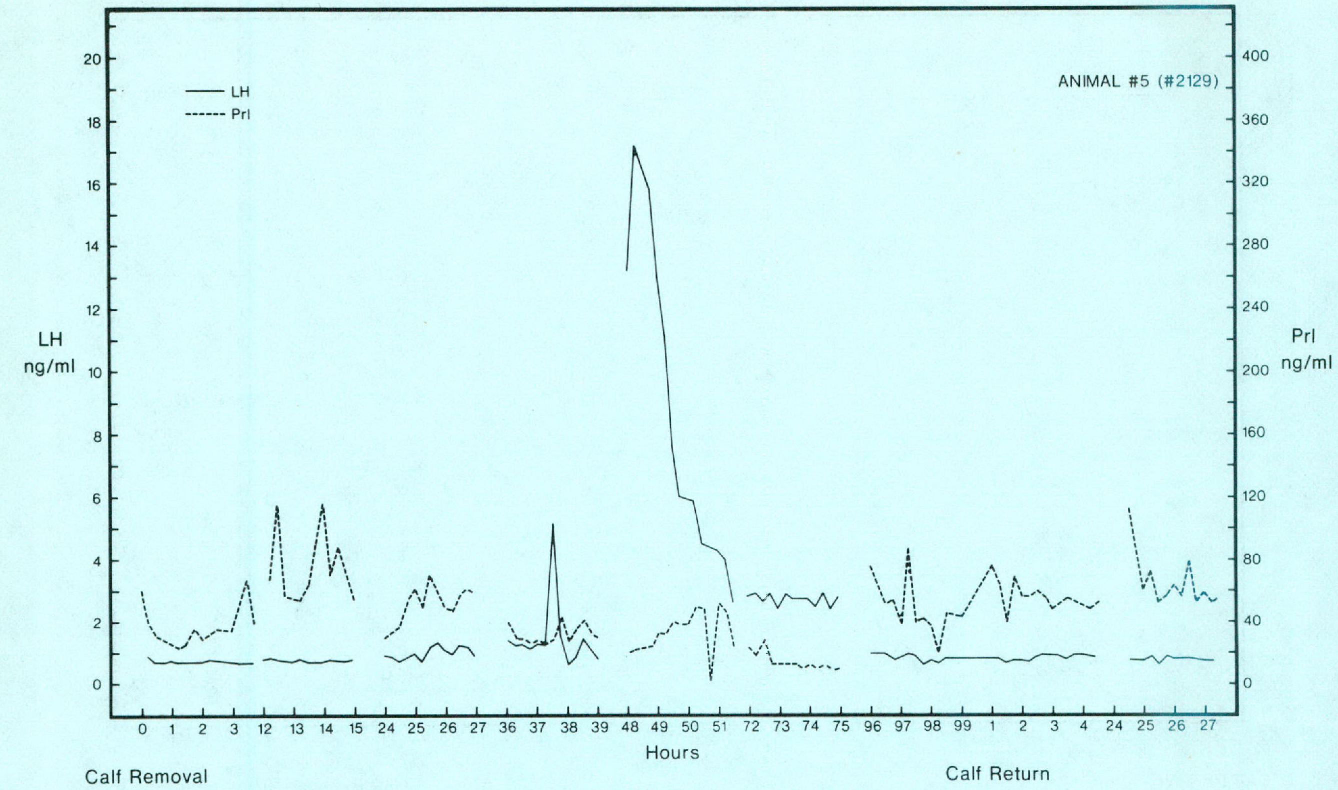

Figure 3. Examples of LH and PRL levels in cows of general hormone pattern 2.

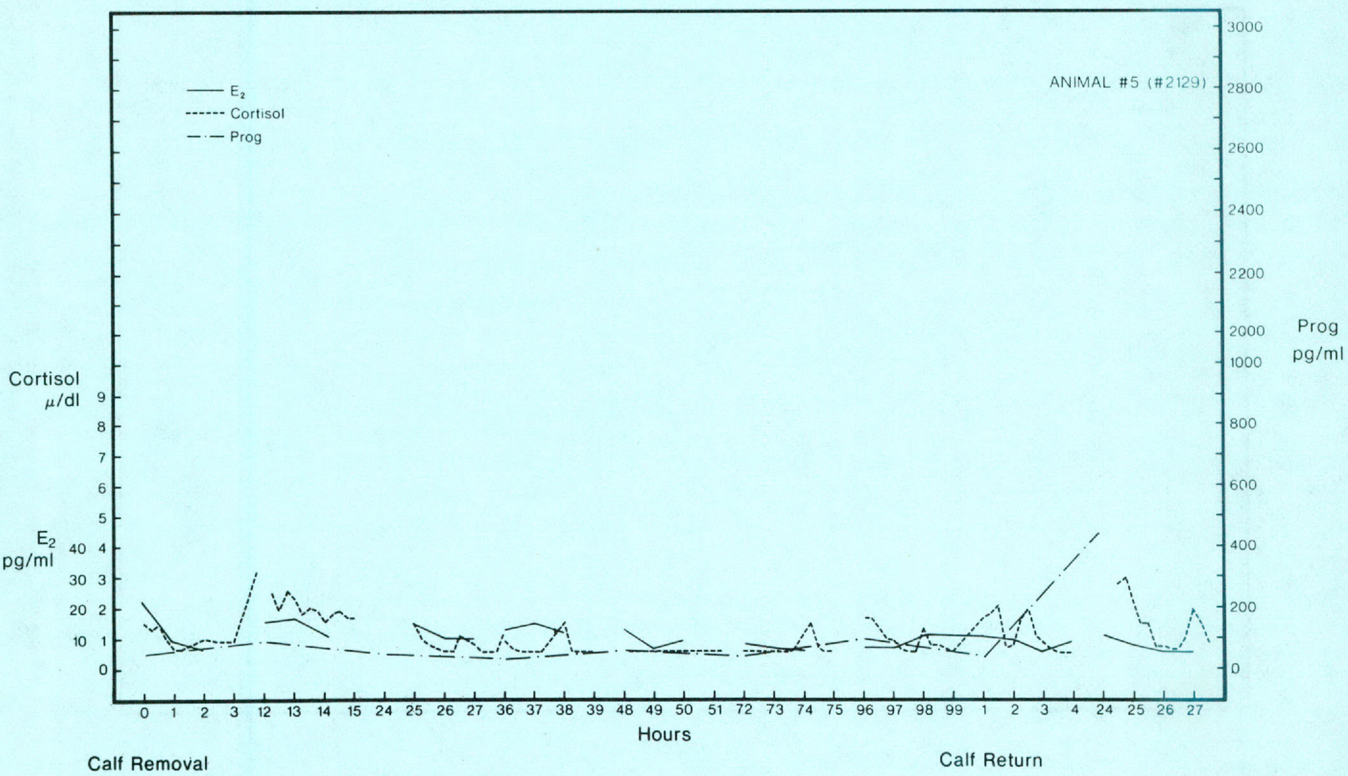

Figure 4. Examples of estrogen, cortisol, and progesterone in cows of general hormone pattern 2.

crease levels of LH and increase prolactin. The interaction between suckling and cortisol on the levels of pituitary and ovarian hormones were studied in this experiment.

Experimental Procedure

Indwelling cannulas were placed in the jugular veins of five crossbred Brahman cows 30 days after calving. Calves were removed, and blood samples were taken every 15 minutes for seven different 3-hour periods (0-3, 12-15, 24-27, 36-39, 48-51, 72-75, and 96-99 hours post calf removal). Calves were returned after 99 hours, and blood samples were again taken every 15 minutes for two 3-hour periods (1-4 and 24-27 after calf return).

Blood samples were immediately placed at 4° C and allowed to clot for 12-24 hours. Samples were centrifuged for 30 minutes at 2,000 revolutions per minute (rpm). Serum was removed and frozen at −10° C. Samples were analyzed by radioimmunoassay techniques for serum hormone levels of prolactin, LH, estradiol, progesterone, and cortisol.

Results and Discussion

Two general hormone release patterns were seen following calf removal: (a) LH levels remained at basal levels when prolactin and cortisol levels were high (Figures 1 and 2) and (b) LH levels increased at 24-48 hours post calf removal when prolactin and cortisol levels were low (Figures 3 and 4).

Estrogen levels were low throughout the entire period in all animals. Some elevated progesterone levels of each general hormone pattern group were seen in one animal.

These data indicate that during a period of calf removal, LH activity will increase within 48 hours when cortisol and prolactin levels remain low. When cortisol and/or prolactin levels increase, LH activity will remain low. This may indicate that not all cows will respond to calf removal because elevated cortisol and prolactin levels interfere with release of LH. Data also indicate that when LH activity occured, it returned to baseline levels after 60 hours of calf removal and remained there during the rest of the 99-hour period of the study.

PR-3782

Cow Condition and Pregnancy

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Summary

Pregnancy rate was 63 and 26 percent lower in cows in poor and moderate body conditions, respectively, than in cows in good condition. The main reason for this difference appears to be the delay in onset of heat following calving in thin cows.

Introduction

Nutrition has two effects on rebreeding in cows: (a) many cows which are thin at calving time do not show heat after calving, and (b) cows losing weight during breeding have a low pregnancy rate.

Experimental Procedure

One hundred and eighty-seven Santa Gertrudis first calf heifers were used in the first study. Cows calved from December 20 to January 9 and assigned a condition score shortly before calving. Following calving, cows were on poor native range and received 5 to 10 pounds of ground sorghum per day. Bulls were turned with the cows from March 13 to May 13. Pregnancy diagnoses were performed when bulls were removed and approximately 40 days after bulls were removed.

The second group of cows, were crossbreds at the Texas Agricultural Experiment Station at Beeville, calved over a 3-month period from January through March. These were given a condition score shortly before calving and placed on full feed of hay or good pasture following calving. Cows were checked for estrus twice daily.

Results and Discussion

Only 24 percent of cows in thin condition became pregnant during the 60-day breeding season compared to 87 percent of cows in good condition (Table 1). The importance of body condition can perhaps best be seen by noting that more cows in good body condition were pregnant after 20 days of breeding than in thin cows after 60 days of breeding (24 percent vs 65 percent).

TABLE 1. COW CONDITION AND PREGNANCY

	Condition score at calving		
	Thin	Moderate	Good
Number of cows	25	139	23
Cows calving first 20 days (Dec. 20 to Jan. 9)			
Pregnant after breeding (%)			
20 days (Mar. 13 to Apr. 2)	4	27	65
60 days (Mar. 13 to May 13)	24	61	87

The main reason thin cows did not become pregnant was the lack of estrus. Of cows in the second study, 78 percent of those in moderate body condition showed estrus by 60 days after calving, in contrast to 43 percent in cows in thin body condition. These results are similar to others and indicate that thin cows must gain considerable weight and body condition before they will exhibit estrus (Table 2).

Pregnancy rate is lowered in cows which are thin at calving because many do not show estrus. Cows should calve in moderate condition to allow rapid return to estrus.

TABLE 2. COW CONDITION AND HEAT

Cow condition at calving	Number cows	Proportion of cows showing estrus after calving by 30 days	45 days	60 days
Moderate	38	10	55	78
Thin	37	5	24	43

PR-3783

Effect of Age at First Calving And Once Daily Suckling Upon Days Open And Calving Interval in First Calf Brahman X Hereford Heifers

R. D. RANDEL

Summary

Brahman x Hereford heifers calving first at 3 years of age returned to estrus an average of 78 days earlier than heifers calving at 2 years of age. Three-year old heifers had a 79-day shorter predicted calving interval than did 2-year-old first calf heifers. By use of the once daily suckling management system, days from calving to pregnancy were shortened by 25 days in 3-year-old heifers and 81 days in 2-year-old heifers. Once daily suckled 3-year-old heifers had the shortest predicted calving interval (348 days) followed by once daily suckled 2-year-old heifers (369 days), normally suckled 3-year-old heifers (371 days) and normally suckled 2-year-old heifers (450 days). Acceptable average calving intervals may be obtained by breeding heifers to calve first as 3-year-olds or by using the once daily suckling technique on heifers bred to calve as 2-year-olds.

Experimental Procedure

Twenty-seven Brahman x Hereford F-1 heifers calving first at 3 years of age and 35 Brahman x Hereford F-1 heifers calving first at 2 years of age were assigned to either a normal or once daily suckling management system. Fourteen 3-year-old and 17 2-year-old heifers were placed in the once daily suckling system and 13 3-year-old and 18 2-year-old heifers in the normal suckling system. The once daily suckling treatment began at 21 days after calving and ended when the heifers reached estrus. After reaching estrus the calves were allowed to suckle normally until all calves were weaned at 205 days of age. During the once daily suckling period the two groups were maintained in separate pastures which were rotated at 3-week intervals to remove pasture effects upon cow-calf performance. Fertile bulls equipped with chin ball markers were maintained with the heifers from 21 days postcalving until all heifers were pregnant. Bulls were rotated between groups at 3-week intervals. Heifers and calves were weighed at 21 and 205 days after calving.

Results and Discussion

Three-year-old heifers were open for the shortest period of time ($P<.005$) with normal suckled heifers getting pregnant in 81.5 ± 7.5 days as compared to 2-year-old normal-suckled heifers getting pregnant in 159.6 ± 17.8 days. Once daily suckling shortened the interval from calving to pregnancy in both age groups ($P<.005$) with 3-year-olds getting pregnant in 56.3 ± 5.3 days and 2-year-olds in 78.7 ± 8.8 days. Predicted calving intervals followed the same pattern with 3-year-old once daily heifers calving in 347.5 ± 5.0 days, 2-year-old once daily heifers in 368.8 ± 8.8 days, 3-year-old normal heifers in 370.9 ± 7.5 days and 2-year-old normal heifers in 449.6 ± 17.8 days between first and second calvings (Table 1).

Three-year-old heifers weaned the heaviest calves ($P<.005$) and normally suckled calves weaned at heavier weights than did once daily suckled calves ($P<.005$). The loss in calf weight at weaning due to once daily suckling was 53.5 pounds for 3-year-olds and 42.3 pounds for 2-year-olds (Table 1). In a previous study it was found that once daily suckling beginning at 30 days of age did not affect weaning weights. The recommendation that calves be 30 days old when beginning the once daily suckling system is based on this data. The weight loss at weaning of the

TABLE 1. EFFECT OF AGE AND SUCKLING ON COW-CALF PERFORMANCE

	Suckling Treatment: Normal, Age 3	Normal, Age 2	Once Daily, Age 3	Once Daily, Age 2
	(Average±Standard Error)			
Days open	81.5± 7.5	159.6±17.8	56.3± 5.3	78.7± 8.8
Calving interval (Days)	370.9± 7.5	449.6±17.8	347.5± 5.0	368.8± 8.8
21-day cow weight (lbs)	938.8±27.2	743.4±19.0	926.8±24.0	763.2±21.1
205-day cow weight (lbs)	977.3±32.5	775.8±20.6	952.9±28.1	843.2±17.4
21-day calf weight (lbs)	132.5± 5.0	113.3± 3.3	122.6± 4.7	117.5± 3.1
205-day calf weight (lbs)	489.2±11.2	431.4± 8.6	435.7±16.7	389.1±13.5
Gain/cow-calf unit (lbs)	395.2±28.9	350.2±21.8	341.4±35.9	351.8±23.4

first calf will be made up by increased age at weaning and increased weight at weaning of the second calf if weaning of the calves is on a single date rather than by age of calf. When total gains of the heifer and calf are taken together, no statistically significant differences were found. The weight gains of the once daily suckled heifers compensated for the lowered weaning weights by the once daily suckled calves. The loss of weaning weight is also more than compensated for by the decreased interval between first and second calves.

PR-3784

Effect of Monensin on Luteinizing Hormone Response of Prepuberal Heifers Administered a Multiple Gonadotropin-Releasing Hormone Challenge

R. D. RANDEL AND R. C. RHODES III

Summary

Ten prepuberal Simmental x Brahman-Hereford heifers weighing 208 ± 4 kilograms (kg) were randomly assigned to receive either 2.7 kg per head per day of ground milo containing 0 milligrams (mg) monensin sodium (C) or 2.7 kg per head per day of ground milo containing 200 mg monensin sodium (M). Both groups of five animals received Coastal bermudagrass hay *ad libitum* throughout the trial. On day 21 of the feeding period, all heifers were fitted with jugular cannulae. Immediately after cannulation, the heifers were injected intramuscularly with 100 micrograms (μg) of gonadotropin-releasing hormone (GnRH) and blood was collected every 10 minutes for 4 hours. Four hours after the first GnRH challenge, a second 100 μg GnRH injection was administered and blood samples were collected at 10-minute intervals for an additional 5 hours. Serum was stored at −20° C until radioimmunoassay for luteinizing hormone (LH). The LH released after each GnRH injection was greater in the heifers fed M than in the control ($P<.05$). Peak LH after the first GnRH challenge was greater ($P<.05$) in heifers fed M than in controls. The area under the first GnRH-induced LH curve had a tendency ($P<.20$) to be greater for the M group than for the controls. The peak LH concentration was greater in heifers fed M than in control heifers as was the duration ($P<.05$) and area under the second GnRH-induced LH curve. In prepuberal heifers, dietary monensin appears to increase hypophyseal capability of releasing LH after a first and second GnRH challenge.

Experimental Procedure

Ten prepuberal Simmental x Brahman-Hereford heifers were randomly allotted, within similar body weights and similar body condition scores, to one of two dietary treatment regimens within a completely randomized experimental design. Five animals were assigned to be fed 2.7 kg per head per day of ground milo containing 0 mg of monensin (C), and the five others to receive 2.7 kg per head per day of ground milo containing 200 mg of monensin. All animals received Coastal bermudagrass hay *ad libitum* throughout the trial. A 7-day adjustment period before the beginning of the trial was used to insure total consumption of the assigned ration. The trial consisted of feeding all heifers the concentrate (with or without monensin) plus hay for 20 days. On day 21, all animals were fitted with an indwelling silastic cannula. All animals were given intramuscular injections of 100 μg GnRH at time zero and again at time 240 minutes. Blood was collected at time zero and at 10-minute intervals for 9 hours.

Serum was harvested and stored at −20° C until analyzed for LH by a modification of the double antibody radioimmunoassay. Antibovine LH serum, B-225, was used as the first antibody. A 1:100,000 dilution of the antibody, which bound 35 percent of the ^{131}I bovine LH, was utilized with nonspecific binding less than 4 percent. Immunochemical LH was used for radioiodination and the antibody hormone complex was precipitated with ovine-antirabbit gamma globulin. Bovine LH (NIH-LH-B9) was used as the reference standard, and results were expressed in terms of this preparation.

Responses to injection of GnRH were assessed by (1) GnRH-induced peak LH concentrations, (2) time interval relationships between GnRH injection and LH response, (3) duration of GnRH-induced LH surges and (4) area under the GnRH-induced LH curves. The area under the LH curve was calculated by integration of the LH concentration over time by a method described by Stein (5). An LH surge was defined as a sustained increase in serum LH at least two standard deviations above LH concentrations before GnRH injections. The duration of the LH surge was determined as the time interval from the initiation of the GnRH-induced LH surge until LH concentration returned to within one standard deviation of the LH concentration before the surge.

Each individual LH measurement parameter was analysed using 2×2 factorial analysis of variance to determine any significant effects of treatments (4).

Results and Discussion

Administration of gonadotropin-releasing hormone (GnRH) to either heifers or bulls has been shown to consistently elicit an acute LH surge (6). Similarly, in the present study, GnRH induced an LH surge after both a first and a second GnRH challenge in prepuberal heifers fed either 0 or 200 mg monensin (Figures 1 and 2). However, there were differences in the characteristics of the GnRH-induced LH surges between the two experimental dietary regimens. Significant differences ($P<.05$) in LH concentrations were observed for the following main effects: treatment (monensin *vs* control), GnRH challenge number

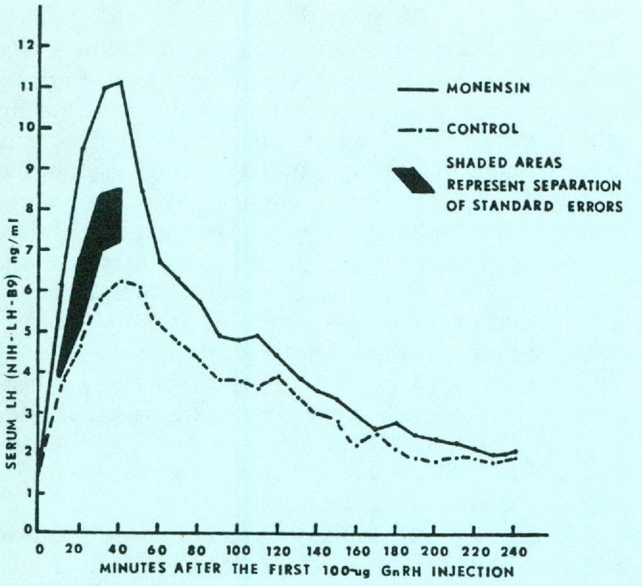

Figure 1. Effect of dietary monensin on the first GnRH-induced LH surge in prepuberal heifers.

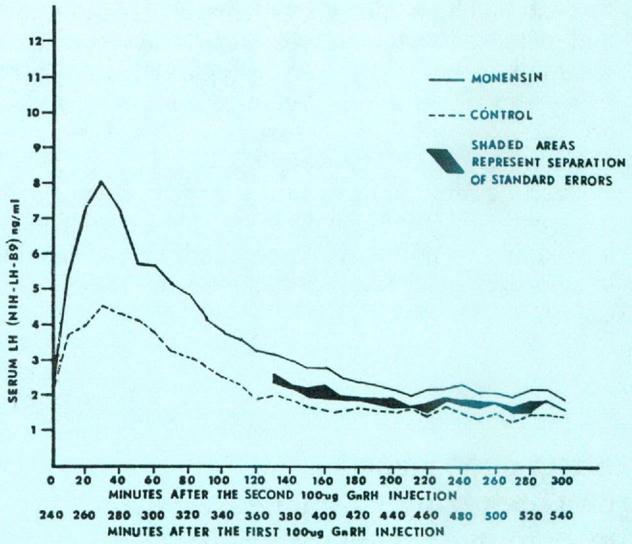

Figure 2. Effect of dietary monensin on the second GnRH-induced LH surge in prepuberal heifers.

(first *vs* second), and time of bleeding. No interactions between the main effect factors were found.

LH concentrations before the first GnRH-induced LH surge did not differ between the two treatment groups (Table 1). After the first GnRH challenge, both treatment groups exhibited LH surges, as indicated by the increase in serum LH within 10 minutes of the injection (Figures 1 and 2). This rapid increase in GnRH is consistent with the observation of Fernandes *et al.* (1) who noted an increase in serum LH within 5 minutes of GnRH injection. The time to peak LH concentration did not differ between the two dietary treatment groups after either the first or second GnRH challenge (Table 2). The control group had a shorter time to peak LH concentration after the second GnRH challenge compared to the first GnRH challenge ($P<.05$), yet the monensin group did not ($P>.10$) (Table 2). The time intervals from GnRH injection to the peak LH concentrations were smilar to those observed by Kesler *et al.* (3) and shorter than the time to peak values reported by Fernandes *et al.* (1). Prior to the second GnRH challenge, serum LH concentrations decreased to preinjection values (Table 1).

TABLE 1. EFFECT OF DIETARY MONENSIN ON PRE-LH SURGE CONCENTRATIONS

	LH (ng/ml)			
	Monensin		Control	
Time	Mean	SE[a]	Mean	SE
Sample prior to first LH surge (0 min)	1.7[b]	.3	1.6[b]	.3
Sample prior to second LH surge (240 min)	2.1[b]	.4	1.9[b]	.2

[a]SE = standard error of the mean.

[b]Means followed by different superscripts differ ($P<.05$).

Peak LH concentrations differed ($P<.05$) between the monensin and control-fed heifers following the first GnRH challenge (Table 3). The monensin-fed heifers responded with a greater peak LH concentration than the control-fed heifers. By 240 minutes after the first GnRH injection, serum LH in both treatment groups had returned to preinjection values (Table 1). Following the second GnRH challenge, the peak LH height was lower ($P<.05$) when comparing peak LH concentrations with the first GnRH challenge (Table 3). In the second GnRH-induced LH surges, the monensin-fed heifers had a greater ($P<.05$) peak LH concentration than did the control heifers. These peak values are somewhat low-

TABLE 2. EFFECT OF DIETARY MONENSIN ON TIME TO PEAK LH VALUE FOLLOWING TWO GnRH CHALLENGES

	Time (min)			
	Monensin		Control	
Number of GnRH challenge	Mean	SE[a]	Mean	SE
First	36[b,c]	5.1	40[c]	3.2
Second	30[b,c]	5.5	24[b]	6.8

[a]SE = standard error of the mean.

[b,c]Means followed by different superscripts differ ($P<.05$).

TABLE 3. EFFECT OF DIETARY MONENSIN ON PEAK LH CONCENTRATIONS FOLLOWING TWO GnRH CHALLENGES

	Serum LH (ng/ml)			
	Monensin		Control	
Number of GnRH challenge	Mean	SE[a]	Mean	SE
First	11.6[b]	2.7	6.5[c,d]	1.2
Second	8.1[b,c]	2.5	4.4[d]	1.3

[a]SE = standard error of the mean.

[b,c,d]Means followed by different superscripts differ ($P<.05$).

er than values reported in the literature for surges following single 100-μg GnRH challenges with several different animal models (1,3,2). The disparity between LH concentrations following the first and second GnRH stimulation may be due to possible hypophyseal depletion of LH during the second GnRH challenge and (or) a refractory hyposensitivity to GnRH during the second GnRH challenge.

The duration of the first GnRH-induced LH surges did not vary between the monensin-fed and control-fed heifers (Table 4). However, there was a difference (P<.05) between the duration of the first GnRH-induced LH surge in monensin-fed heifers and the duration of the second GnRH-induced LH surge in control-fed heifers. A possible explanation for differences in duration between the first and second GnRH challenges may be the depletion of pituitary LH available for secretion into systemic circulation during the second GnRH challenge. Duration of the first and second LH surges in the monensin-fed heifers and the first LH surge in the control heifers were similar to those reported by Kesler *et al.* (3) and Jordan and Swanson (2). However, the duration of the second GnRH-induced LH surge in the control-fed heifers was somewhat shorter than the durations observed in the two studies cited.

TABLE 4. EFFECT OF DIETARY MONENSIN ON DURATION OF LH SURGES FOLLOWING TWO GnRH CHALLENGES

	Time (min)			
	Monensin		Control	
Number of GnRH challenge	Mean	SE[a]	Mean	SE
First	196[b]	14.4	176[b]	7.5
Second	178[b]	20.6	104[c]	26.6

[a]SE = standard error of the mean.
[b,c]Means followed by different superscripts differ (P<.05).

The areas under the LH curve are presented in Table 5. The monensin-fed heifers had a greater area (P<.05) under the curve after the first GnRH injection when compared to the control-fed heifers after the second GnRH injection. There was a nonsignificant decrease in the area between the first and second GnRH challenges in both treatment groups.

TABLE 5. EFFECT OF DIETARY MONENSIN ON AREA UNDER LH CURVES FOLLOWING TWO GnRH CHALLENGES

	Area (units)			
	Monensin		Control	
Number of GnRH challenge	Mean	SE[a]	Mean	SE
First	695.6[b]	110.1	407.8[b,c]	105.4
Second	610.8[b,c]	221.0	277.1[c]	88.9

[a]SE = standard error of the mean.
[b,c]Means followed by different superscripts differ (P<.05).

In summary, dietary monensin fed at a level of 200 mg per head per day, increased pituitary capability of prepuberal heifers to secrete LH upon multiple GnRH challenges. The present study further contributes to recent data indicating that feeding dietary monensin can enhance the reproductive function of the prepuberal heifers.

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PR-3785

Effect of Monensin Upon Ovarian Response Following Gonadotropin Treatment in Prepuberal Heifers

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Summary

Twenty prepuberal Charolais x Brahman-Hereford heifers were randomly assigned to be fed a concentrate containing either 0 milligrams (mg) (C) or 200 mg (M) monensin sodium per head per day. Coastal bermudagrass hay was fed *ad libitum*. Average daily gain was similar for the two groups. Each heifer received 1 mg of porcine follicle stimulating hormone (FSH-P) at 0800 and 2000 hours on days 22 through 26 (10 mg total) and 2,500 IU human chorionic gonadotropin (HGC) on day 27. Flank laparotomy for ovarian examination was performed on day 30, and ovariectomy was performed on day 37. The average ovarian size ± standard error at day 15 was 3,730 ± 66 cubic millimeters (mm^3) and 1,848 ± 55 mm^3 for M and C groups, respectively (P<.025), as measured by rectal palpation. Number of ovulation sites measured at day 30 were 9.1 ± 2.2 and 4.9 ± 1.8 ovulation sites per heifer for M and C groups, respectively (P<.01). After ovariectomy on day 37, M-fed heifers were found to have greater ovarian weight (P<.05), more corpora lutea (CL) (P<.05), greater total luteal weight (P<.05), more follicles (P<.01) and

greater weight of follicular fluid (P<.05) and stroma (P<.025) than C-fed heifers. Corpora lutea were analyzed for progesterone content by spectrophotometric procedures. The monensin-fed heifers had slightly larger CL (P<.10) containing a similar concentration of progesterone compared to C heifers. This resulted in more luteal progesterone per CL and more luteal progesterone per heifer in the M heifers than in the controls. Prepuberal heifers fed monensin, which caused the expected shifts in rumen fermentation and volatile fatty acid production, exhibited an enhanced ovarian response to gonadotropins compared to controls.

Experimental Procedure

Twenty prepuberal Charolais x Brahman-Hereford heifers (age 12 to 13 months, mean weight 240 ±7 kilograms (kg) were randomly assigned to two groups of 10 heifers each. The control group was fed a pelleted concentrate containing 0 mg monensin (C); the other group was fed a similar concentrate containing 200 mg monensin sodium per head per day (M). Both groups were fed approximately equal amounts of the pelleted concentrate ration; Coastal bermudagrass hay was fed *ad libitum* (Table 1).. Rumen fluid samples were taken via stomach tube on days 0 and 14 of the experiment (day 1 is onset of feeding regimen).

All heifers were palpated rectally on day 15 to determine ovarian size and determine that corpora lutea were not present. Each heifer received 1 mg FSH-P IM at 0800 and 2000 hours on days 22 to 26 (10 mg total) and 2,500 IU HCG IM at 0800 hours on day 27. Flank laparotomy was performed on each heifer on day 30 to expose the ovaries. Ovarian volume was measured; ovulation sites and follicles were counted. Bilateral ovariectomies were performed on day 37. Immediately after excision, each ovary was cleared of excess blood and tissue, weighed and photographed. All visible follicles were counted, ruptured and drained of fluid,and the ovary was reweighed. (The difference between ovarian weight prior to and ovarian weight after follicular rupture is referred to as "weight of follicular fluid.") Corpora lutea were then dissected from the ovary. All CL from a given ovary were weighed together ("total CL weight") and separately, after which each CL was labeled and frozen in a plastic vial. Residual ovarian tissue was weighed and termed "stroma." Corpora lutea were individually analyzed for progesterone (P) content spectrophotometrically. Statistical analysis between groups was performed by Students T-test or analysis of variance (5).

TABLE 1. FEED CONTENT AND CONSUMPTION

Ingredient	Internat'l Ref. No.	Mean daily consumption/head (kg) Control	Monensin
Coastal bermudagrass hay	1-00-716	2.93	2.54
Pelleted conc.		3.36	3.27
Conc. composition			
Sorghum milo	4-04-44	2.69	2.62
CSM	5-01-621	.47	.46
NaCL	--	.03	.03
Ca_2PO_4	6-01-080	.03	.03
$CaCO_3$	6-01-069	.01	.01
Molasses	4-00-668	.08	.08
Binders Masonex		.08	.08
Bentonite		.04	.04
Monensin		0	200 mg

Results and Discussion

Both groups of heifers consumed similar amounts of concentrate. More roughage was consumed by C heifers than by M heifers, a response previously demonstrated by Raun *et al.* (3) (Table 1). Rate of gain was not different (P>.10) between groups (Table 2).

After 15 days of experimental feeding, ruminal fluid from the M heifers contained more (P<.05) propionate compared to that from the C heifers (Table 2). Similar results have been reported by Raun *et al.* (3). Ovaries of M heifers were twice as large as those of C heifers at this time (3,730 ± 66 vs 1,848 ± 55 mm^3, respectively). This difference suggests a propionate-triggered ovarian response to endogenous hormones in prepuberal heifers.

Heifers fed M averaged nearly twice as many ovulation sites in response to gonadotropin treatment as C heifers, as measured at day 30 laparotomy (9.1 ± 2.2 vs 4.9 ± 1.8, respectively). More definitive measurements of ovarian response were obtained at day 37 ovariectomy. All ovarian variables measured, including ovarian weight, number of follicles, weight of follicular fluid, number of CL, weight of CL, and weight of stroma, were significantly greater (P<.05) in M heifers than in C heifers. These data are detailed in Table 3. Ovarian sensitivity to the doses of FSH and HCG (7) was amplified in all aspects of ovarian development in the group which was fed monensin sodium and which demonstrated the subsequent increase in ruminal C_3. Progesterone concentration (P) in corpora lutea (microgram per gram (μg/g) tissue)

TABLE 2. EFFECT OF FEEDING GROUP ON FEEDLOT GAIN AND EFFICIENCY

Mean parameter	Feeding groups Control ± SE[a]	Monensin ± SE
Initial weight, kg	239.7±6.8	239.7±6.9
Day 21 weight, kg	255.7±9.3	257.0±7.0
Gain, kg	16.7±3.9	17.3±3.6
ADG, kg	.67± .08	.69± .07
Daily feed intake/ head, kg	6.29± .77	5.82± .67
Feed/gain, kg	9.39	8.43
C_2/C_3, day 15	4.20	2.63

[a]Standard error of the mean.

did not differ (P>.10) between the M and C groups (Table 4). However, as M heifers had more CL of a slightly larger size, the mean luteal P per heifer and the mean P per CL were greater in the M than in the C group. These data suggest both an enhancement in development of immature follicles and a subsequent increase in luteal development of M-group ovaries compared to those of controls.

The mean number of ovulation sites reported at day 30 laparotomy was greater than the mean number of corpora lutea dissected from the same ovaries 7 days later (Table 3). This discrepancy may have been the result of inaccurate initial counts, failure of some ovulation sites to develop into normal CL or merging of adjacent corpora lutea.

The enhanced ovarian sensitivity of heifers fed M and with increased ruminal propionate supports the work of Moseley *et al.* (2), Rhodes *et al.* (4), McCartor *et al.* (1) and Turner *et al.* (6), all of whom showed differences in reproductive performance related to monensin or concentrate-induced rumen fermentation changes.

Although the mode of action is still elusive, this study demonstrates a definite, fast acting, positive relationship between increased ruminal propionate and ovarian response to endogenous and exogenous gonadotropins.

TABLE 3. MEAN OVARIAN VARIABLES OF CONTROL- AND MONENSIN-FED HEIFERS FOLLOWING GONADOTROPIN TREATMENT AS MEASURED AT DAY 37 OVARIECTOMY

	Feeding group	
Ovarian variable	Control ± SE[a]	Monensin ± SE
Ovarian weight (g)	19.4±4.5**	48.3±11.4
Number CL	3.3± .6*	7.0± 1.7
Total CL weight (g)	10.6±2.5*	26.7± 6.8
Number follicles	3.0± .3*	5.2± .5
Weight of follicular fluid (g)	4.2±1.7*	14.2± 1.3
Weight of stroma (g)	3.5± .5*	7.2± 1.3

[a]Standard error of the mean.
*P<.05.
**P<.02.

TABLE 4. ANALYSIS OF CORPORA LUTEA FROM GONADOTROPIN-TREATED PREPUBERAL HEIFERS IN MONENSIN AND CONTROL GROUPS

	Feeding group	
Mean ovarian parameter	Control ± SE[a]	Monensin ± SE
CL weight (g)	2.6± .5	3.5± .4
Progesterone conc. (μg/g)	82.1± 20.7	85.5± 15.8
Progesterone/CL (μg)	192.2± 42.3	324.1± 62.9†
Luteal progesterone/ heifer (μg)	1613.5±527.6	5410.6±1207.7*

[a]Standard error of the mean.
†P<.10.
*P<.05.

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PR-3786

Effect of Alteration of Ruminal Fermentation on Efficiency of Growth and Onset of Puberty in Brangus Heifers

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And L. H. Carrol

Summary

The influence of monensin and an altered roughage:concentrate ratio on age and weight at puberty was determined in 90 purebred Brangus heifers of known age and weight. The heifers were stratified according to weight per day of age and randomly assigned to a control diet of 80 percent alfalfa hay and 20 percent concentrates (C); C plus 200 milligrams (mg) monensin per head per day (M), or to a diet of 50 percent alfalfa hay and 50 percent concentrates (HE). Daily dietary intake of metabolizable energy (ME), crude protein (CP), and major minerals was similar for all diets and resulted in equivalent rates of daily gain [.60 kilograms (kg) per head per day] and similar increases in body condition score (3.46, where 1 = very thin and 10 = very fat). Analysis of volatile fatty acids (VFA) of the rumen fluid (molar percent) at 3, 5 and 7 hours postprandial on day 80 of the trial showed an increase (P<.01) in propionate (C_3) due to M and HE treatments, and a reduction (P<.05) in acetate (C_2). Heifers with elevated ruminal propionate values (M and HE groups) reached puberty 29.5 days younger than controls (P<.009) and weighed 17.2 kg less (P<.03) than controls. It is concluded from these data that treatments which alter ruminal fermentation towards increased ruminal propionate production will decrease age at puberty in beef heifers.

Experimental Procedure

Feeding Trial

Ninety purebred prepuberal Brangus heifers of known age and weight at weaning with a mean age and weight of 316 days and 242 kg, respectively, were stratified according to weight per day of age and randomly allotted to one of two replicates in each of three dietary treatments. Treatments were C, containing 80 percent alfalfa hay and 20 percent concentrates; M, which was the same as C plus 200 mg monensin per head per day; and HE, which contained 50 percent alfalfa hay and 50 percent concentrates. Diets were formulated and fed at levels to provide equal daily crude protein intake and to produce equivalent live weight gains of about 0.59 kg per animal per day. The controlled daily feed was fed once daily and consumption recorded daily by replicates. Unshrunk live weights were taken on days 1, 30, 45, 73, 108, 122, 150, and 157 of the trial. The feeding trial portion of the study was terminated on day 157. Rumen samples were taken via stomach tube on days 12, 80, 123, and 157 of the trial from all heifers in replicate 1 and were assayed for total volatile fatty acids (VFA), using procedures of Erwin *et al.* (3). Rumen samples taken on day 80 were taken at 3, 5 and 7 hours post-feeding to determine uniformity of VFA response over that time period.

Puberty Study

An epididymectomized bull equipped with a chin ball marker was placed with each replicate in each treatment group and the heifers were observed for estrus twice daily. Age at puberty was recorded as the age at which a heifer first accepted the service of a bull accompanied by evidence such as vaginal mucous discharge and swelling of the vulva. Heifers observed to be in estrus were bred artifically or were handmated to a fertile Brangus bull. Weight at puberty was extrapolated from the live weights immediately preceding and following the puberal estrus. Any heifer which did not attain puberty during the feeding trial portion of the study was fed her experimental diet until puberty was observed. To estimate the effects of treatments on fertility, pregnancy rate for each treatment resulting from the pubertal insemination was determined by rectal palpation at least 60 days after breeding.

All variables were submitted to analysis of variance procedures of Barr *et al.* (1). The incidence of first service pregnancy was tabulated by type of mating (artificial or natural) and analyzed by chi-square procedures of Snedecor (9). Volatile fatty acid data for the 80-day sample of rumen fluid were analyzed by procedures of Snedecor (9) using hours after feeding as replicates.

Results and Discussion

Feeding Trial

The percentage of ingredients in the three experimental diets is shown in Table 1. The control diet was designed to contain 80 percent alfalfa, but due to disproportionate feeding during one weigh period the actural percentage of alfalfa fed was 81.9 percent. The M and He treatments were fed in proportions called for in the design. The data in Table 2 show actual amounts of concentrate and hay fed and the estimated intake of protein, energy, Ca, P, K and Mg. All diets were well above requirements for all nutrients. Energy intake and protein intake were slightly higher for C than for M or He heifers. The weights and gains for the three treatment groups are shown in Table 3. Although the C animals consumed more metabolizable energy (ME) than either M or HE and gained slightly more, the difference in ADG was not significant (P>.10). The data in Table 3 indicate that none of the treatments differed significantly with respect to initial and final weights or with respect to live weight gain.

Rumen Volatile Fatty Acid Levels

Since there were no significant differences in patterns of ruminal VFA levels on different dates, the data for only the 80-day sampling are shown in Table 4. The differences in molar percentage of individual VFA's were somewhat less than expected probably due to the fact that all of the daily diet was not consumed within 3 hours after feeding, except for the HE group. All orts were removed from the feed bunks 3 hours postfeeding when sampling began. Molar percentage of acetate (C_2) was increased in C compared to M + HE ($P<.05$) and molar percentage of propionate (C_3) was increased ($P>.01$) by M and HE treatments. Butyrate molar percentage was higher ($P<.01$) in the HE treatment and lower in the M group. Total VFA's were unaffected ($P>.10$) by treat-

TABLE 1. EXPERIMENTAL DIETS

Ingredient	Internat'l Ref. No.	Ratio of roughage to concentrate: 80:20 (Control)	80:20 (Control & Monensin)	50:50 (High energy)
Cottonseed meal	5-01-621	. . .	. . .	14.00
Micronized milo	4-04-444	16.26	18.00	35.00
Salt		.90	1.00	1.00
Sodium tripolyphosphate	6-08-076	.90	1.00	. . .
Alfalfa hay	1-00-050	81.94	80.00	50.00
Monensin (mg/head/day)		. . .	200.00	. . .

TABLE 2. DAILY INTAKE OF CONCENTRATES AND ALFALFA HAY AND ESTIMATED INTAKE[a] OF CRUDE PROTEIN, METABOLIZABLE ENERGY, CA, P, K AND MG

Treatment	Control	Control and Monensin	High energy
Concentrate, kg	1.46	1.37	3.11
Alfalfa hay, kg	6.65	5.46	3.11
Crude protein, kg	1.29	1.08	1.08
ME megcal	15.93	13.50	14.16
Ca, g	127.98	105.22	61.88
P, g	39.47	31.50	26.35
K, g	102.02	84.40	85.08
Mg, g	17.79	14.89	16.61

[a]Estimated from NAS (7).

TABLE 3. EFFECT OF DIET AND MONENSIN ON FEEDLOT GAIN AND EFFICIENCY DURING THE 157 DAY FEEDING PERIOD

Treatment	Conrol	Control and Monensin	High energy
Initial weight, kg	241.1[a]	242.4[a]	246.4[a]
Final weight, kg	342.7[a]	336.9[a]	342.9[a]
Gain, kg	101.6[a]	94.5[a]	96.5[a]
ADG, kg	.65[a]	.60[a]	.61[a]
Feed intake, kg	8.02	6.83	6.22
Feed/gain	12.33	11.38	10.01
ME intake, megcal[b]	15.93	13.50	14.16
ME/kg gain, megcal[b]	24.51	22.50	23.21
Percentage of control		91.81	94.70

[a]Values on the same line bearing common superscripts are not different (P>.10).

[b]Estimated from NAS (7).

TABLE 4. EFFECT OF MONENSIN AND ROUGHAGE:CONCENTRATE RATIO AND TIME AFTER FEEDING ON RUMINAL VOLATILE FATTY ACID (VFA) CONCENTRATION AND % CONCENTRATION OF C_2, C_3 and C_4

Treatment	Time after feeding, hr	3	5	7	$\bar{x}$ SEM
Control	C_2, %	67.00	67.12	67.11	67.05[a]± .24
	C_3, %	21.60	21.01	21.10	21.24[c]± .24
	C_4, %	11.48	11.86	11.98	11.74[c]± .27
	Total mM/1	87.33	81.33	73.62	80.76[a]±2.98
Control and Monensin	C_2, %	67.01	66.90	66.73	66.88[b]± .34
	C_3, %	23.80	23.36	22.94	23.37[d]± .31
	C_4, %	9.18	9.73	10.31	9.74[d]± .19
	Total mM/1	67.00	70.74	73.41	70.38[a]±2.11
High energy	C_2, %	65.19	63.08	62.97	63.74[b]± .50
	C_3, %	22.30	22.76	22.40	22.25[d]± .56
	C_4, %	12.31	14.14	14.67	13.71[e]± .41
	Total mM/1	83.98	80.08	73.67	79.49[a]±2.95

[a,b]Values in the same column bearing different superscripts are different (P<.05).

[c,d,e]Values in the same column bearing different superscripts are different (P<.01).

ment. Time after sampling did not have an effect on either molar percentage of individual VFA or on total VFA values (P>.10).

Reproductive Effects

Since treatments successfully achieved similar rates of gain in heifers of equal age and initial experimental weight, and since the age and weight at puberty were similar for M and HE groups, these two groups were pooled and compared to C for combined treatment effect on age and weight at puberty (Table 6). Using these comparisons there was no difference (P>.05) between C and M + HE with respect to weaning age, weaning weight, initial experimental weight, final experimental weight, ADG, initial condition score and final condition score. There was, however, a difference (P<.009) in age at puberty with C having a mean age at puberty of 514 days and M + HE having a mean age of 485 days, a difference of 29 days (Table 6). Weight at puberty was likewise reduced (P<.03) when M + HE were compared to C. Mean weight at puberty was 332 kg for C and 315 kg for M + HE combined. The fertility of the heifers, as evidenced by first service pregnancy rate, was not significantly affected by treatment (Table 5). The percentage of heifers pregnant from insemination at the pubertal estrus for C, M and HE was 63.3, 58.6, and 61.5, respectively.

This study was designed to test the hypothesis that age at puberty could be reduced by shifting ruminal fermentation toward greater propionate production when all other factors known to affect age at puberty were equalized by experimental design. An earlier study at this laboratory by Mosely *et al.* (6) showed that more heifers fed monensin reached puberty within a given experimental period than control animals. However, Moseley *et al.* (6) did not establish that the puberty response was not due to some effect of monensin other than the known effect of ruminal VFA patterns. This study confirmed the effect of monensin on puberty as shown by Moseley *et al.* (6) when heifers were fed 80:20 roughage:concentrate diets. These data further demonstrate that a 50:50 roughage:concentrate diet, fed at lower levels to achieve equal metabolizable energy intake and ADG, caused a shift in ruminal VFA similar to the 80:20 diet with 200 mg monensin and did result in a similar reduction in age and weight at puberty.

The changes shown in age at puberty in this study cannot be accounted for by any of those factors known to affect age at puberty, such as pre-weaning growth, post-weaning growth, ADG while on experiment, or body condition score. The study by Rhodes *et al.* (8) in which a substantial portion of the energy and protein in a protected lipid diet was rumen-bypassed, and therefore unavailable for rumen fermentation, created faster growing, fatter heifers but reduced (P<.05) the percentage of heifers attaining puberty. More control heifers which were fed a diet that provided more fermentable carbohydrates in the rumen attained puberty than heifers fed the protect-

TABLE 5. PREGNANCY RATE OF HEIFERS AT PUBERTAL ESTRUS FROM ARTIFICIAL (AI) AND NATURAL (N) MATINGS

Type of mating	Treatments						X^z
	Control		Control & Monensin		High energy		
	Proportion	%	Proportion	%	Proportion	%	
AI	8/14	57.1	10/13	76.9	11/16	68.8	1.22
Natural	11/16	68.8	7/16	43.8	5/10	50.0	2.41
Total	19/30	63.3	17/29	58.6	16/26	61.5	.14

TABLE 6. EFFECT OF DIET AND MONENSIN ON AGE AND WEIGHT AT PUBERTY AND CONDITION SCORE

Treatment	Control	Control & Monensin	High energy
Age at puberty, days	514.3 ± 9.98^a	489.9 ± 9.93^b	479.2 ± 7.78^b
Wt at puberty, kg	332.6 ± 6.25^c	314.9 ± 5.28^d	316.0 ± 6.80^d
Initial condition score	$3.90\pm .06$	$3.66\pm .07$	$3.81\pm .09$
Final condition score	$7.15\pm .07$	$7.15\pm .12$	$7.44\pm .10$

[a,b]Values on the same line bearing different superscripts are significantly different (P<.009).

[c,d]Values on the same line bearing different superscripts are significantly different (P<.03).

ed lipid (P<.05). The findings in this study and those of Moseley *et al.* (6) and Rhodes *et al.* (8) in no way alter the conclusions drawn from numerous studies relating energy intake to puberty (2, 4, 5, 10, 11). However, it now is apparent that qualitative aspects of the diet may be as important in determining onset of puberty as quantative aspects of energy intake.

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PR-3787

Effect of Monensin Upon Ovarian Response to FSH-P in Sexually Mature Crossbred Heifers and Brahman Cows

R. D. Randel, L. M. Harrison and T. R. Hansen

Summary

Bovine females in two separate trials were allotted randomly to receive a concentrate containing 0 (C) or 200 milligrams (mg) (M) monensin sodium/head/day. Trial 1, including 33 Simmental x Brahman-Hereford heifers approximately 17 months of age, was conducted in 1979. Trial 2 was initiated in 1980 and employed 14 Brahman cows between 2 and 6 years of age. C and M animals within each group were placed on feed on the same trial day, with the heifers in experiment 1 exhibiting one estrus before further treatment and the cows in experiment 2 fed for 3 months. Each animal was then injected with 1 mg of porcine follicle stimulating hormone (FSH-P) at 0800 and 2000 hours on days 16 through 21 of the estrous cycle or until the animal displayed estrus. In experiment 1, nine C and nine M heifers were ovariectomized in the afternoon of day 21 or the day they reached estrus. The remaining eight C and seven M heifers in the first trial were allowed to ovulate and were ovariectomized on day 11 after the FSH-P treatment. All 14 cows in experiment 2 were allowed to ovulate and were examined by flank laparotomy on day 13 after estrus. Those M heifers allowed to ovulate in experiment 1 had more corpora lutea (CL)/ovary (P<.025), more CL/animal (P<.10), greater mean CL weight (P<.005) and higher total CL weight/animal (P<.10). The heifers not allowed to ovulate had no significant differences between C and

M. The cows in experiment 2 had similar tendencies in ovulation rate as the heifers ovulating in experiment 1. Corpora lutea taken from heifers allowed to ovulate were analyzed spectrophotometrically for progesterone concentration. Although the C group contained more progesterone/CL, the M group tended to have a greater amount of progesterone/animal because of the increased number of CL found in M. Concentrations of progesterone on a μg/g of tissue basis were almost equivalent.

Experimental Procedure

Experiment 1

Thirty-three Simmental x Brahman-Hereford heifers weighing approximately 311 kilograms (kg) and approximately 17 months of age were allotted randomly to receive a diet containing either no monensin (C) or 200 mg monensin (M). The 17 C heifers and 16 M heifers were fed 2.24 kg of 80 percent ground milo and 20 percent cottonseed meal/head/day. The heifers were maintained in drylots with access to Coastal bermudagrass hay *ad libitum*. All heifers were placed on feed on the same day and prior to further treatment exhibited one estrous cycle. Sterile marker bulls were maintained with the heifers to aid in estrus detection. On day 16 of the estrous cycle, each heifer was injected with 1 mg of porcine follicle stimulating hormone (FSH-P) at 0800 hour and at 2000 hour. Injections were continued until day 21 or until the heifer displayed estrus.

Nine C and nine M heifers were ovariectomized in the afternoon of day 21 or the day they reached estrus. Eight C and seven M heifers were allowed to ovulate and develop CL and were ovariectomized on day 11 after the FSH-P treatment estrus.

The ovaries of the heifers not allowed to ovulate were cleaned of excess blood and tissue and weighed. Follicles were then counted and ruptured to weigh follicular fluid and stroma. The ovaries of heifers allowed to ovulate were processed in the same manner, and additionally the CL were enucleated for weighing, then placed in plastic vials and frozen until individually assayed for progesterone content spectrophotometrically.

Experiment 2

Fourteen estrous-cycling, purebred Brahman cows between 2 and 6 years of age were allotted randomly to receive a diet containing either no monensin (C) or 200 mg monensin (M). The seven C cows and seven M cows were fed 1.35 kg of 75 percent ground milo and 25 percent cottonseed meal/head/day. The cows were maintained in paddocks with access to Coastal bermudagrass hay *ad libitum*. All cows were placed on feed on the same day and maintained on the same diet for approximately 3 months (January 3, 1980 to April 6, 1980). Sterile marker bulls were maintained with the cows to aid in estrous detection. Commencing on trial day 81 and on day 16 of the estrous cycle of each cow, each animal was injected with 1 mg FSH-P at 0800 hr and 2000 hr. Injections were continued until day 21 or until the cow displayed estrus. All cows were allowed to ovulate and develop CL and were inspected for ovarian structures by standing flank laparotomy on day 13 after the FSH-P treatment estrus.

Results and Discussion

In both experiments, the animals consuming monensin displayed an altered ovarian response to the FSH challenge when compared to their respective control groups. Statistical analysis, using Student's t test, of the various ovarian indices examined in experiment 1 reveals significant differences between the monensin and control groups in number of CL/ovary ($P<.025$), CL/animal ($P<.10$), average CL weight ($P<.005$), and total CL weight/animal ($P<.10$) (Table 1). The data from older cows in experiment 2 indicate similar tendencies in the number of CL/ovary, number of CL/animal, and approximate CL size (Table 2).

Analysis of the CL extracted from the ovaries of the heifers which were allowed to ovulate in experiment 1 revealed several trends. The M group tended to have a greater amount of progesterone/animal, although the C group contained more progesterone/CL, because of the increased number of CL found in M. Concentrations of progesterone on a

TABLE 1. MEAN OVARIAN PARAMETERS OF CONTROL AND MONENSIN-FED SEXUALLY MATURE HEIFERS FOLLOWING EXOGENOUS FSH-P CHALLENGE AS MEASURED AT ESTROUS CYCLE DAY 11 OVARIECTOMY

	Treatment group	
Ovarian variable	Control ± SE[a]	Monensin ± SE
Ovarian weight (g)	12.483±1.371	14.490±2.378
Stroma weight (g)	5.066± .536	4.046± .458
Follicular fluid weight (g)	3.467± .492	2.626± .466
Number follicles>8mm	33.2 ±2.8	25.0 ±4.0
Number follicles≤8mm	1.0 ± .2	1.1 ± .3
Largest follicle	10.8 ±1.4	8.4 ± .8
CL/ovary	1.6 ± .4*	4.0 ± .9
CL/animal	3.7 ±1.1**	8.0 ±2.4
CL weight (g)	2.504± .321***	1.945± .132
Total CL wt/animal (g)	4.069± .802**	7.702±1.820

[a]Standard error of the mean.
*$P<.025$.
**$P<.10$.
***$P<.005$.

TABLE 2. MEAN OVARIAN PARAMETERS OF CONTROL AND MONENSIN-FED BRAHMAN COWS FOLLOWING EXOGENOUS FSH-P CHALLENGE AS MEASURED AT ESTROUS CYCLE DAY 13 LAPAROTOMY

	Treatment group	
Ovarian variable	Control ± SE[a]	Monensin ± SE
CL/ovary	1.16±.56	1.57±.41
CL/animal	2.33±.71	3.14±.70
CL/size (mm)	15.43±.87	16.27±.82

[a]Standard error of the mean.

micrograms (μg)/g of tissue basis were almost equivalent (Table 3).

Examination of the results of the ovariectomies of those heifers not allowed to ovulate in experiment 1 failed to show any significant differences in response to the FSH challenge (Table 4). These data indicate several aspects of reproduction that can be influenced by monensin. The absence of significant differences between C and M in heifers not allowed to ovulate implies that it is an increased sensitivity to gonadotropins at the time of ovulation that allows the development of more ovarian structures, rather than a preovulatory increase in gross ovarian parameters.

TABLE 3. ANALYSIS OF CORPORA LUTEA FROM CONTROL AND MONENSIN-FED SEXUALLY MATURE HEIFERS FOLLOWING EXOGENOUS FSH-P CHALLENGE

	Treatment group	
Mean ovarian parameter	Control ± SE[a]	Monensin ± SE
Progesterone/animal (μg)	1012±249	1805±534
Progesterone/CL (μg)	272± 48	226± 13
Progesterone conc. (μg/g)	145± 21	145± 14

[a]Standard error of the mean.

TABLE 4. MEAN OVARIAN PARAMETERS OF CONTROL AND MONENSIN-FED SEXUALLY MATURE HEIFERS FOLLOWING EXOGENOUS FSH-P CHALLENGE AS MEASURED BY OVARIECTOMY AT ESTRUS

	Treatment group	
Ovarian variable	Control ± SE[a]	Monensin ± SE
Ovarian weight (g)	7.652± .922	8.256±1.110
Stroma weight (g)	4.634± .502	4.719± .512
Follicular fluid weight (g)	3.018± .506	3.537± .766
Number follicles>8mm	22.7 ±3.3	19.4 ±1.7
Number follicles≤8mm	3.4 ± .8	4.2 ± .9
Largest follicle (mm)	12.6 ±1.0	14.3 ±1.1

[a]Standard error of the mean.

The ovulation rate, while increasing in all monensin-fed bovine females, does not appear to occur in a uniform, unequivocal manner. The older cows had less dramatic increases in the various ovarian parameters measured than the sexually mature heifers. Even greater responses were achieved by the prepuberal heifers given a challenge of FSH and human chorionic gonadotropin (HCG). These graduations in response suggest that the more mature, well-developed endocrine system is in some way less sensitive to monensin-induced physiological changes.

It would seem that the ovarian ability to form luteal cells is also affected as the M heifers had smaller individual CL. It cannot be ruled out, however, that strict spatial limitations may have played a role in luteal development, due to the much greater number of CL formed. Correction of luteal tissue concentrations of progesterone to μg of hormone per gram of tissue basis implies that the ability of the luteal cells to produce progesterone remains largely unaffected, since concentrations when examined under that criterion are very nearly equal.

The results from these trials suggest that the monensin-induced ovarian response noted can be evoked in bovine females of all ages. Several conclusions can be drawn from these data: (1) Dietary monensin exerts an endocrinological effect on bovine females of all ages; (2) the rate of ovulation is markedly increased in monensin-fed cows receiving an exogenous gonadotropin challenge; the magnitude of increase appears to be somewhat dependent upon the sexual maturity of the female; and (3) the ability of CL cells to produce progesterone is not affected by the monensin supplement fed to sexually mature heifers.

PR-3788

Effect of Season and Monensin On the Preovulatory Luteinizing Hormone Surge in Brahman Cows

R. D. Randel and L. M. Harrison

Summary

Twenty-seven estrous cycling Brahman cows between 2 and 6 years of age were allocated randomly to receive a concentrate containing either no monensin (C) or 200 milligrams (mg) monensin per head per day (hd/day) (M). All cows were placed on feed on the same day, and blood samples were taken in January (WI), March (SP), and May (SU) to quantitate the preovulatory luteinizing hormone (LH) surge. The blood samples were taken via tail vessel venipuncture immediately upon detection of standing estrus, and continued hourly until 24 hours (hr) postestrus. Radioimmunoassay was used to determine serum LH concentrations. Dietary monensin increased the number of cows in the WI group expressing an LH surge, (1 of 5 C vs 5 of 5 M) ($P<.010$), but not the number of surges in later samplings. Combined WI and SP values indicated more M displaying a peak LH surge after onset of estrus (3 of 10 C vs 10 of 15 M) ($P<.10$). Comparing WI-C and WI-M groups using an estrus through hr 24 postestrus LH profile, denotes M values being more elevated by treatment ($P<.001$), by period ($P<.001$), and by a treatment x period interaction ($P<.005$). M values were also higher in a SP-C/SP-M comparison by treatment ($P<.005$) and by period ($P<.001$). LH values from SP and SU depict greater LH concentrations in M from the LH peak until basal levels are reached by treatment and period ($P<.001$). Seasonal effects are noted in the number of C cows exhibiting an LH surge in January (1 of 5) and March (9 of 10) ($P<.005$). SP-C and SU-C values did not differ significantly, but

both were greater than WI-C by treatment and by season (P<.001) when compared over the 24-hr period. Basal levels of LH tended to increase from winter to summer. WI-M was not different from SP-M in number of animals exhibiting an LH surge, but had lower LH concentrations than SP-M when compared to the 24-hr profile. These results suggest that seasonal effects, occurring between the shortest and longest days of the year, exert their greatest influence on the preovulatory LH surge in Brahman cows between January and March. Seasonal effects on the LH surge appear to be partially modulated by nutritional factors.

Experimental Procedure

Twenty-seven estrous cycling Brahman cows between 2 and 6 years of age were allocated randomly to receive a concentrate containing either no monensin (C) or 200 mg monensin /hd/day (M). Thirteen C and 14 M cows were fed 1.36 kilograms (kg) of 75 percent milo and 25 percent cottonseed meal daily and were maintained in paddocks with access to Coastal bermudagrass hay *ad libitum.* Sterile heat-check bulls equipped with chin-ball markers were kept with each group to aid in estrous detection. Both groups were observed at least every 4 hr to identify those cows approaching estrus. When a cow stood to be mounted by the marker bull or another cow, she was immediately removed from the herd and bled via tail vessel venipuncture for 24 hours. All cows were placed on feed the same day (January 3, 1980) and blood samples were collected at three different seasons. The first group of samples (WI) consisted of five sets of samples from each of the C and M groups, and were all taken before mid-January. A second set of samples (SP) was taken from 10 C and 10 M cows in March. Monensin was discontinued after the SP sampling, and approximately half of the cows from each group were combined into one control group and tested a final time in late May (SU) to obtain 10 more sets of samples. The remaining cows were returned to the breeding herd. Single blood samples were also taken on days 10, 11, and 12 after estrus to be analyzed for progesterone content to confirm that an LH surge did occur and that an ovulation resulted. All blood samples were immediately placed under refrigeration upon collection, processed to yield serum, and stored at −20° C until assayed for hormone content. The assay used to quantitate LH concentrations was a modification of the double antibody radioimmunoassay.

The parameters of the LH measurements made were (1) timing of the onset of the LH surge, (2) peak LH concentrations, (3) total LH surge profile, as measured by LH magnitude and duration from estrus through hour 24 postestrus, (4) LH profile as measured by LH magnitude and duration from peak LH concentration through hour 24, (5) area under the LH curve from the LH peak to hour 12 after the peak. The area under the LH curve was calculated by integrating the LH concentration over time. An LH surge was defined as a sustained acute elevation of LH at least two standard deviations above basal LH levels at hour 24. The duration of the LH surge was determined by calculating the time interval from the initiation of the estrous-induced LH surge until LH concentration returned to within one standard deviation of the basal LH levels at hour 24.

Analysis of variance (ANOVA) and chi square were used to determine any significant effects of monensin or season within each of the aforementioned parameters.

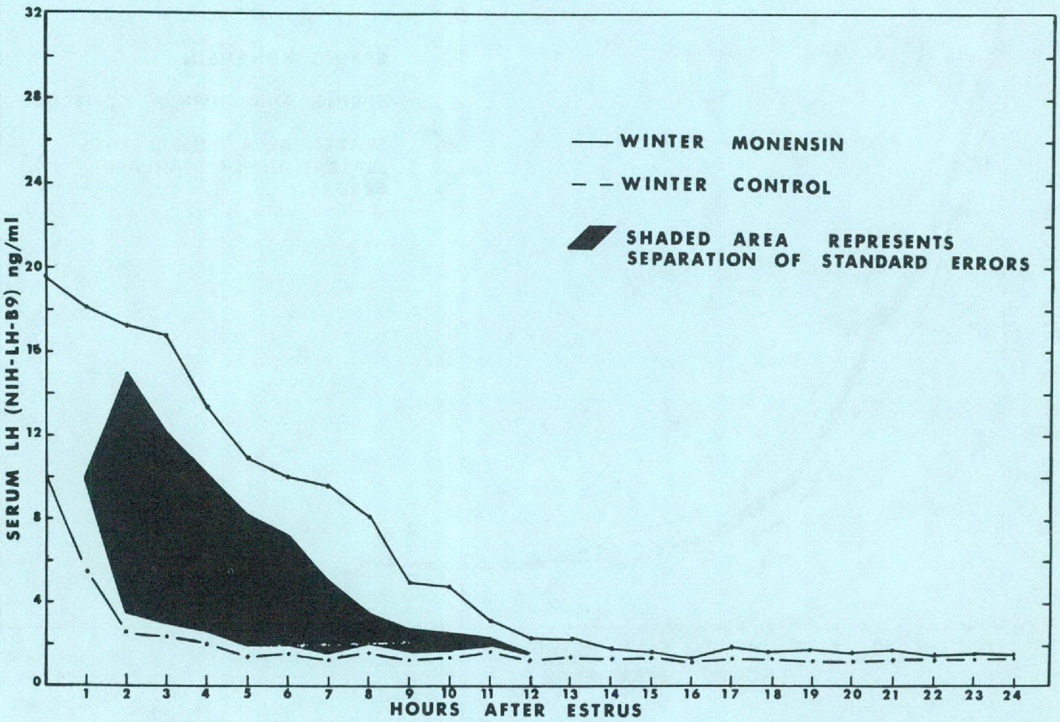

Figure 1. Effect of dietary monensin on the LH surge in Brahman cows in the winter.

Results and Discussion

Examination of the data indicated that both monensin and season exerted an effect on the nature of the LH surge.

Chi square analysis of the timing of the onset of the preovulatory LH surge pointed out distinct differences between C and M. Only one of five cows in the WI-C group manifested an LH surge, whereas five of five WI-M cows had a surge ($P<.010$). Further evidence of an altered timing was attained by combining WI and SP values for analysis. The number of cows where the peak LH value was not the first sample taken with three of 10 for C as opposed to 10 of 15 for M ($P<.10$).

Since analysis of the timing of the onset of the LH surge indicated that the C groups were either exhibiting a delayed behavioral estrus or the LH surge was initiated earlier, it was considered probable that the LH peak had occurred prior to the initial blood sample in a number of cows. Any analyses which

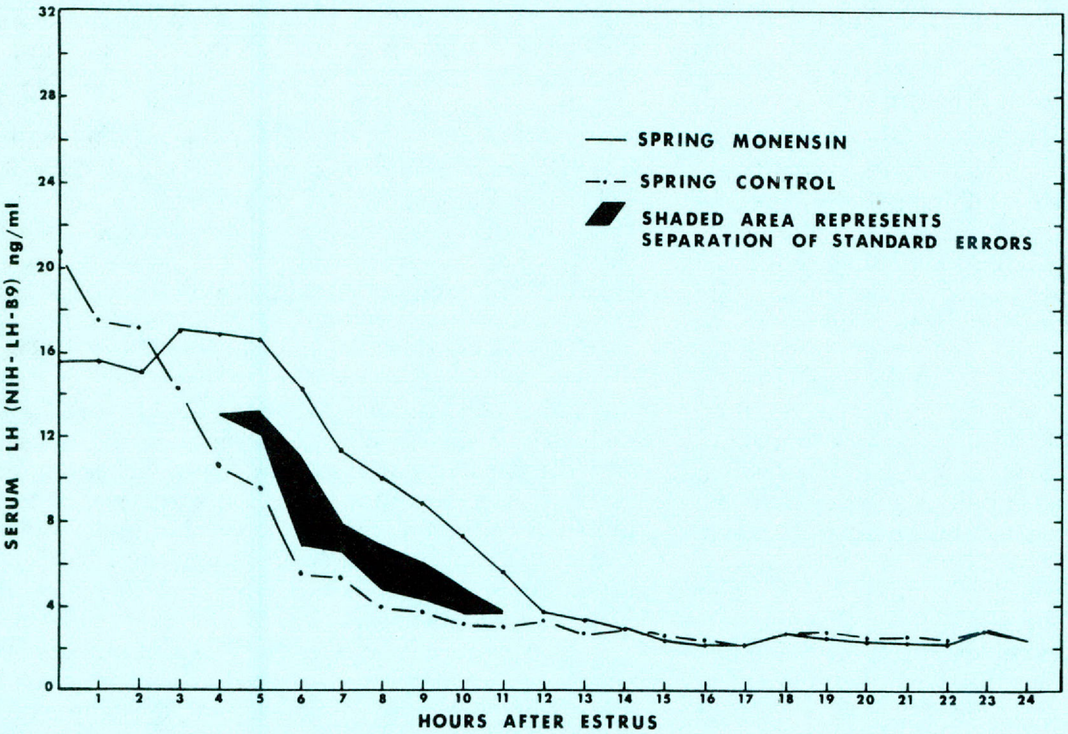

Figure 2. Effect of dietary monensin on the LH surge in Brahman cows in the spring.

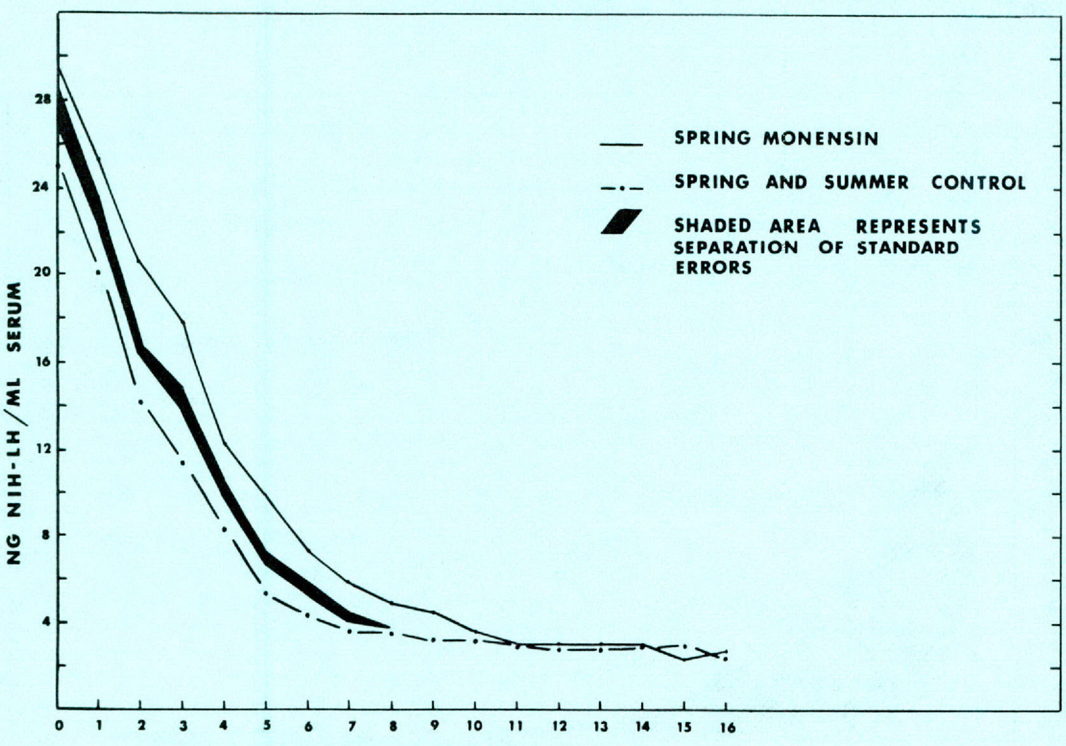

Figure 3. Effect of dietary monensin on the LH peak in Brahman cows in the spring.

portrayed an LH profile from peak concentration to a later time were disregarded as being inaccurate, except those comparisons made where peak LH values were not the first sample taken.

Two separate comparisons were made employing the estrus through hour 24-LH profile to further ascertain any monensin-induced differences. A WI-C/WI-M analysis of variance denotes differences by treatment (P<.001), by period (P<.001), and a treatment x period interaction (P<.005), the monensin values being more elevated in all cases (Figure 1). Comparing SP-C to SP-M yielded similar results. Differences existed between treatments (P<.005) and by period (P<.001), but there was no treatment x period interaction (Figure 2).

As no significant treatment differences were noted between the SP and SU control groups, all values where the LH peak was known were combined to permit a comparison to the SP-M group. A monensin-induced enhancement of the LH surge is

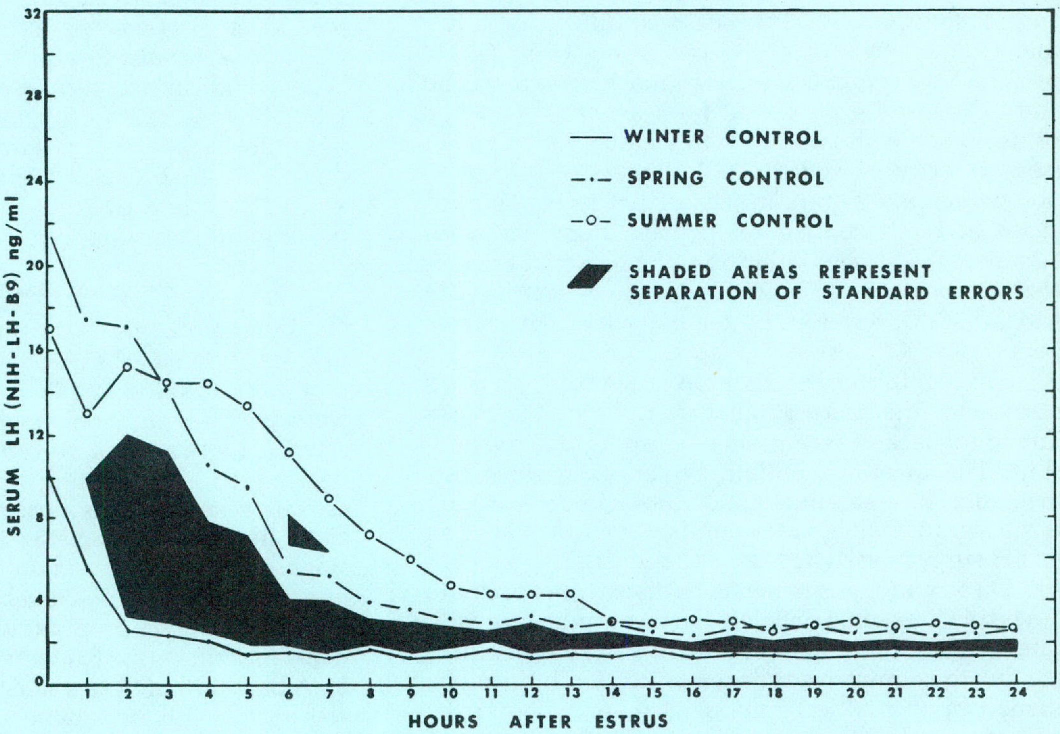

Figure 4. Effect of season on the LH surge in Brahman cows in the winter, spring and summer.

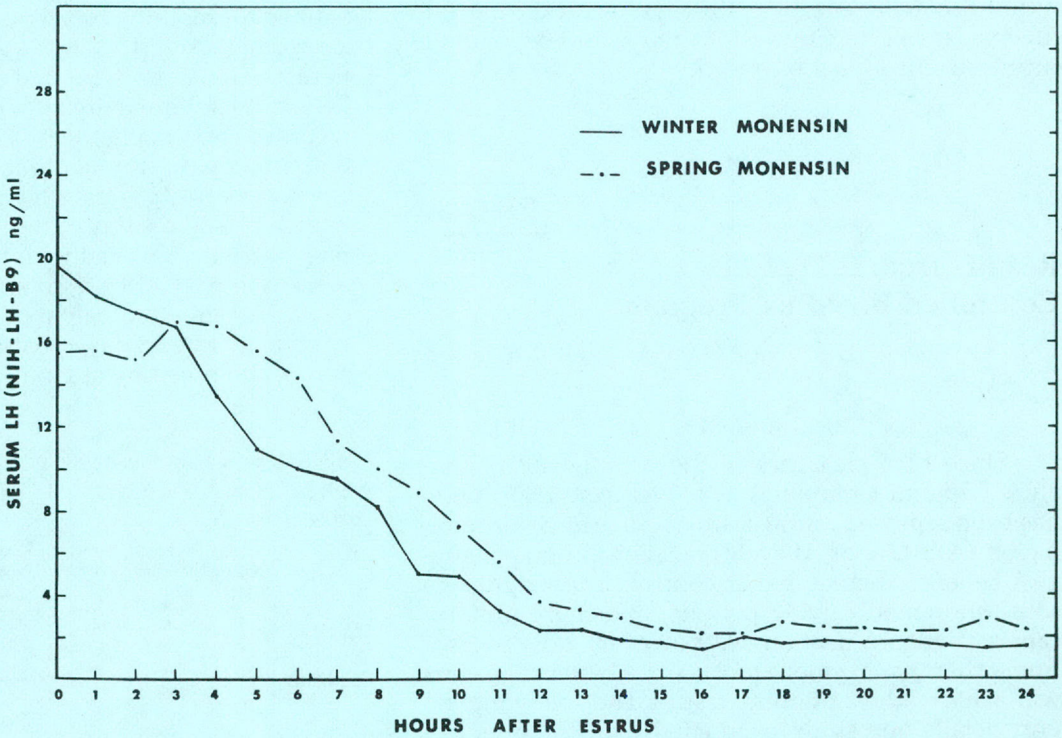

Figure 5. Effect of dietary monensin and season on the LH surge in Brahman cows in the winter and spring.

most clearly seen by this comparison. Again, treatment and period differences were highly significant (P<.001) (Figure 3).

A profound seasonal effect was explained by comparing WI-C to SP-C. Evidence of an LH surge was seen in nine of 10 SP cows but in only one of five WI cows (P<.005). This difference did not appear between the SP-C group and those cows tested in May; all 10 of the SU-M group had an LH surge. While not statistically significant, more of the SU group tended to surge later than the combined WI and SP control cows. This seasonal difference is further clarified by examining the estrus to hr 24-LH profile. No differences were found between the SP and SU control groups, but both exhibited elevated values when compared to WI-C, either by treatment (season) or by period (P<.001) (Figure 4). Although not statistically significant, basal LH levels as measured at hr 24 tended to increase from winter to summer. Additional indication of a seasonal effect is seen by the estrus to hr 24-LH profile between WI-M and SP-M. Differences by teatment (P<.05) and by period (P<.005) resulted (Figure 5).

The significance of this study regarding seasonal/nutritional interaction is somewhat difficult to assess due to the lack of recent data regarding this relationship. The most perceptible evidence of nutritional mediation of a seasonal/endocrinological association is the significantly greater number of cows exhibiting an LH surge in early winter while consuming monensin. Dietary monensin seems to display a capacity to "override" seasonal dictates. Further studies are indicated to determine whether the observed differences are due to an improved plane of nutrition induced by monensin at a critical time of year, or whether the altered volatile fatty acid concentration in the rumen, and subsequent energy pathways, are exerting an effect on the endocrine system above and beyond an improved nutritional balanced.

PR-3789

Results from a Typical Controlled Breeding Program

RICK HARDIN AND J. R. BEVERLY

Summary

Since FDA clearance of the prostaglandin, Lutalyse (Upjohn Company) in November, 1979, there has been renewed enthusiasm about artificial insemination (AI). Use of AI/sychronization programs suggest benefits such as better control of breeding seasons, shortened calving periods, and more uniform calves. Synchronization is, however, no different from other management tools — the better managers will achieve the optimum results.The following report details one study conducted with the intent of optimizing the results from a controlled-breeding program.

Introduction

Pharmaceutical companies have justifiable concern regarding the probable results of synchronization programs in southern beef cow operations. Results from field trails conducted in the southern region of the U. S. (1) have caused some skepticism since differences in pregnancy rates (17 vs 32 percent) between a single fixed time AI breeding and controls bred over a 24-day period were reported. Results from the southern locations have been consistently below those in northern sites in average pregnancy rate. The trial described below was conducted under rigid constraints (a) to maximize pregnancy rates and (b) to compare the results of a two-Lutalyse injection-single fixed time AI program with those of conventional natural service.

Experimental Procedure

Purebred Santa Gertrudis heifers were assigned to either a timed-AI (TAI) or pasture-bred control (C) group. Prior to the initiation of the study, the heifers were weighed and palpated *per rectum* for ovarian activity. Only a small percentage of the heifers were determined to be cycling by palpation, and a poor estrous response was observed following one Lutalyse injection. The heifers were maintained as a single group for 5 weeks on a corn-based ration with minerals and pasture available *ad libitum*.The double Lutalyse injection program was started on May 26 so that TAI heifers (n = 63) were bred on June 10 (Figure 1). A bull evaluated as a satisfactory potential breeder was placed with the C heifers (n = 19) after the second injection. Semen used in the TAI group was examined for motility, total live normal sperm cells, and acrosomal integrity.Two qualified technicians administered AI and rotated approximately every 5 heifers. Estrous activity after the second injection was recorded, and heifers were bred at approximately 80 hours following the last injection irrespective of estrous activity. Heifers which returned to estrus between 17 and 24 days after the TAI were bred AI. Bulls were then placed with the TAI heifers. All bulls were removed after a total breeding season of 58 days. Heifers were palpated *per rectum* to determine pregnancy rate 78 days post-AI and 45 days after the end of the breeding season.

Figure 1. Schematic illustration of the breeding procedure used in the trial.

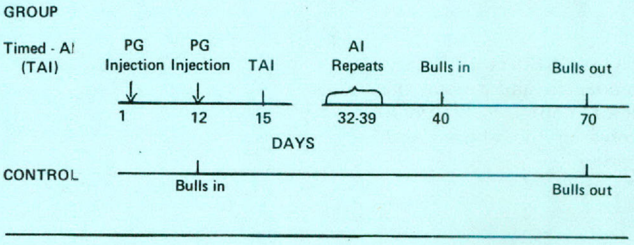

TABLE 1. PREGNANCY RATES FOR TREATMENT GROUPS

Variable	Animal no.	Pregnant no.	%
Treated-AI (TAI)	63	23	37
Not treated-bull (C)	19	7	37

TABLE 2. PREGNANCY RATES FOR AI TECHNICIANS

Variable	Animal no.	Pregnant no.	%
AI-tech "A"	37	13	35
AI-tech "B"	26	11	42

TABLE 3. PREGNANCY RATES FOR ESTROUS DETECTION

Variable	Animal no.	Pregnant no.	%
E (estrus detected)	31	12	39
NE (no estrus detected)	32	11	34

Results and Discussion

In previous years the cattle used in the trials had achieved a 70- to 80-percent pregnancy rate during a 90-day breeding season. From this information, an expected single-service pregnancy rate was calculated to be approximately 35 percent. The single-service pregnancy rate to AI and natural service (24-day period) agree closely with the expected value calculated from previous heifer performance (Table 1). The conception rates achieved by the two technicians (Table 2) did not differ significantly (35 vs 42 percent). The similarity in pregnancy rate (Table 3) between heifers that were detected in estrus (E) and those not detected in estrus (NE) is indicative of the inaccuracy and difficulty of heat detection in Brahman-type cattle. If the NE animals had not been in estrus, the pregnancy rate should have approached zero. Thirty-four heifers were detected in estrus during the repeat AI period. The inaccuracy or overestimation of 24-day non-return rates is reinforced by an actual pregnancy rate of 37 percent rather than 46 percent as forecast by non-returns. One interesting observation was that 11 (32 percent) of the 34 "repeat breeders" observed in standing estrus had previously conceived to the TAI, based on palpation *per rectum.* With the flurry of estrous activity during repeat breedings, herdsmen must recognize that some heifers demonstrating estrus are actually pregnant and thus semen should be deposited mid-cervix so as to avoid possible abortions.

TABLE 4. PREGNANCY RATES AT VARIOUS STAGES OF BREEDING SEASON

		Pregnant at				Pregnant at	
		5 days		25 days		58 days*	
Group	No.	No.	%	No.	%	No.	%
Timed-AI	63	23	37	30	48	38	60
Control	19	-	-	7	37	10	53

*Days of the breeding season.

The pregnancy rates for the different segments of the breeding season (Table 4) demonstrate the major advantage of synchronization in grouping pregnancies early in the season. Note that pregnancy rates in the synchronized/AI cattle are the same in 5 days of breeding as those attained by conventional natural service in 25 days.

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PR-3790

Status of Ultrasonic Devices for Pregnancy Determination in Cattle

RICK HARDIN AND J. R. BEVERLY

Summary

Comparisons between Animark ultrasonic instruments and palpation *per rectum* were conducted on Texas range cows to determine the utility of such devices as an alternative to palpation *per rectum.* Texas ranchers, particularly in the western sector, are faced with coordinating a variety of management tasks at any given gathering of the entire cow herd i.e., pregnancy testing, vaccinations, weaning, and shipping. Ultrasonic instruments potentially offer the utility of eliminating the scheduling of skilled personnel to perform the pregnancy-testing procedure by palpation. The inaccuracy of ultrasonic devices evidenced in this study would indicate that such instruments are a questionable replacement for palpation *per rectum.*

Introduction

The earliest documented use of palpation to determine pregnancy in cows in 1815 (1) has been followed by a barrage of different methods and variations. Pregnancy determination has been well established as a useful tool for profit-minded cattlemen. The improved efficiency of beef production realized after the implementation of a culling program should be ample reason to cull cows that are open at the end of the breeding season. Palpation *per rectum* has been the long-standing method of choice because of the accuracy and speed of each determination. While laboratory analytical techniques are available, the most efficient management policy is to test and sort open cows as they are worked, rather than re-sort cows after laboratory reports are available. Ultrasonic instruments have been advocated as an alternative to palpation. Proprietary data indicate claimed accuracy of 90 percent +, as well as easy, simple, and fast operation. The following studies were conducted to evaluate the feasibility of ultrasonic devices as a management alternative to palpation *per rectum.*

TABLE 1. HERD 1 - PREGNANCY DETERMINATION

Status based on: Palpation	Ultrasonic	Number	Percent accuracy
Pregnant	Pregnant	104	$\frac{104}{(104+11)} \times 100 = 90\%$
Pregnant	Open	11	
Total pregnant		115	
Open	Open	5	$\frac{5}{(5+13)} \times 100 = 28\%$
Open	Pregnant	13	
Total open		18	

TABLE 2. HERD 2 - PREGNANCY DETERMINATION

Status based on: Palpation	Ultrasonic	Number	Percent accuracy
Pregnant	Pregnant	59	$\frac{59}{(59+5)} \times 100 = 92\%$
Pregnant	Open	5	
Total pregnant		64	
Open	Open	8	$\frac{8}{(8+19)} \times 100 = 30\%$
Open	Pregnant	19	
Total open		27	

Experimental Procedure

Two west Texas beef cow herds of 133 and 91 Hereford, Angus, or Angus x Hereford cows were used in the studies. Experienced personnel were used for palpation and application of the ultrasonic method. For comparison, palpation *per rectum* was considered to be 100 percent accurate. The pregnancy determinations for each method were recorded and then compared. The data were partitioned into percent accuracy for pregnant cows and open cows separately.

Results and Discussion

The data for the study are summarized in Tables 1 and 2. The accuracy of 90 percent for pregnant cows is similar to reports in proprietary data. The low accuracy of the ultrasonic method in detecting open cows is, however, the major limitation and problem. Cost of wintering open cows makes such an error intolerable in cost-effective management decisions. While time required to complete each determination was not recorded, palpation was in all cases the more rapid test (approximately two to four times). Presently, the poor accuracy in diagnosing open cows as determined by ultrasonic means is considered sufficiently limiting to preclude the use of such devices as management tools.

Literature Cited

(1.) Cowie, A. T. 1948. As cited in Clinical Methods of Pregnancy Diagnosis. *In Pregnancy Diagnosis Tests: A Review* (Commonwealth Agricultural Bureaux Joint Publication No. 13: Great Britain.)

PR-3791

Selecting Bulls for Fertility

M. F. Smith, N. Parish,
and J. N. Wiltbank

Summary

Four factors were considered in evaluation of bulls for fertility: scrotal circumference, libido, ability to deposit semen in the cow, and number of normal sperm. Data indicated that bulls should be sexually functional, have a scrotal circumference over 30 centimeters (cm) at 15 months of age, and have semen with more than 65 percent normal sperm before being placed with cows. Bulls cannot be properly evaluated for fertility by evaluation of sperm cell motility.

Introduction

Bulls differ in their ability to settle cows. To achieve pregnancy in the cow, a bull must have the desire and ability to mate and must produce an adequate number of sperm of high quality. In this experiment an attempt was made to correlate bull fertility with testicular size and semen quality. An attempt was made to predict bull fertility using testicle size as a measure of sperm production and proportion of normal sperm prior to breeding as a measure of semen quality. Prepuce length, crest size, masculinity and levels of plasma testosterone were also correlated with fertility.

Experimental Procedure

Two hundred and fifty 15-18 month old Santa Gertrudis bulls located at the King Ranch were used. The scrotal circumference, prepuce length, crest size, a subjective score for masculinity, and the number of normal sperm were determined in all bulls approximately 6 weeks prior to the start of the breeding season. Any bull having poor semen quality was evaluated again 3 weeks later. Forty bulls with consistent semen quality were selected to be bred to heifers.

Each bull used in the breeding test was placed with 100 heifers for a 4-day period. The heifers were checked for heat twice daily; a chin ball marker was placed on each bull during the time he was with the heifers.

Libido was measured as the number of heifers bred by each bull compared to the number of heifers observed in heat.

Results and Discussion

Libido

Two bulls (5 percent) never mated a heifer and two (5 percent) mated only three to five heifers. Fertility rate was low in these bulls because of their lack of sexual desire or libido (Table 1). Of two bulls with low libido, one had unsatisfactory fertility rate (less than 20 percent of heifers pregnant) while the fertility rate in the other was questionable (20-40 percent of heifers pregnant).

The level of fertility in medium-and high-libido bulls varied with respect to semen quality and scrotal circumference.

Two points about these data should be noted. First, fertility rate is from a 4-day breeding season and involves only heifers showing heat in that period. Second, many bulls used had poor semen quality. Thus, many bulls with high libido had a low fertility rate. It is obvious that bulls with little or no libido will not result in pregnant cows. However, high libido in a bull is no guarantee of high pregnancy rate because low semen quality can have a detrimental effect on pregnancy rate.

TABLE 1. RELATIONSHIP BETWEEN LIBIDO AND FERTILITY

	Level of libido (sexual desire)			
	No	Low	Medium	High
No. bulls	2	2	12	24
Fertility rate				
Unsatisfactory	100%	50%	58%	29%
Questionable		50%	17%	42%
Satisfactory		0	25%	29%

Several characteristics were used in an effort to identify bulls with high and low libido. Scrotal size was adequate in 75 percent of the low libido bulls (Table 2). Therefore, this could not be utilized to select bulls for libido. There was a tendency for bulls with low libido to have smaller crests. However, only 50 percent of the bulls with no or low libido had a small crest; therefore, selection would be a real problem using crest size.

All bulls were given a subjective score for masculinity. Bulls looking like steers were given a score of 1, while masculine bulls were given a score of 10. Seventy-five percent of the low libido bulls scored from 2 to 4 compared to 33 percent of the medium libido bulls and 29 percent of the high libido bulls. If bulls having a subjective score of 2 to 4 had been classified as low libido bulls, 14 bulls out of 40 would have been called low libido bulls. Of the 14 bulls in this category, 11 had either moderate or high libido. Therefore, subjective score would not be an accurate way to select low libido bulls.

Testosterone level appeared to be a potential tool for selecting low libido bulls as 75 percent of the bulls with low libido also had low testosterone. Only one bull with medium or high libido had a low testosterone level. However, additional work on another group of bulls indicated no relationship between testosterone level and libido. Therefore, testosterone level cannot be used to select bulls for libido.

Scrotal Circumference

The best measure of sperm output has been shown to be scrotal circumference. The larger the scrotal circumference the more sperm produced. Bulls with wide variation in scrotal circumference were used in the breeding trial. Heifers bred to bulls with a scrotal circumference less than 30 cm had unsatisfactory pregnancy rates (Table 3). Pregnancy rates in heifers bred to bulls with scrotal circumference over 30 cm varied because of libido and semen quality.

Bulls with small scrotal size should be culled. The incidence of bulls with small scrotum is usually quite low. As an example, in this study only four

TABLE 2. RELATIONSHIP BETWEEN LIBIDO AND OTHER CHARACTERISTICS

Level of libido	No. bulls	Scrotal size		Width of crest			Masculinity score			Testosterone		
		Small	Adequate	Small	Medium	Large	2-4	5-6	7-8	Low	Medium	High
None or low	4	25%	75%	50%	50%	0	75%	25%	0	75%	25%	0
Medium	12	17%	83%	25%	67%	8%	33%	50%	17%	0	83%	17%
High	24	4%	96%	21%	50%	29%	29%	46%	25%	8%	33%	58%

TABLE 3. SCROTAL CIRCUMFERENCE AND FERTILITY

	Scrotal circumference (cm)		
	<30	30-35	36-42
No. bulls	4	14	21
Fertility rate			
Unsatisfactory	100%	28%	43%
Questionable		43%	33%
Satisfactory		28%	24%

bulls out of 250 (2 percent) had a scrotal circumference less than 30 cm.

It is interesting to examine the causes of infertility in bulls with small testicles. One bull had low libido, in another only a small number of normal sperm were found, whereas the other two exhibited high libido and a high number of normal sperm (Table 4). One would have expected a high pregnancy rate from these two bulls. However, one bull produced a 0-percent pregnancy rate in heifers and the other a 20-percent pregnancy rate.

Semen Quality

The relationship between pregnancy rate and normal sperm 4 to 5 weeks prior to breeding was studied. Bulls with no libido or small testicles were removed from the analysis. Six bulls had 75 percent or more normal sperm, and 83 percent of these bulls achieved a satisfactory pregnancy rate (over 50 percent) (Table 5), while 17 percent achieved an unsatisfactory pregnancy rate (under 20 percent). Fertility will change according to the type of sperm present at the time a bull mates a cow. It should be noted that the sperm evaluated today were manufactured 6 weeks before. Data from this study indicate that high fertility bulls be identified by the presence of 75 percent or more normal sperm.

Physical Traits and Fertility

The correlation between pregnancy and prepuce length was 0.38 (P<.05). This indicates that bulls with long, dangling sheaths have lower fertility. This type of bull should therfore be avoided. Other physical traits measured (size of crest, masculinity score) were not related to fertility.

TABLE 4. SCROTAL CIRCUMFERENCE AND CAUSES OF INFERTILITY

	<30 cm
No. bulls	4
Low libido	1
Few normal sperm	1
High libido and large number of normal sperm	2

TABLE 5. PREGNANCY AND NORMAL SPERM

	Normal sperm[a]			
	<35	35-64	64-74	75 or over
No. bulls	15	6	5	6
Approx. no. heifers bred per bull	18	18	18	18
Fertility rate				
Unsatisfactory (<20%)	20%	17%	60%	17%
Questionable (20-40%)	53%	67%	40%	0
Satisfactory (50% or more)	27%	17%	0	83%

[a]Bulls with low libido and small scrotal circumference removed.

Acknowledgment

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PR-3792

Reproductive Behavior in Beef Cattle

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Summary

This study deals with sexual behavior of beef cattle as it relates to and is affected by odiferous chemicals in urine. A bioassay has been developed for studying sexual behavior of bulls in response to the urine of cows in estrus. Detection of odiferous chemicals was shown to involve an accessory structure of smell known as the vomeronasal system. Dissections of cattle heads disclosed the gross and microscopic anatomy of this organ and of the ducts that conduct odor-bearing materials into the organ. The movements by which bulls get urine and odiferous chemicals into the organ were filmed with time-lapse photography, and a method was developed for reversibly plugging the ducts to the organ, thereby offering a potential management tool. Other studies on the chemical nature of the odiferous chemicals are presently under way.

Introduction

This study has developed as a result of the common belief that one or more odorous chemicals (pheromones) are present in the urine of estrous cows that inform bulls of the presence of heat and which excite them to mating behavior. Therefore, a long-range study of beef cattle reproductive behavior was initiated, with emphasis on the role of pheromones and on manipulation of the normal pheromone "communication system." This program may give cattlemen a new management tool. One of the long-range goals is to identify the pheromone that signals when a cow is in estrus. If that chemical could be identified and synthesized, it could be used to stimulate libido in old or otherwise reproductively unmotivated bulls. This might also be helpful in semen production in artificial insemination programs.

Bulls give off pheromones too, and identifying these may have practical applications. The practicality of such approaches has already been demonstrated in swine, where a commerical pheromone product from boars (Boar Mate, Jeyes Co.) is sprayed in the nose of estrous females to make them more willing to permit mating.

An equally important application is reducing sexual stimulation, such as in feedlot operations where buller steers and bulls are socially disruptive and interfere with weight gains and feed efficiency. Interfering with pheromonal communication should reduce such behavior. Fighting is often sexually motivated and is also clearly disruptive and undesirable.

Experimental Procedures

There is clear experimental evidence that detection of pheromones and the associated changes in reproductive behavior are mediated by a sensory organ in the nose known as the vomeronasal organ (VNO). A multidisciplinary team was assembled to investigate the role of this sensory organ in reproductive behaviors.

Anatomical Studies on the Vomeronasal System

Dissections were made of six male and female bovine heads. One specimen was used to make a plastic cast of the VNO. Digestion of the surrounding tissue permitted a full three-dimensional view of the VNO. Other specimens were preserved in fixative. By examining a series of blocks of tissue, how the shape, size and orientation of the VNO and its ducts change at the various levels between the oral opening and the nasal cavity was determined (1).

Bioassay with Bulls

Bulls in the presence of estrous cows exhibited "flehmen" with sufficient regularity that it is a useful measure for the presence of presumed pheromone. Bulls are usually tested on two cows restrained about 12 feet apart, with one cow in estrus (either naturally or chemically induced) and the other cow in anestrus (or spayed). The bull's behavior is quantified by the number of times that he exhibits flehmen, their durations, and by the amount of time he spends inspecting the tail and vulvar area of each cow. The licking of urine, rubbing of the legs and perineal region of the cow, standing or guarding postures by the bull, penile erections and preputial secretions, as well as any mounting attempts, are noted.

Bulls are also tested on two "dummy cows," rectangular shaped wooden structures that are covered with red canvas and have an artificial tail. A plastic apron is placed under the "tail" to contain urine samples; one "cow" is loaded with estrous urine and the other is loaded with nonestrous urine. The relative responsiveness of the bulls to urine samples allows verification of which samples are most likely to contain large amounts of pheromone; these samples are then saved for chemical analysis.

Analysis of Flehmen Movements

Two estrogen-primed heifers were used for testing nine Brahman bulls. Lip, tongue, and head movements during flehmen were observed in each bull. Time-lapse motion pictures of movements were taken with a 16-millimeter camera equipped with freeze frame/slow motion capabilities allowing the precise sequence of lip and tongue movements to be observed (2).

Plugging the Vomeronasal Ducts

Several bulls were used in the behavioral assay before and after their VNO ducts were plugged with a removable plastic plug. In this way the influence played by tne VNO in heat detection and reproductive behavior was evaluated.

Urine Collection

Urine was collected from normally cycling cows in the Texas A&M University dairy and research herds. In cows that are known to be in estrus, vaginal and cervical mucus was collected to compare it with urine for pheromone potency. The urine of ovariectomized cows served as an experimental control.

Chemical Analysis of Urine

Comparison of estrous *vs.* non-estrous urine is presently in process to see if any chemical (pheromone) is found only in the estrous urine. A wide variety of trial-and-error attempts must be made as several methods of extraction must be attempted. The urine must be extracted with different organic solvents at different pH levels, and, moreover, a variety of chromatographic separation procedures must be employed.

Results and Discussion

The VNO is a paired, blind-ended sac structure located under the floor of the nasal cavity, on either side of the ventral border of the nasal septum. One of its ducts leads from the VNO to join with the incisive duct to form a common duct which opens into the roof of the mouth. The other end of the duct opens into the nasal cavity. The duct which opens into the mouth and its associated pit (one on each side of the midline) are readily compressed by tongue motion.

To understand the mechanisms for introducing urine or vaginal secretions into the VNO, the freeze/frame pictures were examined frame-by-frame. Prior to flehmen, the mouth opens slowly and the tip of the tongue is curled backward to compress the incisive papilla; the body of the tongue protrudes from the mouth, showing the ventral side. The tip maintains its position while the body of the tongue moves forward. The movements are of a compressing nature, and because they occur as a short series of up and down strokes, each movement has been dubbed a tongue-compression stroke (TCS). There are on the average two to four strokes per second. Presumably, the compression during a TCS helps to force liquids up into the VNO where they may be analyzed. During flehmen itself, TCS does not occur.

Although the data are not yet fully analyzed, it appears that plugging of VNO ducts alters flehmen and mating behavior and that removal of the plugs restores normal behavior. Reversible plugs could be used for a variey of practical purposes ranging from reducing "riding" or fighting behaviors in feed lots to preventing bulls from breeding cows at the wrong time of year or at the wrong age of young females.

Several extraction methods have been developed for urine analysis and preliminary separations of urine components have been achieved. The inevitable trial-and-error tests of various procedures are continuing in the effort to discover a urine component that is unique to the estrous state.

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PR-3793

Effects of Breed and Heterosis on Growth and Production Characters of Cattle

C. R. Long

Summary

Breed and heterosis effects on growth and production characters were studied in five straightbreds: Angus(A), Brahman(B), Hereford(He), Holstein(Ho), and Jersey(J) and the 10 F_1 crossbred types (reciprocals pooled): AB, AHe, AHo, AJ, BHe, BHo, BJ, HeHo, HeJ and HoJ. Bulls were individually or group fed; heifers were individually fed or placed on pasture with supplemental feed as needed for normal growth. Heifers were mated to bulls of the same breedtype to produce second generation straightbred and F_2 crossbred calves. Breedtype means for yearling and 18-month weight and height as well as age, weight, and height at puberty are presented by sex-management subclass. Cow production characters based on the first three parturitions include calf survival at birth and to weaning, calf birth weight as well as weaning weight and height, weight and height of cow at calf weaning, plus post-partum and calving intervals. Heterosis of 6 to 16 percent for weight and 0 to 3 percent for height indicate crossbreds to be generally larger at birth, weaning, yearling, and 18-month ages, at puberty, and as cows. Crossbred females on pasture were younger at puberty and first parturition. Crossbred cows producing crossbred calves exhibited a 3-to 6-percent advantage in calf survival, a 9-percent advantage in post-partum interval to first estrus, and a slight advantage in calving interval. In a majority of production situations, the heterosis levels observed in this study would serve to increase efficiency of production. Results of this study also support the contention that breedtypes should be compared in the context of a production system on the basis of total efficiency. Decisions concerning choice of breedtype to use must be made with respect to specific sets of production conditions.

Introduction

Increasing efficiency of beef production by genetic methods rests on two primary activities: (a) selection within breeds to enhance critical characters; and (b) selection among and combination of breeds to produce individuals that better fit production conditions and resources.

The comprehensive research project described here was designed to provide information needed for planning efficient beef production systems. The breeds sampled represent a wide range of size and growth rate, milk yield, and other characters. An assessment of performance levels for these characters for various available breeds and crosses as well as an understanding of the manner in which performance for one influences performance level for another are necessary to best determine the most apropriate manner of using these genetic resources in a beef production system.

Experimental Procedure

Five breeds of cattle were chosen for the project: Angus, Brahman, Hereford, Holstein and Jersey. These breeds represent broad ranges in size and growth rate, milk yield, developmental origin and other critical characters; effects and relationships observed in such a sample should be representative of cattle in general. Cows of these breeds in the herds of cooperating breeders in Texas were artificially inseminated with semen from bulls of each breed; 25 or 30 sires per breed were used. A diallel mating design was followed, and reciprocal crosses were pooled so that the project was conducted as a modified diallel with 5 straightbred groups: Angus, Brahman, Hereford, Holstein and Jersey plus 10 crossbred breedtypes: Angus-Brahman, Angus-Hereford, Angus-Holstein, Brahman-Jersey, Hereford-Holstein, Hereford-Jersey and Holstein-Jersey.

Calves were born in the 1972-73 calf crop year (October through May). Calves of Angus, Brahman, and Hereford dams were weaned at approximately 3 months of age; calves of Holstein and Jersey dams were weaned at 3 to 7 days and reared artificially. All calves were delivered to the Texas A&M University Agricultural Research Center at McGregor by approximately 3 to 4 months of age where they were placed in quarantine for 3 weeks. Calves were then sorted by sex and placed in drylots for ration and location stabilization. At approximately 6 months of age calves were assigned to managerial regimes established according to data collection requirements and facilities available. Bulls were either individually fed for serial slaughter (138) or group fed (286); heifers were individually pennned and fed (91) or placed on pasture (384).

All bulls received the same ration *ad libitum*; this ration consisted of 48.5 percent sorghum grain, 20 percent cottonseed meal, 25 percent cottonseed hulls, 4 percent vegetable fat, and 2.5 percent vitamin and mineral supplement. Group bulls were fed in a common trough with approximately 50 bulls per lot; the individually fed bulls were allowed access to feed for a minimum of 10 hours per day. Further details concerning the management of the bulls are provided by Long *et al.* (3).

Individually penned heifers received *ad libitum* the same ration as the bulls until puberty; after puberty, heifers received a ration consisting of 33 percent sorghum grain, 10 percent cottonseed meal, 50 percent cottonseed hulls, 4 percent vegetable fat, and 3 percent vitamin and mineral supplement. Penned heifers were allowed access to the feed during daylight hours (minimum 10 hours per day). Pastured heifers were provided a salt-limited grain ration when needed to supplement grazing or hay to ensure normal growth. Long *et al.* (2) and Stewart *et al.* (4) describe in more detail the management of the heifers.

Insemination of heifers to bulls of the same breedtype (e.g. Angus-Brahman to Angus-Brahman, Brahman-Hereford to Brahman-Hereford, etc.) in the first generation was begun on an individual basis at the first estrus occurring after puberty plus 105 days. Heifers were inseminated repeatedly until they conceived; the heifers that reached approximately 36-40 months of age without conceiving to A.I. were then exposed to bulls for 3 months; heifers open at the end of this natural service period were declared infertile and sold. This is obviously a very lenient policy and was followed to allow expression of maximum variability in fertility (or infertility). Results from the first three parturitions are presented.

The data were analyzed to provide adjusted (least squares) means for each of the 15 breedtypes for the characters of interest. From these breedtype means, calculations were performed to yield averages for the five straightbreds and 10 crossbreds, respectively. Heterosis in units is estimated as the crossbred minus the straightbred mean; percentage heterosis is obtained by dividing heterosis in units by the straightbred mean and multiplying the quotient by 100.

Results and Discussion

Choice of breeds or crosses to be used in a beef production system should be based on performance in several "character areas," since efficiency of production is affected by the combined performance in all these areas. Three such "character areas" are 1)

TABLE 1. YEARLING WEIGHTS AND HEIGHTS ON BULLS, PASTURED HEIFERS AND PENNED HEIFERS

	Bulls		Pastured heifers		Penned heifers	
Breedtype	Weight (lb)	Height (in)	Weight (lb)	Height (in)	Weight (lb)	Height (in)
Angus (A)	759	44	470	40	589	44
Brahman (B)	676	48	522	47	565	50
Hereford (He)	659	42	405	40	516	44
Holstein (Ho)	779	48	490	45	665	51
Jersey (J)	531	43	351	40	409	45
AB	807	47	537	45	615	48
AHe	786	45	483	41	658	46
AHo	751	46	495	43	630	47
AJ	683	44	433	41	568	45
BHe	774	47	530	45	653	48
BHo	833	51	558	47	693	52
BJ	713	48	473	45	655	50
HeHo	788	46	505	43	645	49
HeJ	655	43	418	41	575	46
HoJ	705	47	443	44	557	48
Means						
Straightbreds	681	45	448	42	549	47
Crossbreds	750	47	488	44	625	48
Heterosis:						
Units	69	2	40	2	76	1
%	10.1	3.2	9.0	2.6	13.9	3.1

Adapted from Long *et al.* (2 and 3).

TABLE 2. EIGHTEEN-MONTH WEIGHTS, HEIGHTS AND CONDITION SCORES[a] OF BULLS, PASTURED HEIFERS AND PENNED HEIFERS

	Bulls			Pastured heifers			Penned heifers		
Breedtypes	Weight (lb)	Height (in)	Condition score	Weight (lb)	Height (in)	Condition score	Weight (lb)	Height (in)	Condition score
Angus (A)	1039	48	5	668	44	5	797	44	6
Brahman (B)	937	51	6	721	50	5	762	50	5
Hereford (He)	1007	46	6	619	43	5	792	44	6
Holstein (Ho)	1153	53	4	753	49	4	955	51	5
Jersey (J)	825	47	4	531	44	4	642	45	5
AB	1131	51	5	735	47	5	857	48	6
AHe	1134	47	6	708	45	5	915	46	6
AHo	1129	51	5	733	47	4	935	47	5
AJ	1073	48	5	639	45	4	817	45	6
BHe	1122	50	6	749	48	5	916	48	6
BHo	1184	54	5	793	51	4	977	52	5
BJ	996	52	5	673	49	4	891	50	6
HeHo	1171	50	5	756	47	4	964	49	5
HeJ	997	47	5	629	45	5	849	46	5
HoJ	1107	52	4	666	48	4	820	48	5
Means									
Straightbreds	992	49	5	659	46	4	790	47	5
Crossbreds	1104	50	5	708	47	5	894	48	6
Heterosis:									
Units	112	1	0	49	1	1	104	1	1
%	11.3	2.8	-	7.5	2.1	-	13.2	2.1	-

Adapted from Long *et al.* (2 and 3).

[a]Subjective condition score based on 9-point scale in which 5 = average fatness, 1 = emaciated and 9 = extreme obesity.

TABLE 3. AGE, WEIGHT AND HEIGHT AT PUBERTY OF BULLS

	Group-fed			Individually-fed		
Breedtype	Age (days)	Weight (lb)	Height (in)	Age (days)	Weight (lb)	Height (in)
Angus (A)	299	646	43	276	553	42
Brahman (B)	391	714	49	401	745	48
Hereford (He)	334	624	42	304	518	41
Holstein (Ho)	330	710	47	259	569	45
Jersey (J)	299	481	43	304	434	41
AB	324	741	46	322	741	47
AHe	280	542	42	312	670	43
AHo	314	668	44	303	644	45
AJ	322	567	42	279	556	43
BHe	322	703	46	343	725	47
BHo	331	802	48	336	780	50
BJ	346	683	47	320	648	47
HeHo	310	699	45	290	611	44
HeJ	334	586	43	274	492	41
HoJ	307	584	45	307	631	46
Means						
Straightbreds	331	635	45	309	564	43
Crossbreds	319	658	45	309	650	45
Heterosis:						
Units	−12	23	0	0	86	2
%	− 3.6	3.6	-	-	15.2	4.7

Adapted from Stewart *et al.* (4).

TABLE 4. AGE, WEIGHT AND HEIGHT AT PUBERTY OF HEIFERS AND AGE AT FIRST CALVING[a]

	Pastured			Penned			
Breedtype	Age (days)	Weight (lb)	Height (in)	Age (days)	Weight (lb)	Height (in)	Age at first parturition (days)
Angus (A)	385	496	42	303	507	40	952
Brahman (B)	479	659	50	382	606	46	1162
Hereford (He)	454	518	43	300	434	40	1032
Holstein (Ho)	361	492	46	288	534	46	847
Jersey (J)	387	368	42	331	362	40	867
AB	399	577	46	378	642	44	1026
AHe	416	549	43	312	551	41	893
AHo	398	536	45	283	505	42	897
AJ	385	470	43	332	485	42	865
BHe	425	600	47	343	608	45	1040
BHo	404	611	49	360	666	48	921
BJ	395	505	46	400	717	48	1058
HeHo	375	514	44	303	545	44	905
HeJ	398	461	43	299	478	42	854
HoJ	385	487	44	311	485	43	857
Means							
Straightbreds	413	507	45	321	489	42	972
Crossbreds	398	531	45	332	568	44	932
Heterosis:							
Units	−15	24	0	11	79	2	−40
%	− 3.6	4.7	-	3.4	16	4.8	− 4.1

Adapted from Long and Cartwright (1).

[a]These breedtype means were adjusted for treatment and month of birth of the heifer.

size and growth rate, 2) puberty traits and 3) cow production characters. These three areas are represented here by the specific characters: yearling and 18-month weight and height (Tables 1 and 2); age, weight and height at puberty (Tables 3 and 4); and selected characters of calves and cows (Table 5).

Heterosis

Heterosis or hybrid vigor has been reported to be generally beneficial in terms of improving efficiency of beef production. To the limited extent that one may judge character performance levels outside the context of a specific production system, heterosis observed in this study appears to be beneficial (2,3). Heterosis levels in the range of 6 to 16 percent for weight and 0 to 3 percent for height indicate crossbreds to be generally larger at birth, weaning, yearling and 18-month ages, at puberty and as cows. Increased size is generally beneficial at early ages when slaughter cattle are marketed but may be in conflict with efficiency when associated with increased maintenance requirements of larger cows. The higher nutritional level of the penned heifers (as compared to pastured heifers) apparently resulted in higher levels of heterosis for weight; this may have been partially expressed in higher fatness levels as indicated by 18-month condition score. In this study (4), the effects of heterosis on puberty age were mixed (Tables 3 and 4); however, results from the group-fed bulls and pastured heifers (the management groupings with the largest numbers of cattle) indicate that crossbreds were younger than straightbreds at puberty; crossbred females were younger at first parturition. Comparing crossbred cows raising crossbred calves to straightbred cows with straightbred calves, crossbreds exhibited a 3-to 5-percent advantage in calf survival, shorter postpartum intervals to first estrus and slightly shorter calving intervals. In a majority of production situations the heterosis levels observed in this study would serve to increase efficiency of production.

Breedtype Differences

Comparison of breedtypes should be done only when a) all relevant characters can be considered and b) evaluation is done in the context of a given production system. We will consider here an example to illustrate that breedtypes, by certain criteria, may excel in one area and be mediocre or poor in another; decisions concerning which breedtypes to utilize should be based on consideration of total production system efficiency. Consider the five crossbred breedtypes Angus-Hereford, Brahman-Hereford, Brahman-Holstein, Hereford-Holstein and Hereford-Jersey; their performance as estimated in this study for 18-month weight of bulls (18-MW), age at first parturition (AFP), calf survival at weaning (CSW), calf weaning weight (CWW), cow weight (CW) and calving interval (CI) are shown below:

Breedtype	18MW (lb)	AFP (days)	CSW (%)	CWW (lb)	CW (lb)	CI (days)
Angus-Hereford	1134	893	82	385	975	462
Brahman-Hereford	1122	1040	97	411	1091	464
Brahman-Holstein	1184	921	88	469	1135	463
Hereford-Holstein	1171	905	87	452	1087	438
Hereford-Jersey	997	854	96	387	856	409

TABLE 5. PRODUCTION CHARACTERS OF COWS BASED ON FIRST THREE PARTURITIONS[a]

	Characters measured on calves					Characters measured on cows			
Breedtype	Alive at birth (%)	Alive at weaning (%)	Birth weight (lb)	Adjusted weaning weight (lb)	Adjusted weaning height (in)	Weight at weaning (lb)	Height at weaning (in)	Post-partum interval (days)	Calving interval (days)
Angus (A)	93	89	63	374	39	938	48	77	436
Brahman (B)	100	78	62	384	43	996	54	117	505
Hereford (He)	97	94	67	357	39	959	48	65	413
Holstein (Ho)	89	84	85	478	44	1083	54	82	449
Jersey (J)	94	83	52	344	40	740	48	77	455
AB	99	92	64	412	41	1019	51	76	476
AHe	93	82	70	385	39	975	48	82	462
AHo	97	90	75	442	42	1033	48	82	462
AJ	97	94	61	390	40	879	52	70	453
BHe	100	97	69	411	42	1091	52	80	464
BHo	98	88	77	469	45	1135	55	81	463
BJ	98	92	60	398	43	1010	52	78	492
HeHo	96	87	81	452	42	1087	52	73	438
HeJ	100	96	63	387	40	856	48	70	409
HoJ	98	95	68	418	43	929	52	73	437
Means									
Straightbreds	95	86	66	387	41	943	50	84	452
Crossbreds	98	91	69	416	42	1001	51	76	451
Heterosis:									
Units	3	5	3	29	1	58	1	−8	−1
%	3.2	5.8	4.4	'7.5	1.9	6.2	.8	−9.5	− .2

Adapted from Long and Cartwright (1).

[a]These breedtype means were adjusted for treatment, calf birth month, calf sex and parity. The records analyzed were those of cows producing their first, second and third calves when mated by artificial insemination to sires of the same breedtype (first generation straightbred and F_1 cows producing second generation straightbred and F_2 calves).

If one of these crossbred types were to be used in a production situation where heavy weaning and 18-month weights, early first calving, high calf survival, light cow weight and short calving interval are favored, the choice would be difficult. Some of these breedtypes excel (with respect to these criteria) for one or several traits while being poor in others, or a breedtype may be intermediate for most of the traits. In order to make the decision, it is necessary to quantify the impacts of the specific production conditions. Evaluation of breedtypes for production efficiency in economic, biologic or other terms must be done in the context of the total system. The results of this study will be used in systems analysis research to provide comparisons and recommendations for specific production circumstances.

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PR-3794

Evaluation of Effect of Cow Size and Milk Production on Herd Productivity in Central Texas

T. C. Cartwright, K. W. Stokes, J. W. Stuth, T. C. Nelson and D. E. Farris

Summary

Computer simulation and an economic analysis of nine different breedtypes of cattle were conducted using data from the Livestock and Forage Research Center at McGregor as a base for establishing forage and cattle production levels. Breedtype traits were set

so as to represent the wide range of breedtypes available to producers. Three different cattle sizes, represented by mature cow weights of 1,213, 1,102, and 992 pounds and three potential milk production levels represented by peak mature lactation of 31, 24, and 18 pounds per day (lb/day), were simulated in all combinations. The simulations of productivity of cow-calf herds were considered to be managed so that grazing pressure on Coastal bermudagrass pastures was equal across breedtypes. For a given cow size, cow condition and pregnancy rate were lower for the breedtypes of higher milk production even though their winter hay was increased. Total liveweight sales of weaning calves and cull cows, per cow in the herd, increased with cow size and with milk production. Total liveweight sales per acre were similar for each cow size but increased as milk production increased. A thorough economic analysis of the results of these simulated herds was conducted utilizing production costs and cattle prices taken from the period 1972 through 1979. For the Central Texas area and the production systems examined, these results indicated that the larger, lower milk-producing cows were the most profitable breedtype, especially if the producer placed his weaned calves in a feedlot for finishing. The simulation results reported here did not include examination of many production practices, including crossbreeding, and were based on only one basic forage system.

Introduction

Deciding which breedtype would be most profitable in a given production situation is difficult because of the many inputs and outputs which enter into the production system. Also there are a number of different management practices that affect productivity of a herd and must be evaluated for a given breedtype, production resource, and market. These practices include breeding season(s), weaning date(s) and age(s), and forage and hay programs. The objective of this research was to compare the herd productivity and profitability of a wide range of cattle types, characterized by nine different breedtypes in a Central Texas location under a given set of production conditions. These comparisons of herd productivity, or systems analyses, were accomplished by simulation of the different herds using data from the Livestock and Forage Research Center at McGregor to establish base production parameters for cattle and forage in the Central Texas Area and to establish the validity of the simulated predictions.

Experimental Procedure

The TAMU Beef Cattle Production Systems Model (1,2) was used to simulate producing herds of nine different breedtypes. Output from the model was then used to analyze the productivity and profitability of nine different breedtypes of cattle and of the management options available to most producers. The beef cattle production systems model was developed to account for genetic, nutritional, and managerial effects on the total production system. Unlike most livestock computer simulation models, this model does not assume a performance level and then calculate the requirements; rather it calculates performance based on the production conditions. That is, the simulated cattle herds are designed to respond to a set of pasture, supplement, management, etc. conditions as a herd of actual cattle of a given breedtype would respond.

The nine different breedtypes of cattle simulated represented three different mature body size potentials and three milk production potentials (Table 1). Size is closely related to growth and maturing rates and nutrient requirements. Milk production is closely related to weaning weights and nutrient requirements. Both characters, size and lactation, affect reproductive performance and both are relatively easily changed by selection. The three size and three milk production levels, in combination, form the nine breedtypes that were simulated. These nine combinations are similar to combinations available in existing breedtypes used for production in the area (3).

Pasture available for grazing, hay production, and cattle performance were based on data taken at the Livestock and Forage Research Center at

TABLE 1. SIZE AND LACTATION POTENTIALS OF NINE SIMULATED BREEDTYPES

Breedtype designation	Potential cow size[a] (lb)	Potential milk[b] (lb/day)	Example breeds[c]
Large Heavy	1213	31	Br. Swiss, Holstein, Simmental
Large Moderate	1213	24	Charolais
Large Light	1213	18	Chianina, Marchigiana
Medium Heavy	1102	31	Red Poll, Shorthorn, Tarentais
Medium Moderate	1102	24	Angus, Hereford-Angus
Medium Light	1102	18	Hereford, Limousin
Small Heavy	992	31	Angus-Jersey
Small Moderate	992	24	Small Angus
Small Light	992	18	Small Hereford, Longhorn

[a]Cow weight at maturity with 25% of weight composed of fat; this weight is used to represent breedtype potentials for weight at all ages.

[b]Milk production at the peak stage of lactation of a mature cow in good condition with no nutritional limitations; this production is used to represent breedtype milk production potential for all cow ages and stages of lactation.

[c]At least a portion of individuals in each breedtype fit the size and milk production potentials indicated.

TABLE 2. CRUDE PROTEIN AND TOTAL DIGESTIBLE NUTRIENTS OF FORAGE[a]

Month	Crude protein, %	TDN, %
January	5.0	53
February	5.5	53
March	6.1+	64
April	6.1+	62
May	6.1+	60
June	6.1+	58
July	6.1+	56
August	5.6	54
September	6.0	54
October	5.4	49
November	4.8	47
December	4.7	53

[a]Hay was fed during December, January and February while cattle were on native range.

McGregor from a grazing research project based on Coastal bermudagrass (4). The data on forage production and quality were converted to a monthly basis (Table 2) since each month is simulated in the model. Simulated cow-calf herds were grazed on Coastal pastures from March to November with harvested hay being fed the remaining months. Hay was harvested during May, June, and July from the same pastures the herds grazed. In the simulation of the nine herds, hay was fed in different amounts in order to equalize the body condition of the cows from December through February. The differences in body conditions that resulted in the simulations were caused by different nutrient demands for milk production and growth. Stocking rates were adjusted so that there was equal grazing pressure for each breedtype on a fixed acreage of land. Nutritional input into the model includes crude protein and dry matter digestibility of the feed (including pasture) and the availability of feed to each animal. Bulls were not included in either pasture and hay consumption or sales.

Breeding females were mated May through August to calve from February through May. Calves were weaned in November. The minimum age for putting replacement heifers in breeding herds was 15 months. Replacement heifers received the same grazing and winter hay as the cows. Culling rate varied with age: 2.5 percent for each year-age-group from yearling through 8 years of age, 4 percent for 9, 10, and 11-year-olds, and all 12-year-olds.

Results and Discussion

Within each breedtype of the same potential size, cow condition decreased as milking potential increased. This lower condition occurred even though cows of each of the breedtypes were fed hay at the level required to equalize the condition level of all breedtypes during the winter months; e.g., heavier milking cows received more hay (Table 3). This variable hay feeding practice was considered a good management practice. Pregnancy rate at the end of the breeding season increased as breedtype size potential increased and decreased within a breedtype size group as milk production potential increased. Pregnancy rate ranged from 81.6 percent for cows of the large, light milking breedtype to 75.7 percent for small, heavy milking cows (Table 3).

Since stocking rates were adjusted to attain equal grazing pressure for each breedtype on a given acreage, herd size varied. Stocking rates (breeding cows/acre) decreased as potential size increased, ranging from 0.84 cows/acre for large, light milking cows to 1.03 cows/acre for small, heavy milking cows. Within the same size breedtypes, stocking rate increased slightly as potential milk yield increased. These stocking rates, based on the number of breeding cows in

TABLE 3. SIMULATED HERD PRODUCTIVITY MEASURES OF THE NINE BREEDTYPES

Productivity measure[a]	Large size			Medium size			Small size		
	Heavy	Moderate	Light	Heavy	Moderate	Light	Heavy	Moderate	Light
Condition[b], %	93.4	93.8	94.0	94.3	94.3	94.4	94.8	94.5	94.9
Pregnancy, %	78.9	80.5	81.6	77.5	78.7	80.1	75.7	76.7	77.7
Calving, %	73.0	74.4	76.1	72.6	73.4	74.1	70.2	71.6	72.3
Weaning weight, lb	517	487	453	495	465	433	473	442	411
Stocking rate, cows/acre[b]	0.86	0.85	0.84	0.93	0.92	0.91	1.03	1.02	1.00
Hay consumed, lb/cow	1451	1246	1010	1444	1246	1014	1426	1232	1010
Total liveweight sold, lb/cow[c]	395	375	370	366	353	333	331	322	313
Progeny liveweight sold, lb/cow	298	280	269	278	269	245	254	245	229
Total liveweight sold, lb/acre[c]	341	321	312	341	327	305	339	327	313
Progeny liveweight sold, lb/acre	255	239	228	259	248	225	261	249	230

[a]Bulls were not included in either pasture and hay consumption or sales.
[b]Fraction of condition potential attained averaged for all ages of cows.
[c]Total liveweight sales include steers, excess heifers and cull cows.

the herd, are affected by fertility, numbers of calves and replacement heifers grazing, and the consumption of hay during the winter months (Table 3). The seemingly suprising results of a higher stocking rate for heavier milking cows was caused by fewer of the heavier milking cows having calves; therefore, there were fewer lactating cows and fewer calves consuming feed.

On the basis of output/cow, larger breedtypes had higher liveweight production (sales) of weaner steers, weaner surplus heifers, and cull cows. Output per cow increased further as milk production potential increased. Total liveweight sold per cow ranged from 395 pounds for large, heavy milking cows to 313 pounds for small, light milking cows. Progeny liveweight sold per cow ranged from 298 pounds for large heavy milking cows to 229 pounds for the small light milking cows (Table 3).

On a per-acre basis, total liveweight sold was very similar for all nine breedtypes, ranging only from 305 to 341 pounds. Within breedtypes of the same size potential, total liveweight sold per acre increased as milking potential increased. Within breedtypes of the same milking potential, progeny (weaner steers and excess weaner heifers) liveweight sold per acre decreased as cow weight increased. Within breedtypes of the same size potential, progeny liveweight sold per acre increased as potential milk production increased (Table 3).

Thorough economic analyses were conducted on the simulated input/output results using cost and price figures taken from 1972 through 1979 (3). The analyses included several production options. Weaned calves could be sold, stocked on winter oat pasture, or placed in a commercial feedlot. For the years 1972-1979, placing the calves in a feedlot at weaning was generally the most profitable; therefore, this report included only the cow-calf herd or weaner calf production phase. On the basis of the weaner calf production, the larger breedtypes were most profitable. Within the largest breedtype, the lowest milk production level was most profitable.

Keeping in mind that these results were simulated and are in effect predictions, and that a restricted set of management and production conditions were examined, it appears that larger, lighter milking breedtype herds are more productive and more profitable for the production resources simulated. Additional research, both actual experimentation and simulation, covering other production practices, such as crossbreeding, is needed before the various interactions of complex cattle production systems can'be well understood.

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Economics and Marketing

Economic risk and uncertainty have always been realities with cattle investments. Total production costs are exceeding $300 per calf weaned in Texas with more of the investment and operation capital being borrowed than ever before. The need to predict market trends, cattle cycles and relative competitiveness of firms readily beomes apparent. Texas Agricultural Experiment Station scientists have attempted to provide producers with marketing and management concepts to effectively compete on new and existing markets.

PR-3795

Producer-to-Consumer Marketing of Beef

D. E. Farris and D. P. Crawford

Summary

Producer-integrated retail operations for beef do not account for a significant volume of beef sold in the United States. Examples of many different kinds of beef marketing operations can be found. They vary from a small facility on a ranch operated by the owner, his wife and a part-time teenage helper to a business with a 5,000-head feedlot, a slaughter plant, and two retail outlets. Many merchandising schemes have been tried. The big advantages these producer-integrated firms have are lower costs, lower retail prices, and flexibility to provide special services. This is sufficient to attract customers to travel to a store just to buy meat. Most purchases are in larger quantity than the average supermarket beef purchase.

At a time when meat packers are building larger, more automated plants, it is interesting that these small firms can effectively compete. They have been

able to compete by concentrating on keeping costs low. Cost of supply is less because they use mostly Good grade heifers. Being a labor-intensive operation, they keep labor costs down by not operating in the high labor-cost areas and remaining small enough to avoid unionization.

Where the small firms have a disadvantage is in sale of by-products. Their returns for by-products are about half those of a modern slaughter plant. On the plant and retail operation, the biggest difficulty is developing a merchandising program to build volume to efficiently utilize labor and facilities. As marketing costs of the conventional systems continue to increase, the producer-integrated operations should be able to expand their market share.

Introduction

Since 1973 there has been much talk of beef producers getting into retailing. It seemed logical since beef producers were losing money, and it was presumed that retailers were making good money. Some producers tried, some failed— but some have apparently had the right combination of luck and judgment to be doing well. To learn more about the business and economics of producer-integrated retail beef operations, 22 firms were interviewed in Texas. Ten were beef producers. These were compared with nine non-producers who slaughtered and retailed and with three specialty meat stores. Retail prices were compared with supermarket firms on a fixed set of eight cuts.

It was not easy to find enough cases to provide a sufficient sample. Those located were scattered over most of Texas. Some had been in business for more than 20 years, some less than 5 years. Each was a unique business in terms of specifics of its operation, but there were some common characteristics that set the group apart from the conventional beef retailing business.

Results and Discussion

Practically all of the producer-integrated operations had free standing units with facilities for slaughter, processing, and retailing at the same place. Nearly all of them provided a variety of services and products. Typically, they provided custom slaughter, processing, wrapping and freezing which accounted for one-fourth to one-third of slaughter. Wholesale business accounted for one-third and the remainder was retailed, mostly as fresh meat (Table 1). Beef was the major source of revenues, but pork was a significant item for most operations. Some businesses carried other grocery items, but they were usually a small part of the business.

Producer-integrated retail meat operations were not significantly different from non-producer slaughter-to-retail operations where all of the slaughter-to-retail operations were performed at one facility. Most producers purchased part of their slaughter livestock elsewhere (Table 2). The producer's own cattle and/or hog supplies were an integral part of the operation, but generally not regarded as critical. Hence, producer-and non-producer slaughter-to-retail operations will be discussed together unless otherwise indicated.

Generally, the slaughter and retail businesses were located in small cities or towns, while a few were in the country on a highway, and a few were in major cities. Some of the businesses started as locker plants and still offer freezer locker space to customers, but the part of the business that has had the most recent rapid growth has been the retail fresh meats. Some of the custom business involves smaller cattlemen who sell animals to friends and neighbors, then arrange for them to be custom slaughtered and processed.

The typical operation was a small State-inspected plant that slaughtered 44 head of cattle and 20 head of hogs per week. The cattle were mostly 700-to 900-

TABLE 1. SOURCE OF SLAUGHTER LIVESTOCK FOR WHOLESALE AND RETAIL TRADE, JUNE 1979

Item	Ten vertically integrated from production through retail	Nine vertically integrated from slaughter through retail
	percent	
Cattle		
Own lot	40.47	a
Custom feedlot	32.43	45.06
Public market	20.82	1.37
Other producers	6.28	53.57
Total	100.00	100.00
Hogs		
Own lot	13.28	a
Public market	22.23	4.49
Other producer	64.39	95.51
Total	100.00	100.00

Source: Personal interview.

[a]Not applicable.

TABLE 2. MARKET OUTLET FOR LIVESTOCK SLAUGHTERED BY DIRECT MARKETING PLANTS, JUNE 1979

Item	Ten vertically integrated from production through retail	Nine vertically integrated from slaughter through retail
	percent	
Cattle		
Custom	22.65	34.97
Wholesale	31.28	37.18
Retail	46.07	27.85
Total	100.00	100.00
Hogs		
Custom	33.27	21.08
Wholesale	10.70	45.34
Retail	56.03	33.58
Total	100.00	100.00

Source: Personal interview.

pound fed heifers comparable to USDA Good grade, and the hogs were mostly number 1 and 2 barrows and gilts. Cattle carcasses were not graded. Inspection is not required on custom-slaughtered animals.

Low labor costs were a key factor in their business. Operations surveyed were all non-union and had an average wage of $4.50 per hour. The range was $3.10 to $6.85. Some employed housewives and students part time. Firms had from 3 to 16 employees operating the plants. Labor costs were about 10 cents per carcass pound for all operations, while variable costs averaged 14 to 18 cents per pound.

It appears that the integrated operations surveyed consistently had lower costs, wage rates, and retail prices than supermarkets in the area. Estimated beef gross marketing margins averaged 21 percent for the producer-integrated, 19 percent for the slaughter integrated, and 23 percent for specialty meat stores. This was about one-half the national average marketing margin estimated by USDA in July 1970 for USDA Choice Beef.

Four representative beef items and four pork items averaged $1.95 per pound in the producer-integrated operations and $1.98 in the slaughter-integrated operations compared to $2.21 for those same items in specialty meat stores and supermarkets in July 1979. The latter included only USDA Choice beef while the integrated operation sold mostly ungraded beef comparable to USDA Good. The quality of the pork was apparently about the same — mostly number 1 and number 2 barrows and gilts in all categories.

Profits were favorable for 1979, averaging 8 percent on sales (includes a return to capital and management). The largest firms had lower than average profit on sales. Estimated profits for slaughter-to-retail operations averaged $51 per head for cattle and $19 per head for hogs.

A few other operations were contacted, but a questionnaire was not completed. These include a rancher who sold yearling cattle, then arranged for them to be custom slaughtered and processed in a nearby plant. Another was a rancher with a feedlot who operates two retail stores in a major city selling boxed frozen beef cuts.

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PR-3796

Live Cattle Futures Prices as Predictors of Cash Cattle Prices, 1973-1979

R. O. Roark and C. E. Shafer

Summary

Increased price volatility during the 1970's clearly increased the forecast errors of both the cash-futures and cash-cash models. However, the question of what alternative forecasts were better or "less poor" than futures or current cash prices remains. If producers simply use futures prices as distant forecasts and do not hedge using that forecast, they face considerable price risk. For example, over a 20 week feeding period, the average price forecast error was plus and minus $7.64, a range of $15.28 per hundredweight. Actual forecast error for the 20 week cash-futures model ranged from $-.06 in April 1976 to $+19.81 per hundredweight in April 1979; i.e., the forecast value was $19.81 per hundredweight below the actual value. In June 1974 the same model forecast at $53.73 or $15.73 per hundredweight above the actual price of $38.00 per hundredweight. A $15.00 per hundredweight error on a 1000 to 1100 pound steer is considerable error per head.

Given these magnitudes of forecast errors, users of futures prices for forward pricing cattle would do well to hedge using those prices rather than simply rely on futures prices as useful forecasts.

Introduction

Accurate forecasts of fat cattle prices for various periods into the future would clearly be invaluable in guiding beef production and marketing. Various beef price forecasts are available. Whether any one is particularly more accurate than the others is difficult to ascertain.

Live cattle future prices for the six contracts traded on the Chicago Merchantile Exchange are one source of price "forecasts." Current cash price is also a possible forecast of distant cash price. Some have argued that futures prices are at least no worse as forecasts than those provided by some rather elaborate econometric price forecasting models. In essence, for example, the argument is that the current live cattle futures price quoted for a distant futures contract month is as good as any other current forecast based on various statistical models or trend-following methods. Unfortunately, intervening events frequently invalidate most distant forecasts.

The objective of this study was to determine how accurate futures prices were as forecasts of actual cash price for periods projected over various lengths of time. Current cash price was also used as a forecast of distant cash prices for comparison with the futures price model.

Experimental Procedure

Simple regressions of closing cash prices on future prices and cash prices from zero to 35 weeks previous were used as one method of evaluating the forecasting efficiency of futures and cash prices. The two models were:

$$CP_m = a_1 + b_1 FP_{m-1} \qquad (A)$$

$$CP_m = a_2 + b_2 CP_{m-1} \qquad (B)$$

where: CP_m = Wednesday Omaha choice steer cash price during closing period of particular futures contract month; m = Feb., April, June, Aug., Oct., or Dec. CP_{m-1} was the same series as CP_m but lagged from zero to 35 weeks.

FP_{m-1} = Closing futures prices price for particular live cattle contract (m) lagged i weeks; 1 = 1, ...35.

There were 36 regressions ranging from current week to 35 weeks lagged. Model (A) will be referred to as the cash-futures model and model (B) the cash-cash model. Mean square errors based on $CP_m - FP_{m-i}$ differences were determined as a second indicator of the reliability of futures prices as forecasts of cash prices. A study by Leuthold (1) reported similar analyses for data from 1965 through early 1973. The present study used data (2) ranging from February 1973 through December 1979 because prices were considerably more variable during the mid and late 1970's than during the 1965-1972 period.

Results and Discussion

Perfect forecasts would have yielded intercepts of zero and slope values of +1.0 in Table 1. As expected, however, the greater the length of time between the futures or cash forecast price and the eventual cash price, the poorer was the prediction, Table 1. While one to two weeks "forecasts" approximated the ideal, the predictive power of both current cash and futures prices dropped rapidly as the prediction interval lengthened. Slope coefficients remained statistically significant throughout the 35 week prediction interval but predictive power dropped rapidly. However, the statistical results were much better than for Leuthold's earlier study, possibly because his data had less variation to "explain." While over 80 percent of the variation in cash prices was "explained" by both futures and cash price of six weeks previous, less than half of the variation was explained over 16 week or longer intervals, Table 1.

Mean square error (MSE) comparisons over the 35 week forecast intervals indicated the forecast error. MSE is the squared difference between the observed cash price and predicted cash price from models (A) and (B), Table 2. The square root of the MSE is the average forecast error in dollars per hundredweight. For example, the average forecast error for two weeks distant was 5.09 = \$2.26 per hundredweight for the cash-futures model and 4.35 = \$2.09 per hundredweight for the cash-cash price forecast model,

TABLE 1. RESULTS OF REGRESSIONS FOR FUTURES AND CASH LIVE CATTLE PRICES AS PREDICTORS OF CASH CATTLE PRICES, FORECASTING FROM 0 TO 35 WEEKS INTO THE FUTURE, FOR FEBRUARY 1973 THROUGH DECEMBER 1979

t	Futures (n = 42) $CP_0 = a + b\ FP_t$						Cash (n = 42) $CP_0 = a + b\ CP_t$					
Weeks[a]	Intercept[b]		Slope[b]		R-Square	D-w	Intercept		Slope[b]		R-square	D-w
0	−0.14	(−.17)[d]	.991	(55.74)	.987	2.14	0.00	(99.99)	1.00	(99.99)	1.000	0.00
2	1.50	(0.90)	.968	(28.29)	.952	2.51	1.54	(1.01)	.976	(30.73)	.959	2.22
4	7.09	(2.69)	.853	(15.73)	.861	1.65	4.43	(2.18)	.916	(21.75)	.922	2.14
6	1.78	(0.64)	.964	(16.69)	.874	1.82	3.21	(1.03)	.946	(14.57)	.842	2.14
8	3.50	(0.81)	.927	(10.31)	.727	1.83	4.53	(1.11)	.918	(10.77)	.744	2.05
10	9.62	(1.77)	.797	(7.10)	.558	1.64	7.56	(1.67)	.859	(9.00)	.669	1.96
12	7.79	(1.60)	.834	(8.33)	.635	1.52	9.09	(2.11)	.832	(9.12)	.675	1.69
14	8.49	(1.65)	.829	(7.75)	.600	1.32	7.15	(1.65)	.864	(9.52)	.694	1.45
16	7.55	(1.32)	.852	(7.10)	.558	1.12	10.00	(1.82)	.812	(6.94)	.546	1.27
18	11.52	(1.79)	.767	(5.69)	.447	0.93	11.45	(1.97)	.789	(6.31)	.499	1.22
20	10.66	(1.64)	.784	(5.77)	.455	1.01	11.17	(2.05)	.798	(6.79)	.536	1.17
22	11.19	(1.88)	.775	(6.20)	.490	0.81	12.15	(2.55)	.779	(6.69)	.528	0.93
24	10.58	(1.73)	.797	(6.13)	.485	0.69	12.93	(2.15)	.763	(5.85)	.461	0.76
26	12.31	(1.88)	.758	(5.47)	.428	0.61	13.08	(2.18)	.760	(5.84)	.460	0.70
28	13.61	(1.89)	.732	(4.79)	.365	0.66	14.17	(2.48)	.739	(5.95)	.469	0.75
30	10.16	(1.53)	.809	(5.71)	.449	0.62	13.73	(2.29)	.756	(5.73)	.451	0.74
32	10.67	(1.60)	.804	(5.63)	.442	0.58	14.51	(2.25)	.739	(5.21)	.404	0.74
34	13.36	(1.79)	.746	(4.74)	.350	0.55	17.05	(2.44)	.682	(4.43)	.329	0.71
35	15.67	(2.12)	.693	(4.37)	.323	0.60	16.89	(2.42)	.688	(4.47)	.333	0.79

[a]The number of weeks the delivery date is into the future.

[b]Coefficients are in dollars per hundredweight.

[c]Only the even-numbered weeks are reported to save space.

[d]Values in parentheses are *t-ratios*.

TABLE 2. MEAN SQUARE ERRORS FROM MODELS (A) AND (B) "FORECASTING" 0 TO 35 WEEKS, FEBRUARY 1973-DECEMBER 1979

Weeks forecast	Mean square error[1]	
	Model (1) Cash - Futures	Model (2) Cash - Cash
	(Dollars per hundredweight)	
2	5.09	4.35
4	14.89	8.35
6	13.45	16.96
8	29.26	27.46
10	47.38	35.40
12	39.13	34.79
14	42.82	32.77
16	47.34	48.61
18	59.17	53.66
20	58.40	49.70
22	54.62	50.52
24	55.17	57.66
26	61.29	57.78
28	68.02	56.84
30	58.99	58.76
32	59.73	63.78
34	69.64	71.82
35	72.52	71.39

[1]The square root of the MSE is the average forecast error for the particular forecast period; i.e., the average forecast error for week 14 was 42.82 - \$6.54 for the cash-futures model.

Table 2. Around the four month forecast period (16-18 weeks), the average forecast error had increased to 59.17 = \$7.69 per hundredweight and 53.66 = \$7.32 per hundredweight for the cash-futures and cash-cash price forecasting models, respectively. While the average forecast error was \$7.69 for the 18 week forecast from the cash-futures model, this model's forecast errors ranged from \$−.89 to \$+18.67 per hundredweight. The average of the 42 cash prices being forecast (Feb. 1973 - Aug. 1979) was \$47.51 per hundredweight, ranging from \$35.00 per hundredweight in February of 1975 to \$77.70 per hundredweight in April 1979, Figure 1. Thus considerable error existed in all but the short interval — six weeks or less — forecasts.

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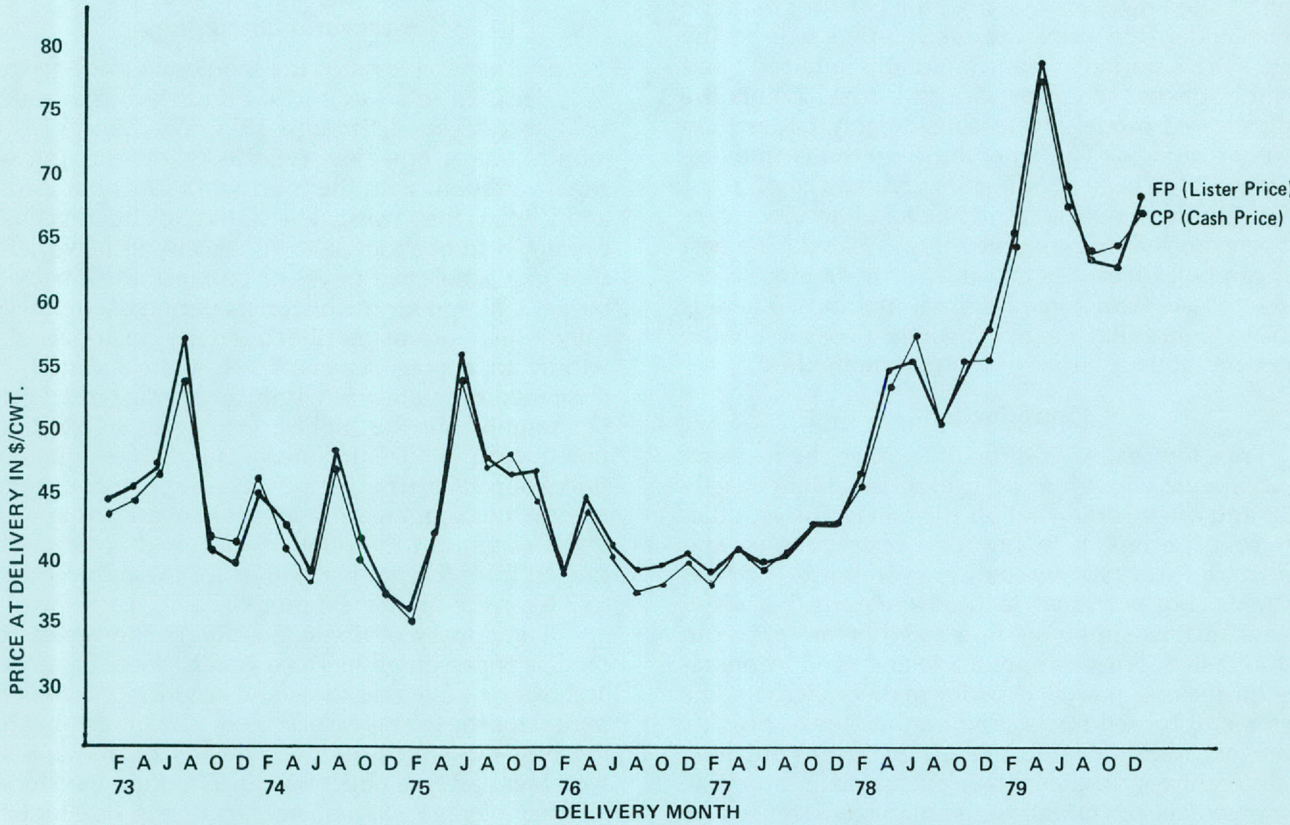

Figure 1. Current futures and cash prices for live beef cattle by month and year of delivery, February 1973 through December 1979.

PR-3797

Comparison of Price Forecasting Models for Manufacturing Beef

I. J. Bourke, D. E. Farris, and C. E. Shafer

Summary

This study evaluates a wide range of forecasting methods for manufacturing beef from the standpoint of their degree of accuracy to forecast average monthly, quarterly and annual prices. They are evaluated in terms of Mean Absolute Error, Root Mean Square Error, Theil's inequality coefficient and the ability to predict turning points. The specific price forecasted was the average price of canner and cutter cow beef at Chicago. Since the United States is the world's largest producer *and* importer of this type beef, price of this quality beef in Central America, Australia and New Zealand is largely derived from the expected Chicago price.

Results show that the Box-Jenkins, reduced form and a simple average of the best methods, or combined models performed better than other models, particularly for annual forecasts. For quarterly and monthly forecasts the advantage of these models over others was not as great but still worthwhile. The sophisticated models were marginally better than the naive model (the price the next period will be the same as this period) when forecasting quarterly and monthly prices. When predicting turning points the sophisticated models were considerably better than all other models. The smoothing methods (moving averages, etc.) gave poor results under all conditions. The findings show that a high level of accuracy cannot be expected from the models evaluated. The best that can be expected is that they provide more accurate forecasts than some informal methods. There is some evidence that a simple average of several of the better methods is superior to any one method.

Introduction

Price forecasting is difficult because the forecaster, if specific enough to be useful, is seldom exactly right and often somewhat off the mark. The best that can be expected is to improve over guesses and informal forecasts by using systematic, formal methods. Some formal methods require that other factors such as supply be forecasted before price can be forecasted. Forecasts are made and used by operating businesses as well as policy makers. Perhaps the best use of formal forecasting methods is to provide managers additional information. Estimates obtained by different approaches can be evaluated and provide reinforcement or caution to the manager who arrives at estimates using his informal "business sense." Forecasting is a way of organizing and evaluating complex market information, but it cannot consider all factors and often a mathematical relationship will underestimate the effect of a sudden or drastic change in market conditions.

This study objectively evaluated nine types of forecasting procedures or models that were applied to annual average cow beef data for the 1960-75 period and for quarterly and monthly data for 1965-75. Forecasts for 1976 were also evaluated (the period beyond the data used for model development).

Methods selected for evaluation were:

a. naive method — this method simply assumes the price for the current period will also be the price for the next period

b. simple moving average method

c. double moving average method

d. single exponential smoothing

e. double exponential smoothing

f. Box-Jenkins method

g. single equation econometric method

h. simultaneous equation econometric method

i. combined method — the simple average of forecasts of those methods judged to be the best.

Wherever possible, the form of the forecasting model was based on the findings of other recently reported research.

Results and Discussion

The general level of the wholesale price for cow beef declined to a low in 1964 and rose to a peak in 1973 and declined through 1975. The quarterly and monthly data, however, reflected short-run and seasonal variation, with the fourth and first quarter (Fall and Winter) the lowest. The statistical equations used explained from about 85 to 95 percent of the variability of the wholesale price for cutter and canner cow beef at Chicago for the historical period used. Specifically, they forecasted the quarterly historical data within an average error of less than 3 cents. The combined estimate was within an average of 2.1 cents per pound, but the highest error was 8.4 cents the first quarter of 1975. In forecasting the four quarterly prices for 1976 (the period outside model development), the combined model again averaged an error of 2.1 cents, but the other models had an error that ranged from 5 cents per pound for the reduced form to 7.6 for the double exponential.

A summary of the evaluation of the forecasting models is presented in Table 1. Each model is ranked according to five measures and according to the time period for the average price used. The model that had the best measure was given a rank of one and the worst was given a rank of eight. The combined model (simple average of the forecasts of the Box-Jenkins, single equation, and simultaneous equation or reduced form) ranked number 1 for all five measures

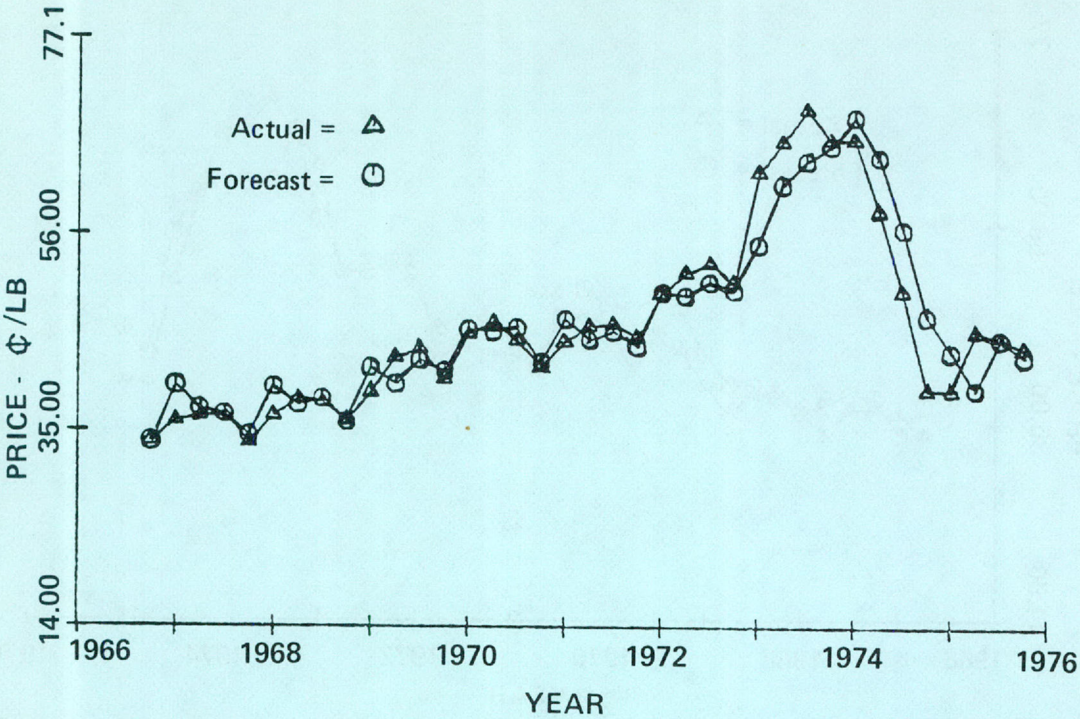

Figure 1. Quarterly Box-Jenkins forecasts, 1966-1975.

when quarterly data were used, number 2 for annual data, did poorly on absolute error for annual and monthly data, but did best on forecasting turning points on the monthly data. Among the individual equations, the Box-Jenkins model ranked highest overall. The smoothing models (moving average and exponential models) did worse than the naive model.

Visual evaluation of the four best quarterly forecasting models can be made by examining Figures 1-4. In all of these, the seasonal price pattern can be seen in the actual data. The Box-Jenkins model was third in rank of the models in picking up these cyclical turning points. It was also third in the statistical turning points (Table 1). The later problem can be seen in Figure 1 where the Box-Jenkins forecasts lag the sharp increase in actual price in 1972-73 and again lag the sharp decline in actual prices in 1973-74.

Although the single equation model ranks sec-

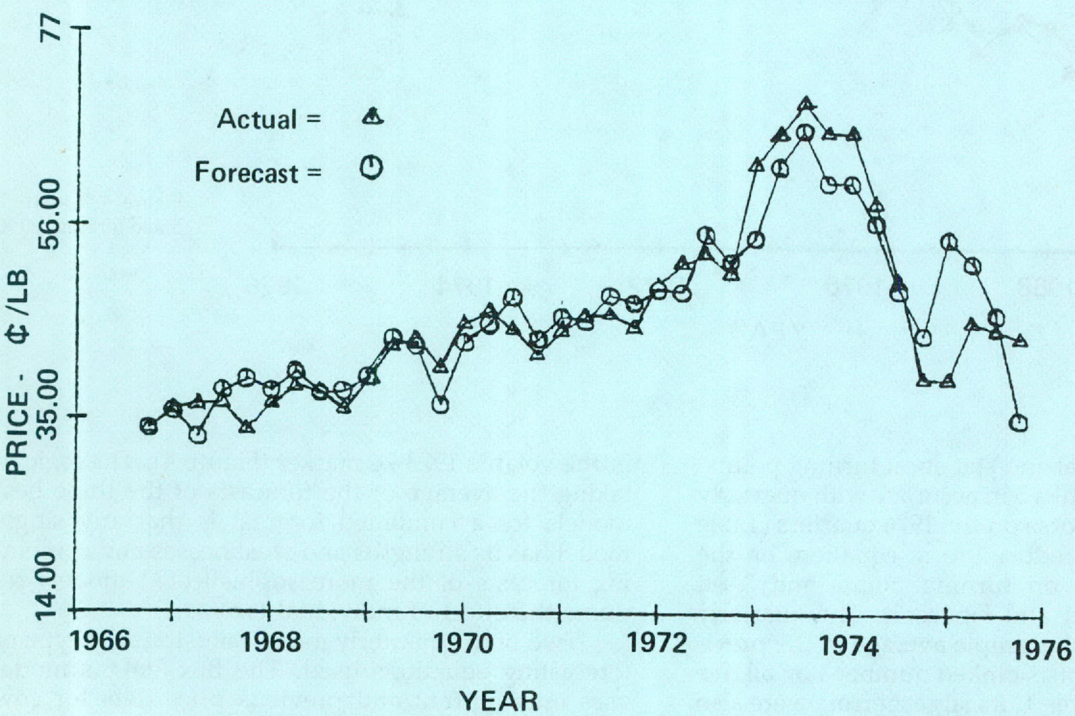

Figure 2. Quarterly single equation forecasts, 1966-1975.

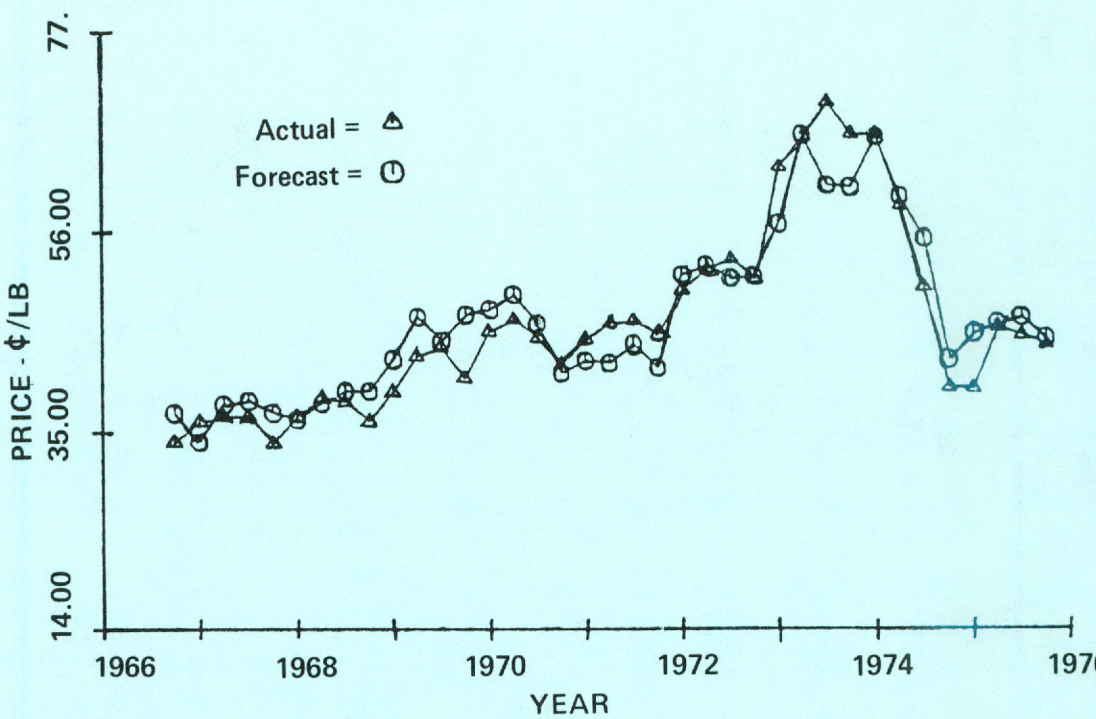

Figure 3. Quarterly reduced form forecasts, 1966-1975.

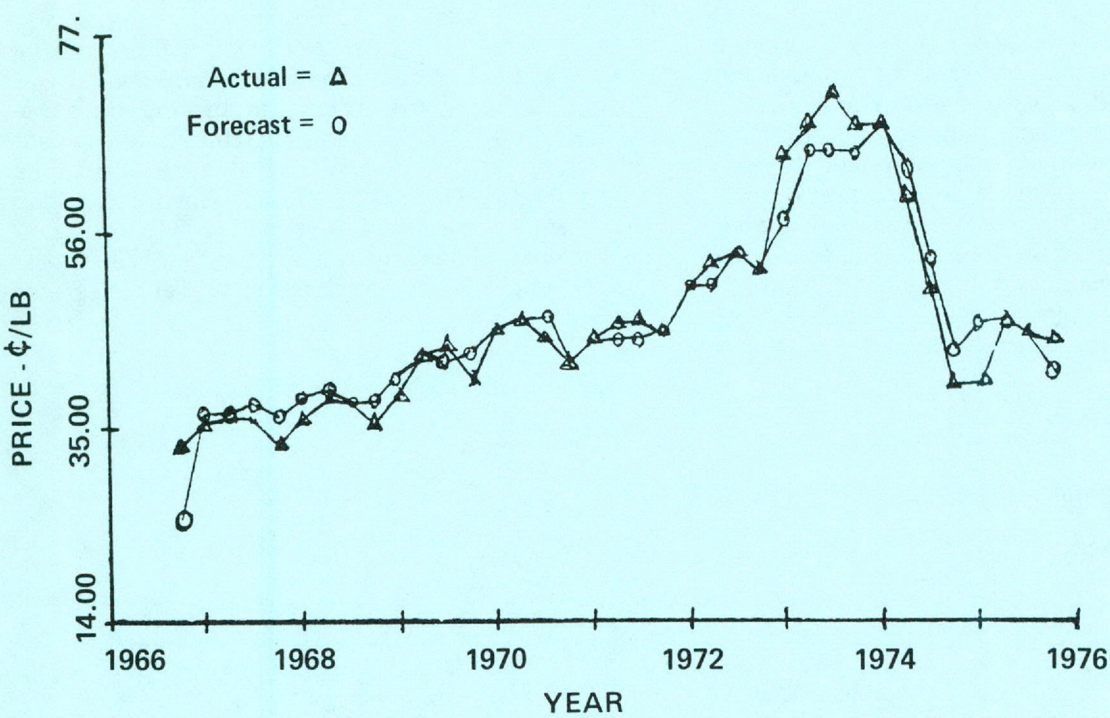

Figure 4. Quarterly combined forecasts, 1966-1975.

ond in both the cyclical and statistical turning points, its average forecast ranks 5 in accuracy with quarterly data and does even worse on the 1976 quarters (Table 1 and Figure 2). The reduced form equation, on the other hand, ranks 4 on turning points and 3 on average error (Table 1 and Figure 3). The quarterly combined forecast is the simple average of the previous three and its forecasts ranked number 1 on all five of the measures in Table 1. Its largest errors were also in the volatile 1973-74 market (Figure 4). The logic of taking the average of the forecasts of the three best models for a combined forecast is that any single model has its strengths and weaknesses and combining forecasts of the more sophisticated models reduces the effect of individual errors.

Two of the quarterly models illustrate the type of forecasting equations used. The Box-Jenkins model uses only current and previous price data for cow

TABLE 1. RANK OF FORECASTING MODELS, BY METHOD OF EVALUATION, 1966-1975

	MAE	RMSE	U	Cyclical turn point	Statistical turn point
Naive					
Annual	4	4	4	NA	NA
Quarterly	4	4	4	7=	6
Monthly	5	4	4	8	5
Simple moving avg.					
Annual	7	6	6	NA	NA
Quarterly	7	7−	7	5=	7
Monthly	8	8	8	1	8
Double moving avg.					
Annual	6	7	7	NA	NA
Quarterly	8	6	8	7=	8
Monthly	7	7	7	6	6
Double exponential					
Annual	5	5	5	NA	NA
Quarterly	6	6	6	5=	5
Monthly	6	6	7	7	7
Box-Jenkins					
Annual	NA	NA	NA	NA	NA
Quarterly	2	2	2	3	3
Monthly	3	1	1	3	3=
Single equation					
Annual	3	3	3	NA	NA
Quarterly	5	5	5	2	2
Monthly	1	3	3	5	3=
Reduced form					
Annual	1	1	1	NA	NA
Quarterly	3	3	3	4	4
Monthly	2	2	2	4	2
Combined					
Annual	2	2	2	NA	NA
Quarterly	1	1	1	1	1
Monthly	6	4	6	2	1

beef to generate the model and the forecasts. The quarterly equation is:

$$Z_{t+1} = 0.938Z_t + 0.960Z_{t-3} - 0.900Z_{t-4} - u_{t+1} - 0.102u_{t-3}$$

where Z_t = the current wholesale price for canner and cutter cow beef at Chicago (U.S. cents/lb)

u_t = random error associated with the forecast of the current price.

The forecast model in this case depends on the current price and the third and fourth preceding prices as well as the random error in the third preceding price forecast. In a forecast of the price for the next period (Z_{t+1}), u_{t+1} is zero because it is unknown before the forecast is made.

The quarterly single equation econometric model is:

$$P = 80.06 - 0.037\,x_1 - 0.004X_2 + 0.046X_3 + 0.0531_{t-1} + 1.76Q_1 - 0.084Q_2 - 2.800Q_3$$

where P = the current wholesale price for canner and cutter cow beef at Chicago (U.S. cents/lb)

X_1 = supply of domestic nonfed beef, million pounds

X_2 = supply of domestic fed beef, million pounds

X_3 = beef imports, million pounds

I_{t-1} = per capita disposable income in the previous year, U.S. dollars

Q_1 = the first quarter of the year.

The forecast depends on the total beef supply as represented by X_1, X_2, X_3 and last year's per capita income with adjustments for the particular quarter. The import variable X_3 has a positive sign which is not logical unless one recognizes that this is simply an association in the data base rather than a cause and effect. Technically, the quarterly adjustments are not statistically different from zero in this case.

The more complex reduced form equation was omitted for the sake of brevity. Details of models and evaluation are explained in Bourke, 1978, and 1979 (1 and 2, respectively).

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Integrated Cattle Feeding Hedging Strategies, 1972-1976

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Summary

Evidence from 47 feeding periods spanning March 1972 through June 1976 gives strong support to the use of futures markets for hedging cattle feeding. Routine cattle hedging was not evaluated because previous studies have shown it to be inappropriate, e.g., locking-in losses. Feeding only when an acceptable return per head was expected during the 2-month planning period based on simultaneous corn and long feeder-cattle hedges and short fat-cattle hedges was the most conservative strategy (LIDF) and definitely profitable when feasible. However, this strategy was used for only 13 of the 47 periods.

The next most conservative and second most profitable strategy (ELI) involved locking-in during the 2-month planning period if possible and, if not, cash feeding with the hope of hedging an acceptable return sometime within the feeding period. Though the ELI strategy returned only half as much per head during the profitabe March 1972-March 1973 period, its overall performance was clearly superior to that of the CM strategy.

Technical trading was clearly the most profitable of the hedging strategies although its variance was also large. Technical trading strategies have also performed well elsewhere and merit serious consideration by cattle feeders with the resources to maintain such activity.

Finally, it must be noted that hedging through the use of futures contracts does not, in fact, "lock-in" profits or particular prices. Locking-in would be successful only if the difference (or basis) between cash price and futures prices could be fully anticipated. Because this difference varies, a hedger is subject to basis risk. However, as illustrated in the 47 simulated feeding periods, basis risk was less than price risk and thus an appropriate selective hedging strategy can probably reduce price risk in cattle feeding.

Introduction

Most major crop and livestock prices became considerably more variable after 1972, resulting in increased producer price risk. Uncertainty in cattle feeding was compounded in that both input (feeder cattle and feed) and product (fed cattle) prices became quite variable after 1972. This uncertainty, accompanied by considerable losses in cattle feeding during the 1973-1975 period, has made hedging a more desirable option (1,9). Several studies have examined a short hedge on live cattle at the beginning of the feeding period as a means of reducing risk and increasing returns to cattle feeders. Selective hedging strategies generally reduced the variance of returns per head as well as improved returns during periods when cash feeding was unprofitable (2,5). Routine hedging of every pen clearly reduced profits during periods when cattle prices were rising while providing some protection during cash-feeding loss periods (6). Feeding live cattle on a cash basis was more profitable than routine hedging prior to 1973 (6).

Previous studies have been concerned only with the variation in live- or fed-cattle prices. This study examines the usefulness of live-cattle, feeder-cattle, and corn futures contracts in integrated hedging strategies for company-owned cattle. "Integrated" refers to the simultaneous use of long hedges with corn and feeder-cattle and short hedges with live-cattle futures contracts during the 2-month planning period prior to actual placing of cattle on feed. Long corn and feeder-cattle hedges were always lifted when cash corn and feeders were purchased to begin the actual feeding period, whereas the short live-cattle hedge could be held (or placed) throughout the feeding period depending on the strategy employed.

Several previous studies have used mean-variance analysis to evaluate the performance of hedging strategies (2,4,5,6,8). The same procedure was followed in evaluating the strategies developed here.

Data Sources and Assumptions

The costs and prices used in the hedging strategies evaluated were those applicable to feedlots in the Castro, Deaf Smith, and Parmer Counties region of the Texas High Plains area with 10,000 head or more capacity. The feedlot's major activity was assumed to be custom feeding, with the option to feed cattle for its own account in unutilized capacity. Thus, custom feeding might well be continuous whereas the feedlot's own feeding program would depend on returns expected under the alternative hedging strategies.

Forty-seven pens of cattle were considered under the alternative strategies during the 52-month period March 3, 1972, through June 16, 1976. This period was determined by the initiation of the Chicago Mercantile Exchange's feeder-cattle futures contract on November 30, 1971, and the most recent data available at the time of the study. A new pen of 200 choice

650-pound feeder steers could be started each month depending on the strategy used. Corn was the major feed grain used in the ration because corn production exceeded grain sorghum production by 35 million bushels in the three-county area. Feed costs per ton and feeder cost per hundredweight were assumed known on the first day feeder cattle were placed on feed. A conversion ration of 8.5 pounds of feed to one pound of gain and 2.7-pound average daily rate of gain yielded an 1100-pound choice steer in 167 days. A 4-percent "pencil shrink" yields a 1056-pound finished steer for sale. Death loss was 1 percent, and thus 198 of the original 200 head were available for sale.

Cash prices for choice 650-pound feeder cattle were weekly averages reported by USDA and Texas Department of Agriculture for the Amarillo Livestock Auction adjusted for transportation costs. Fed-cattle cash prices were for choice 900-1100 pound sales in the Amarillo area. Cash corn prices were for the Plainview-Canyon-Farwell-triangle area adjusted for handling charges and transportation to area feedlots. Prices for other feed ingredients were updated quarterly from information from a typical feedlot in the area.

Futures prices for live cattle and feeder cattle were from the Chicago Mercantile Exchange. Corn futures prices were for contracts of the Chicago Board of Trade. Futures prices were adjusted or localized to relate them to Texas High Plains area cash prices. Two alternative means of adjusting futures prices to High Plains local cash prices were considered. Adjustments A were determined from an examination of actual average bases. Cash prices were established in relation to futures prices at $2.50/cwt under for cattle, $0.75/cwt under for feeder cattle, and $0.10/cwt over for corn. Adjustments B were those suggested by feedlot and brokerage house representatives as applicable "rule of thumb" adjustments used in the study area. Cash prices relative to futures prices with adjustments were $1.75/cwt under for cattle, $1.25/cwt under for feeder cattle, and $0.20/cwt under for corn.

Hedging cattle feeding requires margins to be deposited and commissions to be paid on each futures contract used. Each pen of 200 head was 95 percent hedged by using five live-beef cattle contracts on the Chicago Mercantile Exchange. Two corn futures and three feeder cattle futures contracts were used to hedge 95 percent of the corn and 97 percent of the feeder cattle per pen, respectively.[1] Hedges for corn and feeder cattlewere placed in futures contracts with delivery months expiring as close as possible to the end of the planning period. Hedges for live cattle were placed using futures contracts with delivery months expiring as close as possible to the end of the feeding period. Daily costs for (a) interest on original and maintenance margins and (b) commissions were included in hedging expenses for all strategies.

[1]The futures contracts are for the following volumes: corn, 5,000 bushels; live beef cattle, 40,000 pounds; feeder cattle, 42,000 pounds.

Strategies Considered

A cash market strategy (CM) was used as a basis for evaluating four basic hedging strategies. The four hedging strategies were (a) lock-in or do not feed (LIDF), (b) lock-in or cash market (LICM), (c) extended lock-in (ELI), and (d) technical trading (TT).

Cash Market Strategy (CM)

Cattle were fed regardless of profitability, and returns per head were calculated from the sale of the cattle and variable costs associated directly with a pen of cattle.

Hedging Strategies

In the LIDF, LICM, and ELI hedging strategies a 2-month planning period preceded each scheduled feeding period. An expected lock-in margin (ELIM) per head was computed daily during the planning period.

If the expected lock-in margin (ELIM) was equal to or exceeded a predetermined required lock-in margin (RLIM) during the planning period, hedges were simultaneously triggered short in live cattle and long in feeder cattle and corn. The long feeder-cattle and corn hedges were lifted at the end of the planning period when cash feeder cattle and corn were purchased at the start of the feeding period.

Lock-in or Do Not Feed (LIDF).

If (a) an acceptable RLIM target per head was not locked in during the 2-month planning period or (b) ELIM computed with cash corn and feeder prices and the live-cattle futures price at the beginning of the feeding period was not greater than zero, the cattle were not fed under the LIDF strategy.

Lock-in or Cash Market (LICM).

The LICM strategy was a combination of the CM and LIDF strategies. If ELIM exceeded the RLIM on any day during the 2-month planning period, live cattle were short hedged and feeder cattle and corn were long hedged until feeding started. However, if hedging was not done during the planning period, cattle were fed on a cash basis regardless of the profitability, and this approach yielded the same results as the cash marketing strategy (CM) for those pens.

Extended Lock-in (ELI).

The ELI strategy was the same as the LICM strategy except that a short live-cattle hedge could be triggered on any day during the feeding period when ELIM equaled or exceeded the specified RLIM. ELIM computed during the feeding period used corn and feeder cattle cash prices as of the beginning of the feeding period rather than the adjusted corn and feeder cattle futures prices.

Technical Trading (TT).

Purcel (7) and Price (6) reported moving averages useful for indicating opportune times for placing and lifting live-cattle hedges. The technical indicator used in the study consisted of 10- and 15-day moving averages and is explained in detail by Johnston (3). For the live-cattle futures, if the 10-day moving average dropped below the 15-day moving average by a specified amount and the sum of the most recent three first differences in the 15-day moving average was <0, live cattle futures were sold. Each day that a hedge was open, the lowest closing price since entering the position was multiplied by a specific stop percentage to set the stop price for the following day. Stop percentages for offsetting hedge positions were adjusted according to the amount of recent movement in the futures prices, i.e., the greater the range, the greater the stop percentage. Essentially, hedges were placed by the moving average indicator and lifted if the stop price was reached.

Moving average price indicators were used for placing and lifting long hedges in corn and feeder cattle during the 2-month planning period. Short live-cattle hedges were placed and lifted during the planning period as well as after the feeding period began. Corn, feeder-cattle, and live-cattle hedges were placed and lifted independently as many times as the technique indicated an adverse price movement.

Margin requirements were expected to be less than those for the other strategies although total hedging costs were expected to be greater because of increased commission expenses.

Results

The 52-month period during which the 47 pens were fed can be divided into three subperiods based on returns per head above variable costs for the CM strategy (Table 1). The CM strategy was generally very profitable for pens placed through March 1, 1973, unprofitable for pens placed from April 1973 through October 1974, and very profitable for pens placed from November 1974 through July 1975; some losses occurred from then until early 1976.

Subperiod I: Pens Placed March 1972-March 1973

The CM strategy was most profitable during this subperiod at $30.75 per head average return over the 13 pens fed. The variance of returns was significantly lower. The TT strategy performed similarly to the CM strategy during this period of rising cattle prices.

Subperiod II: Pens Placed April 1973-October 1974

This was a disaster period for the CM strategy with losses averaging $63.54 per head and ranging from −$147.59 to −$5.47 per head. All 19 pens lost money on a cash feeding period basis. In contrast, all hedging strategies' mean returns were significantly greater than CM returns.

Sixteen of the 19 pens were hedged with the ELI strategy in subperiod II, six hedges during the 2-month planning period and 10 short live-cattle hedges after the feeding periods began. Mean returns per head at $14.39 were significantly greater than the $63.54 per head loss with cash feeding, but variances were similar. Only four of the 19 pens lost money with the ELI strategy and three of those pens were unhedged.

TABLE 1. COMPARISON OF MEAN VARIANCE RESULTS AMONG CASH MARKETING, LOCK-IN OR DO NOT FEED[a], LOCK-IN OR CASH MARKET, EXTENDED LOCK-IN, AND TECHNICAL TRADING STRATEGIES, 47 PENS AND SUBPERIODS, TEXAS HIGH PLAINS, 1972-1976

Pen number	Measure	Cash Market Strategy	Lock-in or Do Not Feed	Lock-in or Cash Market	Extended Lock-in	Technical Trading
		dollars per head				
	Mean	30.75	0	Same as	14.65	28.22
	Variance	913.14	0	cash	273.35	1131.42
	Standard Deviation	30.22	0	market	16.53	33.64
1-13	95% Confidence Intervals	(−35.10, 96.07)	0	strategy	(−21.63, 50.67)	(−45.08, 101.52)
	Range	(−10.12, 74.87)	0		(−10.12, 35.66)	(−20.66, 83.97)
	Pens fed/hedged	13/0	0/0	13/0	13/8	13/13
	Mean	−63.54	7.10	−34.46	14.39	22.24
	Variance	1305.96	170.30	2355.16	1827.42	6730.10
	Standard Deviation	36.13	13.05	48.63	42.74	82.04
14-32	95% Confidence Intervals	(−139.07, 11.99)	(−20.30, 34.50)	(−136.37, 67.45)	(−74.93, 103.71)	(−150.04, 194.52)
	Range	(−147.59, −5.47)	(0, 46.15)	(−106.93, 46.15)	(−106.93, 51.76)	(−131.53, 161.71)
	Pens fed/hedged	19/0	6/6	19/6	19/16	19/19
	Mean	46.65	14.42	47.01	37.69	46.85
	Variance	5468.84	481.36	2642.99	511.64	4744.35
	Standard Deviation	73.95	21.94	51.41	22.62	68.88
33-47	95% Confidence Intervals	(−110.86, 204.16)	(−32.53, 61.37)	(−63.01, 157.03)	(10.72, 86.09)	(−100.55, 194.25)
	Range	(−93.98, 146.50)	(−0.95, 60.32)	(−42.30, 145.03)	(−0.95, 71.37)	(−78.13, 184.44)
	Pens fed/hedged	15/0	7/7	15/7	15/15	15/15
	Mean	−2.29	7.47	9.57	21.90	31.75
	Variance	5052.66	244.60	3348.94	1061.59	4487.89
	Standard Deviation	71.08	15.64	57.87	32.58	66.99
1-47	95% Confidence Intervals	(−145.52, 140.94)	(−24.12, 39.06)	(−107.33, 126.46)	(−43.75, 87.55)	(−103.23, 166.73)
	Range	(−147.59, 146.50)	(−0.95, 60.30)	(−106.93, 145.03)	(−106.93, 71.37)	(−131.53, 184.44)
	Pens fed/hedged	47/0	13/13	47/13	47/39	47/47

[a]For ELIM of $20/head and basis adjustments 8.

The TT strategy yielded the best results during the heavy cash loss subperiod II. Mean returns per head of $22.24 were highest, but variance of returns was also highest in comparison with that of other strategies. Six of the 19 pens were losers with the TT strategy which used futures trading for all 19 feed-out periods.

Subperiod III:
Pens Placed November 1974-January 1976

The CM strategy was profitable again during this time with 11 of the 15 feeding periods yielding positive returns. Mean returns were high at $46.65 per head, but the variation in returns was very large; they ranged from −$93.00 to $146.50 per head per pen. In contrast, the ELI strategy returns averaged $37.69 per head, but variance was significantly lower than that for CM; individual returns ranged from −$93 to $71.37 per head over the 15 feeding periods. Results of the TT strategy were similar to those of the CM strategy.

Overall Performance:
47 Feeding Periods

The CM strategy yielded an average loss of $2.29 per head over the 47 feeding periods, whereas each of the hedging strategies showed positive returns (Table 1). Only the $21.90 and $31.75 average per head for the ELI and TT strategies, respectively, were significantly greater than the −$2.29 per head for the CM strategy. Variances of returns were significantly lower for the LIDF, LICM, and ELI strategies than for the CM strategy.

The LIDF strategy initiated feeding in only 13 of the 47 possible pens, eight pens during the planning period under the $20 RLIM criterion and five additional pens on the day feeding began with ELIM, ranging from $1.21 to $22.07. The RAVC per head for the 13 pens fed was only $7.47 when averaged over the 47 pens, not significantly greater than the CM strategy mean (Tale 1). Variance of LIDF returns was significantly lower than the CM variance. However, the eight particular pens during which simultaneous long corn and feeder-cattle hedges and short live-cattle hedges were placed during the planning period out-performed the corresponding cash pens significantly in terms of both higher returns and lower variance (Table 2). Mean returns per head were $51.52 greater than those for cash feeding.

The ELI strategy is probably the most readily adaptable for a feedlot if continuous feeding is desired; i.e., lock-in during the planning period if possible, but if not, commence feeding and short hedge in live cattle futures if the opportunity arises during the feed-out period. The ELI strategy provided both significantly higher returns and lower variance than the CM strategy. More than 80 percent of the 47 pens were eventually hedged with the ELI strategy; eight pens were lock-in during the planning period, and 31 pens were hedged at the beginning or during the actual feed-out period. Starting feeding on a cash basis was, of course, speculative, but most of the

TABLE 2. COMPARISON OF MEAN RETURNS PER HEAD FOR EIGHT PENS HEDGED DURING PLANNING PERIOD WITH SAME CASH MARKET PENS

Subperiod and pen number	Feeding dates	Revenue above variable costs: Cash market	Revenue above variable costs: Lock-in or Do Not Feed
		--------Dollars per head-------	
Subperiod II			
30	8/74-1/75	−94.83	14.22
31	9/74-2/75	−45.34	21.51
32	10/74-3/75	−56.32	24.65
Subperiod III			
33	11/74-4/75	20.76	40.23
42	8/75-1/76	2.62	8.05
43	9/75-2/76	−41.00	16.23
44	10/75-3/76	−93.89	− 0.94
45	11/75-4/76	65.84	46.04
All pens	Average	−30.84	21.25

pens became hedgeable during the feeding period. Eighteen of the 31 hedges which involved only live-cattle hedges were placed within 12 weeks of the start of feeding. The 39 hedges were opened on only 28 dates, and two or three hedges were triggered on the same date on seven occasions. The proportion of live-cattle short hedge opportunities which occurred during the feed-out periods over the 47-month span is consistent with the expectations of experienced hedgers (1).

The TT strategy placed and lifted as many as seven live-cattle short hedges per pen based on indicated price movements, whereas corn and feeder cattle trades were limited to one or two per pen during the planning period. Though the TT strategy was judged the most successful because of highest average returns per head, $31.75, it was also the most complicated to conduct because of the several values which had to be derived and compared daily.

Margin Requirements

All returns for the various hedging strategies are net of hedging costs for commissions and interest on original and maintenance margins. However, acquiring the necessary margin money to maintain hedges under the lock-in strategies is critical to the hedging programs. The maximum margin requirement was $32,174 on June 18, 1975, for pen 36 under the LIDF strategy which incurred hedging costs of $647.42 but returned $46.46 per head. Maximum margin requirement under ELI was $29,874 for pen 37, yielding a hedging cost of $675.58 and returns of $38.93 per head. The average of the maximum margin requirements for the 39 pens hedged with ELI was $12,517 with a standard deviation of $7,343. Minimum and initial margin requirements were $4,500 when only live-cattle hedges were used and $7,300 when live-cattle, feeder-cattle, and corn hedges were placed during the planning period.

Maximum net margin deposits under the TT strategy were only $7,589 (pen 39), or much less than those under the lock-in strategies, because hedged positions were offset when price trends appeared favorable to unhedged positions. In contrast, hedging costs were significantly higher for TT than for the lock-in strategies because of the greater number of round-turns generated under TT. Hedging costs were generally less than $3 per head for lock-in strategies versus $4 to $6 per head for TT.

Though margin requirements per pen did not exceed $32,174 under the lock-in strategies, five pens on feed simultaneously could approach $100,000 in margin requirements during the periods of rising prices.

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Economics of Management/Marketing Alternatives for Cattlemen

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Summary

Guides were developed for the long-run decision of selecting beef-breed type and short-run decisions relating to selling weaner calves or owning them through a stocker stage and/or feeding stage. Profits favored large-frame breeds and cows with lighter milking potential during the period 1972-79. Production costs for weaner calves favored the heavier milking types, but these had higher costs when carried through stocker or feeding stages. Moving weaner calves direct to the feedlot for finishing to "mostly choice" had the lowest costs and highest profits (or least loss) during 1972-79 compared to selling weaner calves, owning them through a stocker stage, or owning them through a stocker-feeder stage, Using a recognized forecast service for decision criteria at weaning or at the end of the stocker stage yielded higher returns than any fixed program alternative other than always moving weaned calves direct to the feedlot in 1972-79. Decisions based on profit hedging with futures was not a profitable alternative.

Introduction

Erratic and cyclical markets are characteristic of the beef industry, and alternatives need to be evaluated over a considerable period to try to find stable decision guides for management and marketing. Computer models of herd performance, costs and returns permit comparisons of many alternative management and marketing systems over a number of years. Results of absolute costs and returns for some historical period may be of little value for future decisions, but comparison of costs and returns among alternatives can provide insight as to best decision criteria and most profitable systems.

Experimental Procedure

Data were based on Central Texas ranching situations with vertical integration alternatives being compared to the standard practice of selling weaned calves in early fall during 1972-79. It was assumed that stocker calves could be grazed on rented small grain pasture and that cattle could be fed in custom feedlots in the Texas panhandle. Published monthly average costs and prices were used where available.

The Texas A&M University Beef Cattle Herd Simulation Model was used to develop estimates of herd production and performance for nine herds of different breed types. This included three frame sizes represented by mature cows weighing 1,213 pounds, 1,102 pounds and 992 pounds for large, medium and small frames, respectively. Each frame size included three levels of milking ability with a daily maximum potential of 31 pounds, 24 pounds and 18 pounds for heavy, medium and light milkings, respectively.

Decisions of how and when to market were compared for fixed or constant systems with choices based on a forecast and on an automatic hedging program. Under the choice systems, if the forecast price of cattle did not indicate a profit from the alternative vertical integration schemes, calves would be sold at weaning. Likewise, if the futures market did not offer an opportunity to lock in at least a modest profit from stocker or feeding operations the weaned calves would be sold. Cattle on feed were marketed when they reached "mostly choice" grade (70 percent USDA Choice).

Results and Discussion

Decision guides were developed concerning the alternatives available to cattlemen who have the type of operation and the financial capability to maintain ownership of calves beyond weaning age. Under those circumstances it was clearly more profitable to maintain ownership through the feedlot during the 1972-79 period. Carrying calves through a stocker operation only was not profitable for the 7-year average, although at times it was, particularly in connection with moving the calves on through the feedlot. The most profitable alternative was the fixed system of moving all calves directly to the feedlot after weaning, regardless of the market signals each year at fall weaning. The next best decision system was the USDA price forecast to select the alternatives based on expected highest profit. These methods of operation were not the best every year, For example, the most profitable alternative was to sell the weaned calves in 1973. This was signaled by the USDA forecast and the fixed systems of stocker and feeding all lost heavily on those animals in 1974. On the other hand, the USDA forecast signaled that 1972 calves should be sold at weaning, but all alternative systems were profitable because of a sharp increase in the general price level for all cattle up to September, 1973 (1). This research indicates that an operator can use guides such as those developed in this study and apply his own judgement to improve his profits substantially.

Use of a computer-simulation model made it feasible to develop estimates of average production costs for nine breed types and six marketing alternatives (Table 1). At weaning, average cost of production per pound was lowest for the large-frame herd with cows that had a heavy milking capacity at $67.79 per hundredweight. The highest cost was for the small-frame cow herd with a light milking capacity at $73.31 per hundredweight. The average over all systems was $70.75. For each of three frame sizes, the heavy-milking cow herd produced weaned calves at lower cost per pound. When performance of these calves were evaluated through stocker and/or feeding stages, however, costs were lower for lower milking capacity herds. For the large-and small-frame herds, the light-milking capacity produced the lowest costs at all the alternatives considered beyond weaning. For the medium-frame herd, medium-milking capacity had slightly lower costs except in the case of the alternative of grazing on wheat November to May and then finished in the feedlot where the difference between medium- and light-milking capacity was trivial.

The conclusion from this evaluation of breed type through all stages is that production cost differences for steers and heifers from herds with different milking capacities were small, but favor cows of lighter milking capacity under Central Texas conditions. Differences in average production cost by frame size were larger and were lowest for the large-frame herd. The lowest cost estimates for each of the alternatives beyond weaning were in the large-frame cow herd with light-milking capacity. When evaluated on a constant land unit basis, these conclusions are the same. In other words, there was no evidence that more small cows per unit of land would yield a higher profit (1).

Average added net returns per head over selling weaner calves were calculated for several fixed systems of vertical integration. During the 1972-79 period, only moving calves direct to feedlot or winter grazing on wheat pastures and finishing in the feedlot were profitable at $38.67 and $16.61 per head, respectively. The stocker operation — winter grazing averaged no profit and the Winter-Spring grazing lost an average of $11.33 per head (Table 2). Winter-Spring grazing and then feedlot finishing lost the most at $15.89 per head. The best fixed system returned only a little more than half that of the standard of "perfect hindsight" at $64.68 per head (Table 2). This estimate was obtained by evaluating the best

TABLE 1. AVERAGE LIVEWEIGHT PRODUCTION COST UNDER ALTERNATIVE FEEDING SYSTEMS FOR THE VARIOUS GENOTYPES, 1972-79[a]

Feeding System	Genotype[b]									
	Large Frame			Medium Frame			Small Frame			Average for all
Milk Capacity	Heavy	Med.	Light	Heavy	Med.	Light	Heavy	Med.	Light	systems
	(dollars per cwt)									
Weaner calf	67.79[x]	69.26	68.91	69.43[x]	69.70	73.02	72.13[x]	72.80	73.71	70.75
Direct to feedlot	58.41	57.81	56.36[x]	59.75	58.32[x]	58.58	61.85	60.35	59.20[x]	58.96[y]
Graze November-February	64.51	64.79[x]	63.56[x]	66.03	65.35[x]	66.84	68.46	68.02	67.66[x]	66.14
Graze November-February then feedlot	59.78	59.15	57.59[x]	61.12	59.76[x]	59.83	63.21	61.84	60.60[x]	60.32
Graze November-May	62.90	62.71	61.22[x]	64.39	63.37[x]	64.16	66.73	65.89	65.08[x]	64.04
Graze November-May then feedlot	60.83	60.19	58.63[x]	62.22	60.90	60.86[x]	64.33	63.02	61.78[x]	61.42

[a]Estimates based on TAMU Beef Cattle Herd Simulation Model.

[b]Frame sizes were mature cow weights of 1213 lbs., 1,102 lbs., and 992 lbs. for large, medium, and small, respectively. Milking capacity was a daily maximum potential of 31 lbs., 24 lbs., and 18 lbs. for heavy, medium, and light, respectively.

[x]Lowest cost of production for a particular feeding system within a frame size.

[y]Lowest average cost over all systems.

TABLE 2. AVERAGE ADDED NET RETURNS PER HEAD OVER SELLING WEANER CALVES UNDER ALTERNATIVE PRODUCTION/MARKETING SYSTEMS FOR THE VARIOUS GENOTYPES, WEAN NOVEMBER 1, 1972-79, CENTRAL TEXAS RANCH

	Fixed systems					Choice systems			
Geno-Type Frame-milk[a]	Direct to feedlot	Winter grazing	Winter graze and feedlot	Winter-Spring grazing	Winter-Spring Graze and feedlot	Hind-Sight[b]	Current price as forecast[c]	USDA forecast	Hedge/w futures
	Dollars/Head								
LGE-HEV	42.98	−3.77	26.36[z]	−21.46	−7.60[z]	71.86	7.96	33.07	2.06
LGE-MID	47.70[z]	−.04	19.35	−13.95	−14.19	72.83[z]	8.03[z]	39.67	2.03
LGE-LIT	45.58	4.16	13.63	−5.43	−19.69	68.58	5.05	41.18[z]	1.00
MED-HEV	33.24	−3.00	24.07	−18.80	−10.79	63.52	4.49	26.08	2.91[z]
MED-MID	40.80	0.70	16.31	−11.25	−15.90	66.23	5.38	33.75	1.96
MED-LIT	42.32	4.60	10.74	−3.47	−19.97	65.02	4.03	33.88	.49
SMA-HEV	25.53	−2.49	20.23	−16.62	−14.80	56.30	2.81	18.59	0.53
SMA-MED	32.94	1.09	12.11	−9.28	−17.92	58.41	2.98	23.76	0.78
SMA-LIT	36.93	4.85[z]	6.67	−1.74[z]	−22.18	59.39	3.63	26.94	−.04
System Avg.	38.67	0.68	16.61	−11.33	−15.89	64.68	4.93	30.77	1.30

[a]Indicates frame type of animal and milking capacity. For example, LGE-HEV is a large-frame animal with a dam of heavy milking capacity such as Simmental; whereas SMA-LIT refers to a small-frame animal with a dam of low milking capacity such as a small Hereford.

[b]Hindsight refers to looking back each year and selecting the system that would have returned the highest profit.

[c]Current prices and costs were used as decision criteria at weaning to predict profit of system.

[z]Highest added return among genotypes over selling weaner calves.

alternative each year after prices and costs were known. The purpose of this estimate is to show what was possible from a perfect forecast of the best alternatives each year.

Among the choice systems, three criteria for evaluating the best alternative at weaning time and at the end of a stocker stage were evaluated. The current price was used as a forecast of the price of the stocker or finished animal to calculate the expected profit from each alternative. This produced an average of $4.93 profit per head (Table 2). This is not a recommended alternative but it might be surprising to know how many cattlemen tend to use this approach to decision-making. Using the USDA forecast to select alternatives each year produced profit of $30.77 per head (Table 2). This was the second best criterion below the fixed practice of always moving weaned calves direct to the feedlot. The practice of using the futures market to select alternatives yielded little average profit per head at $1.30. The approach followed was to examine futures prices and select the alternative that could "assure" a profit from a hedge. For several years a profitable hedge was not available at weaning time so calves were sold at weaning. At other times a profit was expected and a shift in the basis or in a change in costs wiped out the expected profits. The foregoing suggests that careful use of a recognized price forecast is a viable criterion for selecting the best alternative. It does not prove that use of selective hedging is not a good practice, but neither does it indicate the standard procedure used here of using futures as a forecast and automatically hedging those cattle held beyond weaning is a viable alternative.

The "Z" in Table 2 denotes the highest profit genotype for each of the selection criteria. Large-frame cattle generally had the most profit, and milking potential was sufficiently mixed to be inconclusive.

The general conclusion from this study is that for those operators with sufficient size and capital, always selling calves at weaning appears to be a less profitable alternative to owning the cattle through the feedlot.

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International Trends in Beef Production

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Beef production on a global scale has historically proven extremely unpredictable. For example, high beef prices during 1972 and 1973 concerned many governments who considered increasing imports from certain developing countries. Within the short space of one year, however, the picture drastically changed: demand for beef was suppressed by high prices while producers continued to increase output. Within the European Economic Community (EEC), a rapid increase in beef stocks generated substantial surpluses, and pressure was brought by producers to temporarily ban beef imports from Third World Countries. The international beef trade was thus thrown into confusion. Similarly, in other areas of the developed world, the rather rapid transition from apparent beef shortages to "gluts" contributes to the precarious nature of making long term beef production and marketing predictions.

Still, a good deal of merit exists in looking at past developments in the worldwide beef industry as a basis for what is likely to happen in the future. Not only do trends occur in the volume of beef produced but also in the quantity traded internationally. For example, total meat imports by OPEC countries is estimated to have increased seven-fold between the early 1970's and 1978. Conversely, favorable circumstances can transform a particular country from a net importer to a net exporter of beef. Space and time will permit only a brief overview of international trends in beef production, yet this may provide some insight as to the future of the Texas beef industry and to how it may continue to make a significant impact internationally.

Beef Production and Consumption

Although developed countries have only about one-third of the world's cattle they produce two-thirds of the world's beef. An obvious message for developing countries is that, instead of increasing the number of beef cattle, the main challenge is to increase the productivity of the animals they now have — or perhaps, have fewer selected but more productive cattle.

Hand in glove with lower production are the higher consumption patterns in developed countries. The world average animal protein consumption per capita daily is about 25 grams; this, however, varies from about 9 and 11 grams per head per day in the Far East and Africa, respectively, to about 70 grams in the United States. More beef than any other kind of meat is consumed in all regions of the world, except the Near East (where mutton is the preferred meat) and the Far East.

Existing high beef consumption in developed countries will be followed by further, if not so marked, increases in the 1980's. In the developing world, promising possibilities exist for increasing beef production but this is unlikely to bring about any significant increase per capital since population growth (in the region of 3 percent in many cases) more than offsets the projected increases. In fact, evidence points to a somewhat declining beef production consumption per capita in recent years in a number of developing countries. There is little indication that there will be a marked reversal in this trend during the next 5-10 years. In an effort to improve the population's intake of animal protein, policy makers in these countries are looking not only to beef but to a range of alternatives.

Alternatives to Beef

World beef output declined in 1978 for the first time since 1971. Simultaneously, worldwide production of swine and poultry meat expanded, largely as the result of a greater demand for these meats as others (particularly beef) became scarcer and more expensive. Long-term predictions during the early to mid-1970's for beef consumption within EEC member countries proved to be off target; the assumption that demand would continue to increase in line with previous trends did not agree with the reality of consumers switching to alternative sources (swine and poultry meat mainly) as beef prices increased. A similar trend can be observed from time to time within the United States. Nevertheless, throughout most of the developed world, beef consumption is expected to increase in the long term, even if at a slower rate than during the 1960's and 1970's.

Even with due allowance for the potential of increasing beef supply in developing countries, there are serious obstacles to efficient production. Where animal protein consumption is extremely low, the matter of providing it in the form of beef, in preference to fish, or swine or poultry meat, may have little relevance. The low purchasing power of communities is the reason why demand for lower cost poultry meat continues to remain buoyant. In line with this trend, much attention and research are now focused on non-conventional sources of animal protein. The potential of buffalo to gain satisfactorily and produce acceptable meat, as well as milk, when fed and managed properly is recognized and may figure more prominently in the future (1). There is renewed interest in wild animals as a source of meat (4). Because of the increased efficiency with which rabbit converts roughages to liveweight gain, it will likely continue to receive attention in the future. Current interest in such an "exotic" species as the crocodile suggests that the list is far from exhausted.

Relative Importance of Dairy and Beef Breeds

In Europe and the Soviet Union, most beef is traditionally produced from dairy herds, in contrast to the United States where specialized beef farms take animals through various phases of their life cycle. As milk and beef are demanded in a certain ratio, generally considered to be 4-5:1 (6), this may be met by maintaining about 15 percent of the total herd as dairy cows and the remaining 85 percent as cattle of recognized beef breeds. This is not very dissimilar to the current system in the United States. With the introduction of higher yielding breeds and selection within purebreeds proceeding simultaneously during the past 30 years, the milk demand can now be met with a small percentage of total cattle population in the United States and many other developed countries.

The widespread use of local (mainly humped Zebu) breeds in developing countries for both milk and beef, in that order, implies that productivity is low among unselected cows which are subjected to climatic stresses and are fed on relatively poor quality forages. If crossbred (European x local Zebu) cattle could be increased in numbers, it is felt that these animals could produce the milk:beef ratio of 4-5:1 required in many developing countries. There is already some progress along these lines in a number of countries.

Within the beef breeds, the larger framed, better muscled and faster gaining European breeds are gaining increased popularity in developed countries. With continued efforts towards producing the maximum amount of lean meat most efficiently, these will likely play an even greater role in the future.

The focus is considerably different throughout much of the developing world where heat stress and lower quality forages demand an animal with both adaptability to the environment and an acceptable rate of gain. One long-term approach is the selection of genetically superior animals within the local population; it is now realized, albeit very late, that had a selection program been started 50 years ago much of the required progress could already have been achieved. Mason (5) in his defense of Zebu cattle breeds states that "cattle which have been naturally selected to be able to live and reproduce in a certain environment may well be the best animals for producing beef in that environment. Do not be misguided by racial prejudice to believe that European breeds are necessarily better than African or Asian ones." Obviously, where feeding and management are optimum, productive advantages exist in having animals with a proportion of "exotic" genes.

Feed Resources

During the past two decades considerable strides were made in the production of good quality fodders but more striking increases occurred in grain growing for animal feeding. Grain use in animal feeds increased by an estimated 60 percent worldwide between 1963 and 1977, caused largely by the increased production of low cost grains such as corn, sorghum and barley. A higher proportion of grain is used for livestock feeding in the United States than in Europe where the high grain prices set by the EEC encourage the incorporation of a higher percentage of roughages in beef rations (3). FAO estimates reveal that worldwide grains supply about three quarters of the metabolizable energy and about half of the crude protein for livestock.

The inclusion of grains in beef cattle rations increased rapidly during the 1950's and 1960's in line with the accelerating demand for livestock products, especially in developed countries. The world food crisis of 1973 and 1974 caused a considerable deceleration in the use of grains due to shortages and high prices as well as a falling off in demand for beef as a result of the 1974 economic slowdown. The better harvests in 1975 encouraged an upswing in the use of grains but, due to lower economic growth rates in industrialized countries, it is expected that rates of increase during the next 5 years will be lower than previously.

About 80 percent of the world's feed-grain is used in developed countries, with the United States alone accounting for 25-30 percent (2). Major expansions in U. S. grain-feed usage during the 1950's and 1960's were checked in 1973 because of high grain prices; a reduction of 36 million tons (25 percent of the total grain used) occurred between 1973 and 1974, brought about by a return to more pasture-based beef production. Between 1977 and 1978 feedlot beef became more attractive again when grain prices declined and the price of beef increased.

In Western Europe, considerable quantities of grain were used for beef feeding during the 1960's but the subsequent high EEC grain prices encouraged the replacement of grains with cheaper substitutes such as beet pulp, cassava and copra meal. Grain feeding nearly tripled in the Soviet Union during the 1960's due to an increase in domestic production; the expansion in beef production during the 1970's could only be maintained through substantial grain imports to compensate for the insufficient home-produced grain.

Because of competition between human populations and livestock for grains in developing countries, widespread grain feeding to livestock is often difficult to justify. Consequently, only small amounts of grain, or less than 20 percent of the world feed-grain utilization, is fed to livestock. In these countries, grain feeding is confined mainly to dairy, pig and poultry enterprises situated near urban areas, with only small amounts fed to beef cattle.

Future Projections

Projections to the year 1985 (3) call for considerable increases in the demand for livestock products. World demand for meat is expected to increase from 108 million tons during 1972 to 1974 to about 144 million tons in 1985. Between 1980 and 1985 production of beef, veal and mutton is expected to grow at a slower rate than during the 1960's and 1970's, but swine and poultry meat could continue increasing just as rapidly as in the past. This latter trend will be particularly strong in many developing countries. As a result, feed gains are predicted to increase from 483 million tons during 1972 to 1974 to more than 628 million tons in 1985. The major part of the increase is likely to occur in developed countries where the 1985 demand is expected to be over 515 million tons versus a little more than 113 million tons in developing countries.

Growth in demand for feed grains over the next decade is, however, predicted to be lower than in the previous one. Contributing factors include: (a) the already high meat consumption in developed countries and (b) the estimated small increases in both population and income. In developing countries, however, meat production is expected to increase, leading to a strong demand for feedstuffs; demand for feedgrains is envisaged to rise by 3.9 percent per annum versus 1.9 percent in developed countries. If this growth rate is put in proper perspective, however, the volume increase in developing countries for 1985 (30 million tons) will be only about one third of the 90 million tons increase estimated for developed countries.

Projections of this nature are subject to so many uncontrollable factors that the trend, rather than projected figures, may be the more meaningful. Obviously, the figures quoted should be treated with a degree of caution and reservation.

Impact of Texas Research

Texas and other states in the southern United States having predominantly subtropical climates were faced early with particular problems related to efficient beef production. It is a fitting tribute to past research workers that these difficulties were tackled and solved, paving the way for one of the most efficient beef industries in the world. Although the expressed purpose was to help Texas beef producers, due to a similarity of climate with a good part of the developing world, a "spin-off" occurred in the new technology which could be adopted in tropical and semi-tropical countries, either in its original or a modified form.

Imported Indian breeds of cattle, although well adapted to the climate of the southern United States, were early recognized genetically incapable of producing beef efficiently and economically. Research was prompted to crossbreed Indian breeds and led to the development of the Brahman breed which combines a satisfactory performance rate together with good climate adaptability. As feed quality improved genetically superior stock were needed, to that provided by the mixture of Zebu parentage making up the Brahman breed; crossbreeding work was then conducted involving European breeds and the foundation Brahman cattle. The excellent results from this research had a significant impact on not only the southern United States but on a number of developing countries where the findings were both properly interpreted and adapted to suit local conditions.

The breeding and propagation of more productive species of grasses and legumes kept pace with the spread of genetically superior cattle. Improved systems of both pasture and range management ensured maximum utilization of the extra feed and a high beef production per acre. The hot climate encouraged research into practical means of modifying the microenvironment to improve both reproductive and productive efficiency.

Factors limiting reproductive performance, notably protein, phosphorus and trace minerals, were researched and quantified. A variety of feed additives and growth promotants were evaluated with a view to their economical use under production conditions.

Research conducted in the southern United States (Florida to Texas and beyond) and subtropical Australia is having an impact far beyond the sites of implementation. This is not to say that research conducted elsewhere in the developed world has little or no application; the climatic similarity of the former to semitropical countries makes much of the research more meaningful, applicable and, perhaps, more credible to possible users in developing countries.

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Estimates of Corn and Grain Sorghum Processing Cost in Commercial Feedlots

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Summary

Five grain processing alternatives were compared for corn and grain sorghum in feedlots of 5,000 and 20,000 head capacity by estimating net value per ton of processed grain dry matter. Cattle responses for each processed grain were obtained from published literature, and 1980 grain processing budgets were obtained from feedlots and commercial mill construction firms. Net value per ton ranged from $7.71 to a negative $9.35 for 5,000-head feedlots and from $9.33 to a negative $8.50 for 20,000-head feedlots. The typical rank (most to least favorable) of net value per ton was reconstitution, steam flaked, dry processed, early harvested-ground-stored in trench silo, followed by early harvested-acid treatment. Grain sorghum typically offered more potential net value per ton than corn.

Introduction

The efficient utilization of all feeds fed to cattle has long been a goal of cattle feeders and nutritionists. Most feed grains respond favorably to several processing techniques by reducing grain dry matter required to produce tissue gain. Typical cattle managed through feedlots each consume from 2,000 to 2,800 pounds of grain. Therefore, small improvements in utilization of grain have significant economic impact. All grain processing techniques utilize some energy, and their net economic benefit has declined as fuel costs have escalated more rapidly than other costs. Current budgets were therefore established for five prominent grain processing alternatives with corn and grain sorghum for commercial feedlots of two sizes.

TABLE 1. SUMMARY OF CATTLE RESPONSES TO PROCESSED GRAINS

Grain	Method of processing	Number of trials[a]	Change over dry grain, %[b]	
			Gain	Grain conversion
Corn	Steam flaked	7	2.31	7.46
Corn	Reconstituted	6	−.27	7.97
Corn	Early harvest-ground-trench	10	−1.87	11.14
Corn	Early harvest-acid treated	9	2.35	3.97
Grain sorghum	Steam flaked	9	5.83	8.11
Grain sorghum	Reconstituted	13	1.59	12.32
Grain sorghum	Early harvest-ground-trench	7	5.97	9.35
Grain sorghum	Early harvest-acid treated	3	−2.08	8.11

[a]Number of trials reported in literature that utilized dry grinding or rolling as controls. Only data that fell within specified standards for each grain processing technique were included.

[b]All responses represent weighted averages. Grain conversion applied only to processed grain dry matter.

Experimental Procedure

Five grain processing methods for which cattle performance and partial budgets were developed included 1) dry processing (rolled or ground) to serve as a control, plus 2) steam flaking, 3) reconstitution, 4) early harvested, ground and stored in trench silos, and 5) early harvested-acid treatment of grain. These five techniques were evaluated for both corn and grain sorghum in feedlots with a one-time rated head capacity of 5,000 or 20,000.

Published literature was surveyed to determine representative animal responses for each grain processing alternative and are summarized in Table 1. Initial investment, cost of operation, and depreciation schedules for each process were estimated through industry visitations. With these data a net economic response was projected. Interest on both fixed and variable cost was charged at 15 percent per annum. Grain needs were estimated by assuming a 90 percent feedlot occupancy with 2,600 pounds of grain fed per head for the dry grain controls. Annual grain dry matter requirements were then estimated by applying feedlot turnover rates of 2.12 and 2.03 for corn and grain sorghum, respectively. The same annual grain dry matter requirements and purchases were assumed for each method of processing. Improvements in conversion of grain dry matter utilization were then reflected as more cattle fed per year within each system. This approach was utilized so that each grain processing system would reflect its net economic response with a uniform amount of grain processed each year. Operational cost to process corn and grain sorghum were assumed to be identical. Corn was assumed to cost $5.00 per hundredweight and grain sorghum, $4.50 per hundredweight. No inventory losses were assessed except 1 and 2 percent during storage for early harvested ensiled and acid treated, respectively.

Results and Discussion

Each grain processing alternative improved grain dry matter conversion for fattening cattle, a well established fact from the published literature (1). However, the combined results of projected cattle

TABLE 2. ESTIMATED CATTLE PERFORMANCE AND COST OF PROCESSING CORN, 5,000-HEAD FEEDLOT

Item	Method of processing				
	Dry processed	Steam flaked	Reconstituted	Early harvested: Ground ensiled	Early harvested: Acid treated
Cattle performance					
Estimated daily gain, lb.[a]	2.62	2.68	2.61	2.57	2.68
Pounds of grain/lb. of gain[a]	5.79	5.36	5.33	5.14	5.56
Days on feed[b]	172	168	172	175	168
Annual turnover rate[b]	2.12	2.17	2.12	2.09	2.17
Cattle fed/year[b]	9,540	10,305	10,363	10,639	9,735
Cost of processing, $					
Initial investment/head of capacity[c]	17.07	31.92	36.82	33.39	28.67
Processing cost/ton of dry grain[d]	2.57	9.79	6.11	12.55	15.69
Net value per ton of grain dry matter when compared to dry processed[e]		.24	4.42	.60	−9.35

[a]Adapted to average industry performance from Table 1.

[b]Reflects influence of rate of gain differences.

[c]Considers 1980 "turn key" cost for grain processing equipment only.

[d]Assumes fuel cost of $2.00/mcf and electricity at $.05/kwh.

[e]Net value obtained by considering value of grain saved and cost of processing compared to dry rolling.

TABLE 3. ESTIMATED CATTLE PERFORMANCE AND COST OF PROCESSING CORN, 20,000-HEAD FEEDLOT

Item	Method of processing				
				Early harvested	
	Dry processed	Steam flaked	Reconstituted	Ground ensiled	Acid treated
Cattle performance					
Estimated daily gain, lb.[a]	2.62	2.68	2.61	2.57	2.68
Pounds of grain/lb. of gain[a]	5.79	5.36	5.33	5.14	5.56
Days on feed[b]	172	168	172	175	168
Annual turnover rate[b]	2.12	2.17	2.12	2.09	2.17
Cattle fed/year[b]	38,160	41,221	41,453	42,556	38,944
Cost of processing, $					
Initial investment/head of capacity[c]	13.15	22.74	26.14	24.88	20.60
Processing cost/ton of dry grain[d]	1.74	6.37	3.59	11.45	14.01
Net value per ton of grain dry matter when compared to dry processed[e]		2.83	6.12	.87	−8.50

[a]Adapted to average industry performance from Table 1.
[b]Reflects influence of rate of gain differences.
[c]Considers 1980 "turn key" cost for grain processing equipment only.
[d]Assumes fuel cost of $2.00/mcf and electricity at $.05/kwh.
[e]Net value obtained by considering value of grain saved and cost of processing compared to dry rolling.

performance and estimated grain processing cost suggest important items for consideration by feedlot owners and managers (Tables 2, 3, 4 and 5). The net value per ton of processed grain dry matter, compared to dry processed grain, ranged from $7.71 to a negative $9.35 for feedlots with 5,000-head capacity. For 20,000-head feedlots, the range was from $9.33 to a negative $8.50 per ton. In most comparisons grain sorghum reflected a more favorable net benefit than corn and the least energy intensive processing alternative (reconstitution) indicated the most favorable net benefit.

However, each system of processing has unique attributes which may influence the process eventually selected for individual feedlots. Steam flaking is more logical for either grain in 20,000-head commercial feedlots than for 5,000-head feedlots. Early harvesting followed by grinding and ensiling in a trench is more logical for corn than grain sorghum and may easily complement the requirements of farmer-feeders that typically utilize on-farm storage. Acid-treated early harvest of either grain appears to be the least viable alternative due to high interest cost during storage plus the direct cost of the acid. It is also unlikely that a single acid treatment (as assumed in these budgets) would be adequate for year-long storage, especially in warmer climates. Both of the early harvesting systems hold the potential to allow purchase of large volumes of grain at harvest when grain prices are often low. This consideration was not reflected in these projections. Reconstitution uniformly offered the greatest potential net benefit for either

TABLE 4. ESTIMATED CATTLE PERFORMANCE AND COST OF PROCESSING GRAIN SORGHUM, 5,000-HEAD FEEDLOT

Item	Method of processing				
				Early harvested	
	Dry processed	Steam flaked	Reconstituted	Ground ensiled	Acid treated
Cattle performance					
Estimated daily gain, lb.[a]	2.50	2.65	2.54	2.64	2.45
Pounds of grain/lb. of gain[a]	6.09	5.60	5.34	5.52	5.60
Days on feed[b]	180	170	177	170	184
Annual turnover rate[b]	2.03	2.15	2.06	2.15	1.98
Cattle fed/year[b]	9,135	9,934	10,418	9,977	9,736
Cost of processing, $					
Initial investment/head of capacity[c]	17.07	31.92	36.82	33.39	28.67
Processing cost/ton of dry grain[d]	2.53	9.71	5.91	11.89	14.89
Net value per ton of grain dry matter when compared to dry processed[e]		.12	7.71	−1.36	−5.42

[a]Adapted to average industry performance from Table 1.
[b]Reflects influence of rate of gain differences.
[c]Considers 1980 "turn key" cost for grain processing equipment only.
[d]Assumes fuel cost of $2.00/mcf and electricity at $.05/kwh.
[e]Net value obtained by considering value of grain saved and cost of processing compared to dry rolling.

TABLE 5. ESTIMATED CATTLE PERFORMANCE AND COST OF PROCESSING GRAIN SORGHUM, 20,000-HEAD FEEDLOT

Item	Method of processing				
				Early harvested	
	Dry processed	Steam flaked	Reconstituted	Ground ensiled	Acid treated
Cattle performance					
Estimated daily gain, lb.[a]	2.50	2.65	2.54	2.64	2.45
Pounds of grain/lb. of gain[a]	6.09	5.60	5.34	5.52	5.60
Days on feed[b]	180	170	177	170	184
Annual turnover rate[b]	2.03	2.15	2.06	2.15	1.98
Cattle fed/year[b]	36,540	39,737	41,672	39,910	38,943
Cost of processing, $					
Initial investment/head of capacity[c]	13.15	22.74	26.14	24.88	20.60
Processing cost/ton of dry grain[d]	1.71	6.31	3.47	10.82	13.24
Net value per ton of grain dry matter when compared to dry processed[e]		2.70	9.33	1.11	−4.59

[a]Adapted to average industry performance from Table 1.
[b]Reflects influence of rate of gain differences.
[c]Considers 1980 "turn key" cost for grain processing equipment only.
[d]Assumes fuel cost of $2.00/mcf and electricity at $.05/kwh.
[e]Net value obtained by considering value of grain saved and cost of processing compared to dry rolling.

grain-feedlot size combination but involved the greatest initial investment per head. Some feedlots have considered applying combinations of several processing techniques which would only appear logical during an interval of transition from one to another.

Grain processing techniques represent a major consideration for feedlot owners and managers. Those systems that provide the greatest net benefit combined with the greatest flexibility and compatibility with specific needs should emerge as those most widely applied in industry.

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Acknowledgments

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PR-3802

Use of Interfirm Comparisons by the Texas Cattle Feeding Industry

R. S. Knight and L. M. Schake

Summary

An interfirm comparison program was developed in 1975 and offered to the managers of commercial feedlots of Texas. A 1978 survey established that all participating feedlot managers considered interfirm comparisons of at least average usefulness to their operation. Data on cattle performance resulting from this interfirm comparison were analyzed to establish performance characteristics of the industry. From 1976 to 1980 average daily gains for steers and heifers was 2.76 and 2.41 pounds, feed conversion was 7.09 and 7.15 pounds while on feed for 150.4 and 143.2 days, respectively. Daily gains followed a seasonal trend with superior gains from cattle closed out from July to September. Death losses were more than twice as great for heifers as for steers (1.92 *vs.* .89 percent) with the highest incidence reported for cattle closed out in March , April, and May. Total cost of gain and health related expenses are reported.

Introduction

Texas feedlots have the capacity to feed in excess of 5 million cattle annually, which represents the world's largest concentration of feedlots. Large feedlots (greater than 8,000-head capacity) account for over 90 percent of all cattle fed in Texas, and most of those are commercial feedlots which are in direct competition for clients, cattle, feed, supplies, labor, and other inputs and services. Therefore, managers

TABLE 1. RESPONSE OF 30 PARTICIPATING FEEDLOT MANAGERS[a]

Question	Percent of participants responding	Response, as percent of those responding	
How useful are the interfirm reports as an aid in managing your feedlot?	70.00	Extremely useful	24.0
		Avg. usefulness	76.0
		Not useful	0.0
		Total	100.0
Please list the three primary areas of activity in which these reports are useful in managing your feedlot.	66.6	Feedlot operational cost	33.9
		Cattle performance and gain cost	30.5
		Employee statistics	11.8
		Feedlot occupancy	6.8
		Ration characteristics	6.8
		Death loss of cattle	5.1
		Fuel cost	5.1
		Total	100.0

[a]Questionnaire was mailed to each of 30 participating feedlot managers.

of these feedlots are interested in their comparative effectiveness within the industry. Interfirm comparisons were developed to serve this need by identifying strengths, weaknesses, and trends of idividual feedlots when compared to an industry average.

Experimental Procedure

A feedlot interfirm comparison program was developed and implemented for managers of competing commercial feedlots (1). The program has been active for 5 years, and a considerable body of information has become available for analysis. A portion of the interfirm comparison report deals with performance of fat steers and heifers sold each month. Other items in each monthly report include cattle inventory, ration and feedmill characteristics, employee statistics, and financial comparisons. Input data for these interfirm comparisons are collected by telephone each

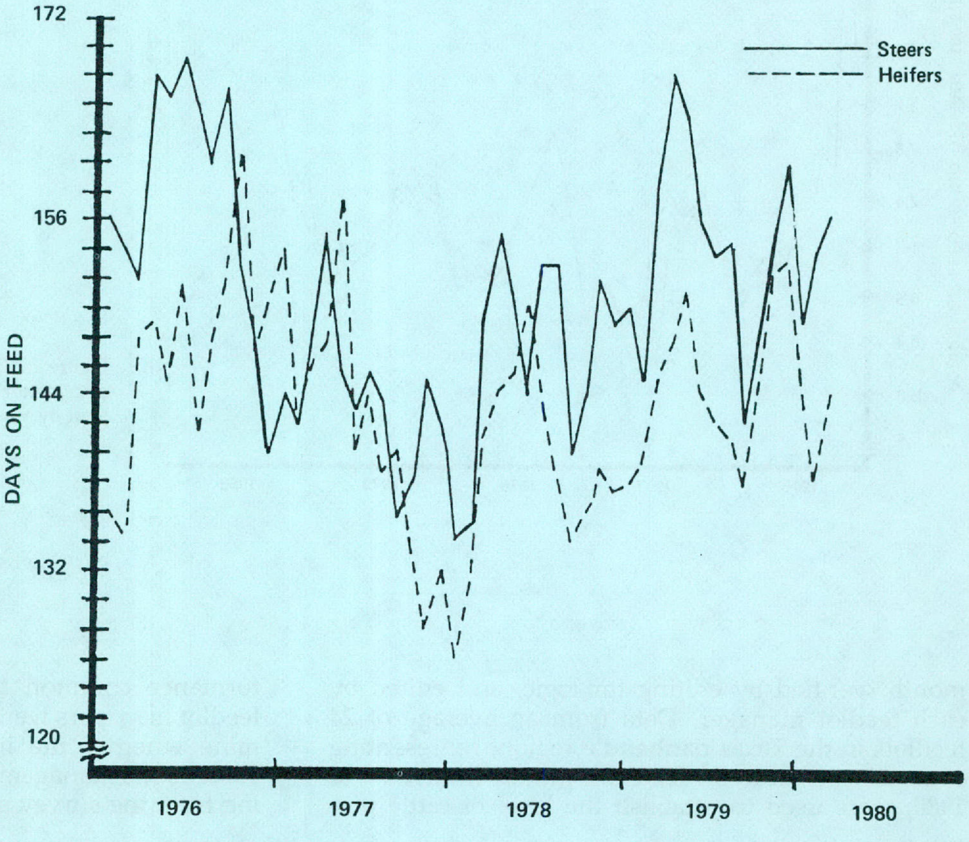

Figure 1. Average days on feed for cattle closed out by years.

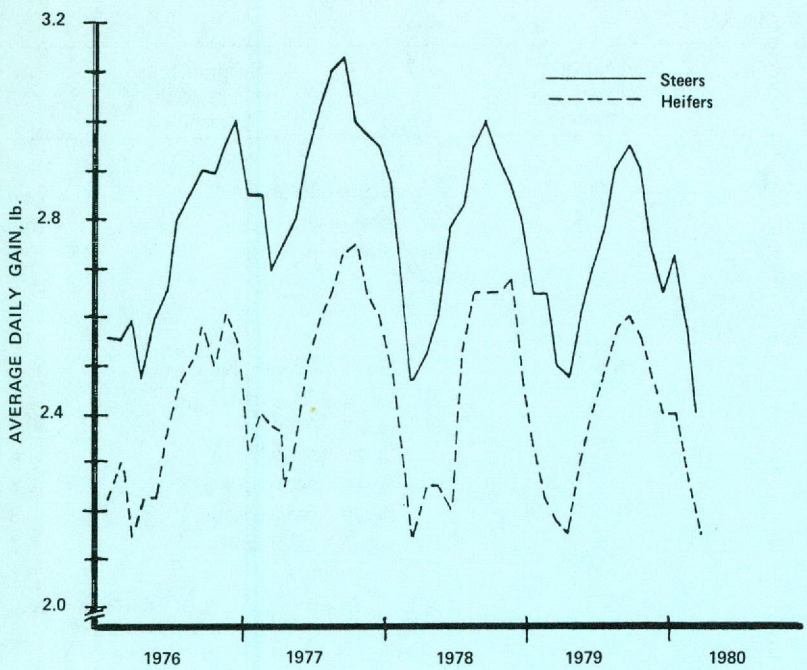

Figure 2. Average daily gain for cattle closed out by years.

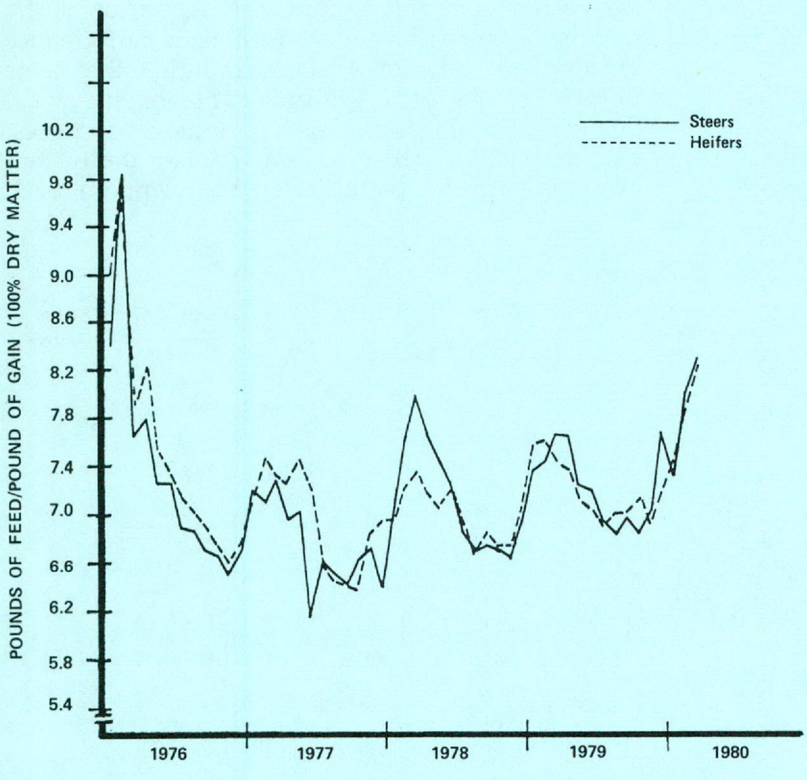

Figure 3. Pounds of feed dry matter per pound of gain by years.

month, verified by editing for logic, and edited by each feedlot manager. Data from an average of 24 feedlots in the Texas panhandle region, representing over 600,000 cattle on feed per month from 1976 to 1980, were used to establish the level of cattle performance common to this industry. Participating feedlot managers were also surveyed in 1978 to determine whether the interfirm comparisons were of value to the management of their feedlot. Data resulting from the survey and the monthly interfirm com-

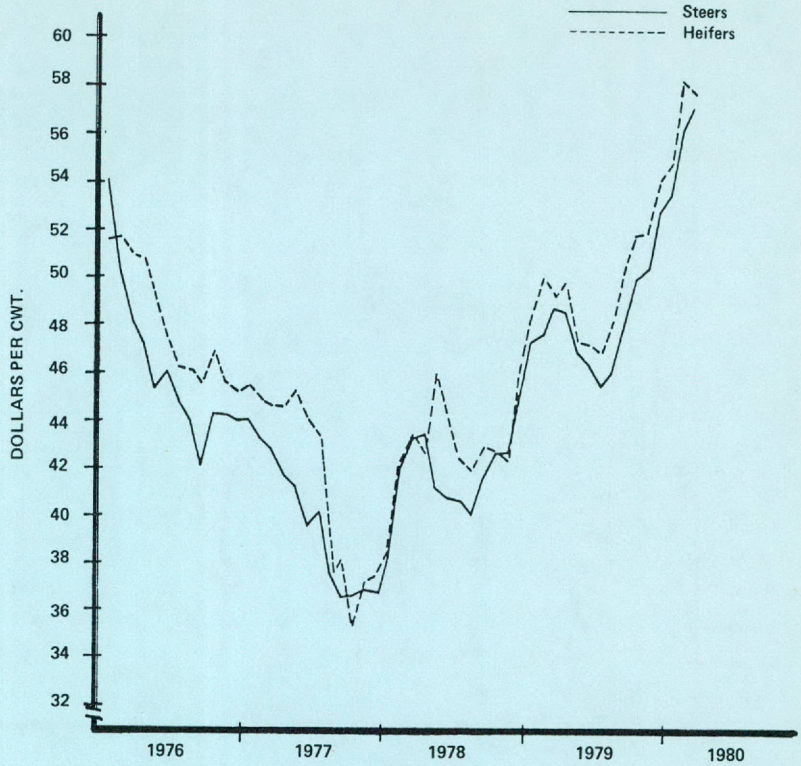

Figure 4. Cost of gain (exclusive of interest) for cattle closed out by year.

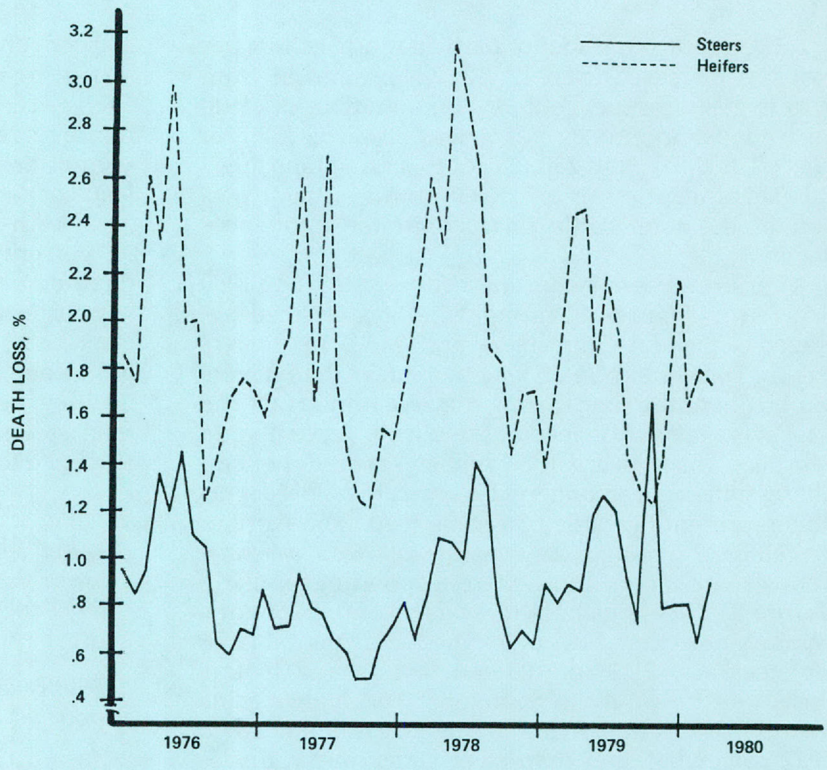

Figure 5. Death loss of cattle closed out by year.

parison report were analyzed to assist in establishing a continuous measurement of industry performance.

Results and Discussion

Seventy percent of the participating feedlot managers responded to the questionnaire (Table 1). Of those responding, 76 percent indicated that the monthly interfirm reports were of average usefulness and 24 percent indicated that they were of extreme usefulness. They further indicated that feedlot operational cost and cattle performance and cost of gains were areas of primary interest to their management.

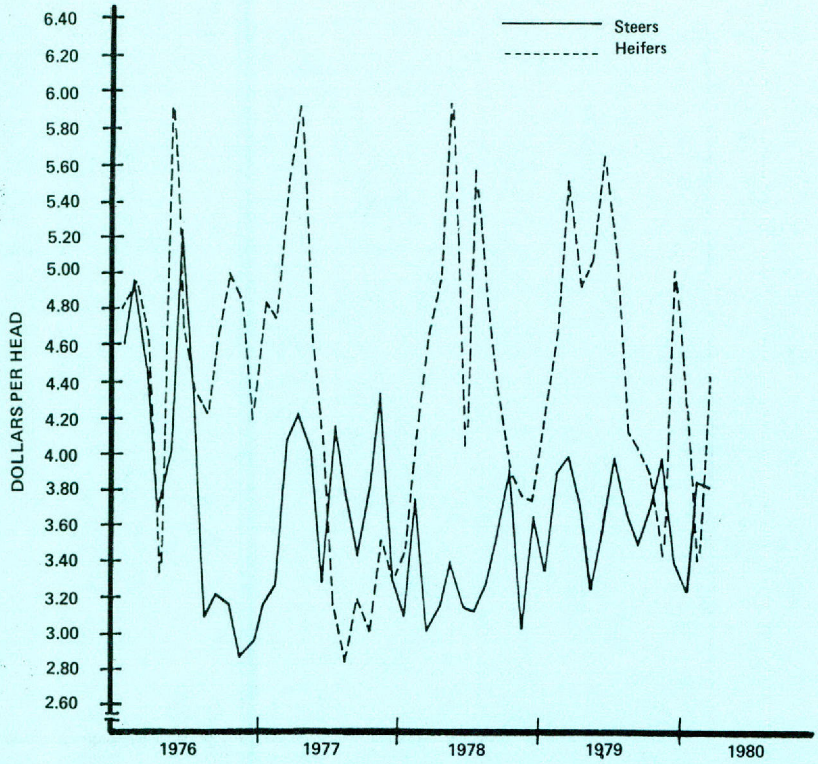

Figure 6. Health expense per head by years.

The average number of participating feedlots per year has increased from 17, 17, 28, 29, and 31 from 1975 to 1980, respectively. Average number of cattle on feed per month by years was 334,225, 453,388, 794,357, 800,817, and 730,627 for this same time interval. This inventory of cattle represents a major portion of the total cattle on feed in the Panhandle region.

Performance of steers and heifers for 1976 to 1980 is given in Figures 1 through 6. Days on feed averaged 150.4 days for steers and 143.2 for heifers (Figure 1). Steers were on feed more days than heifers 88 percent of the time during the 5-year interval. The least average days on feed occured from September to February most years for both steers and heifers. These statistics are obtained from cattle closed out, thus representing cattle placed on feed from April to September. Average daily gains followed seasonal trends, with steers and heifers responding similarly (Figure 2). Steers gained an average of 0.35 pounds per day more than heifers for the 5-year period (2.76 for steers *vs.* 2.41 for heifers). Steers and heifers closed out from July to September had higher gains than those of other months. Heifer gains tended to peak somewhat later than steer gains during this 5-year period.

Conversion of feed dry matter to net liveweight gain also reflected seasonal influences (Figure 3). Steers and heifers closed out from August to November exhibited the most desirable conversions with no consistent difference between sexes. The average feed dry matter required to produce a unit of gain was 7.09 and 7.15 pounds for steers and heifers, respectively. Total cost of gain includes all feeding related costs except cost of interest (Figure 4). Yearly average cost of gains ranged from \$37.13 to \$51.59 per hundredweight for steers and from \$37.07 to \$53.12 per hundredweight for heifers, mainly a reflection of feed cost.

Death loss was more than twice as high (1.92 *vs.* .89 percent) for heifers as for steers from 1976 to 1980 (Figure 5). Additionally, heifer death losses increased more during the March-April-May interval than did steer losses. Health related expenses averaged \$3.62 for steers and \$4.41 for heifers (Figure 6). Heifer health expenses tend to be higher and more sporadic than steers, which is consistent with the observed response for death loss.

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Acknowledgments

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Health and Health Management

The total economic loss to beef cattle due to diseases, parasites, stress and other factors of management resulting in death or reduced performance is a major industry limitation. Many technological advances in herd health controls have been accomplished but practical and economical applications are also needed. More than ever before, it is becoming clear that desirable herd health patterns must result from the complex of genetics, nutrition, prevention, control and management. Progess reports on this critical continuum of beef cattle health management are here presented.

PR-3803

Economic Analysis of U. S. Bovine Brucellosis Program and Selected Program Alternatives

R. A. DIETRICH, S. H. AMOSSON AND J. A. HOPKIN

Summary

This report analyzes policy implications and results from the National Brucellosis Technical Commission (NBTC) studies (1,2). A systems simulation model was designed to estimate physical losses resulting from alternative bovine brucellosis programs. Benefit-cost ratios were calculated by program alternatives for determining economic and epidemiologic implications. Results indicated that all alternative programs considered yielded benefit-cost ratios greater than one. Wholeherd (adult) and calfhood vaccination programs yielded the highest benefit-cost ratios.

Introduction

Bovine brucellosis is a reproductive disease that causes abortions, light weight calves, extended calving intervals and reduced milk production in beef and dairy cows. In 1976, estimated losses from bovine brucellosis in the United States exceeded 65 million pounds of beef and 35 million pounds of milk (1,2). During that year 75 million dollars were spent by producers, state and federal authorities to control the spread of brucellosis. Thus, the selection of programs to control and/or eradicate bovine brucellosis has a major economic impact on cattle producers, consumers and taxpayers.

Experimental Procedure

The basic model (NBTC model) used to measure the impact of various brucellosis policy alternatives upon the spread, control and/or eradication of brucellosis within the beef and dairy sectors over a 20-year time horizon was a systems simulation model. This model was patterned, in part, after the model developed by Beal and Kryder (3), but was modified substantially to facilitate the analysis deemed appropriate by the NBTC.

States were divided into eight regions (Figure 1) and grouped on basis of their similarity with respect to such selected criteria relating to brucellosis as level of infection, herd size distribution, method of operation, trading patterns, and effectiveness of brucellosis surveillance and control. The model was designed to determine simultaneously the effect of various policy alternatives upon both the beef and dairy sectors. In addition, it was designed such that infected and detected herds could be placed in a "quarantine" status while undetected infected herds remained on a non-quarantined status. Details concerning the structure of the model, related assumptions, data inputs and coefficients are included in the NBTC study (1).

Program alternatives modeled were as follows:

1. *Base Model.* The base model was designed to simulate existing conditions within the industry during 1975-76. Included in this model were 1975-76 levels of infection, surveillance efficiency ratios, levels of vaccination, levels of management and prevailing uniform methods and rules (UMR). The other program alternatives were then designed to measure a single modification from the base program.
2. *Base Model plus Accelerated Program.* This model was designed to simulate conditions which might prevail under the APHIS "10-year Accelerated Eradication Program." The accelerated program involved down-the-road or area testing of about one-third of the herds, and also first-point-of-concentration (FPC) testing in addition to the Market Cattle Testing (MCI) and Brucellosis Ring Test (BRT) surveillance systems. Two accelerated alternatives were modeled. In accelerated program 1, it was assumed that program quality would remain at the high level reached during area testing and FPC testing, while accelerated program 2 assumed that program efficiency would drop back to the same level after area testing as prevailed in the region prior to area testing.
3. *Base Model Plus Calfhood Vaccination.* This model assumed that incentives would be established for increased calfhood vaccination in regions 3,4,5,6 and 7 (South, Southeast and Plains states). The base program was applied in all other areas. Three calfhood vaccination levels were modeled: 90 percent or higher (high), 60-89 percent (medium), and 20-59 percent (low).
4. *Base Model Plus Whole Herd (Adult) Vaccination.* This model was designed for use in high prevalence regions 3,4, and 5 (South and

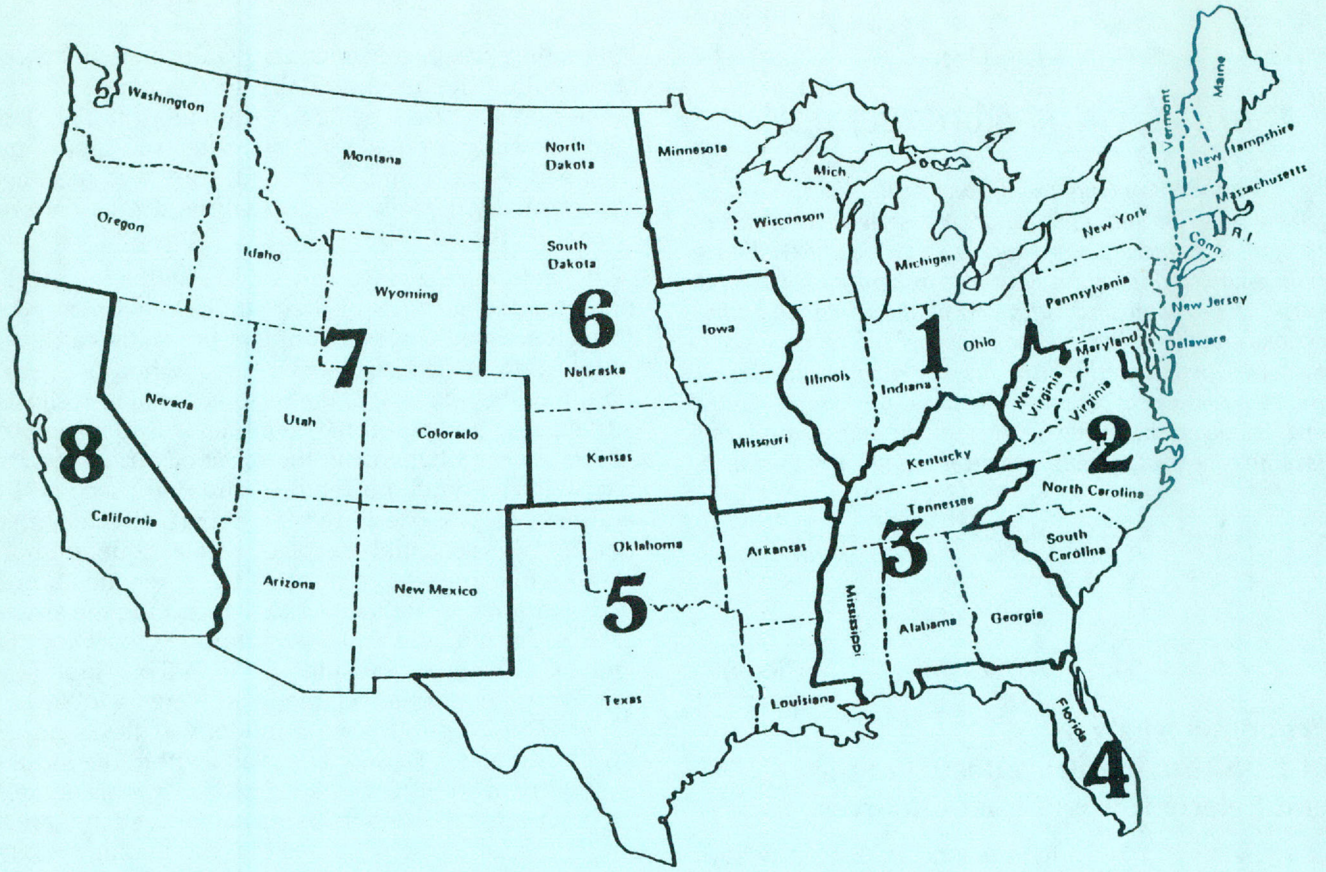

Figure 1. Regional demarcation, brucellosis study, United States, 1978.

Southeast). The base program was applied in all other areas. Whole herd vaccination levels were programmed at 3 levels: 90 percent or higher (high), 60-89 percent (medium) and 20-59 percent (low).

Results and Discussion

Results of program alternatives are ranked according to four criteria in Table 1: (1) change in infection rates, (2) change in benefits (total welfare), (3) change in program costs and (4) benefit-cost ratios.

In terms of benefit-cost ratios, the whole herd vaccination alternatives ranked highest, with the medium level option first, followed by the low level and high level options (Table 1). The low level and medium level calfhood vaccination options came in fourth and fifth, respectively. These were followed in order by the accelerated 1 and accelerated 2 programs. The high level calfhood vaccination option, which ranked first in terms of total benefits ranked eigth in terms of benefit-cost ratio.

The highest cost program alternative was the high level calfhood vaccination program. The second highest program cost alternative was the medium level calfhood vaccination option followed by accelerated 1 and 2 programs. The wholeherd vaccination programs were the lowest cost options since they were applied to only three regions compared to five regions for the calfhood programs.

Ranking among programs on the basis of reduction in infection showed that calfhood vaccination at the high level ranked first followed by high level wholeherd vaccination, medium level calfhood vaccination, accelerated program option 1, low level wholeherd vaccination, low level calfhood vaccination, and accelerated program option 2.

The change in benefits on total welfare is the summation of the change in consumer surplus and producer surplus for the program alternative considered. All program alternatives revealed positive changes in total welfare with the high and medium level calfhood vaccination options showing the greatest increases.

Results of this research suggest that investment of funds in epidemiologically sound modifications of the present program (1976) which are specifically targeted to varying requirements of herds, states and regions will produce a favorable return. Further, results revealed that vaccination programs, both calfhood and wholeherd, would be highly effective in reducing infection in the high prevalence regions. However, it must be emphasized that while vaccination is effective in reducing infection and individual producer losses, it will not eradicate brucellosis.

Acknowledgments

This study was financed by the U. S. Animal and Plant Health Inspection Service, U. S. Department of Agriculture. Members of the National Brucellosis

TABLE 1. TOTAL BENEFIT/COST RATIOS, VARIOUS PROGRAM ALTERNATIVES RELATIVE TO THE BASE PROGRAM[a]

Program	Infected[b] cattle	Changes in[c] benefits	Alternative program costs	Base program costs	Marginal benefit/cost ratio
Accelerated - 1	−87.5	615.4	1,598.0	1,356.6	2.55
Accelerated - 2	−69.1	535.8	1,597.6	1,356.6	2.23
Calfhood vaccination-low	−76.3	651.9	1,515.4	1,356.6	4.11
Calfhood vaccination-medium	−89.2	980.2	1,733.1	1,356.6	2.60
Calfhood vaccination-high	−93.1	1,064.2	1,896.2	1,356.6	1.97
Whole herd vaccination low	−79.2	636.0	1,274.7	1,356.6	7.76
Whole herd vaccination medium	−87.1	802.2	1,390.0	1,356.6	24.02
Whole herd vaccination high	−91.5	894.3	1,504.6	1,356.6	6.04

[a]Computed for 19 years or from 1977 to 1995 and represent discounted present values.
[b]Percentage change in infected cattle from year 1 of base program to year 20 of alternative program.
[c]Total change in benefits of the program alternatives over the basic program.

Technical Commission were Dr. R. K. Anderson, Minneapolis, Minnesota; Dr. D. T. Berman, Madison, Wisconsin; Dr. W. T. Berry, Denver, Colorado; Dr. J. A. Hopkin, College Station, Texas; and Dr. Robert Wise, Togus, Maine. Dr. R. A. Dietrich and Mr. S. H. Amosson were special assistants to the Commission.

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PR-3804

Prevention of Brucellosis in Beef Cattle

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Summary

Brucellosis in beef cattle was found to decrease reproductivity efficiency and increase economic losses due to birth of abnormal or dead calves. Cows vaccinated as young calves had a significantly lower rate of brucellosis reactors than did nonvaccinated cows in the same quarantined beef herds, indicating that calfhood vaccination is beneficial in producing protective immunity. Adult vaccination of cows, in addition to providing a degree of protective immunity, may facilitate earlier diagnosis of infected animals; however, a dosage of 3 billion live strain 19 bacteria in adult cows may induce prolonged strain 19 infections in a few instances. Although calfhood vaccination and reduced dosage adult vaccination induced protection against brucellosis exposure, the protection was not absolute and may be overcome by field challenge. Additionally, adult vaccinated herds became free of detectable *Brucella* infection within 1 year after vaccination, provided good management techniques were employed simultaneously and infected cattle removed as soon as possilbe. Coyotes were proven to harbor *Brucella abortus* for considerable periods of time and transmit the infection to their offspring; however, no transmission from coyotes to cattle has yet been documented. Significant progress on a semi-automated enzyme-linked immunosorbent assay for brucellosis diagnosis was accomplished which may allow more specific and sensitive detection and differentiation between vaccinated and infected cattle.

Introduction

Brucellosis, a worldwide disease affecting cattle, cost American cattlemen more than $50 million in 1979. Texas, which has a large number of infected herds, has absorbed nearly 30 percent of these losses (over $14 million). Prevalent throughout the southeastern United States, brucellosis displays many signs: abortions, delayed conception, retained placentas, weak calves, reduced milk production, infertility in cows and sterility in bulls. To reduce economic losses and to assure continued freedom of exportation of Texas cattle, increased epidemiologic knowledge, improved preventive measures, and better detection techniques for this disease are necessary.

Experimental Procedure

Epidemiologic data were collected from naturally as well as experimentally infected beef herds to clarify the relationship between the causative organism, *Brucella abortus*, the cattle, and the environment. Data related to abortions, bacteriologic isolation, and serologic reactivity were also collected. Other data were derived from a series of experiments to evaluate the role of the nonbovine reservoir, such as deer, wild rodents, opossums, raccoons, and coyotes, as potential contributors to the maintenance or spread of brucellosis in Texas.

The use of the reduced dosage vaccination in adult cows was evaluated to determine the protection and diagnostic use that such a procedure might yield. Additionally, development of diagnostic tests, such as serological blood tests and bacteriological culture of secretions or tissues, was continuously underway. The card test, the complement fixation test, the rivanol test, the standard tube test, and the newly developed enzyme-linked immunosorbent assay were sequentially used to monitor the serologic reactivity of vaccinated and nonvaccinated animals in infected beef herds. Data were continuously collected, such as calving interval, abortion rate, and calf-mortality to help establish coefficient values needed for computer modeling to determine the economic impact that new research developments and regulatory programs may have in the future.

Results and Discussion

Data collected support the concept that brucellosis in Texas beef cattle decreases reproductive efficiency and increases economic losses. The production of calves by cows infected with field strains of *Brucella abortus* in Texas was significantly reduced when compared to the productivity of nonreactor control cows in the same herd. Although no significant difference occurred between weaning weights of live calves (Table 1), when the number of viable weaned calves were considered (Table 2) from diseased cows versus nonreactor cows, total production of calves was significantly lower from cows with brucellosis.

Assessment of the value of strain 19 vaccination of beef cattle has demonstrated that the reactor rate of calfhood-vaccinated cows was significantly lower than the reactor rate of nonvaccinated cows in the same quarantined beef herd (Table 3). Nonreactor adult cows from seven quarantined beef herds were vaccinated with the recommended adult-vaccinated dosage (3 billion live strain 19 bacteria), and reactor rates during the 12 months following vaccination varied from 5 to 32 reactors per 100 cows vaccinated with a mean of 19 reactors per 100 cows. The majority (53 percent) of the reactor cows were serologically positive at 2 months post-vaccination, and data suggest that vaccination of adult cows in quarantined herds might be used to facilitate earlier diagnosis of infected cows in addition to providing protection to susceptible cows. However, one disadvantage of the strain-19 dosage used (3 billion live strain bacteria) in the adult cows was that nine of the 28 isolations of *B. abortus* from the 474 adult-vaccinated cows were strain 19.

TABLE 1. WEANING WEIGHT OF BEEF CALVES AT 205 DAYS OF AGE FROM PREGNANT COWS INFECTED WITH *BRUCELLA ABORTUS* COMPARED TO CALVES FROM PREGNANT NONREACTOR COWS IN SINGLE SIRE HERDS, POUNDS*

Infected cow	Nonreactor cow
295	363
353	328
358	463
421	371
died†	431
died	died
died	died
dead§	356
aborted∞	292
dead	301
aborted	417
aborted	468
aborted	406
aborted	343

*paired for age and sex
†viable term fetus that died before weaning
§nonviable term fetus
∞premature nonviable fetus

TABLE 2. CALF PRODUCTION FROM COWS INFECTED WITH *BRUCELLA ABORTUS* COMPARED TO NONREACTOR CONTROL COWS IN THE SAME SINGLE SIRE HERD

	Disposition of Cattle	
Brucellosis status	Dead	Alive
Infected cow	10	4
Nonreactor	2	12

X^2 = 9.33; highly significant difference in viability at weaning.

TABLE 3. BRUCELLOSIS REACTOR RATE IN CALFHOOD VACCINATED AND NONVACCINATED BEEF CATTLE IN A HERD WITH BRUCELLOSIS

	Serologic Activity		
Vaccination status	No. cattle at risk	No. reactors	Reactor rate/100
Strain 19	104	11	11
Nonvaccinated	113	31	27

X^2 = 9.8, highly significant difference in reactor rates.

Results of the serologic and bacteriologic evaluation of rodents, opossums, raccoons, and white-tailed deer did not provide any evidence of a nonbovine reservoir of *B. abortus*; however, of 188 coyotes from 20 counties in Texas, 27 percent (50 from 13 counties) were documented to be naturally serologically positive to *B. abortus*. Furthermore, *B. abortus* biotype 1 was isolated from 14 coyotes in four Texas counties, although there is no evidence yet of transmission of the infection from coyotes to cattle. Coyotes which ate *B. abortus*-contaminated placentas or fetuses became infected, and some retained infection for extended periods. Further studies demonstrated that infected female coyotes can transmit *B. abortus* to their unborn fetuses.

The card test was evaluated as a screening test while the complement fixation and rivanol tests were used as supplemental procedures. Essentially, data derived from the continuous serologic monitoring of vaccinated and nonvaccinated beef cattle validated the conclusions reached by other investigators that with proper herd history and repeated use of screening and supplemental tests, an accurate diagnosis can be made with a minimal overkill (something less than 5 percent). The new enzyme-linked immunosorbent assay (ELISA) was successfully implemented as a blood testing procedure and was demonstrated to have a high degree of sensitivity with a specificity at least equal to or greater than the currently used serologic techniques for screening and supplemental brucellosis testing and diagnosis. Additionally, ELISA was semi-automated and potentially could be connnected with computers for recording, interpreting, and even distributing the results. The ELISA offers considerable advantage in that it can be adapted to detect specific types of *Brucella* anitbodies that are more likely to be produced in an infected cow than in a vaccinated cow.

Although it is not possible to predict the outcome of research, its objectives can be discussed, and speculation of the application of the objectives made possible should they be obtained. If an automated ELISA procedure is developed to detect the classes of bovine serum and milk antibodies specifically reacting with *Brucella* antigens and if a specific antigen can be isolated from field strains of *Brucella* distinct from strain 19, the ELISA method could be used with the isolated agtigen to produce a very sensitive, yet highly specific automated diagnostic method. This method could greatly improve the ability to distinguish between infected and vaccinated beef cattle with a single test. Furthermore, if ongoing research is able to validate the efficacy of highly reduced dosages of strain 19 as an immunizing agent for both calves and adult cows, the vaccine should produce minimal interference with diagnostic procedures by greatly reducing the likelihood of prolonged vaccination-induced infections. Therefore, if the ELISA diagnostic test is coupled with the highly reduced dosage strain 19 vaccination for calves and cows, the possibility of eliminating bovine brucellosis would become much more feasible.

Acknowledgments

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PR-3805

Cattle White Blood Cells — Their Contribution to Disease Resistance

J. Caldwell

Summary

Studies in man, mice, and several other mammalian species have shown that some of the genes controlling disease susceptibility or resistance are part of, or linked to, a cluster of genes that comprise the major histocompatibility gene complex (MHC). This new technology is now being applied in ruminants to study the genetic factors controlling disease susceptibility and to the development of more effective ways to identify disease-resistant cattle. The product of the MHC genes are serologically detectable glycoproteins on the surface of cells. This research has identified several of these glycoproteins (antigens) on cattle lymphocytes and has shown these to be genetically controlled. Evidence for additional antigens suggests that a great variety of lymphocyte antigens exists in the cattle population.

Introduction

Even though tremendous advances have been made in improving the productivity and performance of farm animals such as cattle, sheep, and pigs, it is not yet possible to use these advances to the fullest extent. Continual bombardment of livestock by a variety of diseases tends to reduce or even halt their potential to produce or reproduce. It is evident, however, that differences exist between animals with respect to their ability to withstand disease stress. These observations would suggest that intensive selection for higher and higher productivity (i.e. faster growth rate) may have resulted in the reduction of genetic traits present in native stocks which increase resistance to a variety of diseases. This has greatly restricted the areas in the world where the most economically valuable animals can be grown. In addition, it has placed greater demands on the need to medicate and carefully manage such animals to minimize loss from disease.

Several disease conditions (e.g. brucellosis, anaplasmosis, leukemia, etc.) severely affect the performance of beef cattle. Although variations in susceptibility to these diseases have been noted, the inheritance of this susceptibility has not been identified or linked to any identifiable phenotypic trait. However, advances in the investigation of the mechanisms of immune regulation suggest that a partial solution may be possible which can be applied to the detection of and breeding for increased levels of disease resistance in cattle.

Studies in humans, mice, and chickens have shown that genes influencing susceptibility to certain diseases are associated with the MHC (the chromosomal region which regulates immune responses). Although this type of research in cattle is relatively new, initial results indicate that a major histocompatibility complex (MHC) exists in cattle which is similar in structure and function to that of other species studied. However, more extensive investigations are needed to determine the influence of the bovine MHC on disease resistance.

Experimental Procedure

The serological definition of a cell surface protein (antigen) involves the reaction of these antigens with a specific immune reagent (antibody). The antigens investigated in this study exist on essentially every nucleated cell of the body; however, the lymphocytes (white blood cells) were used for testing because of their availability in blood. The antibodies used for detecting specific antigens were obtained from three sources: a) from skin grafting cattle, b) from white blood cell immunization and c) from serum of cows which had delivered at least one calf.

In each of the three methods of reagent production, antibodies were produced by cows as a result of their being immunologically stimulated by foreign tissue (skin, lymphocytes, and fetus). The antibodies, in turn, are capable of destroying an antigen against which it was produced. A total of 1,522 antisera have been collected, the largest proportion of which were derived from pregnancy sera. Most of these have been tested for lymphocytotoxicity and certain ones selected for further studies to identify specific lymphocyte antigens.

In most cases the antisera contained multiple forms of antibodies which made it necessary to eliminate all but one type of antibody from each serum. This was accomplished either by diluting the antiserum or absorbing it with lymphocytes from other cattle. These processes generally yielded usable reagents for detecting cattle lymphocyte antigens.

Cattle representing a number of breeds, including Hereford, Angus, Brahman, Charolais and Texas Longhorn were tested according to procedures previously developed (1). Cattle from University and private herds located throughout the United States were used in this study. The major emphasis of the research to this point has been determining the number of different antigens which exist on cattle lymphocytes and their differences in frequency between breeds. Also by studying specific families, it was possible to determine the mode of inheritance of these immune factors (3).

Results and Discussion

Antisera from pregnant cows and from animals immunized with skin grafts or cells from selected donors were used to define the MHC in cattle. These results were utilized in a microcytotoxicity test (1) which allowed for the identification of specific lymphocyte antigens. Although the major histocompatibility antigens exist in virtually all nucleated cells, peripheral blood lymphocytes were used as the test cells in this study. Approximately 20 milliliters (ml) of whole blood was obtained from each animal and the lymphocytes isolated by differential centrifugation. Upon mixing the cells with each reagent, a cellular antigen was identified if the antibody caused cell destruction.

Of the 1,522 antisera collected, most of these have been eliminated from the test panel since they either did not possess an antibody or were too complex and thus had limited value at this time. However the remaining sera have been tested on about 2,500 cattle of various breeds in order to identify as many lymphocyte antigens as possible. Table 1 shows the 16 antigens which have been observed at the Bovine Lymphocyte Antigen (BoLA) A locus discovered in Texas (TX A) and 7 antigens believed to be controlled by alleles of the B locus (TX B). The A and B loci are believed to be linked on the same chromosome. It is felt that as additional tests are performed, new antigens will be identified in cattle.

TABLE 1. LYMPHOCYTE ANTIGENS OBSERVED IN CATTLE

TX A Locus Antigens	TX B Locus Antigens
W 2	T 768
W 4	T1045
W 5	T 940
W 6	T 145
W 6.2	T 638
W 7	T1058
W 8	T 945
W 9	
W 10	
W 11	
W 12	
W 16	
W 20	
192	
802	
1334	

Although 16 different A locus antigens have been detected in the cattle population, differences were observed in the frequency of each antigen among breeds (2). For example, the W2 antigen has a relatively high frequency in Herefords but very low frequency in Brahman. This particular lymphocyte antigen has never been observed in Holstein Cattle. The 802 antigens may exist only in Texas Longhorn cattle since they have been observed only in that breed.

Although it was not known at this stage whether these antigens are associated with susceptibility to any given disease, an initial study (4) on ocular squamous cell carcinoma (commonly called "cancer eye") indicates that these immune factors may in fact influence the impact which diseases have on cattle. It is recognized that several diseases need to be studied; however, more work is first needed to establish the genetic control of MHC before any valid studies can be performed on disease associations. Thus, effort is continuing to identify additional lymphocyte antigens and other components of the cattle MHC.

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PR-3806

Antibacterial Host Defense in the Bovine Lung

A. B. RICHARDS AND H. W. RENSHAW

Summary

Ten bovine lungs were filled with an appropriate fluid and washed to collect the phagocytic cells (predominantly alveolar macrophages) responsible for most of the antibacterial action in the lower lung. Cells were tested to measure relative response to bacterial stimulation by the technique of luminol-dependent chemiluminescence (LDCL). Levels of LDCL were significantly higher ($P<.001$) for the bacterially treated samples than for control samples lacking bacteria at all times except the initial 5-minute reading. The intensity and pattern of response for cells from individual animals following bacterial stimulation was highly variable ($P<.001$). Peak LDCL was observed at 60 minutes which appears delayed in comparison to other species. Although preliminary, these data may suggest that increased susceptibility of cattle to respiratory disease might be caused by differences in the ability of individual animals to respond to infection. Furthermore, as compared with other species, cattle may be compromised in their overall ability to protect themselves against infectious agents that gain access to the respiratory tract.

Introduction

Cattle are known to be highly susceptible to a number of respiratory disease agents which account for hundreds of millions of dollars in lost profits annually (7). In a survey of over 400,000 head of yearling feedlot cattle approximately 1 percent died prematurely with shipping fever indicated as the cause of approximately 48 percent of the deaths (5). While many factors have been reported as contributing to shipping fever (4) the majority of sicknesses and deaths have been attributed directly to the bacterial agents *Pasteurella hemolytica* and *Pasteurella multocida* (6).

Green and Kass (3) demonstrated that the primary source of clearance of infectious agents from lower levels of the lung, where the *Pasteurella* species results in disease, is a large phagocytic cell designated as the aveolar macrophage (AMO). Although it has been suggested that bovine AMO may have a reduced ability to ingest (phagocytize) and kill bacteria when compared to other species, little work has been done to clarify the protective capacity of this important host phagocyte (8). To examine the antibacterial activity of bovine AMO, a relatively new method called luminol-dependent chemiluminescence (LDCL) was employed. When phagocytic cells are bacterially stimulated they produce modified oxygen molecules which, upon reaction with the bacteria, give off light (chemiluminescence). Upon the addition of the chemical luminol, chemiluminescence increases tremendously, and therefore the test can be used even with very low concentrations of phagocytic cells. The level of LDCL is correlated with antibacterial activity and also phagocytosis (2).

Experimental Procedure

Lungs obtained from 10 beef cattle were filled with an appropriate fluid for cell collection. The pulmonary fluids obtained were filtered through sterile gauze, and cells were washed twice. These pulmonary cells (PC) were then standardized to 1×10^7 viable cells per milliliter. The method of Allen and Loose (1), with minor modification, was used to perform LDCL assays. The chemiluminescent reaction samples contained 2×10^6 viable PC incubated with 150 microliters of a standardized *Eschericia coli* (K12) suspension. Vials containing the LDCL mixtures were placed in a shaking water bath at 37° C, and light production counted in a scintillation counter at 5, 25, 45, 60, 90, 120, 150, and 180 minutes after mixing of the reactants. Control cultures consisted of exactly the same formula as the treatment group minus bacteria.

Results and Discussion

Differential cell counts revealed that bovine AMO represented 85.2 ± 17.5 percent of the PC obtained by lung washings from the 10 animals. At all counting times, except 5 minutes, LDCL values for control cultures were significantly lower than bacterially stimulated cultures ($P<.001$) (Figure 1). There was also a significant level of interaction ($P<.001$) when comparing animals with treatments which implies that individual animals respond to bacterial stimulation in significantly different ways. Although the average LDCL for the bacterially stimulated phagocytic lung cells was consistantly higher than the nonbacterially stimulated cells the variability between individual animals was large. Whether a prestimulation of the phagocytic cells occurred in the lung before collection or whether innate and inborn differences between individual animals caused the variability is presently not known. If innate and fixed factors are responsible, it would suggest that an in-

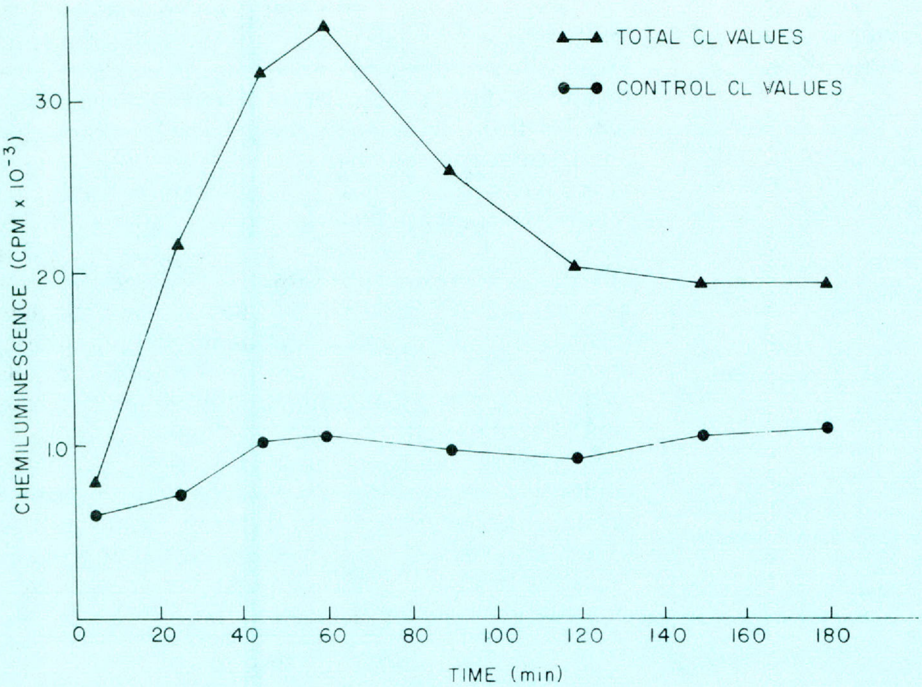

Figure 1. Average luminol-dependent chemiluminescence (LDCL) levels (counts per minute) for 10 animals. Total LDCL values are from bacterially stimulated pulmonary cell (PC) samples and control values are from unstimulated PC samples.

creased susceptibility to respiratory diseases may exist for certain animals. The LDCL pattern (Figure 1) obtained from the experiment shows a rapid increase in levels of LDCL for the first 60 minutes, a decline during the next 60-minute period and a final 60-minute period of relatively constant LDCL values. While the LDCL pattern is similar in shape and magnitude to the few reported studies from other species, peak LDCL levels were attained at 60 minutes after initiation of the experiment which is delayed as compared to other AMO studies (1,9). Differences in the time of peak LDCL values have been associated with many factors, however, it is probable that factors relating to differences between bacterial species or animal species from which th AMO are collected are likely causes. If indeed overall depression of phagocytic cell activity is species related, these data would suggest a possible explanation for the increase in respiratory disease in cattle as compared with other species. Using new techniques, such as LDCL, a better understanding of normal bovine lung defense function and capacity can be obtained. Adequate knowledge of normal bovine lung defense will provide scientists, veterinary clinicians, and cattle raisers with improved insight about therapeutic, immunoprophylactic, and genetic methods for minimizing losses caused by bovine respiratory disease problems.

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PR-3807

Influence of Implants, Feed Additives and Pen Size Upon Incidence of Buller Steers

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Summary

Three experiments were conducted in commercial feedlots in the Texas Panhandle area to identify factors involved in the expression of buller steers. Pen size, but not square footage allowance per steer, was correlated ($P<.0001$) to incidence of bulling. Steers weighing between 650 and 799 pounds expressed more bulling than either lighter or heavier steers. Both Synovex-S implants and monensin in-

creased incidence of bullers compared to DES implants or oral DES. Sequence of feeding steers and time of implantation were not related to overall expression of bullers. These data confirm opinions that bulling is a rather complex expression of steers related to numerous factors.

Introduction

The buller steer syndrome is considered the second most prevalent health disorder among feedlot steers after shipping fever-pneumonia (3). Bullers represent from 1 to 3 percent of all steers on feed with an average economic loss of about $25 per buller steer (2, 5, 6). Buller steers are those within a herd that allow themselves to be ridden by herd mates as a cow or heifer in standing estrus (submissive behavior). Numerous herd mates will repeatedly mount the buller until he becomes injured or exhausted, resulting in reduction of weight gain, and occasional death. Additional facilities, labor, and record keeping are required to remove bullers from herd mates. Numerous unanswered questions remain about the influence of implants and feed additives upon the expression of the buller syndrome in steers. Since a herd size larger than that used in most experiments is required for the expression of bullers, field trials were conducted in commercial feedlots to identify possible causes and management controls.

Experimental Procedure

Two feedlots in the Texas Panhandle area cooperated in a series of field trials supervised by interning Master of Agriculture, feedlot management students. All established management protocols remained the same for each feedlot except those indicated below.

Experiment I

Ten months of performance data were analyzed to establish the incidence of buller steers to initial weight, pen (herd) size, and space allowance per steer. Pens available varied in size from 18.7 to 69.4 thousand square feet with 19,835 mixed-breed steers assigned to these pens. Steers averaged 693 pounds upon arrival and were fed high energy rations for 132 days before being sold at 1,053 pounds. Pens of cattle were inspected at least once daily for incidence of buller steers.

Experiment II

Two growth promotant implants (DES and Synovex-S) were evaluated in combination with two feed additives (DES and monensin) with 970 steers (Table 1). DES implants provided 30 milligrams (mg) of diethylstilbestrol per steer and Synovex-S provided 200 (mg) of progesterone + 20 mg of estradiol benzoate per steer. The feed additives were fed at 10 mg of DES per head per day or 260 mg of monensin per head per day. Both feed additives were withdrawn from the high concentrate finishing ration 14 days prior to slaughter. Steers were fed and inspected for incidence of buller steers twice daily. Steers averaged

TABLE 1. DES, SYNOVEX-S AND MONENSIN COMBINATIONS, NUMBER OF STEERS

Feed additives	Implants[a]	
	DES	Synovex-S
DES	244	243
Monensin	243	243

[a]Two replicates for each of the four treatments.

535 pounds upon arrival, were fed for 135 days, and sold at an average of 1,098 pounds.

Experiment III

Sequence of Synovex-S implantation (200 mg of progesterone + 20 mg of estradiol benzoate per steer) was evaluated under two feeding schedules. Half of the 1,050 steers were implanted upon arrival at the feedlot and half were delayed until 34 days postarrival for implanting. Each sequence of implantation was represented by two pens of steers. One pen of steers was fed on schedule by never being allowed to be without feed; the other pen of steers was allowed to be without feed twice per week for 3 hours before being fed. Feedbunk allowance averaged 11 inches per steer. Steers were inspected for bullers once daily. Initial weight was 705 pounds, and final sale weight was 1,045 pounds after 160 days on feed.

Results and Discussion

Experiment I

The percentage of bullers observed in this trial was higher (3.63 percent) than previously reported (2, 5,6). Synovex-S has been observed to increase incidence of buller steers and enhance the binding capacity of the plasma protein which is involved in thyroid hormone transportation resulting in increased amounts of progesterone and estradiol (1, 4). The release of these hormones is considered by some researchers to initiate bulling since higher circulating blood estrogen levels are present in bullers than nonbullers.

Pen (herd) size was found to be highly correlated ($P<.0001$) with the incidence of buller steers (Table 2). The explanation may lie in the establishment of the social order or the dominance hierarchy. In a small size pen (herd), the social order would be less complex, resulting in fewer potential conflicts than in larger pens (herds). The square feet available per head was not related to occurrence of buller steers, suggesting that overcrowding is not a predisposing factor in the incidence of the buller steer syndrome. However, some degree of confinement is an integral aspect of buller expression since smaller pen areas render the buller steer more vulnerable to riding as he is less likely to escape herd mates.

Entry weight (Table 3) of the steers was also involved ($P<.05$) in the expression of the buller steer syndrome. Steers entering the feedlot weighing between 650 and 799 pounds expressed more bulling than either lighter or heavier steers. The cause of this relationship is not known.

TABLE 2. PEN SIZE AND INCIDENCE OF BULLERS

Pen size (1,000 ft.^{2})	Square footage allowance/steer	No. of pens observed	No. of steers represented	No. of bullers	Bullers observed, %
18.7	137	1	136	0	0.00
22.9	190	4	479	9	1.87
23.1	159	13	1,891	47	2.48
46.2	173	42	11,218	414	3.69
69.2	177	1	390	13	3.33
69.4	182	15	5,721	238	4.16
	TOTALS	76	19,835	721	

TABLE 3. EXPRESSION OF BULLING IN RELATION TO THE IN-WEIGHT UPON ARRIVAL AT FEEDLOT

In-weight range, lbs.	No. of steers	No. of bullers	Buller steers, %
450-499	377	9	2.38
500-549	1,102	35	3.17
550-599	1,744	39	2.23
600-649	2,010	58	2.88
650-699	5,079	197	3.87
700-749	4,982	179	3.59
750-799	4,069	199	4.89
800-849	355	4	1.12
850-899	117	1	0.85
TOTALS	19,835	721	

Experiment II

Steers implanted with DES (Table 4) resulted in expression of 54 percent fewer ($P<.20$) bullers than those implanted with Synovex-S. Within each implant combination, those cattle fed monensin exhibited bulling more ($P<.05$) than those fed DES, suggesting that either the absence of DES or the presence of monensin may influence bulling. This does not support most of the present concepts regarding development of buller steers.

Experiment III

Schedule of feeding apparently was not related to the incidence of bulling in this experiment, which does not support that widely held industry opinion (Table 5). The schedule of implantation greatly influenced expression of bullers. Half or more of the

TABLE 4. INFLUENCE OF DES, SYNOVEX-S AND MONENSIN UPON EXPRESSION OF BULLER STEERS

		Treatments			
Item	Implant: + Feed additive:	DES + DES	DES + Monensin	Synovex-S + DES	Synovex-S + Monensin
Number of bullers		1	3	7	10
Total buller head days		122	196	564	867
Percent bullers		.4	1.2	3.0	4.0
Percent buller head days/ total head days represented		.37[a]	.60[a,b]	1.72[b,c]	2.75[c,d]

[a,b,c,d]Means with different superscripts differ from each other ($P<.05$).

TABLE 5. INFLUENCE OF TIME OF SYNOVEX-S IMPLANTATION UPON BULLER EXPRESSION, NUMBER OF BULLERS

	Days on feed					
Treatment	0-33	34-66	67-100	101-134	>135	Totals
Implanted on day 0						
Fed on schedule	9	4	7	0	2	22
Misfed[a]	1	2	1	2	4	10
Totals	10	6	8	2	6	32
Implanted on day 34						
Fed on schedule	2	5	5	1	0	13
Misfed[a]	1	9	0	3	6	19
Totals	3	14	5	4	6	32

[a]Cattle without feed twice per week for 3 hours.

buller steers were observed within 66 days after implantation.

It is interesting to note that the steers which were not implanted for 34 days developed three bullers before being implanted compared to 10 bullers during the same time interval for those implanted upon arrival at the feedlot. Overall incidence of bullers after 135 days on feed was not influenced by either feeding or implant schedule.

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PR-3808

Field Application of Hyperthermia Instrumentation for Treating Cancer Eye

N. J. Adams and Z. L. Carpenter

Summary

More than 1600 cows on 15 West Texas ranches were examined for the presence of cancer eye tumors. Of this number, 232 cows were found to have tumors in some stage of development. A new hyperthermia device developed by Los Alamos Scientific Laboratory and manufactured by private industry was used to treat the tumors on the eyes of the affected cows. Six to nine weeks after treatment the cows were reexamined and 90.6 percent of all treated tumors, regardless of size or location on the eye, had completely regressed. For tumors less than 0.2 inch in diameter a 95-percent remission was achieved. As the size of tumor increased, the rate of remission after treatment decreased. The overall success of the hyperthermia technique for treating cancer eye established these devices as effective tools for field treatment of cancer eye.

Introduction

Bovine cancer eye (ocular squamous cell carcinoma) causes serious economic losses in cattle (1). It is particularly prevalent in Hereford cattle and occurs more frequently in geographic areas with high levels of sunlight. Cancer eye in cattle is the leading cause of whole carcass condemnation at slaughter. Economic losses in Texas have been estimated in the millions of dollars annually. Most of this occurs in the western half of the state where Herefords are the predominant breed of cattle. Losses are in the form of reduction in salvage value due to condemnation, reduction of weaning weights of calves nursing affected cows, weight losses of affected cows and a shorter productive life span of cows and associated replacement costs.

Research on the induction of hyperthermia in animal tumors by the passage of radio-frequency electric currents through the tissues resulted in the design of localized current field devices with specific electrode configuration. Heat was induced by the passage of radio-frequency current through the tissues between and under the electrodes. A small hand-held device was developed at Los Alamos Scientific Laboratory for treating cancer eye tumors in cattle. The device was designed to induce a temperature of 122° F under and between the two electrodes. A treatment constitutes application of the electrodes to the tumor site for 30 seconds. Power source for the device is a self-contained 12-volt battery, or the device can be operated from a cigarette-lighter receptacle in a pickup. The research at the Los Alamos Scientific Laboratory indicated cancer cells can be successfully treated by heating the tumor tissue above normal body temperature. The cancer cells are usually more susceptible to damage than normal body cells and are preferentially killed with little or no permanent injury to adjacent normal tissue cells. These findings led to the development of the field unit described above. This technology was shared with private industry groups, and equipment is now on the market for use by veterinarians and ranchers.

The purpose of this evaluation was to provide information on the effectiveness of the hyperthermia technique for treating cancer eye tumors under practical conditions on West Texas ranches.

Experimental Procedures

A thorough examination was made on over 1600 Hereford cows on 15 West Texas ranches. Cooperating ranchers were sought where a relatively large number of cancer eye tumors were present and full cooperation could be achieved in treatment and followup evaluations. All cows carried an individual tattoo or ear tag number. Each affected cow was placed in a squeeze chute with her head securely held in a head gate. A detailed diagram was made of the location of all tumors and their approximate size. No histopathological examination was made of tumor cells, and all tumors were treated except for seven advanced eye tumors. It has been reported that 20 to 25 percent of the cases grossly diagnosed as cancer eye are not squamous cell carcinoma (4). However, ranchers would not be aware whether observed tumors were malignant or benign and would treat every lesion; such was the procedure in this evaluation.

Each tumor was treated by the use of an electrothermal probe device according to the manufacturer's directions and those set forth by the developer (2). Most treatments were made by the first author. However, by demonstrating the technique during treatment on each ranch, the ranch owner, county agents, and ranch foremen were all involved in treating cows on the respective ranches. Therefore, data presented represent results accomplished by various personnel using the thermal device under varying ranch conditions.

Treated cows on each ranch were reexamined between 6 and 9 weeks after treatment. The diagram of infected eyes was used to establish the exact location of the treated tumors. After 6 months a sample of treated cows was examined for recurrence of cancer cell growth in areas where treatment had been performed.

Results and Discussion

Table 1 provides data for the 232 cows diagnosed as having cancer eye tumors in some state of development. Only mature cows in the breeding herds were examined and reported. An average of 14.5 percent of the cows in the selected breeding herds had some degree of cancer eye. With the very close observation technique used in the evaluation, every small tumor was located, recorded and treated. This fact, plus a relatively high number of older cows in some herds, accounted for the higher incidence of affected cows. Other workers in the southwestern United States have reported the average incidence in herds at 4 to 10 percent.

There were 411 individual tumors identified on the 232 cows for an average of 1.77 tumors per cow. Seven cows had eye tumors in the advanced invasive stage with some having secondary infections. No treatment was attempted on these cows.

TABLE 1. SUMMARY OF CANCER EYE EVALUATIONS

Number of cows examined	1600	
Number of cows with tumors	232	
Incidence in cows examined[1]	14.5	
Number of tumors observed	411	
Number located on eyeball[2]	332	- (80.8%)
Number located on upper or lower eyelids	37	- (9.0%)
Number located on 3rd eyelid	42	- (10.2%)
Tumors per affected cow	1.77	

[1]Only mature breeding age cows were examined.
[2]Includes seven eyes in advanced invasive stages.

In this evaluation, 80.8 percent of all tumors on affected cows occurred on the eyeball and 19.2 were on the eyelids. Of the 19.2 percent occurring on the eyelids, about half occurred on the outer surface of the upper or lower lid and half occurred on the third eyelid. Table 2 provides data on the results of treatment according to the location of the tumor on the eye and size of tumor. Tumors were classified according to size as indicated in the table. However, when tumors required additional treatment applications due to irregular shape or location, they were placed into the category according to the number of treatment applications required for complete coverage. Evaluating the data by size of tumor, regardless of where the tumor occurred, 95-percent remission was achieved for all tumors less than 0.2 inch in diameter. However, as the size of tumor increased, the rate of remission after treatment decreased. Regarding remission rate and location of the tumor on the eye, it can be seen that 93.2 percent of all tumors located on the eyeball regressed after one treatment. The small tumors (less than 0.2 inch) had a regression rate of 96.9 percent. Remission rates declined to 91.9, 78.6, and 52.9 percent, respectively, for tumor size requir-

TABLE 2. RESULTS OF TREATMENT BY SIZE AND LOCATION

No. of tumors by location	Tumor Size[1]: Less than .2 inch (1 application)	.2 to .4 inch (2 applications)	.4 to .6 inch (3 applications)	.6 inch and larger (4 or more applications)	Total
No. on eyeball	257	37	14	17	325
No. regressed	249	34	11	9	303
% regressed[2]	96.9	91.9	78.6	52.9	93.2
No. on upper or lower lid	19	6	5	7	37
No. regressed	18	5	4	6	33
% regressed	94.7	83.3	80.0	85.7	89.1
No. on 3rd eyelid	22	14	5	1	42
No. regressed	16	11	3	0	30
% regressed	72.7	78.6	60.0	0	71.4
TOTALS BY SIZE ONLY	298	57	24	25	404
NO. REGRESSED	282	50	18	15	366
% REGRESSED	95.0	87.7	75.0	60.0	90.6

[1]Size of tumor fell within the dimensions indicated or shape and location required the number of applications indicated.
[2]Regression rate based on one treatment.

ing two, three, and four or more treatment applications. Tumors occurring on the surface of the upper or lower eyelids responded well to treatment regardless of size. The small tumors requiring but one instrument application had a very high (94.7 percent) remission rate. Tumors occurring on the third eyelid were more difficult to treat as indicated by the lower rate of regression after one treatment. As experience was gained in treating these third-eyelid tumors, a higher degree of success was noted in herds treated later in the evaluation period. A random check of a small number of treated cows 6 months after tumors had been diagnosed cured showed no recurrence of tumors at the site where treatment was performed.

The overall 90.6-percent success of tumor regression after one treatment establishes the hyperthermia technique as a highly successful method of treating cancer eye tumors. The results obtained in this evaluation are similar to the results reported from Colorado and California (3,5). In addition, the technique is simple enough to be used by anyone who is familiar with cattle and has received some professional instruction or demonstration of the equipment.

Due to the heritable nature of cancer eye, it should be emphasized that this method of treatment should be used in an effort to reduce production losses and particularly losses due to condemnation. Animals with cancer eye should be identified and eliminated from the herd as soon as economically feasible.

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Acknowledgments

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PR-3809

Performance and Behavior of Calves Weaned at Four Herd Densities

C. E. Richmond and L. M. Schake

Summary

One hundred thirty-nine (139) calves were removed from their dams and weaned at different densities in two experiments to evaluate possible influences of calf density during weaning upon their performance and behavior. Calves in low density confinement (8.87m^2/calf) gained more with less feed dry matter than medium and high density treatments. A combination of low density confinement for 4 days followed by 14 days of pasture resulted in the most liveweight gain. All calves lost from 5.7 to 7.4 percent of their liveweight during a 16-hour shrink imposed at the termination of these experiments, which represented most of their previous weight gain. Calf behavioral activities of walking and bawling were reduced ($P<.05$) by the higher density treatments with calves from either farm or ranch conditions. High density confinement at weaning tended to favorably influence stress-related expressions of behavior but disfavored calf performance as measured by feed intake, weight gain, and feed conversion.

Introduction

One of the major concerns of cow-calf, stocker, and feedlot operators is the poor performance, excessive illness, and relatively high death loss associated with newly weaned calves. Perhaps the most stressful period in a calf's life is weaning. The newly weaned calf is subjected to a variety of environmental, nutritional, and physiological stresses when removed from its dam, marketed, transported, and adapted to new environments. It has been estimated (3) that the U.S. beef cattle industry suffers a $20-million annual economic loss during this transition period of calf development. The apparent fear and anxiety due to separation from the dam, the irritations casued by bawling, changes in feed and water, and the fatigue caused by walking fencelines add stress that predispose calves to diseases. Some data (2) have indicated that pen space allowance influenced performance of young calves, but no data are available on the influence of calf density during weaning upon their performance and behavior. Therefore, two experiments were designed to evaluate the influence of calf density during the weaning process upon calf performance and behavior.

Experimental Procedure

One hundred thirty-nine crossbred calves from two sources were allotted to two experiments to evaluate the influence of calf density during 2.5 weeks of weaning at the Texas A&M University Agricultural Research Station at Angleton. In Experiment I, 47 steers and 32 heifers of mixed Brahman x British breeding, averaging 208.5 kilograms (kg) at 8 to 10 months of age, considered to represent typical farm-raised calves, were assigned to one of four treatments. Three of the four density treatments were conducted in concrete surfaced pens (Figure 1) allowing 2.93 (high), 5.86 (medium) and 8.78 square meters (m^2) per calf (low) and one Coastal bermudagrass [*Cynodon dactylon* (L.) Pers.] pasture allowing approximately 405 m^2 per calf. In Experiment II, 60 steers of mixed Brahman x British breeding, averaging 192 kg at 6 to 8 months of age, considered to represent typical ranch-raised calves were randomly assigned to the same three treatments in drylot (high, medium, or low density). Calves in Experiment I were held overnight with their dams without access to feed or water to obtain initial shrunk weights, but were able to suckle their dams during this period. Following weighing, the calves were randomly assigned by weight and sex to one of the four treatments, with 12 steers and 8 heifers in the drylot treatments and 11 steers and 8 heifers in the pasturre treatment. The calves in the pasture treatment were held in a pen of the same dimension as the low density treatment for the first 4 days.

Calves in Experiment II were separated from their dams and weighed at their ranch of origin and transported 60 miles by truck to the research station. Upon arrival (2100), the calves were placed in pens with access to Coastal bermudagrass hay and water.

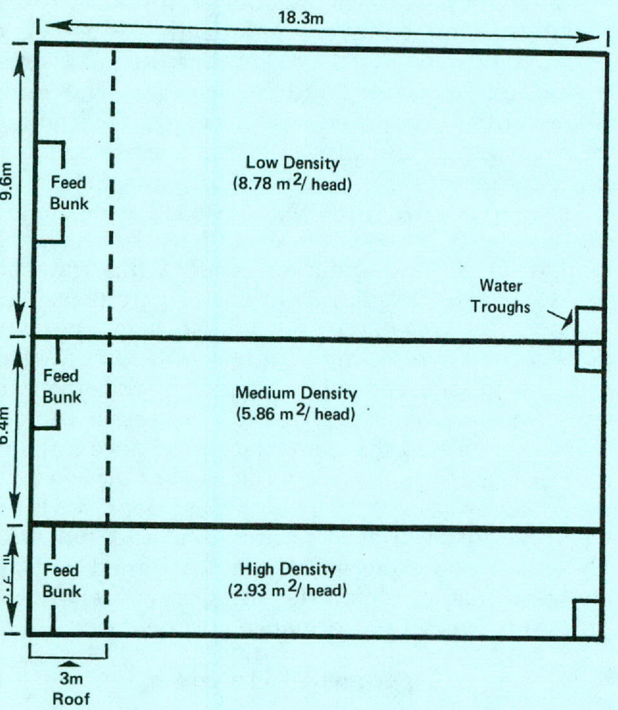

Figure 1. Pen configuration of concrete surfaced feedlot.

The following morning the calves were weighed and randomly assigned, 20 to each of the three drylot treatments (high, medium,or low density). The calves in both experiments were weighed at the end of the trial, following 16 hours without feed or water, to obtain shrunk weights.

The calves in both trials were fed a 72-percent concentrate ration starting at a level equal to 1 percent of average body weight and increased by 1 kg/head/day until *ad libitum* consumption was reached. The calves were fed twice daily at 0800 and 1800 hr. The calves in Experiment I were fed for 18 days and those in Experiment II, 17 days.

The behavior of the calves in each treatment was observed and recorded each morning (0730-0830) and evening (1630-1800) prior to feeding. The duration of each observation was 4 minutes per treatment. At each observation the following data were recorded for each treatment: number of calves standing, lying, eating, bawling, walking, and drinking water. In order to be counted as eating or drinking, a calf had to be actively engaged in that activity during the observation period, and lying included all postures of that activity. Walking was defined as an incessant walking of the pen or fenceline in an apparent state of apprehension or stress. Calves were considered standing only if not engaged in one of the other five activities.

Results and Discussion

The feed intake, weight gain, and behavioral data from the three confinement treatments for Experiment I and II were pooled for analyses. The data indicated that the calves in the low density treatment had the highest daily gain and the most desirable feed efficiency, followed by the medium and high densities, respectively (Table 1). Previous work (2) had indicated that artifically reared dairy calves with a larger space allowance per head gained less and had less efficient feed conversion than calves with a smaller space allowance. The data from these two trials suggest that the opposite may be true for either farm or ranch raised beef calves.

TABLE 1. GAIN, FEED INTAKE AND CONVERSION OF CALVES, POOLED DATA, EXPERIMENTS I AND II (KILOGRAMS)

	Treatment		
	High	Medium	Low
Number of calves	37	40	42
Initial weight	202.5	198.0	194.0
Final weight[a]	206.0	202.0	199.0
Average daily gain	.21	.23	.29
Feed intake[a]			
Per head	87.7	86.18	78.88
Per head per day	4.81	5.07	4.64
Total	3,023.0	3,447.0	3,313.0
Feed required per unit liveweight gain	26.06	21.15	15.93

[a]Based on 17 days (average of both trials).

TABLE 2. INDIVIDUAL WEIGHT GAIN (LOSS) BY SEX AND WEIGHT CLASS, MEANS WITH STANDARD DEVIATIONS, TRIAL I (KILOGRAMS)

		Treatment				
		High	Medium	Low	Pasture	Overall
Class	No. of calves	mean ± S.D.	mean ± S.D.	mean ± S.D.	mean ± S.D.	mean ± S.D.
Sex						
Steers	46	.42 ± 8.36	2.42 ± 8.52	(.3) ± 9.46	5.73 ± 10.10	1.39 ± 9.48
Heifers	32	(6.88) ± 6.36	1.88 ± 7.88	1.75 ± 8.76	2.00 ± 7.50	(.31) ± 8.25
Initial weight classification, kg						
132-185	21	(1.6) ± 8.53	5.00 ± 1.63	(.8) ± 10.23	4.86 ± 9.84	2.00 ± 8.65
186-225	29	(0.4) ± 11.30	2.38 ± 7.82	(.86) ± 5.08	8.86 ± 8.13	1.62 ± 9.22
226-279	28	(3.75) ± 5.18	.63 ± 20.82	(1.29) ± 12.66	(3.4) ± 3.78	(1.82) ± 8.86
Mean		(2.45)	2.2	(1.0)	4.1	.95

Table 2 includes data from the pasture treatment in Experiment I. No significant differences due to density treatments were observed for concentrate intake or weight gain of calves. Calves in the high, medium, low density, and pasture treatments lost 5.7, 6.9, 6.3, and 7.4 percent of their body weight, respectively, during the 16-hour shrink imposed at the termination of this experiment. This suggests that most of the liveweight gain of the calves observed earlier in the experiment was ingesta fill. Neither sex nor weight classifications significantly influenced liveweight of these calves, although lighter weight steer calves appeared to have adapted somewhat better to these weaning conditions than other calves. There were no major health or on-feed-related problems associated with any treatments in either experiment.

There were differences ($P<.005$) due to treatment effects in the number of calves standing (Figure 2). Fewer calves were standing as opposed to eating, drinking, or walking in the high compared to the medium or low density treatments. Calves in the high and low density treatments indicated increased lying from day 5 to 7.5, which agrees with earlier observations (1). Effects due to treatment ($P<.004$) and time ($P<.001$) were significant for walking. This treatment effect was the result of calves having more area available for walking in the low compared to the medium and high density treatments. The time effect was due to the cessation of walking, as defined, after day 8 in both experiments (Figure 3). A greater ($P<.05$) number of calves were observed bawling in the low compared to the medium and high densities. The effecto of time ($P<.0001$) upon bawling is indicated in these data since bawling decreased to zero by day 7 (Figure 3). There were no significant effects due to treatment, experiment, or time upon eating; however, the percent of calves observed eating over time

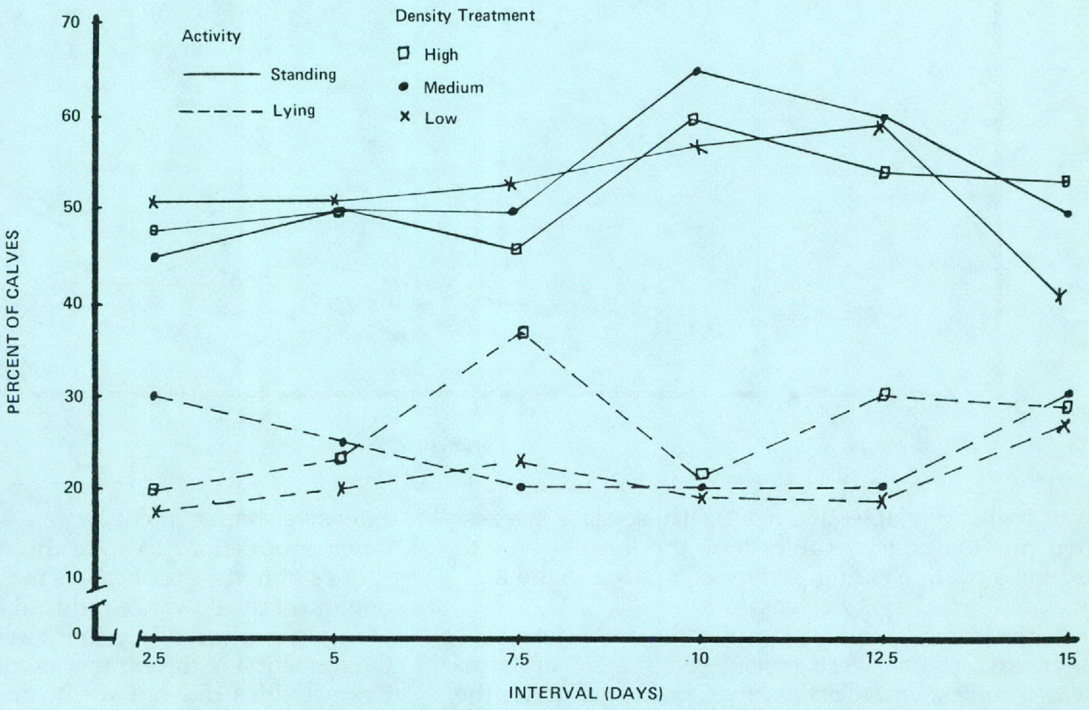

Figure 2. Standing and lying of calves in low, medium, and high density environments.

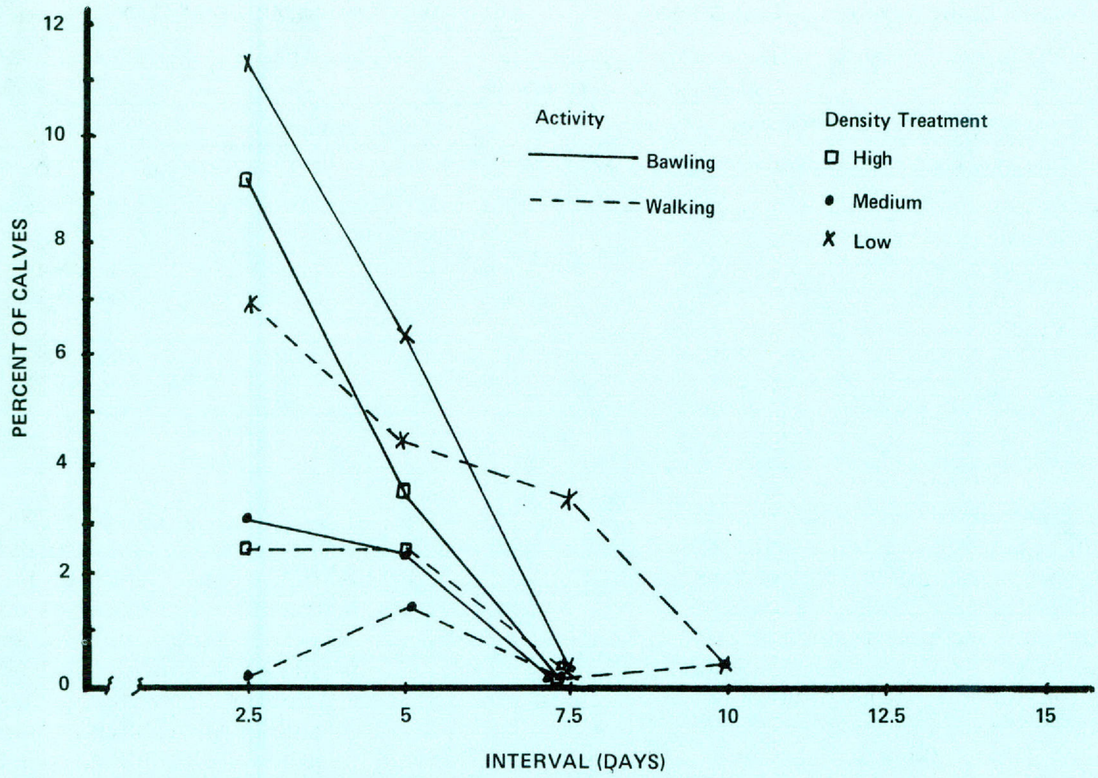

Figure 3. Bawling and walking of calves in low, medium, and high density environments.

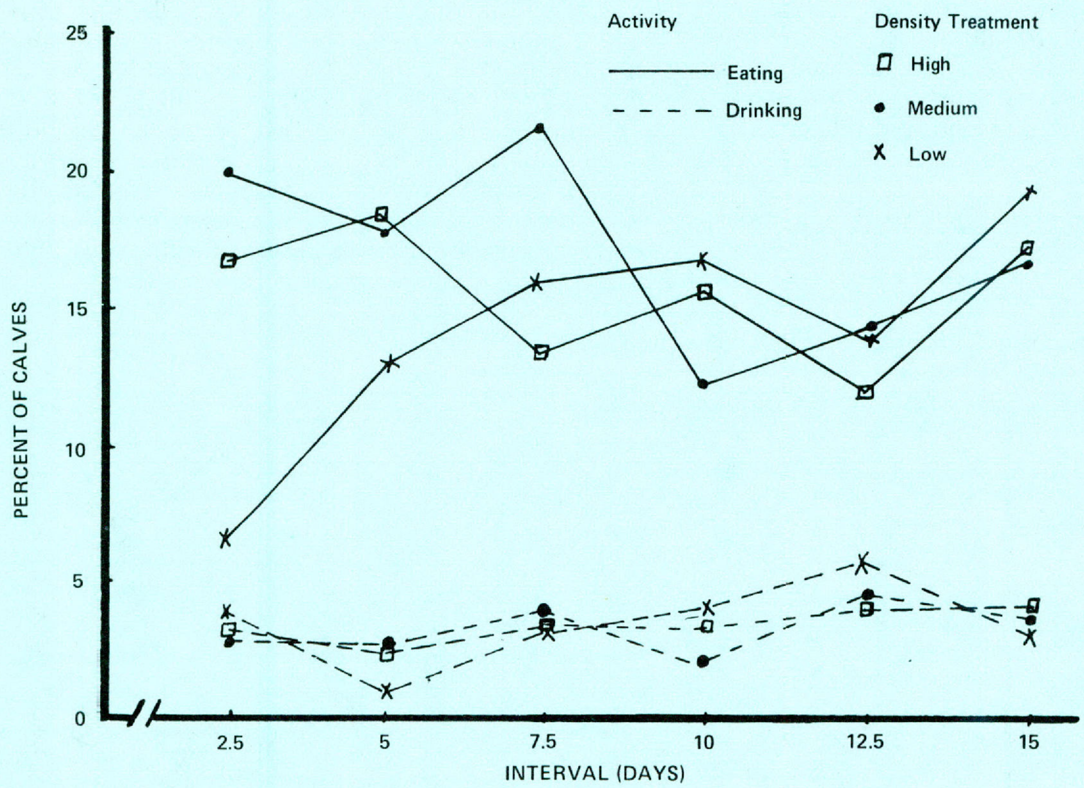

Figure 4. Eating and drinking of calves in low, medium, and high density environments.

was highly variable (Figure 4). These data suggest that the low density calves took the longest time to exhibit a routine eating pattern compared to the high and medium density calves.

The calves produced under the intensive management system were considered typical of farm-reared calves, whereas the calves produced under the extensive management system were typical of large ranch production. Despite these differences, the response of both sets of calves indicates that the reduction in space allowance reduced bawling and walking of calves produced in either environment. However, the reduction in the expression of these stress suggestive activities did not result in more favorable performance of calves as measured by feed intake and liveweight gains.

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PR-3810

Rail Transport of Feeder Cattle

T. H. FRIEND, G. B. THOMPSON,
AND D. P. HUTCHESON

Summary

Activity and weight loss of 360-pound calves were studied in a double-deck railcar equipped with hay and water during transport from Memphis, Tennessee, to Amarillo, Texas. Fifty calves were loaded in each of two 40 × 8.5-foot compartments (6.25 square feet per head). Calves commenced eating and drinking immediately after being loaded in the railcar. Up to 75 percent could lie down while the car was not in motion. Calves stood at high speeds on unimproved track but continued to eat, drink and move about. Weight loss of 50 similar calves shipped by truck was 10.6 percent while rail calves lost 4.5 percent during truck transport to the railcar (11.3 hours) and 2.1 percent during rail transport (57 hours) for a total of 6.6 percent. Cost of transportation was 21 to 40 percent less for these calves than for those shipped in fully loaded trucks.

Introduction

Recent increases in the cost of energy makes transport of cattle by rail, which has at least a four-to-one fuel efficiency advantage over trucks (1), more attractive. However, most U.S. railroads refuse to transport livestock, citing problems in conforming to the "28-hour" law (Public Law No. 340), enacted in 1906. This law requires that animals transported by ship or rail for more than 36 hours be unloaded every 28 hours for 5 hours of feeding and rest. The law has not been amended to cover motor transport but does provide that when animals have "proper feed, water, space and opportunity to rest," the provisions in regard to their being unloaded shall not apply.

The purpose of this study was to monitor the behavior and performance of feeder calves shipped in a railcar equipped with feed and water, and at a density that would allow them to lie down. These data were then used to determine if this method of transport conformed to the intent of the "28-hour" law. Performance and cost were also compared to a similar group of calves transported by truck.

Experimental Procedure

A double-deck, 85 × 8½-foot "jumbo" railcar was used. A 1,100 gallon water tank was installed in the center of each deck, dividing the car into four compartments, and one drinking well was placed in each compartment. Hay racks, made of strips of automobile tires, were installed the length of each compartment and contained 1,485 pounds (lb) of hay. Television cameras were installed at both ends of the top-forward compartment and activity was continuously monitored during transport with portions videotaped for later analyses.

One hundred and fifty Angus and Hereford steer and heifer calves averaging 360 lb were obtained in Newport, Tennessee. Fifty calves were transported directly to the Texas Agricultural Experiment Station feedlot at Bushland by truck and were placed in compartments at the same density as if the truck had a typical full load. The remaining 100 calves were transported by truck to Memphis, Tennessee, transferred to the railcar, and moved to Amarillo. Fifty calves were loaded into the forward compartment of each deck (6.25 square feet per head) of the railcar with rear compartments serving as quarters for researchers. Upon arrival at Amarillo, cattle were transported to the feedlot at Bushland by truck. Loading and unloading of the railcar was accomplished by merely backing the trucks up to the railcar at a convenient siding.

Results

Calves were in the railcar a total of 57 hours. Time spent in transit, distance traveled, and speed of the different phases of shipment are summarized in Table 1.

Calves were loaded in the railcar on June 26 at 1800 hours and immediately commenced eating hay and drinking water. Thirteen different calves drank during the first 30 minutes, suggesting water deprivation during transport to the railcar. The first animal was observed lying down at 2000 hr. At 2233 hr two-thirds of the calves were lying down.

Most cattle were lying down while the train was standing (25 percent of the time in transit) or moving at slow speeds (30 miles per hour (mph) or less). Lying while moving commonly occurred from midnight of the first day on. If the ride was rough, almost all cattle would stand. Those that remained lying were usually along a wall or in the blind area by the door separating compartments, perhaps to reduce being stepped on by calves attempting to maintain their balance.

The ride became extremely rough (pitch and sway) when the train was moving at high speeds (60 mph) over unimproved sections of track. These periods rarely lasted more than 1 to 2 hours because the train was required to slow down when going through metropolitan areas. Since the car was pulled at the end of the train, occasional strong jolts were received during changes in speed due to the accordian action of the cars. Twice the train broke an air line and the automatic brake system caused an abrupt halt. Only once, however, was a calf observed to lose its footing during such a stop. Some calves appeared to be aided in maintaining balance by physical contact with others. Examination of video tapes showed that calves positioned themselves in a random manner throughout the car without regard to speed or smoothness of ride.

Calves continued to eat hay and drink regardless of the smoothness of the ride. Thirty-six different calves drank during an hour of the roughest ride experienced. When the car was standing still, hay and water consumption was greatly reduced as calves lay down to rest. When the car started moving, calves stood up and commenced eating and drinking. Apparent hay (11.2 lb) and water (5.5 gallons) consumption per head per day was normal for calves in a feedlot (2). There was little wastage of hay and a float board in the water effectively prevented splashing.

Five mounting attempts and frequent self and mutual groomings were observed. Social grooming occurred even at moderate train speeds.Calf movement within the railcar was relatively uninhibited (Figures 1 and 2). Animal density permitted 75 percent to lie down at one time when the car was still, which accounted for 14.3 hours of the trip. Many calves continued to lie when the train was moving at slow to moderate speeds.

Weight loss of calves shipped by truck was 10.6 percent, while the rail shipment had a lower (P<.01) weight loss of 6.6 percent (Table 1). Since the calves could not be weighed until after being trucked to Bushland, some of the 2.1-percent loss attributed to the railcar may have been caused by truck transport from Amarillo to Bushland. Four of 50 calves in the truck shipment and five of the 100 rail calves were treated for shipping fever after arrival at Bushland. One calf in the truck shipment was dead on arrival (pneumonia). Rail calves had a significantly higher average daily gain at 7 and 15 days post-transit but this became similar after 28-48 days (Table 2), indicating complete recovery.

The railroad charged $1.64 per mile while truck transport cost $1.39 per mile. Assuming 200 calves were transported in the railcar at the density used in this study (50 calves in each compartment) and the trucks were carrying a "typical" full load of 360-lb calves (100 head each), transport by rail could save 40 percent per mile transported. When the cost of truck transport (39 percent of the distance moved by truck) and all feed costs are included,an overall savings of 21 percent or $717 compared to shipment by truck resulted.

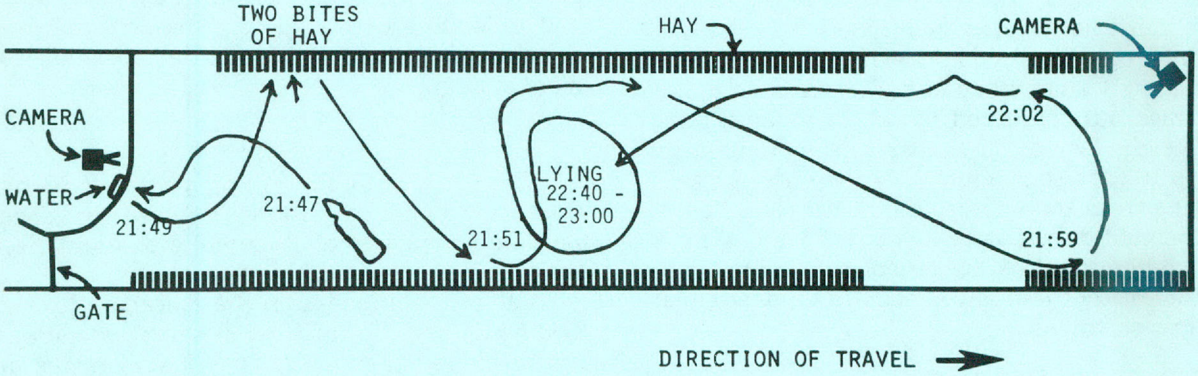

Figure 1. Activity of calf no. 5 from 2147-2300 hours on June 26. Calves were loaded on railcar on June 26 at 1800 hours. The train started moving slowly through the yard at 2300 hours.

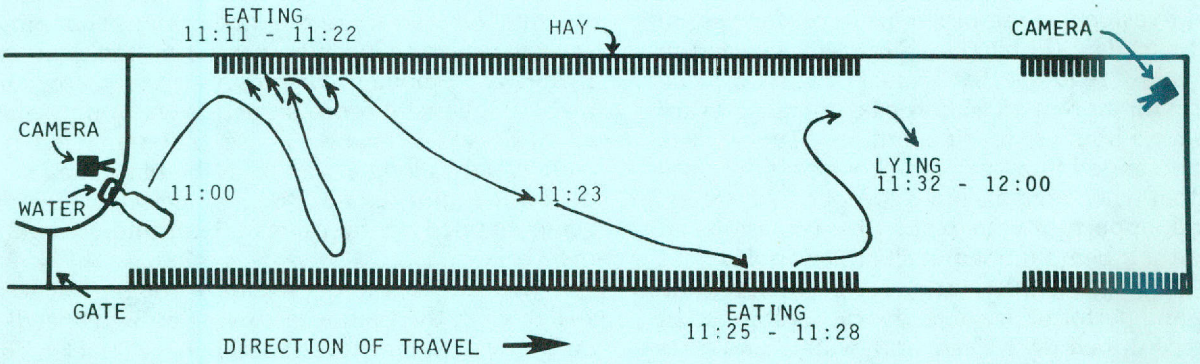

Figure 2. Activity of calf no. 9 from 1100-1200 hours on June 27. The train was moving at a high speed (60 mph) on poor track and slowed to 30 mph at 1132 hours.

TABLE 1. RATE OF TRANSPORT AND CALF SHRINK

Carrier	Distance (miles)	Average speed (mph)	Time (hr)	Weight loss (%)
Truck (Newport to Memphis)	465	41.2	11.3	4.5
Railcar (Memphis to Amarillo)	760	13.3	57.2	
Truck (Amarillo to Bushland)	15	19.8	.75	2.3
Overall	1,240	17.7	69.2	6.6
Truck (Newport to Bushland)	1,225	34.0	36.0	10.6

TABLE 2. POST-SHIPMENT PERFORMANCE OF CALVES

	Average daily gain (lb)	
Period[a]	Rail	Truck
Preshipment to 7 days on feed[b]	.99 ± 3.23	−.04 ± 2.28
Preshipment to 14 days on feed[b]	1.74 ± 1.67	1.28 ± 1.94
Preshipment to 28 days on feed	2.13 ± 1.10	2.07 ± .95
Preshipment to 48 days on feed	2.11 ± .73	2.18 ± .51

[a]Performance calculated from preshipment pay weight to indicated days on feed.

[b]Rail differed from truck ($P<.05$).

Discussion

Transport by rail in cars with feed, water and adequate space appears to have some advantages over transport by truck. Calves were transported at a cost savings and reduced weight loss. The difference in weight loss, however, was only temporary. Calves transported by truck fully compensated by approximately 30 days past-shipment. A major problem with rail transport is the increased time in transit and the possibility of extended delays. The use of unit trains (composed largely of cattle with same origin and destination) may reduce transit time. Cattle at the density and weight used in this study could have remained on the car much longer without ill effect based on their appearance; however, hay and water would have to be replenished.

The Animal and Plant Inspection Service (the enforcement agency of the U.S. Department of Agriculture) has recently ruled that transport of cattle under the conditions used in this study conforms to the intent of the "28-hour" law. Additional research is necessary, however, to refine spatial requirements for different-size cattle.

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Acknowledgments

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PR-3811

Potassium Addition to Receiving Diets of Transported Feeder Calves

D. P. HUTCHESON, N. A. COLE, AND J. B. MCLAREN

Summary

One hundred and seven steer calves were used to study the effect of potassium addition to receiving diets of shipped stressed steers. When a high energy diet was fed 3 days prior to shipping, potassium additions during the receiving period did not affect performance or morbidity of animals. When hay was fed 3 days prior to shipping, potassium additions increased daily gains significantly during the first 28 days post-arrival.

Introduction

Potassium has been recognized as a nutritionally important mineral since the early work of Ringer in 1883. Potassium functions in osmotic balance, acid-base equilibrium, ionic balance, as a cofactor of several enzyme systems and in maintenance of water balance in the body. Potassium requirements of growing, finishing beef cattle have been reported to be between .6 and .8 percent of dietary dry matter (3).

Cattle subjected to the stresses of marketing and shipping encounter many metabolic changes, one of which is weight loss, due to losses of body and digestive tract water. In the case of water losses due to stress, when potassium moves out of cells and only sodium salts are available to replace electrolyte balance, cellular deficiency of potassium may occur. Potassium equilibrium within body pools is accomplished within 48 hours after feeding (2). The objective of this study was to determine the influence of added potassium in the receiving diet of shipped stressed steers on performance, morbidity, and mortality.

Experimental Procedure

This trial was conducted in September and October of 1977. Cattle were purchased from seven farms in Tennessee, weaned, and moved to an auction market for 1 day, then to an order-buyer barn for 3 days. The experimental design was a $2 \times 2 \times 2$ factorial arrangement of treatments. Preshipment treatments were either intramuscular vaccination for infectious bovine rhinotracheitis (IBR) or no vaccination. Calves were fed 5.9 pounds per head per day (lb/head/day) of a 50-percent concentrate, high antibiotic ration (Table 1), similar to Koers (1), or grass hay for 3 days in the order-buyer barn. Post-shipment treatments were 1.0 percent potassium receiving rations 1 and 3 (Table 2) and 1.5 percent potassium rations 2 and 4 (Table 2) fed for 2 weeks post-arrival. Rations 1 and 2 were fed the first week and 3 and 4 were fed the second week. All steers were fed ration 5 (Table 2) the remaining 2 weeks of the trial. Steers were weighed as they were loaded on the truck, after arrival at the feedlot before being fed and watered, and at 7, 14, and 28 days post-arrival. Morbidity data were recorded daily and steers subjectively determined to be sick were placed in separate pens and treated with antibiotics for a minimum of 3 consecutive days.

Results and Discussion

Preshipment vaccination treatment had no significant effect on any variable measured. Weight changes are presented in Table 3. There were no significant differences in transit weight losses between preshipment high energy diet and hay treatments. Average transit shrinkage for the steers was 9.0 percent, and average feedlot arrival weight was 401.5 lb. Steers regained weight loss from shipping in an average of 6 days after arrival. Average daily gains (Table 3) were calculated from average feedlot arrival weight of steers. Animals receiving hay preshipment and no additional potassium during the receiving period had significantly lower average daily gains ($P<.05$) after 28 days on test than steers fed hay preshipment with additional potassium in the receiving ration and steers fed the high energy preshipment ration with or without additional potassium. However, no difference was detected among the hay preshipment treatment plus potassium or the high energy ration with or without additional potassium.

Feed consumption and feed efficiencies are presented in Table 4. Individual values presented are

TABLE 1. PRESHIPMENT RATION

Ingredient	IRN[a]	% (DM basis)
Corn, steam flaked	4-02-859	32.0
Cottonseed hulls	1-01-599	45.0
Soybean meal	5-04-604	7.0
Sugarcane molasses	4-04-696	4.0
Salt, trace mineralized	6-04-152	.5
Limestone, ground	6-02-632	.7
Dicalcium phosphate	6-01-080	.3
Propylene glycol	--------	5.0
Vitamin - antibiotic premix[b]	--------	5.5

[a]International reference number.

[b]To supply 1,100 mg of oxytetracycline and 5,000 IU of vitamin A per kg of ration.

TABLE 2. RATIONS USED IN THE RECEIVING PHASE (DRY MATTER BASIS), PERCENT

		Ration Number				
Ingredient	IRN[a]	%	%	%	%	%
Milo, flaked	4-08-138	23.0	22.0	28.7	27.7	34.4
Corn, flaked	4-02-931	13.5	13.5	16.8	16.8	20.2
Animal fat	4-00-409	.4	.4	.6	.6	.7
Sugarcane molasses	4-04-695	1.3	1.3	1.7	1.7	2.0
Supplement[b]	--------	1.8	1.8	2.2	2.2	2.7
Alfalfa cubes	1-00-059	20.0	20.0	20.0	20.0	10.0
Corn silage	3-08-153	40.0	40.0	30.0	30.0	30.0
Potassium chloride	--------		1.0		1.0	
Crude protein[c], %		11.60	11.60	11.60	11.60	11.01
Calcium[c], %		.28	.28	.44	.44	.45
Phosphorus[c], %		.26	.26	.38	.38	.29
Potassium[c], %		1.00	1.50	.97	1.47	.74

[a]International reference number.

[b]Supplement is a commercial supplement which contains cottonseed meal, urea, calcium carbonate, ammonium sulfate, salt, defluorinated rock phosphate, and trace minerals.

[c]Nutrient values are calculated.

TABLE 3. WEIGHT CHANGES DURING SHIPMENT AND POST-SHIPMENT

	Treatments			
	High Energy Diet		Hay	
Item	Normal K	+K	Normal K	+K
Number of steers	26	25	27	29
Transit shrink (lbs)	36.5	37.2	33.2	37.2
Arrival weight (lbs)	404.4	381.0	414.3	405.7
Post-shipment cumulative daily gains (lbs)				
7 days	6.64	6.03	5.36	6.11
14 days	3.59	4.16	4.44	4.20
28 days	3.10[a]	3.26[a]	2.68[b]	3.08[b]

[a,b]Mean in same row with different superscripts are significantly different ($P<.05$).

TABLE 4. AVERAGE FEED INTAKE AND EFFICIENCY OF GAIN (DRY MATTER BASIS)

	Treatments			
	High Energy Diet		Hay	
Item	Normal K	+K	Normal K	+K
Cumulative daily feed intake (lbs/hd)				
7 days	8.4	9.9	8.5	8.2
14 days	8.7	10.5	9.8	10.0
28 days	10.5	13.4	11.6	11.5
Cumulative feed efficiency				
7 days	1.26	1.64	1.58	1.36
14 days	2.42	2.53	2.21	2.39
28 days	3.39	4.11	4.31	3.73

TABLE 5. MORBIDITY DURING FEEDLOT PHASE

Treatments		Rectal temperature, C	Number of sick calves	Average number of treatment days
Pre-shipment	Post-shipment			
High energy	Normal K	104.2	8	5.75
	+K	103.3	1	4.00
Hay	Normal K	105.4	4	6.50
	+K	103.5	6	6.17

means of two pens of cattle. High energy preshipment plus potassium group consumed more feed per day during the 28-day period than the other treatments. The poorest feed efficiency was noted in the group fed hay preshipment and 1.0 percent potassium post-shipment. Low feed efficiencies for the first 2 weeks reflect the regaining of weight loss during the stress of shipping.

Average rectal temperature of steers when subjectively considered sick was 104.2° F. Average temperature of sick animals by experimental treatments is illustrated in Table 5. No significant differences were observed among rectal temperatures of sick cattle from different experimental treatments. Average length of time of clinical treatment per sick steer was 5.9 days, with no significant differences among experimental treatments. Two animals died, one from the high energy with additional potassium treatment and another from the hay without additional potassium treatment.

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Acknowledgments

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PR-3812

Use of a Living, Nonfreeze-dried *Lactobacillus Acidophilus* Culture for Receiving Feedlot Calves

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Summary

Eighty steer calves from two sources were used to determine the effects of feeding a living, nonfreeze-dried *Lactobacillus acidophilus* culture (LAC)[1] during a 28-day receiving period. In the early parts of the two trials, the LAC calves gained faster than control calves; however, when consumption of the LAC exceeded 15 grams (g) per day, performance was reduced. Consumptions of more than 15 g of LAC per head per day may result in over-population of the lower gastro-intestinal tract which, in turn, may result in reduced nutrient absorption.

Introduction

Microorganisms play an important role in animal agriculture. Microbic contributions, however, may be either an advantage or a disadvantage to the host. Although many gastrointestinal tract microbes synthesize nutrients essential for the host, others may utilize essential nutrients. The increased intestinal bacteroids in persons subjected to stress is not understood. However, data suggest a change in gastrointestinal microflora during stress (2). The presence of excess microbes may physically limit nutrient absorption in the intestine (3). Intestinal microbes could equal in number and exceed in metabolic capability the cells of the animal body (1). Some intestinal microbes may be beneficial in returning homeostasis to the lower intestinal tract of shipped stressed cattle. *Lactobacillus acidophilus* is a species of bacteria which has been widely used in agriculture and which, when fed to monogastrics, resides in the intestinal tract. The objective of this experiment was to evaluate the use of LAC in receiving lightweight calves.

Material and Methods

Eighty steer calves averaging 440 kilograms (kg) were used in two trials. Calves in trial 1 were shipped 400 miles from Nebraska, and those in trial 2 were purchased at a local auction and shipped 12 miles. The calves were vaccinated with a four-way clostridial vaccine[2]. The calves were randomly allotted to two treatments, either no LAC or LAC given as an oral paste [15 milliliters (ml)] upon arrival and incorporated into the diet at the rate of 1.25 grams (g) per pound of diet. The calves were placed in pens equipped with individual feed-monitoring devices. All calves were weighed and temperatures were taken upon arrival at the station and at 7, 14, 21, and 28 days after arrival.

Results and Discussion

The 77-percent concentrate diet is outlined in Table 1. The diet contained 13.2 percent crude protein, 0.6 percent calcium, 0.5 percent phosphorus, and 1 percent potassium (Table 2) and was fed in both trials.

TABLE 1. RATION INGREDIENTS

Ingredient	International reference no.	Percent of dry matter
Cottonseed hulls	1-01-599	33.20
Corn, ground	4-02-931	44.50
Cottonseed meal	5-01-621	16.00
Molasses, sugarcane	4-04-696	4.00
Calcium carbonate	6-02-632	.75
Dicalcium phosphate	6-01-080	.75
Potassium chloride	--------	.25
Salt	6-04-152	.50
Trace minerals & Vitamin A premix[a]		.05

[a]Trace minerals were added to provide zinc (50 ppm), manganese (10 ppm), iron (50 ppm), copper (5 ppm), and cobalt (0.1 ppm). Vitamin A was added to provide 5,000 IU/kg. Trace minerals and vitamin A were two different premixes.

In Trial 1, 45 percent of the control calves and 20 percent of the calves receiving LAC were treated for bovine respiratory disease (BRD). In trial 2, 45 percent of the calves in each group were treated for BRD (Table 3). The average percentages treated for BRD in the two trials were 45 for the control calves and 32.5 for the LAC calves.

TABLE 2. CALCULATED NUTRIENT COMPOSITION OF RATION (DRY MATTER BASIS)

Nutrient	Composition
Net energy of maintenance (mcal/kg)	1.7
Net energy of gain (mcal/kg)	.9
Crude protein (%)	13.2
Calcium (%)	.6
Phosphorus (%)	.5
Potassium (%)	1.0

TABLE 3. CALVES TREATED FOR BOVINE RESPIRATORY DISEASE

Trial	Treatment	Number of calves	Calves treated	Days treated	Repulls[b]
1	Control	20	9	3.0	0
	LAC[a]	20	4	3.5	0
2	Control	20	9	4.0	4
	LAC[a]	20	9	3.7	2

[a]LAC is a living, nonfreeze-dried *Lactobacillus acidophilus* culture.
[b]Number of calves requiring retreatment for BRD.

Average daily gains in trial 1 were significantly greater for LAC calves than for control calves at 3 weeks (Table 4). However, during the fourth week, after calves began to consume more than 15 g of LAC per day, gains decreased 33 percent and were 0.77 pound lower than the controls. In trial 1, daily dry matter consumption was not significantly affected although LAC calves' consumption tended to be higher than controls. The average daily gains at 28 days for calves in trial 1 were 1.30 kg for control calves and 1.58 kg for LAC calves.

Average daily gains also decreased in trial 2 after the calves began to consume more than 15 g of LAC per day (Table 5). This decrease occurred after the second week in trial 2. During the third and fourth weeks, the LAC calves had poorer gains than controls. The average daily gains at 28 days for calves from trial 2 were 0.63 kg for the control and 0.64 kg for LAC calves.

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TABLE 4. AVERAGE FEED INTAKES, CONSUMPTION, PERFORMANCE, AND LAC INTAKES OF CALVES IN TRIAL 1

Variables	Treatment	Days after arrival 1-7	8-14	15-21	22-28	28-day cummulative
Daily dry matter consumption (kg)	Control	3.1	7.8	11.6	13.6	9.0
	LAC[a]	3.0	8.6	11.9	14.8	9.6
Daily dry matter consumption (% body wt)	Control	.71	1.68	2.47	2.78	1.91
	LAC[a]	.68	1.86	2.46	2.96	1.99
Average daily gain (kg)	Control	−2.66	1.78	2.68	3.34	1.30
	LAC[a]	−2.72	2.64	3.87	2.57	1.58
Average daily intake LAC per day (g)	LAC[a]	3.81	10.69	14.94	18.50	11.98

[a]LAC is a living, nonfreeze-dried *Lactobacillus acidophilus* culture.

TABLE 5. AVERAGE FEED INTAKES, CONSUMPTION, PERFORMANCE, AND LAC INTAKES OF CALVES IN TRIAL 2

Variables	Treatment	Days after arrival				28-day cummulative
		1-7	8-14	15-21	22-28	
Daily dry matter consumption (kg)	Control	7.1	10.2	13.6	14.8	11.4
	LAC[a]	7.3	12.4	14.5	14.9	12.3
Daily dry matter consumption (% body wt)	Control	1.56	2.67	2.78	2.98	2.50
	LAC[a]	1.50	2.44	2.94	3.06	2.45
Average daily gain (kg)	Control	−1.30	1.39	2.89	2.78	1.41
	LAC[a]	− .50	1.98	1.72	2.33	1.39
Average daily intake LAC per day (g)	LAC[a]	9.06	14.75	18.19	18.62	15.16

[a]LAC is a living, nonfreeze-dried *Lactobacillus acidophilus* culture.

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[1]Probios, Pioneer Hi-Bred International, Inc., Portland, Oregon 97201.

[2]Franklin Laboratory, Amarillo, Texas 79106.

Growth and Meats

Today's consumer is selecting cuts of beef with less visible fat and more lean than in the recent past. This shift is entirely compatible with reduced marbling (fat) requirements for carcasses, a desire to reduce caloric intake and improved biological efficiency in the production of beef. Texas Agricultural Experiment Station researchers are committed to research programs that may result in the establishment of production and processing techniques that may enhance the eating and health attributes of lean beef, while at the same time contribute to efficiencies of production. A more comprehensive understanding of tissue growth in cattle of different genetic potentials should allow partial control of tissue synthesis, body and hence carcass composition. These concepts, combined with meat quality research, should provide consumers with adequate quantities of lean beef with desirable eating qualities at reasonable prices. Overall, this is the objective of beef cattle research programs in Texas. Representative reports of research in the areas of growth and meats are presented here.

PR-3813

Status of Rate and Composition of Growth in Beef Cattle

F. M. Byers

Renewed interest in producing "lean beef" for the consumer population, which is beginning to appreciate the merits of beef with less fat, has promoted the need to understand mechanisms of growth whereby leaner beef can be economically produced using common cattle feeding and management systems. While it was thought for a time that alternatives for modification of lean tissue (protein) and fat growth in cattle through nutrition and management systems were essentially nonexistent, recent research supports concepts documented earlier this century indicating that nutritional levels and feeding systems regulate and control the composition of weight gained in cattle. Using these options to best advantage is predicated on understanding the control of tissue growth in cattle, and especially the regulation of lean tissue and protein growth. Recent research at Ohio (1,2), supported by reports from Michigan (6) and California (5), has led to a clearer conception of growth and development in feedlot cattle (3).

Initial studies clearly demonstrated that cattle fed high grain diets grew faster and were fatter at lighter weights than similar cattle fed high forage diets (4). Research then followed to elucidate the relationship between rate of growth and composition of growth, and to address the apparent biological limits for protein growth in cattle.

Experiments with steers fed a range of forage/grain levels indicated that daily empty body protein growth approached maximum limits at 1.0 kilogram (kg) gain per day with little additional protein gain with faster rates of gain (6). Implanting with estrogens (Figure1) increased actual limits for daily protein growth 30 percent at rates of gain similar to nonimplanted cattle. Anabolic implants therefore alter the partitioning of energy between protein and fat and increase the physiological limits for daily protein growth in beef cattle, effectively enhancing lean beef production.

Two approaches, restricting feeding and anabolic implants, appear useful in increasing total lean tissue growth in steers of a given biological type. While it

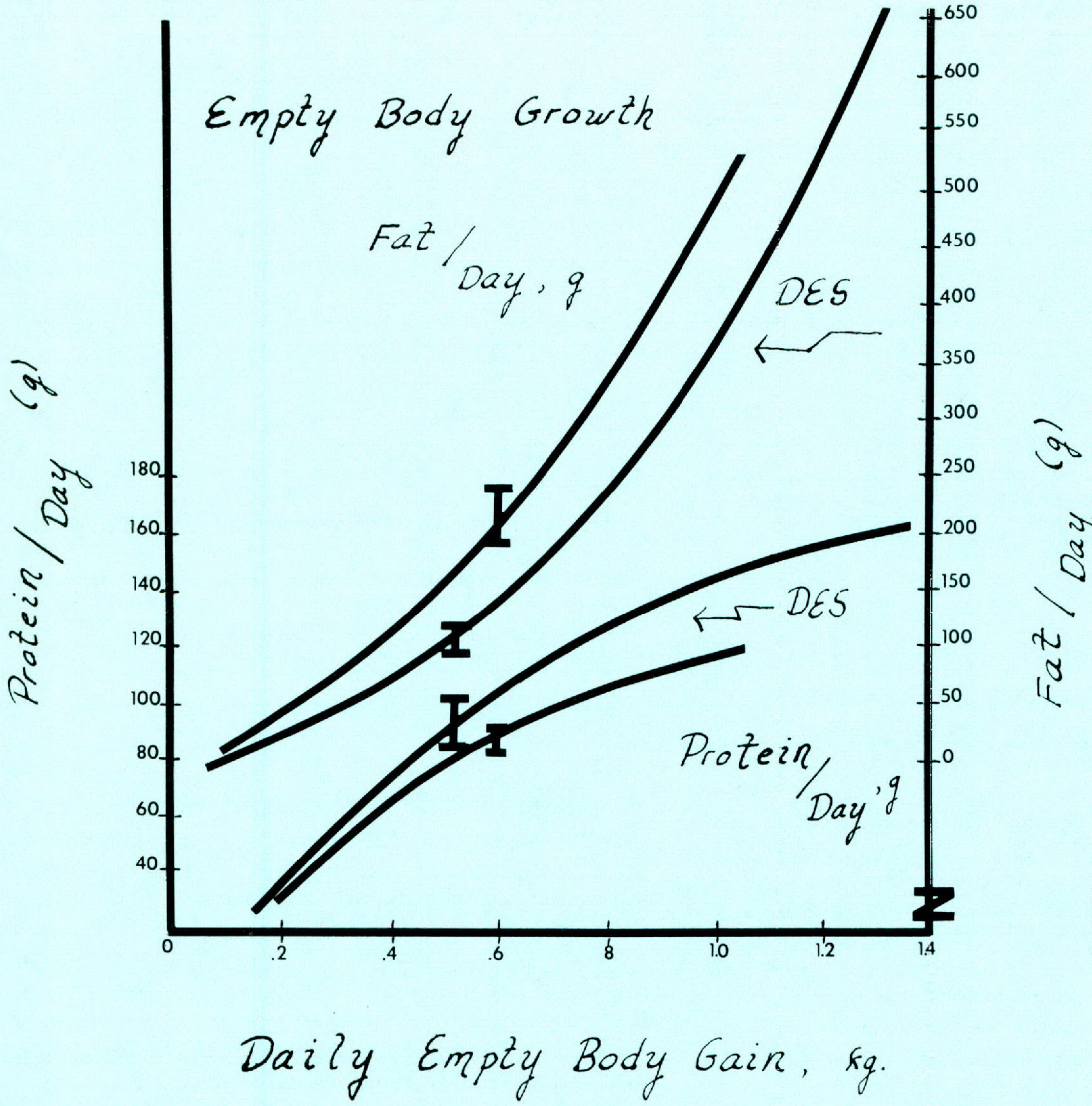

Figure 1. Effect of DES on tissue storage over a range of growth rates.

can be argued that limiting growth rate is not an economical system of producing more lean beef per steer, most systems in cattle production usually include some phase of deferred growth such as wintering, backgrounding, stockering, winter and summer grazing, or even forage finishing. Whether anabolic implants would be useful in these deferred growth phases has been a question of interest. Research with forage fed steers (weaning-slaughter) receiving no implants indicated that maximum limits for protein growth were reached at less than 1.0 kg per day. Whether an implant could effectively increase protein growth in cattle fed corn silage diets from weaning to slaughter was evaluated. One hundred-thirty Hereford steers (205 kg) were allotted to 13 groups for initial slaughter and 12 groups fed corn silage diets at several levels of intake. Feeding periods lasted 181 to 258 days and all cattle were implanted twice with DES. Response in daily protein growth (Figure 2) to rate of gain indicates that maximum limits were approached at 1.0 kg empty body gain with protein growth beginning to plateau. As is evident, percent protein growth decreased markedly with rate of growth, reflecting the increase in fat deposition as a fraction of total gain with increasing rate of gain. Daily protein growth reached 50 grams per day with empty body gains of .9 kg and above; rates of protein growth were 50 grams per day greater than those observed for similar unimplanted Hereford steers fed corn silage diets in two studies. Empty body fat (percent) at similar final empty body weights (370 kg) reflected these modifications in growth and ranged from 16 percent for cattle gaining .6 kg per day to 26 percent for cattle gaining 1.0 kg per day.

Rates of protein growth acheived with the implanted steers fed forage diets are as high as any observed even with high grain feeding programs. Thus it is apparent that maximum daily lean tissue growth can be acheived with corn silage diets, with the only component of growth limited from that possible on higher grain diets being fat.

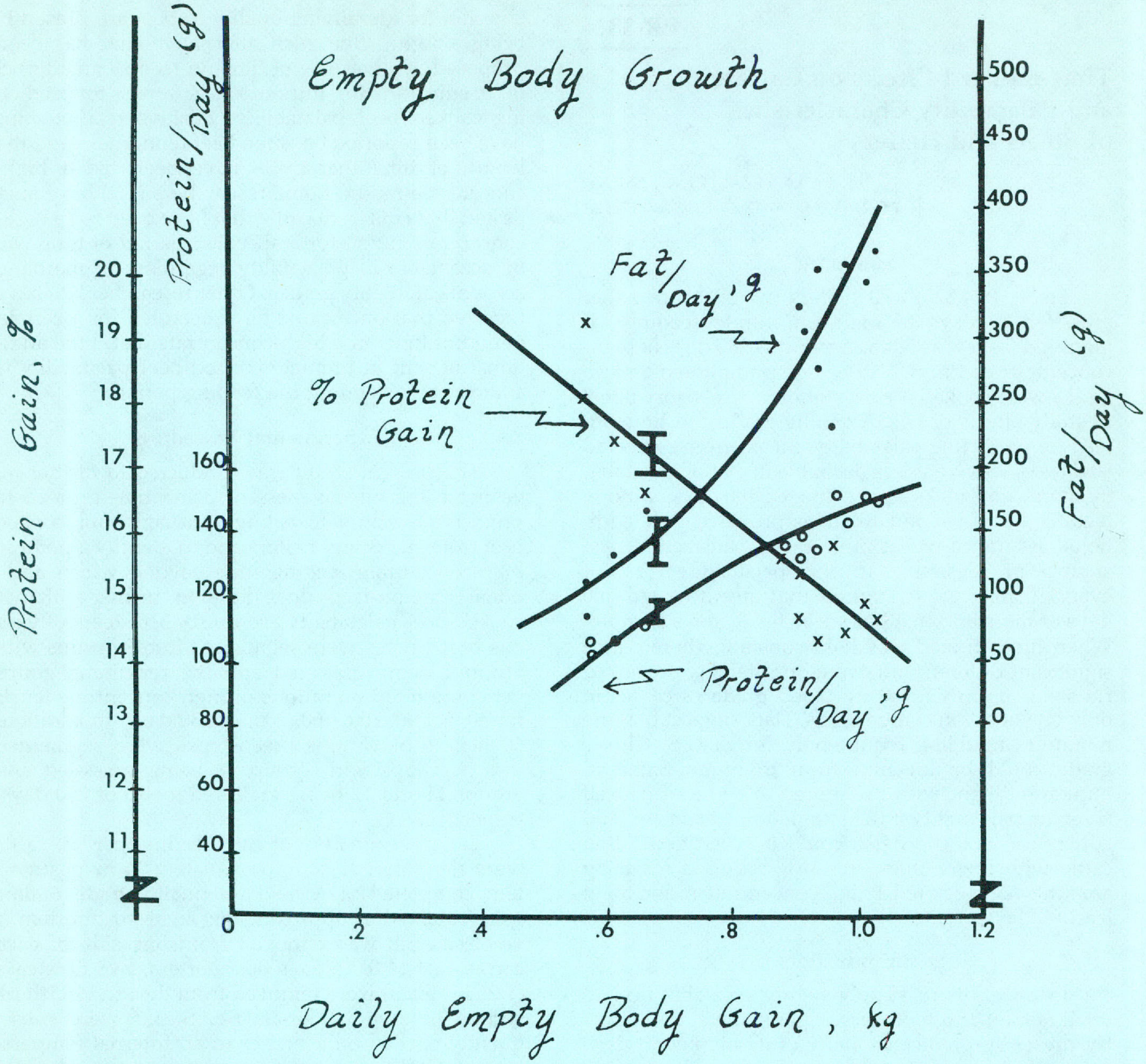

Figure 2. Rate and composition of growth in implanted steers fed corn silage diets.

Feeding bulls or modifying the current upper limits for daily protein growth would allow even faster growth rates in cattle and would result in greater lean tissue growth. Modification of the apparent upper limit for daily protein growth represents a real challenge to beef cattle scientists and yields great promise in enhancing the biological efficiency of lean beef production of the future.

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PR-3814

Time-on-Feed Effects on Carcass and Palatability Characteristics of Steers and Heifers

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Summary

Steers (n=326) and heifers (n=68) were either grass-fed (0 days of high-concentrate feeding) or grain-fed (as few as 30 to as many as 230 days of high-concentrate feeding). Cattle were slaughtered and rib steaks were cooked for evaluation by a sensory panel to study effects of USDA quality grade and time-on-feed for predicting palatability. Steaks from steers fed 90 days or less were less desirable in overall palatability than were steaks from cattle fed 100 days or more; feeding steers beyond 100 days provided little additional assurance of desirable eating satisfaction. Assurance of "desirable" overall palatability for 9 of every 10 rib steaks required that steers be fed 100 days or more and that heifers be fed 90 days or more. When time-on-feed was held constant, there was a significant difference in overall palatability of cooked rib steaks from Choice *vs.* Good grade carcasses in only one of seven comparisons. Data suggest that the minimum marbling requirement for th U.S. Choice grade could be lowered from minimum-Small to minimum-Slight with no appreciable loss of cooked rib steak palatability if the stipulation was made (and adherence to the proviso could be "certified") that cattle with lower than presently required marbling amounts had been fed a high-concentrate ration for at least 90 days.

Introduction

In an effort to supply highly palatable beef to retail market and food service consumers, the industry presently predicates many of its marketing decisions on USDA grades. At present, the industry uses the USDA quality grades to segment carcasses into groups on the basis of expected eating quality. Most beef cattle breeders and feedlot operators have concentrated their efforts on producing and marketing cattle that are expected to produce U.S. Choice carcasses since that grade presently serves as a product-quality benchmark for maximizing profits.

There are researchers (3) who believe that USDA quality grades are closely related to the quality attributes (flavor, juiciness, tenderness) of cooked beef; other researchers (4) are equally convinced that USDA quality grades are not very closely related to cooked-beef palatability. Whichever is the case, there is increasing concern within the industry that present USDA quality grades unnecessarily emphasize marbling and — as a result — encourage over-fattening of cattle and carcasses.

Alternatives to use of marbling as the definitive criterion for identifying quality in beef are presently being sought. One such alternative that has been proposed involves use of time-on-feed as an adjunct to, or substitute for, intramuscular fatness for predicting cooked beef palatability. Positive relationships have been reported between beef tenderness and the length of time that cattle have been fed a high-concentrate ration. Some researchers (1,2) have suggested that cuts from cattle that have been fed a high-concentrate ration for a specified period of time will be acceptable in palatability regardless of marbling amounts or quality grades. Other researchers (5) have reported that once cattle have been fed for a certain period of time on a high-concentrate diet, little additional benefit in ultimate cooked beef palatability is attained by extending the feeding period.

Experimental Procedure

The present study was conducted to further investigate the effectiveness of using time-on-feed to predict the untimate eating satisfaction of cooked beef from steers and heifers and to identify a point in high-concentrate feeding time beyond which additional time-on-feed does little to further enhance cooked beef palatability. To do so, 326 steers of various breed-types were segmented into 9 groups with group 1 being grass-fed and the remaining goups being grain-fed on rations of high concentrate levels for 30, 60, 90, 100, 160, 200, or 230 days. In addition, 68 heifers of various breed-types were segmented into 3 groups with group 10 being grass-fed and groups 11 and 12 being grain-fed for 90 or 200 days, respectively.

Upon termination of each feeding period, cattle were slaughtered. At approximately 24 hr postmortem, complete USDA yield and quality grade (6) data were obtained; at approximately 48 hr postmortem, a wholesale rib was removed from one side of each carcass. At 14 to 16 days postmortem, two rib steaks (1.25 in. thick) were removed from the 9th to 11th rib section of each wholesale rib. Steaks were subsequently cooked on a broiler to an internal temperature of 158°F and used for sensory panel and shear force analyses.

Results and Discussion

Palatability attributes of steaks from steer carcasses are described in Table 1. As time-on-feed increased, flavor desirability increased with the largest between-time-interval changes occurring between 0 *vs.* 30 days and between 100 *vs.* 130 days. Juiciness ratings were not closely associated with time-on-feed. The largest difference in tenderness of cooked beef associated with time-on-feed was that between rib steaks from cattle fed 0 to 90 days *vs.* those from cattle fed 100 to 230 days; shear force values were highest (indicative of greatest toughness) for rib steaks from cattle which were grass-fed (0 days on feed), intermediate for rib steaks from cattle which were fed for 30, 60, or 90 days, and lowest (indicative of greatest tenderness) for rib steaks from cattle which were fed

TABLE 1. PALATABILITY ATTRIBUTES OF STEAKS FROM STEER CARCASSES

Time on feed (days)	N	Flavor rating[a]	Juiciness rating[a]	Tenderness rating[a]	Overall palatability rating[a]	Shear force value (lb)[b]
0	39	4.7[f]	5.1[c]	4.8[ef]	4.4[e]	18.2[e]
30	29	5.3[de]	4.5[e]	4.6[f]	4.5[de]	14.2[d]
60	20	5.1[e]	4.6[de]	5.1[ef]	4.8[de]	11.8[d]
90	38	5.3[de]	5.0[cd]	5.2[e]	4.9[d]	12.4[d]
100	40	5.5[d]	5.1[c]	6.0[cd]	5.6[c]	9.5[c]
130	43	5.9[c]	4.9[cd]	5.7[d]	5.6[c]	9.6[c]
160	45	5.9[c]	5.2[c]	5.8[d]	5.6[c]	9.3[c]
200	37	5.9[c]	5.0[cd]	5.8[d]	5.6[c]	8.5[c]
230	35	5.9[c]	4.9[cd]	6.4[c]	5.9[c]	7.8[c]

[a]8 = extremely desirable flavor, extremely juicy, extremely tender and extremely desirable in overall palatability.

[b]Pounds of force required to shear a 0.5 inch diameter core of cooked muscle.

[cdef]Means in the same column bearing a common superscript letter are not different (P>.05).

for 100, 130, 160, 200, or 230 days. Time-on-feed was related to overall palatability of cooked rib steaks in the following manner: steaks from cattle fed 0 days were less desirable than were steaks from cattle fed 90 days or more, steaks from cattle fed 90 days or less were less desirable than were steaks from cattle fed 100 days or more, and feeding steers beyond 100 days provided little additional assurance of desirable overall palatability or eating satisfaction.

Palatability attributes of steaks from heifer carcasses are described in Table 2. As time-on-feed increased from 0 to 90 to 200 days, flavor desirability and overall palatability increased. In this group of heifers, tenderness of rib steaks was not associated with time-on-feed. These data suggest that rib steaks from heifers do not increase in overall palatability when time-on-feed increases from 90 to 200 days.

Frequency percentages of "desirable" (mean sensory panel ratings of 4.50 or higher) palatability ratings are presented in Table 3. Feeding of heifers for 90 days or of steers for 100 days resulted in rib steaks that had 90 percent or higher frequencies of "desirable" ratings for flavor, tenderness, and overall palatability; feeding steers for 90 days or less resulted in production of rib steaks that had 70 percent or lower frequencies of "desirable" ratings for overall palatability. Assurance of "desirable" eating satisfaction for 9 of every 10 rib steaks required that steers be fed 100 days or more and that heifers be fed 90 days or more (90 days may not be the minimum for heifers — in this study, no data were obtained for feeding periods between 0 and 90 days).

Overall palatability ratings for rib steaks from steer carcasses of different USDA quality grades are presented in Table 4. When cattle were fed to grade Standard (30 days on feed) and some graded Choice or Good, their rib steaks did not differ in palatability from those which came from Standard carcasses. When cattle were fed to grade Good (90 or 100 days on feed) and some graded Choice or Standard, their rib steaks did not differ in palatability from those which came from Good carcasses in three of four comparisons. When cattle were fed to grade Choice (130, 160, 200, or 230 days on feed) and some graded Good or Standard, their rib steaks did not differ in palatability from those which came from Choice carcasses in four of seven comparisons. Knowledge of grade alone, without a knowledge of the feeding regimen — especially the period of time that the cattle were fed prior to slaughter — is not as indicative of expected palatability of cooked steaks as would be desired. In 6 of 7 comparisons of Choice *vs.* Good in Table 4, there was no significant difference in overall palatability of rib steaks.

As a test of the hypothesis that some required time-on-feed minimum could be used to make possible a lowering of the minimum marbling requirement for the U.S. Choice grade, data presented in Table 5 were assembled. The postulation to be tested was that carcasses with a minimum-Slight (the present minimum marbling requirement for the U.S. Good grade) amount of marbling would produce steaks which are as palatable as those from U.S. Choice carcasses if the stipulation was that the cattle which

TABLE 2. PALATABILITY ATTRIBUTES OF STEAKS FROM HEIFER CARCASSES

Time on feed (days)	N	Flavor rating[a]	Juiciness rating[a]	Tenderness rating[a]	Overall palatability rating[a]	Shear force value (lb)[b]
0	13	4.7[d]	5.1[c]	6.2[c]	5.0[d]	8.1[c]
90	15	5.7[c]	4.7[d]	6.0[c]	5.5[cd]	10.8[d]
200	39	6.0[c]	5.2[c]	6.2[c]	5.8[c]	7.3[c]

[a]8 = extremely desirable flavor, extremely juicy, extremely tender and extremely desirable in overall palatability.

[b]Pounds of force required to shear a 0.5 inch diameter core of cooked meat.

[c]Means in the same column bearing a common superscript letter are not different (P>.05).

TABLE 3. FREQUENCY PERCENTAGES OF "DESIRABLE" PALATABILITY RATINGS

Time on feed (days)	Percentage "desirable" ratings[a]					
	Steers			Heifers		
	Flavor	Tenderness	Overall palatability	Flavor	Tenderness	Overall palatability
0	64.1	59.0	51.3	57.1	92.8	57.2
30	93.1	48.3	58.6	--	--	--
60	90.0	90.0	70.0	--	--	--
90	79.0	68.4	63.2	100.0	93.3	93.4
100	95.0	100.0	92.5	--	--	--
130	100.0	93.0	90.7	--	--	--
160	100.0	100.0	93.3	--	--	--
200	100.0	94.6	94.6	100.0	100.0	94.9
230	100.0	100.0	97.2	--	--	--

[a]"Desirable" = mean sensory panel ratings of 4.50 or higher.

TABLE 4. OVERALL PALATABILITY RATINGS FOR RIB STEAKS FROM STEER CARCASSES OF DIFFERENT USDA QUALITY GRADES

Time on feed (days)	USDA quality grade		
	Choice	Good	Standard
30	4.6^{a}	4.5^{a}	4.5^{a}
90	5.3^{a}	5.4^{a}	4.2^{b}
100	5.6^{a}	5.3^{a}	5.6^{a}
130	5.8^{a}	5.2^{b}	5.2^{b}
160	5.6^{a}	5.6^{a}	5.4^{a}
200	5.7^{a}	5.4^{a}	---
230	6.1^{a}	5.9^{ab}	5.3^{b}

[ab]Means in the same row bearing a common superscript letter are not different (P>.05).

produced carcasses with minimum-Slight marbling had been fed a high-concentrate ration for 90 days or more or for 100 days or more. Data in Table 5 support such a hypothesis — low-Good carcasses from cattle fed 0 to 230 days produced steaks which differed from those of Choice carcasses in flavor, tenderness, shear force, and overall palatability; however, low-Good carcasses from cattle fed 90 days or more produced steaks that were essentially equivalent in palatability to those steaks from Choice carcasses. Identical results were obtained when steaks from low-Good carcasses from cattle fed 100 days or more were compared to steaks from Choice carcasses — steaks from low-Good carcasses were essentially equivalent in palatability to those steaks from Choice carcasses. Applying similar logic in an attempt to support inclusion of carcasses that presently grade high Standard in a "new" Choice grade was only partially successful — rib steaks from high-Standard carcasses were not interchangeable with those from

TABLE 5. PALATABILITY AND SHEAR FORCE DATA FOR SPECIFIED RIB STEAK POPULATIONS

USDA quality grade	Choice (0 to 230 days); Good and/or Standard (0 to 230 days)				Choice (0 to 230 days); Good and/or Standard (90 to 230 days)				Choice (0 to 230 days); Good and/or Standard (100 to 230 days)			
	Flavor rating[a]	Tenderness rating[a]	Overall palatability rating[a]	Shear force (lb)[b]	Flavor rating[a]	Tenderness rating[a]	Overall palatability rating[a]	Shear force (lb)[b]	Flavor rating[a]	Tenderness rating[a]	Overall palatability rating[a]	Shear force (lb)[b]
Population I												
Choice	5.8^{c}	6.0^{c}	5.7^{c}	8.8^{c}	5.8^{c}	6.0^{c}	5.7^{c}	8.8^{c}	5.8^{c}	6.0^{c}	5.7^{c}	8.8^{c}
High Good	5.6^{d}	5.6^{cd}	5.4^{cd}	10.7^{d}	5.6^{c}	5.8^{c}	5.5^{c}	9.5^{c}	5.6^{c}	5.6^{c}	5.3^{c}	9.5^{c}
Avg. Good	5.7^{cd}	5.9^{c}	5.5^{cd}	11.2^{d}	5.7^{c}	5.9^{c}	5.5^{c}	10.1^{c}	5.9^{c}	6.0^{c}	5.7^{c}	9.2^{c}
Low Good	5.6^{d}	5.4^{d}	5.1^{d}	10.6^{d}	5.7^{c}	5.8^{c}	5.5^{c}	9.4^{c}	5.8^{c}	5.9^{c}	5.6^{c}	9.1^{c}
Population II												
Choice	5.8^{c}	6.0^{c}	5.7^{c}	8.8^{c}	5.8^{c}	6.0^{c}	5.7^{c}	8.8^{c}	5.8^{c}	6.0^{c}	5.7^{c}	8.8^{c}
High Good	5.6^{de}	5.6^{cde}	5.4^{cd}	10.7^{d}	5.6^{cd}	5.8^{cd}	5.5^{cd}	9.5^{c}	5.6^{c}	5.6^{c}	5.3^{c}	9.5^{cd}
Avg. Good	5.7^{cd}	5.9^{cd}	5.5^{cd}	11.2^{de}	5.7^{cd}	5.9^{cd}	5.5^{cd}	10.1^{c}	5.9^{c}	6.0^{c}	5.7^{c}	9.2^{cd}
Low Good	5.6^{de}	5.4^{de}	5.1^{de}	10.6^{d}	5.7^{cd}	5.8^{cd}	5.5^{cd}	9.4^{c}	5.8^{c}	5.9^{c}	5.6^{c}	9.1^{cd}
High Standard	5.3^{e}	5.2^{e}	4.9^{e}	13.0^{e}	5.5^{d}	5.4^{d}	5.1^{d}	11.7^{d}	5.7^{c}	5.8^{c}	5.4^{c}	10.1^{d}

[a]8 = extremely desirable flavor, extremely tender and extremely desirable in overall palatability.

[b]Pounds of force required to shear a 0.5-inch diameter core of cooked meat.

[cde]Means in the same column and for the same grade comparison bearing a common superscript letter are not different (P>.05).

Choice carcasses if the time-on-feed constraint was 90 days, but they were interchangeable with those from Choice carcasses if the time-on-feed constraint was 100 days.

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PR-3815

Improving Tenderness of Meat from Young Bulls

J. W. Savell, G. C. Smith, C. E. Murphey, F. K. McKeith, and Z. L. Carpenter

Summary

Thirty Santa Gertrudis bulls were slaughtered, dressed and split into sides. The right side of each carcass was electrically stimulated (ES) while the left side served as a nonstimulated control (not-ES). At 24 hours after slaughter, USDA quality and yield grade data were obtained from each side. On the second day after slaughter, all sides were fabricated and strip loins, top sirloin butts and ribeyes were obtained from each side for postmortem aging and blade tenderization studies. Steaks were removed after a postmortem aging period of 4 or 18 days and before (not-BT) or after blade tenderization (BT) for sensory panel evaluations or shear force determinations. ES sides had more youthful lean maturity, higher marbling, higher USDA quality grades and finer-textured lean than did nonstimulated (not-ES) sides. ES significantly improved palatability traits in two of 24 comparisons; BT significantly improved palatability traits in 12 of 24 comparisons; and 18-day postmortem aging significantly improved palatability traits in seven of 12 comparisons. No significant reductions in shear force values were observed for steaks from ES versus not-ES sides while significant reductions were observed for steaks from BT versus not-BT cuts (four of six comparisons) and for steaks from cuts aged for 18 versus 4 days (10 of 12 comparisons). BT and 18-day postmortem aging were more effective for increasing palatability or for decreasing shear force requirements than was ES; however, ES greatly improved lean color of meat from bulls.

Introduction

In order to maximize production of lean beef for hamburger manufacturing, several suppliers of ground beef to "fast-food" chains are buying bullocks or feeding young bulls for slaughter. These suppliers attempt to sell higher-valued wholesale cuts to lower the break-even price of the ground beef. These wholesale cuts — possibly due to the lack of adequate fat on the carcass to prevent "cold shortening" toughness and/or because of the inherent variation in tenderness observed in meat from bulls — may not be of satisfactory quality for distribution as block-ready beef. It may be, with the use of postmortem tenderization processes like electrical stimulation, postmortem aging, or blade tenderization or some combination of these processes, that few palatability problems would occur with steaks produced from young bulls if tenderization techniques were used. This study was conducted to determine the singular and combined effects of these three postmortem tenderization techniques on the palatability of meat from certain primal cuts of young bulls.

Experimental Procedure

Electrical Stimulation

Thirty Santa Gertrudis bulls (approximately 15-18 months old) that had been fed a high-concentrate grain ration for about 130 days were slaughtered, dressed and split into sides. The right side of each carcass was electrically stimulated (ES) while the left side served as a nonstimulated (not-ES) control. Electrical stimulation was administered by the use of an experimental "Lectro-Tender™" unit with a setting of 550 volts (AC), 5 amps and 17 impulses (1.8 sec impulse duration; 1.8 sec interval between impulses) applied to each right side. Carcasses were placed in a cooler which had a temperature of 41° F at the beginning and 30° F at the end of the 24-hour chilling period.

Quality Characteristics and Subprimal Removal

At 24 hours after slaughter, USDA quality and yield grade data were obtained by Texas Agricultural Experiment Station (TAES) personnel. On the second day after slaughter, all carcasses were shipped to a fabrication plant by refrigerated truck. On the third day after slaughter, certain subprimal cuts were removed from each carcass: boneless strip loin, top sirloin butt and boneless ribeye roll. All subprimal cuts were vacuum packaged, boxed and transported to the Texas A&M University Meat Laboratory.

Postmortem Aging

On the fourth day after slaughter, all subprimal cuts were removed from vacuum packages and each subprimal cut was divided into two sections. The two sections from each subprimal cut were alternately assigned to the 4-day or 18-day aging periods so that each aging period had one-half of the posterior and/or medial sections and one-half of the anterior and/or lateral sections. All subprimal cut sections allocated to the 18-day aging treatment were vacuum packaged and held at 33 ± 1° F for 14 additional days.

Blade Tenderization

After the appropriate aging period, two steaks were removed from each section of the strip loin and top sirloin butt (for palatability and shear force determinations) and one steak was removed from each section of the ribeye (for shear force determinations). In order to compare blade tenderized (BT) steaks to steaks that were not blade tenderized (not-BT), remaining sections of each subprimal were passed through a Ross TC-700 reciprocating blade tenderizer one time and additional steaks were removed in the manner described above. All steaks were double-wrapped in polyethylene-coated paper, frozen at −30° F and stored at −10° F until palatability and shear force determinations were made.

Palatability and Shear Force Determinations

Steaks were removed from the freezer, thawed for 18 hours and cooked to an internal temperature of 158° F over Faberware Open Hearth broilers. For palatability evaluations, appropriate muscles from loin and sirloin steaks in each treatment were served, while warm, to an eight-member trained sensory panel. For shear force determinations, cooked loin, sirloin or rib steaks from each treatment were cooled to room temperature and cores were removed parallel to the orientation of the muscle fibers. All cores were sheared by use of the Warner-Bratzler shear machine.

Data Analysis

Data were analyzed by paired-t distribution analysis, analysis of variance and mean separation.

Results and Discussion

USDA quality grade data (Table 1) revealed that ES sides had more youthful lean maturity, younger overall maturity, higher marbling, finer-textured lean and higher USDA quality grades than did nonstimulated (not-ES) sides. The effect of ES in improving USDA quality grade factors and other quality-indicating characteristics of the lean of beef carcasses is well-documented (3,4,5,6,7,8). That ES will improve the color and texture of the lean from bull carcasses is very important — research has shown that meat from bulls is considerably darker and coarser in texture than that from steers (1,2).

Mean palatability ratings for steaks from strip loins and top sirloin butts from each treatment are reported in Table 2. ES, used singularly, resulted in significant improvements in palatability traits in two of 24 comparisons (muscle fiber tenderness and overall tenderness of 18-day top sirloin steaks); BT resulted in significant improvements in palatability traits in 12 of 24 comparisons (juiciness ratings were significantly lower in three of four comparisons); and 18-day postmortem aging resulted in significant improvements in palatability traits in seven of 12 comparisons. ES did not increase tenderness in this population of steaks from bulls to the extent observed in our previous research using beef from steers, heifers and/or cows. On the other hand, results of this study regarding the positive effects of BT and 18-day postmortem aging in increasing tenderness confirms our previous findings from research on steaks from steers, heifers and/or cows.

TABLE 1. MEAN VALUES FOR CERTAIN CARCASS TRAITS

USDA yield grade factor[a]	Mean
Hot carcass weight, lb	736.1
Longissimus muscle area, 12th rib, in.^{2}	12.9
Adjusted fat thickness, 12th rib, in.	.35
Kidney, pelvic and heart fat, %	2.2
USDA yield grade	2.4

	Paired sides		
USDA quality grade factors[a]	Nonstimulated control (not-ES)	Electrically stimulated (ES)	Level of probability[b]
Lean maturity	B^{11}	A^{86}	P<0.0001
Skeletal maturity	A^{70}	A^{70}	NS
Overall maturity	A^{92}	A^{81}	P<0.001
Marbling	Slight^{01}	Slight^{22}	P<0.002
Lean texture[c]	6.3	6.5	P<0.02
USDA quality grade	U.S. Good^{00}	U.S. Good^{20}	P<0.001

[a]For maturity, A^{00} = approximately 9 months of age; A^{100} = approximately 30 months of age; B^{100} = approximately 42 months of age.

[b]The probability that the difference between treatments is statistically significant. P>0.05 was reported as nonsignificant (NS).

[c]8 = extremely fine, 1 = extremely coarse.

TABLE 2. MEAN PALATABILITY RATINGS FOR STEAKS FROM STRIP LOINS AND TOP SIRLOIN BUTTS FROM EACH TREATMENT

Palatability trait and treatment group[a]	Strip loin 4-day aging	Strip loin 18-day aging	Top sirloin butt 4-day aging	Top sirloin butt 18-day aging
Juiciness				
Not-ES, Not-BT	6.7^{b}	6.6^{b}	5.6^{b}	5.4^{b}
ES, Not-BT	6.3^{c}	6.2^{b}	5.7^{b}	5.3^{bc}
Not-ES, BT	5.8^{d}	5.4^{c}	5.5^{b}	4.9^{c}
ES, BT	5.8^{d}	5.3^{c}	5.4^{b}	5.1^{bc}
Muscle fiber tenderness				
Not-ES, Not-BT	5.9^{b}	7.5^{b}	6.4^{b}	7.1^{b}
ES, Not-BT	6.1^{b}	7.6^{b}	6.7^{b}	7.5^{c}
Not-ES, BT	6.6^{bc}	8.2^{c}	7.7^{c}	8.7^{d}
ES, BT	6.9^{c}	8.2^{c}	7.8^{c}	8.6^{d}
Connective tissue amount				
Not-ES, Not-BT	8.0^{b}	8.8^{b}	8.5^{b}	8.9^{b}
ES, Not BT	8.2^{b}	9.0^{b}	8.7^{b}	9.0^{b}
Not-ES, BT	8.7^{c}	9.1^{b}	9.2^{c}	9.6^{c}
ES, BT	8.8^{c}	9.2^{b}	9.4^{c}	9.5^{c}
Overall tenderness				
Not-ES, Not-BT	6.0^{b}	7.6^{b}	6.4^{b}	7.1^{b}
ES, Not-BT	6.1^{bc}	7.6^{b}	6.8^{b}	7.5^{c}
Not-ES, BT	6.7^{cd}	8.2^{c}	7.7^{c}	8.7^{d}
ES, BT	6.9^{d}	8.2^{c}	7.8^{c}	8.6^{d}
Flavor				
Not-ES, Not-BT	7.7^{b}	7.8^{b}	7.6^{b}	7.4^{b}
ES, Not-BT	7.5^{b}	7.8^{b}	7.5^{b}	7.5^{b}
Not-ES, BT	7.6^{b}	7.6^{b}	7.7^{b}	7.5^{b}
ES, BT	7.6^{b}	7.7^{b}	7.6^{b}	7.6^{b}
Overall palatability				
Not-ES, Not-BT	6.1^{b}	7.4^{b}	6.3^{b}	6.7^{b}
ES, Not-ES	6.1^{b}	7.3^{b}	6.5^{b}	7.0^{b}
Not-ES, BT	6.6^{b}	7.5^{b}	7.2^{c}	7.5^{c}
ES, BT	6.7^{b}	7.4^{b}	7.2^{c}	7.6^{c}

[a]Scores of 10.0 to 8.6 were assigned to samples which were extremely juicy, extremely tender, extremely desirable in flavor, extremely desirable in overall palatability or which had very little (none to practically none) connective tissue. At the opposite end of the scale, scores of 2.5 to 1.1 were assigned to samples that were extremely dry, extremely tough, extremely undesirable in flavor, extremely undesirable in overall palatability or which had abundant connective tissue.

[bcd]Means in the same column bearing a common superscript letter are not different.

Means in the same row and for the same subprimal cut that are underscored by a common line are not different.

Warner-Bratzler shear force values for muscles from ribeyes, strip loins and top sirloin butts from each treatment are found in Table 3. There were no significant reductions in shear force values for steaks from ES versus nonstimulated (not-ES) sides but there were significant reductions in shear force values for steaks from BT versus non-BT cuts (four of six comparisons) and for steaks from cuts aged for 18 rather than 4 days (10 of 12 comparisons). That ES did not significantly reduce the shear force values in this study warrants further comment — it has been suggested that ES appears to tenderize muscles in those carcasses that would otherwise be tough while ES does not appear to tenderize the muscles of those carcasses that would otherwise be tender. Comparison of mean shear force values for loin steaks from nonstimulated (not-ES) sides in the present study with comparable values for loin steaks from previous studies suggest that steaks from this population of bulls were tender at the outset (untreated, 4 days postmortem) and thus were not likely to benefit from electrical stimulation. Perhaps these bulls produced steaks that were tender because they had been fed a high-concentrate diet for a substantial period of time (approximately 130 days) prior to slaughter or because chilling conditions were conducive to muscle protein breakdown and/or were not conducive to "cold-shortening." The proper combination of high muscle mass, thick fat cover and high cooler temperature will preclude occurrence of "cold-shortening" and will enhance the activity of lysosomal enzymes; under such circumstances ES is not likely to result in further tenderization of beef. Conversely, BT and 18 days of postmortem aging are probably effective in reducing shear force values of steaks from a population of animals — regardless of their initial tenderness — because these tenderization treatments are more severe in their action (as applied in this study) than is the ES process. From a consumer viewpoint, it is possible that BT or long-term aging can "over-tenderize" meat regarded as adequately tender without such treatment.

In conclusion, blade tenderization and 18 days of postmortem aging were more effective for increasing palatability or for decreasing shear force requirements than was electrical stimulation. ES had a significant effect on the quality-indicating characteristics — especially lean color — and could be useful for improving the appearance of bull beef destined for retail display prior to its sale and consumption. It is probable that beef from young bulls can be made equal to that from young steers and/or heifers in palatability if young bulls are managed properly — for example, fed a high-concentrate ration for a sufficient period of time and/or allowed to deposit adequate fat and if appropriate tenderization techniques are employed to improve and to reduce variability in palatability of their steaks.

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TABLE 3. MEAN WARNER-BRATZLER SHEAR FORCE VALUES FOR STEAKS FROM RIBEYES, STRIP LOINS AND TOP SIRLOIN BUTTS FROM EACH TREATMENT

Treatment group[a]	Ribeye[b] 4-day aging	Ribeye[b] 18-day aging	Strip loin 4-day aging	Strip loin 18-day aging	Top sirloin butt 4-day aging	Top sirloin butt 18-day aging
Not-ES, Not-BT	11.2[b]	7.9[b]	11.2[b]	8.1[b]	10.6[b]	10.8[b]
ES, Not-BT	10.6[bc]	8.4[b]	11.0[bc]	8.4[b]	10.1[bc]	9.9[b]
Not-ES, BT	9.9[cd]	7.3[c]	10.1[bc]	7.7[b]	9.2[cd]	7.7[c]
ES, BT	9.2[d]	7.0[c]	9.9[c]	7.9[b]	8.8[d]	7.3[c]

[a]Shear force values were determined by shearing cores with a Warner-Bratzler shear force machine. Treatment groups include combinations of electrical stimulation (ES or not-ES), postmortem aging (4 days or 18 days) and blade tenderization (BT or not-BT).

[bcd]Means in the same column bearing a common superscript letter are not different.

Means in the same row and for the same subprimal cut that are underscored by a common line are not different.

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Effect of Forage Availability on Carcass Traits of Calves Slaughtered at Weaning

F. M. ROUQUETTE JR. AND Z. L. CARPENTER

Summary

Twenty-four fall-born calves were slaughtered when weaned at an average age of 259 days. Preweaning treatments consisted of grazing a bermudagrass-ryegrass-arrowleaf clover sward at three levels of forage availability (FA). Cow and calf average daily gains (ADG) from the low, medium, and high FA paddocks were −.25 and .67; −.02 and .76; and .47 and .97 kilograms (kg), respectively. The low, medium, and high FA paddocks supported stocking rates of 6.27, 4.52 and 2.72 cow-calf units per hectare (ha), and calf weaning weights of 236, 251, and 289 kg, respectively. Carcasses from calves in high FA paddocks were fatter (5.08 millimeters (mm) versus 1.27 mm over the *longissimus* muscle) ($P<.05$) and also had more than 18 percent larger ($P<.05$) *longissimus* muscle areas than carcasses from the low FA paddocks. Marbling scores and quality grades of carcasses from calves in high FA paddocks were 33 percent and 27 percent higher ($P<.05$), respectively, than those of calves in low FA paddocks. There were few significant differences in palatability-related traits of loin steaks from carcasses of calves on the three levels of FA. Also, except for juiciness, steaks from 22 grain-fed steers generally had higher ($P<.05$) taste panel scores and lower shear force values than did steaks from carcass of any of the three FA groups of calves. Steer carcasses had higher ($P<.05$) ADG, weaning weight, and *longissimus* muscle areas than did heifers; whereas, heifers had greater ($P<.05$) fat thickness over the *longissimus* muscle, more kidney, pelvic and heart (KPH) fat and a higher yield grade number (lower cutability) than did steers. There were no differences ($P>.05$) in other carcass characteristics nor in any of the palatability-related traits of loin steaks between steers and heifers.

Introduction

In the past, interest in forage-fed beef has been cyclical in nature and has been mainly influenced by the cost of feedlot gain and its effect on the comparative prices of feeder cattle and slaughter cattle. Popularity of this type beef has also been associated with consumer interests associated with fat versus lean beef and world food shortages. At the present time, economic conditions, which are primarily associated with USDA grading standard, do not favor the production of forage-fed beef. However, as recently as 1975, prices of feeder cattle were much lower than prices of slaughter cattle resulting in the slaughter of large numbers of calves and other non-grain-fed steers and heifers.

It has been well-documented that grain-fed (high-concentrate) beef has higher physical and sensory quality traits than does forage-fed (low-concentrate) beef (2, 3, 4, 5, 7, 9, 13). There also are logistical problems related to producing year-round dependable supplies of forage-fed beef due to variations in the weather, and to the seasonality of forage production. Nevertheless, forage-fed beef is a marketable product and when the economics of production are such that it is again more advantageous to slaughter forage-produced steers and heifers than to place them in feedlots for further feeding, information will be needed as to how such beef can be produced most efficiently.

One aspect of forage-fed beef production that has received little research attention is that of slaughtering calves at weaning. By using high milk-producing beef cows (such as Brahman X Hereford) and by providing the cows and calves with an abundance of high quality forage, steer calves weighing more than 360 kg and heifers weighing more than 310 kg, at weaning, can be produced without the use of creep feed (8). Thus, from the standpoint of their weight, such calves are from 3 to 6 months ahead of other calves that are conventionally produced for ultimate finishing on high-energy diets in feedlots. Since there are numerous forage-beef management systems in operation and, as a result, a considerable variation in the condition and weight of calves at weaning, this study was designed to not only examine carcass characteristics of calves at weaning but also to determine the effects of forage availability or stocking rate on these carcass traits. The potential of producing heavy weight weanling calves for direct slaughter would drastically reduce the logistical problems related to the production of long-yearling, forage-finished steers and heifers and would also provide cow-calf producers an additional opportunity to maximize the economic returns on their operations.

Experimental Procedure

Twenty-four fall-born, half-Santa Gertrudis calves and their F-1 Brahman X Hereford dams grazed bermudagrass-ryegrass-arrowleaf clover paddocks at the Texas A&M University Agricultural Research and Extension Center at Overton from February 18 to July 14, to three levels of forage availability (FA). Four calves and their dams were assigned to each of six groups based on calf age, weight, and sex. Each group was then randomly allocated to one of two replicate groupings in each of three grazing pressure treatments. All animals were weighed at the start of the trial and at 28-day intervals during the 146-day grazing period. Paddock sizes ranged from one to two ha. Neither cows nor calves had access to supplemental feed during the trial period. Grazing was continuous rather than rotational, and a put-and-take, variable stocking rate technique was used to maintain the desired levels of FA. The heavily stocked paddocks (low FA level) were grazed to a level at which there was essentially complete utilization of forage above a 5-centimeter (cm) height. The lightly stocked paddocks (high FA) were grazed to a level at which the quantity of available forage would not restrict *ad libitum* intake of the grazing animals. The forage height in these high FA paddocks was approximately 30 to 35 cm at all times. Forage availability on the medium-stocked paddocks was intermediate between that in the lightly stocked and heavily stocked paddocks. Using the cage-difference technique (6), the FA in each replicate paddock was monitored at 28-day intervals.

On July 14, all calves were weighed, transported 120 kilometers (km) to a commercial slaughtering facility, and allowed to rest overnight. The calves were slaughtered at 24 hours post-weaning and, at 48 hours postmortem; the following data were recorded for each carcass: carcass weight, fat thickness over the *longissimus* muscle at the 12th-13th rib interface; estimated percentage of kidney, pelvic and heart (KPH) fat; *longissimus* muscle area; USDA yield grade; amount of marbling and USDA quality grade. Three 2.5-cm thick *longissimus* muscles steaks were removed from the 10th-12th rib region of each carcass and frozen for future sensory trait evaluations. The steaks were oven-broiled in a 177° C oven to an internal temperature of 75° C. Using an 8-point scale, an eight-member, trained taste panel scored samples of steak from each carcass for the following traits: juiciness, tenderness, connective tissue, flavor desirability, and overall desirability. Identical steaks from carcasses of 22 grain-fed steers (50 percent USDA Choice and 50 percent USDA Good) produced in another trial were also evaluated by the taste panel and used for sensory comparison purposes. Warner-Bratzler shear force values were obtained using 1.3-cm steak cores. In addition, one side of a steer carcass and one side of a heifer carcass from each treatment were fabricated to determine the following compositional traits: percentage wholesale primal cuts; percentage boneless, trimmed primal cuts; percentage total fat trim; percentage total bone; percentage total lean and percentage tendons, fascia and connective tissue. Data were analyzed by analysis of variance, and mean separations were made according to the Duncan multiple range test.

Results and Discussion

Stocking rates, in which the put-and-take technique was used to control forage availability, ranged from 2.72 to 6.27 animal-units/ha. Forage availabilities and corresponding cow and calf preweaning performances are presented in Table 1. The most dramatic effect of FA on animal performance occurred with cow average daily gains (ADG); cows on the lightly grazed paddocks had .72 kg higher ($P<.05$) ADG than did cows in heavily grazed paddocks. When weaned, calves in the lightly grazed docks were heavier ($P<.05$) and had higher ($P<.05$) ADG than did calves from the other two grazing pressure treatments. Grazing pressures of approximately 1:1, when expressed as a ratio of the average monthly animal live body weight to the average monthly forage dry matter available, apparently allowed for near maximum cow and calf performance under the continuous grazing scheme used in this study. The buffering capacity of milk production on the effect which variations in FA have on the com-

TABLE 1. ANIMAL PERFORMANCE STRATIFIED BY LEVELS OF GRAZING PRESSURE

Item	Grazing pressure		
	Heavily grazed	Medium-grazed	Lightly grazed
Forage availability, kg/ha	84	476	1848
Grazing pressure[a]	48:1	7:1	1:1
Stocking rate, au/ha	6.27	4.52	2.72
Animal live weight/ha, kg	4069	3241	2048
Age at weaning, days	258[b]	259[b]	261[b]
Weaning weight, kg	236[c]	251[c]	289[b]
Calf ADG, kg/da	.67[c]	.76[c]	.97[b]
Cow ADG, kg/da	−.25[d]	−.02[c]	.47[b]

[a]Average 28-day cow + calf weight/ha ÷ average 28-day weight of forage dry matter/ha.

[bcd]Means in the same row with the same superscript do not differ significantly (P<.05).

parative ADG of cows and calves was illustrated by the 153-percent reduction in cow ADG with increased grazing pressure from "light" to "heavy," but a corresponding reduction in calf ADG of only 31 percent.

In nearly every carcass trait, calves from the medium-grazed paddocks had intermediate scores between those of carcasses from calves in the heavily and lightly grazed paddocks. Carcass characteristics of calves from the three levels of FA are shown in Table 2. The fat thickness of the calves on the lightly grazed paddocks was 4 times (5.08 mm *vs* 1.27 mm) that of calves on the heavily grazed paddocks (P<.05). Calves from the lightly grazed areas had superior carcass ratings (P<.05) than did calves assigned to the heavily grazed areas. The *longissimus* muscle area of the calves from the lightly grazed areas was more than 18 percent greater than the area of this muscle for calves from the heavily grazed areas. Calves from the high FA paddocks had quality grade and marbling scores that were 27 percent and 33 percent higher (P<.05), respectively, than those of calves from the low FA paddocks. Carcasses from calves in the lightly grazed paddocks graded 75 percent Standard and 25 percent Good. Medium-grazed paddocks produced calves whose carcasses graded 14 percent Utility, 57 percent Standard and 29 percent Good; whereas, calves from heavily grazed paddocks had carcasses which graded 57 percent Utility and 43 percent Standard.

TABLE 2. CARCASS CHARACTERISTICS STRATIFIED BY LEVELS OF GRAZING PRESSURE

Item	Grazing pressure		
	Heavily grazed	Medium-grazed	Lightly grazed
Dressing, %	54.1[i]	55.7[i]	58.1[h]
Fat thickness, mm	1.27[j]	2.79[i]	5.08[h]
KPH fat, %	1.88[i]	2.31[hi]	2.41[h]
Longissimus muscle area, cm^2	42.63[i]	46.31[hi]	50.63[h]
USDA yield grade	1.88[i]	2.01[hi]	2.29[h]
USDA quality grade[a]	5.86[i]	7.71[hi]	8.00[h]
Marbling[b]	5.75[i]	8.00[hi]	8.63[h]
Marbline texture[c]	2.00[i]	2.25[hi]	2.63[h]
Fat color[d]	2.63[h]	2.63[h]	2.25[h]
Lean color[e]	3.50[h]	2.38[i]	2.50[i]
Lean firmness[f]	4.25[h]	2.88[i]	3.00[i]
Lean textures[g]	2.88[h]	1.50[i]	2.13[hi]

[a]Average Good = 10, low Good = 9, high Standard = 8, *etc.*

Slight+ = 12, typical slight = 11, *etc.*

[c]Fine = 3, Medium = 2, Coarse = 1.

[d]Dark yellow = 1, white = 5.

[e]Moderately dark red = 4, dark red = 3, very dark red = 2, *etc.*

[f]Moderately firm = 5, slightly soft = 4, soft−3, *etc.*

[g]Slightly coarse = 3, coarse = 2, very coarse = 1.

[hij]Means in the same row with the same superscript do not differ significantly (P<.05).

Sensory panel ratings from an eight-member panel and Warner-Bratzler shear force values for loin steaks from calves in the three forage treatments, and for conventionally grain-fed steers are presented in Table 3. Steaks from the calves in the heavily grazed paddocks rated higher in juiciness (P<.05) than did steaks from calves in each of the other two grazing pressures, and also rated higher than the grain-fed steers. Bowling *et al.* (1) also found that calves slaughtered at weaning had juiciness ratings which were not exceeded by eight other finishing alternatives. Shear-force values and panel ratings for the other sensory traits evaluated usually did not vary significantly for steaks from calves from different levels of FA. Thus, data from this study suggest that although calves from the lightly grazed paddocks had carcasses with superior quality grade characteristics (Table 2), quality grade may not be a good indicator of the eating quality of such beef. Tatum *et al.* (11) found that steaks produced by cattle fed 100, 130, or 160 days were similar in palatability irrespective of quality grade. Steaks from calves in heavily grazed paddocks also had less cooking loss(P<.05) than did steaks from calves in the other grazing levels. It is likely that this was related to the lower degree of fatness of these carcasses. Except for juiciness, the grain-fed steers generally had considerably higher (P<.05) taste panel scores and lower shear force values than did steaks from carcasses of any of the three FA groups of calves.

The similarities between carcass and palatability-related characteristics of steers and heifers are shown in Table 4. Steers had significantly (P<.05) higher ADG, weaning weight, and *longissimus* muscle areas while heifers had greater (P<.05) fat thickness (100 percent), more KPH fat (32 percent), and higher USDA yield grade number (lower cutability). There were no differences (P>.05) in palatability-related traits between steaks from steer and heifer carcasses. These data imply that any price differentials between heifer and steer carcasses should reflect only differences in physical traits. Comparisons of carcass yields of wholesale primal cuts; boneless, trimmed primal cuts; fat trim; bone and lean stratified by FA level and sex are presented in Table 5. None of the differences in these yields was significant (P>.05).

In separate studies, Trenkle *et al.* (12) and Bowl-

TABLE 3. SENSORY PANEL RATINGS AND SHEAR FORCE VALUES FOR LOIN STEAKS FROM WEANLING CALVES AND GRAIN-FED STEERS

	Grazing pressure			
Item	Heavily grazed	Medium-grazed	Lightly grazed	Grain-fed steers[a]
Juiciness[b]	5.56^{g}	4.89^{gh}	4.66^{gh}	4.64^{h}
Tenderness[c]	5.28^{h}	5.34^{h}	4.91^{h}	6.54^{g}
Connective tissue[d]	6.61^{h}	6.88^{h}	6.94^{h}	7.37^{g}
Flavor desirability[e]	5.56^{h}	5.98^{gh}	5.91^{gh}	6.29^{g}
Overall desirability[e]	5.16^{h}	5.33^{h}	5.24^{h}	6.15^{g}
Cooking loss, %	25.98^{h}	29.33^{gh}	29.66^{gh}	30.89^{g}
Shear force, kg[f]	5.25^{g}	5.16^{g}	5.14^{g}	3.89^{h}

[a]Means of 22 grain-finished steers (50% USDA Good, 50% USDA Choice).
[b]Means based on an 8-point scale (8 = extremely juicy; 1 = extremely dry).
[c]Means based on an 8-point scale (8 = extremely tender; 1 = extremely tough).
[d]Means for organoleptically-detectable connective tissue based on an 8-point scale (8 = none; 1 = abundant).
[e]Means based on an 8-point scale (8 = extremely desirable; 1 = extremely undesirable).
[f]Warner-Bratzler shear force values using 1.3 cm cores.
[gh]Means in the same row with the same superscript do not differ significantly (P<.05).

ing *et al.* (1) showed that a 105 to 125 day post-weaning, high-concentrate, dry-lot feeding period was necessary to produce a 365 to 375 kg steer. With a feed:grain ratio of 8:1, that amount of gain would require about 1,000 to 1,050 kg of feed at a present-day cost of about $150 to $200 per steer. Thus, the biological potential to produce 360 kilogram slaughter steers when weaned at 9 to 10 months of age (8) may provide sufficient economic incentive to allow such forage-finished calves to be produced for slaughter directly off pasture. Certainly, the logistics of producing this kind of beef is more favorable than is the production of forage-fed, long-yearlings since such animals have a relatively narrow time span in which they should be slaughtered if certain gain per animal:gain per hectare relationships are maximized. The overall palatability of such beef from heavy-weight weanling calves likely would not be equivalent to that produced by the dry-lot feeding of steers to heavier weights. However,by using one or more of the now available post-slaughter techniques such as electrical stimulation, delayed chilling, pelvic suspension of the sides and blade tenderization (10), the tenderness of forage-fed beef could be significantly enhanced. And, since tenderness is the most important aspect of beef palatability,it is possible that such treated beef would be nearly interchangeable with dry-lot produced beef.

TABLE 4. CARCASS CHARACTERISTICS AND SENSORY TRAITS STRATIFIED BY SEX

	Heifers	Steers
Age, days	260	259
ADG, kg	75^{i}	$.85^{h}$
Weaning weight, kg	242^{i}	275^{h}
Dressing, %	55.6^{h}	56.3^{h}
Fat thickness, mm	4.06^{h}	2.03^{i}
KPH fat, %	2.50^{h}	1.90^{i}
Longissimus muscle area, cm^2	44.31^{i}	48.76^{h}
USDA yield grade	2.23^{h}	1.88^{i}
USDA quality grade[a]	7.60^{h}	6.92^{h}
Marbling[b]	8.08^{h}	6.83^{h}
Shear force, kg[c]	5.7^{h}	4.7^{h}
Juiciness[d]	4.88^{h}	5.19^{h}
Tenderness[e]	4.87^{h}	5.48^{h}
Connective tissue[f]	6.67^{h}	6.95^{h}
Flavor desirability[g]	5.83^{h}	5.81^{h}
Overall palatability[g]	5.07^{h}	5.42^{h}
Cooking loss, %	28.92^{h}	27.73^{h}

[a]Average Good = 10, low Good = 9, high Standard = 8 *etc.*
[b]Slight+ = 12, typical slight = 11, *etc.*
[c]Warner-Bratzler shear force values using 1.3 cm cores.
[d]Means based on an 8-point scale (8 = extremely juicy; 1 = extremely dry).
[e]Means based on an 8-point scale (8 = extremely tender; 1 = extremely tough).
[f]Means for organoleptically-detectable connective tissue based on an 8-point scale (8 = none; 1 = abundant).
[g]Means based on an 8-point scale (8 = extremely desirable; 1 = extremely undesirable).
[hi]Means in the same row with the same superscript do not differ significantly (P<.05).

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TABLE 5. YIELDS OF PRIMAL CUTS AND COMPOSITION OF CARCASSES STRATIFIED BY GRAZING PRESSURE AND SEX

Item	Grazing pressure			Sex	
	Heavily grazed	Medium-grazed	Lightly grazed	Heifers	Steers
	(%)				
Wholesale primal cuts					
Rib	7.30	7.45	7.05	7.10	7.43
Loin	15.70	15.55	14.55	16.03	14.50
Chuck	27.50	26.25	28.00	26.50	28.00
Rump	4.55	4.45	4.80	4.53	4.67
Round	18.90	18.60	17.25	17.93	18.57
Total	73.95	72.30	71.65	72.10	73.17
Boneless, trimmed primal cuts					
Rib	5.00	5.25	4.90	5.00	5.10
Loin	10.20	10.85	9.95	10.47	10.20
Chuck	20.95	20.85	23.15	21.10	22.20
Rump	3.20	3.10	3.30	3.13	3.27
Round	16.10	15.45	14.40	15.20	15.43
Total	55.65	55.50	55.70	55.03	56.20
Total fat trim	4.65	7.90	7.95	8.13	5.53
Total bone	22.85	17.80	17.70	19.03	19.87
Total lean	69.40	72.40	71.85	70.13	72.30
Tendons, facia and connective tissue	1.45	1.45	1.45	1.37	1.53

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Feeder Cattle Frame Size, Muscling and Subsequent Carcass Characteristics

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Summary

Sixty feeder steers were assigned scores for "frame size" (small, medium or large) and "muscling" (Nos. 1, 2 or 3) and were slaughtered after 112 days of feeding. Grade data were collected for all 60 carcasses; 12 sides (four from each muscling group) were fabricated into boneless, closely-trimmed retail cuts; and 12 rounds (four from each muscling group) were physically separated in muscle, fat, and bone. Marbling score and USDA quality grade varied with frame size ($P<.05$). Carcass quality grades were: 33.3 percent Choice, 67.7 percent Good, 0.0 percent Standard for small-framed cattle; 30.3 percent Choice, 42.4 percent Good, 27.3 percent Standard for medium-framed cattle; and 5.5 percent Choice, 66.7 percent Good, 27.8 percent Standard for large-framed cattle. Although carcasses from steers assigned No. 3 muscling scores had smaller ($P<.05$) *longissimus* muscle areas than did carcasses from steers assigned No. 1 muscling scores, mean yield grades for the groups were not different ($P>.05$); the larger mean *longis-*

simus muscle area of carcasses from steers in the No. 1 muscling group was offset by heavier carcass weight and greater thickness of fat over the *longissimus* muscle. Carcasses from cattle assigned muscling scores of No. 1 had the highest ($P<.05$) muscle:bone ratios of the round (4.1 to 1) while carcasses from cattle assigned muscling scores of No. 3 had the lowest ($P<.05$) muscle:bone ratios of the round (3.4 to 1).

Introduction

A number of practical systems (usually based on geographic origin, breed, sex and/or type) for describing feeder cattle have been developed. However, since these "industry standards" have never been formalized by description or illustration, they are subject to wide variations in interpretation (3). Consequently, they have not been a satisfactory vehicle for accurately and uniformly collecting and reporting prices and market information about feeder cattle sales. The former USDA grade standards for feeder cattle (6) were used for market news reporting but were seldom used by cattlemen.

In 1979, USDA revised their feeder cattle grade standards to consist of separate evaluations of "frame size" and "thickness" (9). In this system of grades, evaluations of "frame size" identify feeder cattle for the weights at which they will attain a specific carcass quality grade under normal feeding and management practices, while evaluations of "thickness" are intended to identify feeder cattle for differences in carcass ratio of muscle to bone and carcass cutability.

The present investigation was conducted to determine the effectiveness of using evaluations of "frame size" and "muscling" to stratify feeder cattle of unknown history into homogeneous groups with respect to their carcass characteristics after a constant period of feeding. "Muscling" scores in the present study were those of the original study draft (5) for revision of feeder cattle grade standards and not the "thickness" scores of the USDA feeder cattle grade standards (9).

Experimental Procedure

Sixty crossbred feeder steers of unknown history, representing three general breed-types (British x British, British x exotic, British x Brahman),were evaluated by a three-member committee experienced in live animal evaluation comprised of one representative each from the Agricultural Marketing Service, US Department of Agriculture (USDA); Federal Research, US Department of Agriculture; and the Texas Agricultural Experiment Station (TAES). Evaluators independently estimated subcutaneous fat thickness over the 12th rib, age (in months), frame size (in thirds — 1 = large-plus; 2 = large-typical; *et cetera*) and muscling (in thirds — 1 = No. 1-plus; 2 = No. 1-typical; *et cetera*). Steers were fed for 112 days on rations of whole plant grain sorghum plus sorghum grain; four rations were used and steers were stratified (by frame size and muscling scores) to preclude confounding of USDA feeder grade factors with ration.

At the end of the feeding trial, steers were slaughtered at the TAES meat laboratory and carcasses were chilled at 33 ± 1° F. On the second day following slaughter, the left side of each carcass was ribbed, carcass conformation (7) was evaluated, and quality and yield grade factors (8) were collected. In addition, the left sides of 12 carcasses (each of the carcasses from the four steers in the No. 3 muscling group and four randomly selected carcasses from the steers in the Nos. 1 and 2 muscling groups) were fabricated (2) to determine carcass percentage yields of closely trimmed, boneless retail cuts. Rounds from the right sides of these same carcasses were also physically separated into muscle, fat and bone components to determine muscle:bone ratios of that wholesale cut.

A 0.50-inch thick cross-section of the *longissimus* muscle was removed from each wholesale loin at the 12th-13th rib interface. Moisture content (by drying for 24 hours at 216° F) and intramuscular fat content (by extracting for 8 hours with diethyl ether) were determined for each sample. Percentages of intramuscular fat were calculated on a whole tissue basis (WTB) and on a moisture-free basis (MFB).

Means, standard deviations, and coefficients of variation were computed for all variables. Differences in mean values were tested (4) for significance using analysis of variance and analysis of covariance. Analysis of variance techniques included paritioning sums of squares due to ration, frame size, muscling and all first-order interactions. Differences in mean values due to the main effects (frame size and muscling) were tested for significance; when F-tests were significant ($P<.05$), mean separation (1) was performed.

Results and Discussion

Feeder cattle frame size is supposedly (5) positively correlated with growth rate and mature size and, consequently, with the weight at which, under normal feeding and management practices, a feeder animal will produce a carcass of a specific USDA quality grade. Feeder steers of Large, Medium, or Small frames generally exhibit (5,9) excellent, average or relatively slow growth rate, respectively, and would be expected (5,9) to produce Choice carcasses at live weights in excess of 1,200 pounds (lb) (Large frame), between 1,200 and 1,000 lb (Medium frame), or less than 1,000 lb (Small frame).

Mean values for certain feeder cattle characteristics and certain qualitative-related carcass characteristics stratified according to feeder cattle frame size are presented in Table 1. Marbling score and USDA quality grade varied inversely ($P<.05$) with frame size, but differences in intramuscular fat percentages were not always consistent enough for statistical significance ($P>.05$) between carcasses from Medium- and Large-framed cattle. In comparison with Medium-framed and Large-framed steers, Small-framed steers were evaluated as fatter ($P<.05$) at the beginning of the feeding period and subsequently produced slightly higher grading (USDA quality grade) carcasses that

TABLE 1. MEAN VALUES FOR CERTAIN FEEDER CATTLE AND CARCASS CHARACTERISTICS STRATIFIED ACCORDING TO FEEDER CATTLE FRAME SIZE SCORE

Item	Feeder cattle frame size score		
	Small	Medium	Large
Number of steers	9	33	18
Feeder cattle characteristic:			
Initial weight, lb	528.8[c]	541.1[c]	577.4[c]
Initial subcutaneous fat thickness, in.	0.18[c]	0.14[c]	0.10[e]
Initial age[a]	4.44[c]	4.73[c]	4.67[c]
Slaughter weight, lb	797.8[c]	819.7[c]	861.1[c]
Average daily gain, lb	2.40[c]	2.49[c]	2.53[c]
Carcass characteristic:			
Maturity[b]	A^{50}[c]	A^{44}[c]	A^{42}[c]
Marbling score	$Slight^{95}$[c]	$Slight^{64}$[cd]	$Slight^{23}$[d]
Intramuscular fat (WTB), %	4.11[c]	3.05[d]	2.79[d]
Intramuscular fat (MFB), %	15.11[c]	11.53[d]	10.88[d]
Quality grade[b]	High Good[c]	Average Good[cd]	Low Good[d]

[a]Age score: 3 = 8 months of age (estimated); 4 = 10 to 11 months of age; *et cetera*.

[b]Based on descriptions in beef carcass grading standards (8).

[cde]Mean values in the same row bearing a common superscript letter are not different (P>.05).

were slightly more mature and had significantly higher levels of intramuscular fat (P<.05). Average daily gain varied directly with frame size but differences were not statistically significant.

A comparison of percentages of Choice, Good, and Standard carcasses from steers of each frame size (Table 2) indicates that the proportion of U.S. Choice carcasses decreased and the proportion of U.S. Standard carcasses increased as frame size increased. Small-framed cattle produced the highest percentage of U.S. Choice carcasses and the lowest percentage of U.S. Standard carcasses, while Large-framed cattle produced the lowest percentage of U.S. Choice carcasses and the highest percentage of U.S. Standard carcasses. These data suggest that if feeder cattle are fed to produce carcasses of the same quality grade (e.g., U.S. Choice), Large-framed feeder cattle must be fed for a longer period of time — and to heavier weights — than smaller-framed feeder cattle. Correspondingly, the data also suggest that feeder cattle frame size evaluations would be useful for segregating feeder cattle into groups with respect to the time-on-feed and live weight at which they would produce carcasses of the same quality grade.

Thickly muscled slaughter cattle supposedly (5,9) produce carcasses with higher muscle:bone ratios and percentages of muscle than do thinly muscled slaughter cattle. The present study provided information for evaluating the effects of muscling differences among feeder cattle on subsequent quantitative-related carcass traits. These data are presented in Tables 3 and 4. Cattle assigned muscling scores of No. 1 were heavier (P<.05) and fatter (P<.05), gained more rapidly (P<.05), and produced fatter (P<.05) and heavier (P<.05) carcasses than did cattle assigned muscling scores of No. 3. Carcasses produced by cattle with No. 1 muscling had the highest (P<.05) carcass conformation scores, the largest (P<.05) *longissimus* muscle areas, and the highest muscle:bone ratios, while carcasses from cattle with No. 3 muscling had the lowest (P<.05) carcass conformation scores, the smallest (P<.05) *longissimus* muscle areas, and the lowest (P<.05) muscle:bone ratios.

Although carcasses from steers assigned No. 3 muscling scores had significantly (P<.05) smaller *longissimus* muscle areas than did carcasses from steers assigned No. 1 muscling scores, mean yield grades for the two groups were not different (P>.05); the larger mean *longissimus* area of the carcasses from the steers in the No. 1 muscling group was offset by heavier carcass weight and greater thickness of fat over the *longissimus* muscle. When (a) initial weight and initial fat thickness and (b) carcass weight and carcass fat thickness were held constant (Table 5), yield grades were ranked in the expected order relative to feeder cattle muscling scores but these differences were not statistically significant (P>.05). Although there were significant differences in the mean actual *longissimus* muscle areas between carcasses in the three muscling groups (Table 3), and also when initial weight and initial fatness were held constant (Table 5), these differences were not significant when carcass weight and carcass fat thickness were held constant (Table 5). Even though data are presented here for weight-standardized cattle and/or carcasses,

TABLE 2. PERCENTAGES OF U.S. CHOICE, U.S. GOOD AND U.S. STANDARD CARCASSES STRATIFIED ACCORDING TO FEEDER CATTLE FRAME SIZE SCORE

Feeder cattle frame size score	USDA carcass quality grade[a]		
	U.S. Choice (%)	U.S. Good (%)	U.S. Standard (%)
Small	33.3	66.7	0.0
Medium	30.3	42.4	27.3
Large	5.5	66.7	27.8

[a]Based on descriptions in USDA (1975) beef grading standards.

TABLE 3. MEAN VALUES FOR CERTAIN FEEDER CATTLE AND CARCASS CHARACTERISTICS STRATIFIED ACCORDING TO FEEDER CATTLE MUSCLING SCORE

Item	Feeder cattle muscling score		
	No. 1	No. 2	No. 3
Number of steers	15	41	4
Feeder cattle characteristic:			
Initial weight, lb	574.9[d]	549.2[d]	467.3[e]
Initial subcutaneous fat thickness, in.	0.16[d]	0.14[d]	0.08[e]
Initial age[a]	4.73[d]	4.71[e]	4.00[e]
Slaughter weight, lb	877.6[d]	822.7[e]	708.5[f]
Average daily gain, lb	2.71[d]	2.44[e]	2.16[e]
Carcass characteristic:			
Carcass conformation[b]	Choice[93d]	Choice[40e]	Good[58f]
Fat thickness, in.	0.31[d]	0.28[de]	0.14[e]
Longissimus muscle area, sq. in.	11.41[d]	10.49[d]	8.85[f]
Kidney, pelvic and heart fat, %	2.40[d]	2.27[d]	2.25[d]
Carcass weight, lb	534.2[d]	492.7[e]	408.1[f]
Yield grade[c]	2.10[de]	2.20[d]	2.00[e]

[a]Age score: 3 = 8 months of age (estimated); 4 = 10 to 11 months of age; *et cetera*.
[b]Based on descriptions in beef carcass grading standards (7).
[c]Based on descriptions in beef carcass grading standards (8).
[def]Mean values in the same row bearing a common superscript letter are not different (P>.05).

TABLE 4. MEAN VALUES FOR MUSCLE:BONE RATIOS OF WHOLESALE ROUNDS AND PERCENTAGE CARCASS YIELDS OF BONELESS, CLOSELY TRIMMED MAJOR RETAIL CUTS STRATIFIED ACCORDING TO FEEDER CATTLE MUSCLING SCORE

Feeder cattle muscling score	Number	Muscle:bone ratio of wholesale round	Boneless, closely trimmed major retail cut yield (%)
No. 1	4	4.1[a]	57.9[a]
No. 2	4	3.9[a]	57.5[a]
No. 3	4	3.4[b]	55.9[b]

[ab]Mean values in the same column bearing a common superscript letter are not different (P>.05).

TABLE 5. LEAST SQUARE MEANS FOR CERTAIN CARCASS CHARACTERISTICS STRATIFIED ACCORDING TO FEEDER CATTLE MUSCLING SCORE

Item	Feeder cattle muscling score		
	No. 1	No. 2	No. 3
Number of steers	15	41	4
Carcass characteristic[a]:			
Carcass conformation, grade	Choice[85c]	Choice[41d]	Choice[70e]
Subcutaneous fat thickness, in.	0.28[c]	0.24[c]	0.22[c]
Longissimus muscle area, sq. in.	11.19[c]	10.50[d]	9.57[e]
Kidney, pelvic and heart fat, %	2.38[c]	2.28[c]	2.33[c]
Carcass weight, lb	518.9[c]	493.3[d]	459.6[e]
Yield grade	2.00[c]	2.10[c]	2.20[c]
Carcass characteristic[b]:			
Carcass conformation, grade	Choice[79c]	Choice[41d]	Good[80e]
Subcutaneous fat thickness, in.	0.28[c]	0.28[c]	0.28[c]
Longissimus muscle area, sq. in.	10.86[c]	10.57[c]	10.08[c]
Kidney, pelvic and heart fat, %	2.34[c]	2.28[c]	2.44[c]
Carcass weight, lb	479.4[c]	479.4[c]	479.4[c]
Yield grade	2.00[c]	2.10[c]	2.30[d]

[a]Initial weight and subcutaneous fat thickness were held constant using analysis of covariance techniques.
[b]Carcass weight and fat thickness were held constant using analysis of covariance techniques.
[c]Based on descriptions in beef carcass grading standards (8).
[def]Mean values in the same row bearing a common superscript letter are not different (P>.05).

cattle with No. 1 muscling should be heavier and their carcasses should be heavier than those of No. 2 or No. 3 muscling, if the cattle and their carcasses are of the same skeletal size and fatness.

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PR-3818

Frame Size and Muscling Effects on Cattle Performance and Carcass Characteristics

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Summary

An evaluation was made of performance and carcass data from 157 steers which were classified into "frame size" and "muscling" categories similar to those in the new USDA feeder cattle grading standards. The population consisted of British, British X European crossbreds, dairy, Brahman and Longhorn steers of which 30 percent were Large-framed, 61 percent were Medium-framed and 9 percent were Small-framed. Average daily gains for Large, Medium, and Small steers were 3.17, 2.66, and 2.60 pounds, respectively; fat thicknesses opposite the 12-13th rib were 0.33, 0.45, and 0.54 inches, respectively. USDA quality grades for carcasses increased as "frame size" decreased, which supports principles regarding liveweight x frame size x carcass quality grade relationships in the new USDA feeder grade standards. The population consisted of 19 percent steers with No. 1 muscling, 64 percent with No. 2 muscling and 17 percent with No. 3 muscling. Carcasses from steers which had, as feeders, No. 1 muscling scores had higher quality grades; had higher ($P<.05$) conformation scores, edible portion to bone ratios, muscle to bone (foreshank estimate) ratios; and had larger ($P<.05$) ribeye areas than did carcasses from steers which had, as feeders, No. 3 muscling scores. Differences in USDA yield grade, between carcasses from steers with No. 1 versus No. 3 muscling, were not significant, probably because cattle were slaughtered after similar periods of time on feed rather than at similar liveweights.

Introduction

The most recent (1979) revision of USDA grades for feeder cattle involves grading such animals on the basis of separate evaluations of "frame size" and "thickness." Numerous segments of the cattle industry are presently debating the merit of such a system, attempting to identify both negative and positive aspects of this new system. "Frame size" and "thickness" were selected as criteria for new feeder cattle grading standards because they were considered easy to estimate and relatively unaffected by management (the two factors should change little during growth and development of cattle).

The new standards provide for three "frame sizes" (Large, Medium, Small) and for three "thicknesses" (No. 1, No. 2, No. 3, which correspond to "thick," "thin," and "very thin," respectively). The grade for a given feeder cattle would consist of both a "frame size" designation and a score for "thickness"; e.g., Large-No. 3, Small-No. 2, Large-No. 2, *et cetera.* One additional grade, U.S. Inferior, is provided to identify unthrifty, unmerchantable, or abnormal (i.e., "double-muscled") cattle.

The present evaluation was made to test the principles incorporated in the new USDA feeder cattle grading standards to determine the effectiveness of a system that would classify feeder cattle into groups differing in "frame size" and in "muscling." "Muscling" scores in the present study were those of the origional study draft for revision of feeder cattle grade standards and not the "thickness" scores of the 1979 USDA feeder cattle grade standards.

Experimental Procedure

An evaluation was made of some performance and carcass data from 157 steers which had been classified as feeders, according to "frame size" and "muscling." This group of steers was extremely heterogeneous, yet typical of the loads of feeder cattle presently coming to market and eventually entering the feedlots of this country. The population included 60 (38 percent) straightbred or crossbred steers of British breed origin, 55 (35 percent) British x Exotic (large European breeds) crossbred steers, 21 (13 percent) straightbred dairy or dairy x British crossbreds, 10 (6 percent) straightbred Brahman steers and 11 (7 percent) straightbred Longhorn steers. Data from this population, analyzed differently, have previously been published (1,2,3,4).

The steers were fed in two separate studies of comparable management — preconditioning, energy of ration, and time on feed. The endpoint for determining time to slaughter in both groups of steers was subjectively determined for grade (low Choice) or in keeping with economical feeding practice and/or desired carcass weight for types or kinds not likely to reach low Choice at reasonable weights.

Each steer was assigned scores for "frame size" and "muscling" during the early phase of the feeding period. Nine-point scales were used for assigning "frame size" or "muscling" to each steer; however, these scores were converted to classify the steers into the three "frame sizes" (Large, Medium, Small) and into the three "muscling" groups (No. 1, No. 2, No.3) described in the USDA study draft for grading of feeder cattle.

Results and Discussion

Mean values for certain performance and carcass characteristics of steers stratified according to "frame size" are presented in Table 1. Of the 157 steers in this population, 30 percent were of Large "frame size," 61 percent were of Medium "frame size" and 9 percent were of Small "frame size." The average daily gain of steers with Large frames was 3.17 pounds per day during the feeding period; at a final live (shrunk) weight of 1,126 pounds these steers had 0.33 inch of fat thickness opposite the ribeye at the 12-13th rib and graded high Good. The Large-frames steers had not attained the live weight (1,200 pounds) at which the USDA feeder grade standards say Large-framed steers would be expected to grade U.S. Choice nor had they deposited the amount of fat (0.50 inch) opposite the ribeye specified by the USDA standards as being normally associated with deposition of a "small" amount of marbling. Since the Large-framed steers were within one-third of a USDA quality grade of attaining U.S. Choice, the data appear to support the contention in the USDA feeder cattle grading standards regarding Large-framed steers. The fact that Medium-framed and Small-framed steers graded U.S. Choice at close to live weights specified (1,000 to 1,200 pounds and less than 1,000 pounds for Medium and Small frame steers, respectively) in the USDA feeder grade standards further supports the proposed use of "frame size" to segregate feeder cattle into meaningful classes.

Steers with Large frames gained ($P<.05$) more rapidly; had lower ($P<.05$) conformation scores, marbling scores, USDA quality grades, fat thicknesses, USDA yield grades, percentages of fat trim; had larger ($P<.05$) ribeye areas; and had higher ($P<.05$) percentages of bone and edible portion than steers with Small frames. Differences ($P<.05$) between Large and Medium frame steers (average daily gain, fat thickness, ribeye area, USDA yield grade, fat trim percentage, bone percentage, edible portion percentage) and differences ($P<.05$) between Medium and Small frame steers (conformation score, USDA quality grade, fat trim percentage, bone percentage, edible portion percentage) were less evident than were differences between Large frame and Small frame steers but, in every case, were consistent with principles specified in the USDA feeder grade standards.

Mean values for certain performance and carcass characteristics of steers stratified according to "muscling" are presented in Table 2. Of the 157 steers in this population, 19 percent were in the No. 1 "muscling" group, 64 percent were in the No. 2 "muslcing" group and 17 percent were in the No. 3 "muscling" group. Steers with No. 1 muscling gained ($P<.05$) more rapidly; had higher ($<.05$) dressing percentages, conformation scores, marbling scores, USDA quality grades, fat thickness, muscle:bone (foreshank estimate); had larger ($P<.05$) ribeye areas; and had smaller ($P<.05$) KPH fat percentages than steers with No. 3 muscling. Differences ($P<.05$) between steers with No. 1 and No. 2 muscling (average daily gain, conformation score, ribeye area, USDA yield grade, fat trim percentage, edible portion percentage, edible portion:fat) and differences ($P<.05$)

TABLE 1. MEAN VALUES FOR CERTAIN PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS STRATIFIED ACCORDING TO FRAME SIZE

Trait	Frame size		
	Large	Medium	Small
Number of steers	47	95	15
Average daily gain, lb	3.17[a]	2.66[b]	2.60[b]
Live slaughter weight, lb	1126	981	944
Dressing percentage	61.1[a]	61.1[a]	61.6[a]
Conformation score	Choice°[b]	Choice°[b]	Choice+[a]
Marbling score	Sl+[b]	Sm−[ab]	Mt−[a]
USDA quality grade	Good+[b]	Choice−[b]	Choice°[a]
Fat thickness, in.	.33[b]	.45[a]	.54[a]
Ribeye area, sq. in.	12.71[a]	11.61[b]	11.26[b]
USDA yield grade	2.65[b]	2.93[a]	3.16[a]
Fat trim, %	13.8[a]	15.7[b]	18.0[c]
Bone, %	14.7[c]	13.8[b]	12.9[a]
Edible portion, %	71.5[a]	70.3[b]	68.9[c]

[abc]Means in the same row bearing a common superscript letter do not differ ($P>.05$).

TABLE 2. MEAN VALUES FOR CERTAIN PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS STRATIFIED ACCORDING TO MUSCLING

Trait	Muscling		
	No. 1	No. 2	No. 3
Number of steers	30	101	26
Average daily gain, lb	3.54[a]	2.79[b]	2.24[c]
Live slaughter weight, lb	1133	1005	933
Dressing percentage	61.7[a]	61.2[a]	60.1[b]
Conformation score	Prime –[a]	Choice +[b]	Good +[c]
Marbling score	Sm –[a]	Sm –[a]	Sl +[b]
USDA quality grade	Choice –[a]	Choice –[a]	Good +[b]
Fat thickness, in.	.39[a]	.47[a]	.26[b]
Ribeye area, sq. in.	13.38[a]	11.66[b]	11.18[b]
KPH fat, %	3.25[a]	3.30[a]	4.90[b]
USDA yield grade	2.59[b]	2.90[a]	2.70[ab]
Fat trim, %	13.9[b]	16.0[a]	14.3[b]
Bone, %	14.1[ab]	13.8[a]	14.6[b]
Edible portion, %	71.9[a]	70.1[b]	70.9[ab]
Edible portion:bone	5.12[ab]	5.16[a]	4.89[b]
Edible portion:fat	5.34[a]	4.60[b]	5.10[ab]
Rib, edible portion:bone[d]	4.94[a]	4.83[a]	4.37[a]
Foreshank estimate, muscle:bone[d]	3.80[a]	3.79[a]	3.62[b]

[abc]Means in the same row bearing a common superscript letter do not differ ($P > .05$).

[d]Number of observations are 17, 41 and 21 for No. 1, No. 2 and No. 3, respectively.

between steers with No. 2 and No. 3 muscling (average daily gain, dressing percentage, conformation score, marbling score, USDA quality grade, fat thickness, KPH fat percentages, fat trim percentages, bone percentages, edible portion:bone, muscle:bone — foreshank estimate) were generally, but not always, in support of principles described in the USDA feeder grade standards.

The fact that carcasses from steers with No. 3 muscling scores had lower ($P < .05$) ratios of edible portion (muscle plus acceptable subcutaneous and intermuscular fat) to bone and lower ($P < .05$) ratios of muscle to bone (foreshank estimate) than carcasses from steers with No. 1 muscling scores supports hypotheses in the new USDA feeder cattle grading standards. The findings (Table 2) regarding USDA yield grade differences between carcasses from steers which had No. 1 versus No. 3 "muscling" scores, as feeders, agree with those previously reported (5,6); when feeder steers differing in muscling were fed for a constant period of time, those with No. 3 muscling were not fatter than those with No. 1 muscling. Most of the steers in the No. 3 muscling group were of Holstein, Brahman, and Longhorn breeding — such steers generally have higher percentages of KPH fat, gain less rapidly and deposit less subcutaneous fat than is the case for exotic or British breed cattle. Cattle of the No. 3 muscling group weighed 200 pounds less at slaughter than did cattle of the No. 1 muscling group; had cattle in the two muscling groups been slaughtered at the same live weight, it seems likely that those in the No. 3 muscling group would have been as fat or fatter (opposite the ribeye), less muscular (ribeye area) and lower yielding (higher numerical USDA yield grade) than those in the No. 1 muscling group. Unfortunately, the present study was not designed to test the latter hypothesis.

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Muscle:Bone Ratios in Beef Rib Sections

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Summary

Steers (n=38) and heifers (n=30), 12 to 16 months of age, from F_1 Hereford X Brahman cows bred to Angus or Hereford bulls and either forage-fed (123 days on millet-Bermudagrass pasture) or grain-fed (90 days in confinement on a high-concentrate diet) were commercially slaughtered. Texas Agricultural Experiment Station (TAES) personnel (a) assigned scores or took measurements on each carcass for all factors used in yield grading and quality grading, (b) measured the length of hind leg (HL) and carcass length (CL), and (c) assigned a score for carcass muscling (MS) and an adjusted *longissimus* muscle area (ALA). The 9-10-11 rib section from one side of each carcass was physically separated into muscle, fat, and bone. Muscle:bone ratios ranged from 2.38 to 4.37. With both age and carcass weight held constant, diet, breed, and sex explained only 35.8 percent of the variability in muscle:bone ratio. The best simple correlation with muscle:bone ratio was ALA divided by CL (r=.59). Other measures significantly correlated with muscle:bone ratio included ALA (r=.55) and carcass weight (r=.49). Multiple regression analyses identified a three-variable subset comprised of ALA, carcass weight, and CL which was ($P<.01$) related to muscle:bone ratio (R^2 = .41). Data suggest that muscle:bone ratios differ quite widely among beef carcasses of similar genetic-management history and that there are carcass measures useful for predicting muscle:bone ratios.

Introduction

The quantitative aspect of carcass merit can be evaluated by determining the amounts of muscle, fat, and bone (3). Another such measure is the USDA yield grade equation which estimates the yield of boneless, closely trimmed, major retail cuts as a percentage of the carcass weight. However, the accuracy of that equation is improved when muscle:bone ratio is substituted for ribeye area (1).

The monetary value associated with differences in muscle:bone ratios is easily seen when fat and bone are held constant. In comparing carcasses with the same weight of bone — 100 pounds for example — and the same weight of fat but with 3.0:1 *vs* 4.0:1 muscle:bone ratios, the carcass with a 4.0:1 muscle:bone ratio would be worth substantially more because it would contain 100 pounds of additional muscle. The difference in value (per cwt) betweeen two such slaughter steers will depend upon the value of the muscle and the cost of its production. However, for a producer of feeder steers, for example, assuming no difference in the cost of production, a difference of 50 pounds in weight of muscle and the value of muscle at $2 per pound, a feeder steer with a 4.0:1 muscle:bone ratio would be worth $100 more than one with a 3.0:1 muscle:bone ratio.

Previous research has shown that muscle:bone ratios differ due to genetic variation (2,4,6,8,10,12), feeding regimen (3,9), and plane of nutrition (7).

The purpose of the present study was to characterize the variability in muscle:bone ratio among steer and heifer carcasses of Zebu X British breed cattle which had beef fed grain or forage; to examine the effects of feeding regimen, breed, and sex on muscle:bone ratios; and to identify accurate and easily obtainable carcass traits which would be useful for predicting muscle:bone ratio.

Material and Methods

Steers (n=38) and heifers (n=30), 12 to 16 months of age, from F_1 Hereford X Brahman cows bred to Angus or Hereford bulls, were divided into two groups which were then either forage-fed (123 days on millet-Bermudagrass pasture) or grain-fed (90 days in confinement on a high concentrate diet) at the Texas A&M University Agricultural Research and Extension Center at Overton.

The cattle were commercially slaughtered. At 24 hours postmortem, TAES personnel obtained measurements or assigned scores for all factors used in the USDA yield and quality grades for beef (14). Additional measurements of carcass length (CL) and length of hind leg (HL) were taken, and each carcass also was assigned a muscling score (MS) in terms of conformation grade based on muscling (15) and an adjusted *longissimus* muscle area (ALA) in which the actual *longissimus* muscle area was adjusted (up or down) to reflect the comparative development of the muscling of the entire carcass in relation to the actual *longissimus* muscle area. Since the 9-10-11 rib portion of the wholesale rib cut has been found to be a good indicator of carcass composition, that portion was removed from one side of each carcass (11), and it was then physically separated into subcutaneous fat, intermuscular fat, *longissimus* muscle, "remaining soft tissue," and bone (including *ligamentum nuchae*). The "remaining soft tissue" and a sample of the *longissimus* muscle were each thoroughly ground, sampled, frozen in liquid nitrogen, comminuted in a blender, and subsampled for fat analysis by extraction with diethyl ether. The percentage of muscle was calculated on an intramuscular fat-free basis and divided by the percentage of bone to formulate muscle:bone ratios.

The data were analyzed using analysis of variance, analysis of covariance, least squares analysis, mean separation analysis, and a stepwise multiple regression analysis which maximized R-square.

Results and Discussion

Mean, minimum, and maximum values for certain carcass traits are presented in Table 1. The carcasses ranged in USDA quality grade from Standard to Choice and in USDA yield grade from 0.6 to 3.6. Muscle:bone ratios of the 9-10-11 rib sections ranged from 2.38 to 4.37 with a mean of 3.32.

Frequency distributions for rib section muscle:bone ratios by sex classes, feeding regimens, breeds of sire, warm carcass weight groups, and chronological age groups are in Table 2. Muscle:bone ratios for steers and heifers each ranged from approximately 2.4 to 4.4. Muscle:bone ratios for grain-fed beef ranged from 2.8 to 4.4, while these ratios for

TABLE 1. MEAN, MINIMUM AND MAXIMUM VALUES FOR CERTAIN CARCASS TRAITS AND MUSCLE:BONE RATIO (n=68)

Trait	Mean	Minimum	Maximum
USDA maturity score[a]	A^{43}	A^{20}	A^{90}
USDA marbling score[b]	Tr^{98}	PD^{00}	Sm^{50}
USDA quality grade[c]	Gd^{15}	St^{00}	Ch^{17}
Warm carcass weight, lb	534.58	369.23	713.50
Fat thickness, in.	0.30	0.05	0.70
Actual *longissimus* muscle area, sq. in.	10.92	8.30	14.50
Adjusted *longissimus* muscle area, sq. in.	11.01	8.80	15.10
Estimated kidney, pelvic and heart fat, %	2.17	1.00	4.50
USDA yield grade	2.20	0.60	3.60
Muscling score[c]	Ch^{09}	Gd^{30}	Pr^{20}
Muscle:bone ratio (9-10-11 rib)	3.32	2.38	4.37
Length of hind leg, in.	28.82	26.42	31.30
Carcass length, in.	47.29	43.10	51.30

[a]The range of A^{00} to A^{100} in maturity score represents a range in chronological age from about 9 months to about 30 months.
[b]Marbling: Sm = small, Sl = slight, Tr = traces, PD = practically devoid.
[c]Quality grade and muscling score: Pr = Prime, Ch = Choice, Gd = Good, St = Standard (13).

TABLE 2. FREQUENCY DISTRIBUTIONS FOR MUSCLE:BONE RATIO STRATIFIED ACCORDING TO DIET, BREED OF SIRE, SEX, WARM CARCASS WEIGHT, AND CHRONOLOGICAL AGE

	Muscle:bone ratio (9-10-11 rib)				
Variable	2.38 to 2.77	2.78 to 3.17	3.18 to 3.57	3.58 to 3.97	3.98 to 4.37
Diet					
Grain-fed	0	8	12	10	4
Forage-fed	7	13	8	3	1
Breed of sire					
Angus	2	8	11	9	3
Hereford	4	5	4	0	1
Sex					
Steers	2	11	13	9	3
Heifers	5	10	7	5	3
Warm carcass weight (lb)					
370-469	6	8	5	2	1
475-559	1	11	6	2	3
574-715	0	2	9	10	0
Chronological age (days)					
556-579	1	5	5	2	2
581-603	5	6	3	2	1
607-638	0	2	7	5	1

TABLE 3. MEANS AND STANDARD DEVIATIONS FOR CERTAIN CARCASS TRAITS AND MUSCLE:BONE RATIO FOR GRAIN-FED AND FORAGE-FED BEEF

	Grain-fed		Forage-fed	
Item	Mean	S.D.	Mean	S.D.
Number of observations	34		32	
Warm carcass weight, lb	600.40[b]	67.25	452.83[c]	44.57
Muscling score[a]	Ch^{26}[b]	41.16	Gd^{88}[c]	36.70
Actual *longissimus* muscle area, sq. in.	11.52[b]	1.20	10.22[c]	1.06
Adjusted *longissimus* muscle area, sq. in.	11.71[b]	1.29	10.23[c]	0.93
Length of hind leg, in.	28.91[b]	1.17	28.80[b]	1.10
Carcass length, in.	48.00[b]	1.54	46.69[c]	1.53
Muscle:bone ratio (9-10-11 rib)	3.47[b]	.35	3.11[c]	.38
Fat thickness, 12th rib, in.	0.44[b]	0.09	0.15[c]	0.11
Estimated kidney, pelvic and heart fat, %	2.72[b]	.74	1.50[c]	.40
USDA yield grade	2.74[b]	.45	1.61[c]	.43

[a]Muscling score: Gd = Good, Ch = Choice (13).
[bc]Means on the same line bearing a common superscript letter are not different (P>.05).

forage-fed beef and for carcasses from animals sired by either Angus or Hereford bulls ranged from 2.4 to 4.4. To minimize the effects of chronological age and warm carcass weight on muscle:bone ratio, the carcasses also were segmented into three chronological age groups and three warm carcass weight groups. In each of these groups, there was more than a one-unit difference in muscle:bone ratio.

Means and standard deviations for certain carcass traits and muscle:bone ratio are presented in Table 3. The carcasses from the grain-fed animals had a significantly ($P<.05$) heavier warm carcass weight, higher muscling score, larger actual and adjusted *longissimus* muscle areas, higher muscle:bone ratio, and greater carcass length than did the forage-fed beef; these results are in general agreement with those of previous studies (3,5,9).

No significant ($p<.05$) interaction was found between breed of sire and feeding regimen. Mean comparisons for certain carcass traits and muscle:bone ratios of Angus-sired and Hereford-sired offspring fed grain or forage are presented in Table 4. Grain-fed Angus had a higher muscling score, larger actual and adjusted *longissimus* muscle areas, higher muscle:bone ratio, and greater carcass length than forage-fed Angus and forage-fed Herefords. Forage-fed Herefords had a lower muscling score, smaller adjusted *longissimus* muscle area, and lower muscle:bone ratio than grain-fed Angus, grain-fed Herefords and forage-fed Angus. Forage-fed Angus were comparable to grain-fed Herefords in muscling score, muscle:bone ratio, and carcass length.

The effects of diet, breed of sire, sex, chronological age, and warm carcass weight on muscle:bone ratio are shown in Table 5. Diet independently accounted for 20.7 percent of the variability in muscle:bone ratio, and the difference between the means for the grain-fed and forage-fed cattle was highly significant ($P<.01$). In the model containing diet, breed of sire, and sex, diet was again highly significant ($P<.01$). Since chronological age ranged from 556 to 638 days, analysis of covariance was used to remove the effect of age on muscle:bone ratio in a model with diet, breed of sire, and sex. In that model, diet was still a highly significant ($P<.01$) source of variability in muscle:bone ratio. However, when both

TABLE 4. MEANS FOR CERTAIN CARCASS TRAITS AND MUSCLE:BONE RATIO OF ANGUS-SIRED AND HEREFORD-SIRED OFFSPRING FED GRAIN OR FORAGE

Item	Grain-fed		Forage-fed	
	Angus	Hereford	Angus	Hereford
Number of observations	17	6	16	8
Muscling score[a]	Ch^{30b}	Ch^{25bc}	Gd^{94c}	Gd^{59d}
Actual *longissimus* muscle area, sq. in.	11.89^b	11.53^b	10.41^c	9.11^d
Adjusted *longissimus* muscle area, sq. in.	11.88^b	11.86^b	10.39^c	9.36^d
Muscle:bone ratio (9-10-11 rib)	3.54^b	3.40^{bc}	3.25^c	2.83^d
Carcass length, in.	48.16^b	47.13^{bc}	46.73^c	46.26^c

[a]Muscling score: Gd = Good, Ch = Choice (13).

[bcd]Means on the same line bearing a common superscript letter are not different ($P>.05$).

TABLE 5. LEAST SQUARES MEANS AND RESULTS OF ANALYSES OF VARIANCE FOR MUSCLE:BONE RATIO

	Factors in the model					
	Main effect					
Item	Diet	Breed of sire	Sex	Diet, breed of sire, sex	Diet, breed of sire, sex (age held constant)	Diet, breed of sire, sex (age and carcass weight held constant)
Diet ($n=66$)						
Grain	3.47			3.43	3.46	3.42
Forage	3.11			3.06	3.07	3.11
	($P<.01$)			($P<.01$)	($P<.01$)	($P<.13$)
Breed of sire ($n=47$)						
Angus		3.40		3.40	3.38	3.37
Hereford		3.07		3.09	3.15	3.16
		($P<.02$)		($P<.02$)	($P<.02$)	($P<.15$)
Sex ($N=68$)						
Steer			3.35	3.32	3.35	3.34
Heifer			3.28	3.17	3.18	3.19
			($P<.50$)	($P<.20$)	($P<.14$)	($P<.20$)
R^2	.207	.118	.007	.331	.355	.358

chronological age and warm carcass weight were held constant in a model containing diet, breed of sire, and sex, the effect of diet was not significant (P>.05).

Breed of sire independently accounted for 11.8 percent of the variation in muscle:bone ratio. Differences in means between breed of sire groups were significant (P<.05) until either age or age and carcass weight were held constant. Sex was not a significant (P>.05) source of the variability in muscle:bone ratio regardless of the model used.

The model containing diet, breed of sire, and sex effects — without either chronological age or warm carcass weight held constant — accounted for 33.1 percent of the variation in muscle:bone ratio. When chronological age was held constant, diet, breed of sire, and sex explained 35.5 percent of the variability in muscle:bone ratio, and this percentage was increased to only 35.8 percent when both chronological age and warm carcass weight were held constant.

Simple correlation coefficients between carcass traits and muscle:bone ratio for the entire population of carcasses are presented in Table 6. As expected, the correlations between muscle:bone ration and (a) muscling and (b) adjusted *longissimus* muscle area divided by carcass length were highly significant (P<.01). That was because the values for each of those traits reflected the simultaneous consideration of variations in thickness of muscling and skeletal size. As such, these correlations are very meaningful. Warm carcass weight; fat thickness over the 12th rib; actual and adjusted *longissimus* muscle areas; estimated kidney, pelvic and heart fat, and yield grade also were each significantly and positively correlated with muscle:bone ratio. However, those traits likely are not meaningful indicators of muscle:bone ratio because, in this study, the higher plane of nutrition of the grain-fed cattle resulted in their having carcasses which were fatter (Table 3) and, based on other research (3,9), it undoubtedly also resulted in increasing their muscle:bone ratio. Similar explanations are applicable to the positive — but nonsignificant (P>.05) — correlations between carcass or leg lengths and muscle:bone ratio. Among carcasses of the same weight and fatness, carcass length would be expected to be negatively associated with muscle:bone ratio.

TABLE 6. SIMPLE CORRELATION COEFFICIENTS BETWEEN CARCASS TRAITS AND MUSCLE:BONE RATIO

Trait	Correlation coefficient
Warm carcass weight	.493**
Fat thickness, 12th rib	.385**
Actual *longissimus* muscle area	.505**
Adjusted *longissimus* muscle area	.552**
Estimated kidney, pelvic and heart fat, %	.449**
USDA yield grade	.281*
USDA marbling score	.198
Muscling score	.502**
Carcass length	.106
Length of hind leg	.071
Adjusted *longissimus* muscle area/carcass length	.586**

N=68
*(P<.05)
**(P<.01)

Stepwise regression procedures which maximized R-square and which involved 10 independent variables (muscling score; actual *longissimus* muscle area; adjusted *longissimus* muscle area; warm carcass weight; length of hind leg; carcass length; fat thickness over the 12th rib; estimated kidney, pelvic, and heart fat; marbling score and length of hind leg plus carcass length) were used to develop an equation for estimating muscle:bone ratio in which all independent variables were significant (P<.05). That equation is as follows: Muscle:bone ratio = 5.96+.1090 (adjusted *longissimus* muscle area, square inches) ∸.1085 (carcass length, inches) + .002404 (warm carcass weight, pounds). This equation has an R^2 of .4144 and a SEE of .33. As expected, this equation contains a measure of muscle (adjusted *longissimus* muscle area), a measure of bone (carcass length), and a trait which establishes a size perspective for each of these two variables (warm carcass weight). Also, as expected, the beta for adjusted *longissimus* muscle area was positive, and that for carcass length was negative.

In conclusion, in this study which included only offspring from Hereford X Brahman cows bred to Angus or Hereford bulls and fed on either forage or grain, there were important differences in muscle:bone ratios of the 9-10-11 rib sections. When age and carcass weight were held constant statistically, diet, breed of sire, and sex accounted for only 35.8 percent of the variation in muscle:bone ratios. The remaining 64.2 percent of the observed variability in muscle:bone ratio was due either to experimental error — which to the best of our knowledge was held to a minimum — and/or to the actual differences in muscle:bone ratio between individual animals. A three-variable multiple regression equation (R^2=.4144) was developed for estimating muscle:bone ratio using easily obtainable carcass traits. Because of the possible economic importance of variations in muscle:bone ratio of cattle to all segments of the industry, efforts to better identify such differences in live animals and carcasses should be intensified.

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PR-3820

Site of Zeranol Placement and Effect of Calf Gains on Maternal Weight Changes

A. B. JOHNSON, J. R. FRASURE AND P. W. ROUNDS

Summary

Implanting zeranol in the muscle attachment at the base of the ear did not alter average daily gain of either steers or heifers over normal placement of the implant which is subcutaneous on the backside of the midpart of the ear. Implanting at the normal position or at the alternate site improved performance over the nonimplanted group by 12 percent (P<.05), but level of gain by the calves did not influence weight changes of their dams.

Introduction

Use of anabolic implants, both horomonal and nonhormonal, has become routine in many management schemes. Increases in average daily gain have been shown for both steers and heifers of various weights. However, placement of the implant may also be important. This study was conducted to determine 1) if placing the implant at the base of the ear would influence calf gains and 2) if calf weight gain may affect weight change of the dam.

Experimental Procedure

Calves of 26 first-calf Hereford/Angus heifers were stratified by sex and weight and allotted to one of three treatments. Treatments were 1) a control, nonimplanted group, 2) a group implanted at the normal site and 3) a group implanted at the basal location. Site of normal placement was subcutaneous on the backside of the midpart of the ear. Basal placement was at the point of muscle attachment at the base of the ear between the ear and the skull.

The trial began in November when calves were approximately 60 days of age and was terminated at weaning in July. Calves were reimplanted after 118 days on trial and both cows and calves were weighed every 28 days. Cows grazed native range throughout the entire trial and received 3 pounds per day of a 20-percent crude protein supplement from December through February. Calves received no creep feed during the trial.

Results and Discussion

Initial average weights were 152, 145, and 144 pounds for the control, normal and basal implant calves,respectively. Over the first 118 days (the first implant) a difference in gain between the nonimplanted control and the basal implant location was observed (P<.05) (Table 1). The average daily gain of implanted calves during the second implant period (119-223 days) was higher than the control calves (P<.05). Over the entire 223-day trial, differences (P<.05) between the control and the implant calves regardless of location of implant were noted. No differences were obtained between calves implanted at the normal site and calves implanted at the base of the ear attachment. This differs with results of researchers at Kansas State University who observed differences due to implant location (1). They observed a 6.6-percent increase in gain with heavier calves on small grain pastures or concentrate rations.

No difference in gain was seen due to sex of the calf. Both sexes responded to implanting with increased gain. No excessive udder development of the heifers was noted.

Initial weight of the calf affected the daily gain response during the first implant period, but initial weight had no effect upon weight gain over the entire length of the trial (Table 2).Calves with an initial weight of 155 pounds or more gained significantly (P<.05) more than lighter calves during the first

TABLE 1. EFFECT OF SITE OF IMPLANT ON AVERAGE DAILY GAIN OF STEERS AND HEIFERS

Item	Control		Implant - normal		Implant-basal	
	Steer	Heifer	Steer	Heifer	Steer	Heifer
Initial wt (lb)	157	147	143	146	144	144
ADG, 0-118 days	1.21[a]	1.28[a]	1.31[ab]	1.28[ab]	1.49[b]	1.41[b]
ADG, 119-223 days	1.94[a]	1.90[a]	2.27[b]	2.22[b]	2.17[b]	2.13[b]
ADG, 0-223 days	1.55[a]	1.57[a]	1.77[b]	1.72[b]	1.81[b]	1.75[b]
Final weight	491	498	536	530	547	534

[a,b]Means within a row with a different subscripts differ significantly (P<.05).

TABLE 2. EFFECT OF INITIAL CALF WEIGHT ON RESPONSE TO IMPLANT

Starting weight	Number of animals	Implant Period		Total
		0-118 days	119-223 days	0-223 days
Less than 155 lb	15	1.27[a]	2.08[a]	1.65[a]
155 lb or more	11	1.42[b]	2.15[a]	1.77[a]

[a,b]Means within a column with different subscripts differ significantly (P<.05).

TABLE 3. RELATIONSHIP (CORRELATION COEFFICIENTS) OF COW WEIGHT CHANGE TO CALF WEIGHT GAIN DURING THREE PERIODS

Period	Correlation
0-118 days	−0.077
119-223 days	0.156
0-223 days	−0.078

implant period. This suggests that gains of light (or young) calves were limited. The young calf had not increased his foraging ability to supply the additional level of nutrients needed for maximum gain, so the anabolic effect of the implant was of little benefit. Since these were first-calf heifers, milking ability of the dam certainly would be questionable in supplying an adequate amount of nutrients for maximum gain.

No relationship between cow weight change and calf weight gain was observed in this trial, as shown in Table 3. Cow weight change during the winter feeding period (0-118 days) and throughout the trial was independent of calf weight gain. This agrees with Hays and Brinks who suggest cow measurements, including weight, are of limited usefulness in predicting adjusted weaning weight of calves (2).

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Research Briefs

A new feature of this publication is the inclusion of research briefs as a means of highlighting research in progress. These early reports span the topic areas previously addressed and are intended to assist in keeping the readers informed of current research programs.

PR-3821

Calving Difficulty and Economic Effects in a Charolais Herd

C. F. ELLIOT, J. K. RIGGS,
AND C. R. LONG

This analysis of calving difficulty, its causes and economic effects, was based on records of 3,493 calves, the progeny of 35 sires and born over a 5-year period, 1970-74, in a Charolais herd in East Central Texas. The record for each calf included sire and dam identification, sex of calf, age of dam, date of birth, actual birth weight, calving difficulty score, and calf status (live or dead) 48 hours after birth. Calving difficulty was scored: 1 = no assistance; 2 = easy pull, no mechanical pullers used; 3 = hard pull, mechanical pullers used; 4 = Caesarian section. Costs were assessed through interviews with the ranch manager, ranch labor, attending veterinarians, and large animal veterinary specialists at Texas A&M University. The hourly charge for ranch labor was $3.05. Obstetric tools, used in delivering calves born with calving score 3, were estimated to cost $100 per set and one set was purchased each year. The cost of Caesarean delivery was $100 which included the fee for the attending veterinarian and the cost of drugs administered; the expense for ranch labor was additional. One percent of cows giving birth with calving scores 3 and 4 died. Birth weight was significantly related to both percent calving difficulty and percent calf death loss. Calves causing difficulty were 4.5 kilograms (kg) heavier than the mean birth weight of all calves. Calving difficulty was lowest at 32 kg birth weight when all cows were considered but was lowest at 23 kg when only 3-and 4-year-old cows were considered. Cows 3 and 4 years old experienced 29.9 and 12.0 percent difficult births, respectively, as compared to 4.2 percent for cows 5 through 9 years old. Of cows experiencing some degree of calving difficulty, 80.9 percent were 3 and 4 years old among which male calves caused 5.7 percent more difficult births and weighed 2.7 kg heavier than female calves. Calves born in February, March, April, and May were heavier and therefore caused more difficult births, especially in 3- and 4-year-old cows, than those born in other months. Year of birth significantly influenced percent calving difficulty which ranged from 5.2 to 13.1 percent, the lowest figure occurring in 1970 and the highest in 1972. Sire of calf also significantly affected percent calving difficulty, the incidence among 35 sires ranged from 0 to 29 percent with a mean of 8.6 percent. Sire did not significantly influence percent calf death loss. The average calf death loss in this herd was 5.6 percent. Age of dam, calf birth weight, and calving score were significantly related to calf death loss which appeared lowest at approximately 41 kg birth weight and increased as this weight increased or decreased. Calving score seemed to be the most important. Losses in calves with difficulty scores of 1, 2, 3, and 4 were 3.3, 7.5, 31.2, and 73.0 percent, respectively. Losses were 13.2, 7.2, and 3.3 for cows 3, 4, and 5 through 9 years old, respectively. Major costs associated with calving difficulty were (1) labor, (2) veterinary, (3) loss in rebreeding efficiency, and (4) calf death loss. The average cost of calving difficulty per calf weaned in this herd was $15.26. Total cost per case of calving difficulty was $10.49, $85.50, and $243.24 for calving scores 2, 3, and 4, respectively. Every calf weaned in the herd bore a charge of $15.26 because of the level of calving difficulty which prevailed during the 5-year period.

PR-3822

Economic Value of Sire Selection in a Charolais Herd

C. F. ELLIOT, J. K. RIGGS
AND C. R. LONG

As commercial and purebred cattle breeders realized that growth rate may be increased through selection, they accepted the performance program but found progress slow under practical production conditions. Initially, most emphasis in performance programs was placed on rapid growth rate. Later, widespread public interest in leaner beef created a trend toward greater muscularity of carcasses. As a result, many cattlemen opted for larger, faster growing, more muscular breeds as evidenced by the introduction and rapid increase in numbers of Charolais, Simmental, Limousin, South Devon, and other "new exotic" breeds since the late sixties. Unfortunately, this movement toward faster growth rate and greater muscularity was accompanied by increased size, heavier birth weights, and greater incidence of calving difficulty at a time when cowmen were under great economic pressure to increase percent calf crop as well as weaning weight. Therefore, selection of sires based purely on ability to produce heavier calves, while important, is too simplistic; and a study was made to combine the cost of calving difficulty and market value of progeny into a system to select sires based on more complete economic value. Records of 2,951 calves born from 1970 through 1974, the progeny of 30 sires in a Charolais herd in East Central Texas, provided data for the study. Record for each calf included sire and dam identification, sex of calf (bull or heifer), date of birth, birth weight, calving difficulty score, calf status (live or dead) 48 hours after birth, weaning date, weaning age, and weaning weight. Analysis revealed that a sire having a high progeny weaning weight ratio did not necessarily have a high progeny value ratio since the correlation between the two ratios was only 0.54. The economic value of a sire was a function of market price of calves, their weaning weight and the cost of calving difficulty. Cost of calving difficulty was determined and is reported separately. The sire with the top progeny value was 10 percent above the average of 30 sires and 24 percent above the sire having the lowest progeny value. Assuming equal progeny numbers per sire (mean was 145), with only the top 14 sires being used, calving difficulty cost would have been 29 percent less and total progeny value over the 5-year period almost 6 percent more.

PR-3823

Development of A Method for Measuring *In Vivo* Rate of Particle Size Degradation and Passage

K. R. Pond, J. Guererro,
M. Urbantke and W. C. Ellis

The level and efficiency of beef production in Texas is commonly low due to the low digestibility and intake of the dominant warm-season perennial grasses. An improved knowledge of and ability to predict intake and digestibility is needed in order to more effectively utilize these existing resources and develop new and improved varieties of forages. Several theories have been proposed to explain the factors involved in determining digestibility and intake; these, however, have not been extended primarily because of the lack of methodology for measuring these dynamic processes. Voluntary intake (especially of less digestible forages) appears to be limited by (a) volume of rumen, (b) volume occupied therein by forage residues undergoing digestion and (c) the rates of chemical and physical processes which determine turnover of this volume. A method has been developed to estimate the physical degradation of ingested particles by the cow during mastication, rumination and chemical hydrolysis.

This method has been applied to cattle grazing Coastal bermuda plots of three maturities (average of 14, 30 and 39 days regrowth) and grazed sequentially for 2 days each by A, B and C grazer. Dietary particles of leaf and stem masticated to sizes > 1.6 millimeters (mm) (representing collectively approximately ⅓ of ingested diet) were sampled and a 200 gram (g) portion of each labelled with $^{169}Yb\ Cl_3$ and $^{141}Ce\ Cl_3$, respectively, and dosed via rumen cannulae to each animal[3]. Rumen and fecal samples were separated into seven particle sizes by dry sieving and marker concentration in each measured at 18 times post-dose. Measurements were made for A, B and C grazer grazing each maturity on two occasions to yield 18 animal observations. Rates of degradation and passage were significantly ($P<.05$) lower for all size particles derived from stem than from leaf for all grazers and maturities. Rates of degradation and passage were both reduced due to advancing maturity and grazer progression (A to C).

A model has been developed to describe these processes. To further test the model and enable additional particle marking, several rare earths (Ce, Er, Eu, Ho, La, Lu, Sm, Tb and Yb) have also been evaluated as particulate markers. Current studies have utilized eight rare earths applied to eight different particle sizes of Coastal bermudagrass. Marker concentration in the samples were then assayed by neutron activation analysis at the Nuclear Science Center. Neutron activation analysis is very accurate and also eliminates radioactive contamination of the experimenters. With the data from this and subsequent studies utilizing varied quality forages, the validity of the model will be tested. If valid, the model will provide quantification of intake. If not valid, alternative concepts will then be developed.

PR-3824

Abomasal Nutrient Flow as Affected by Stocking Rate

A. B. Johnson, J. R. Frasure
and R. K. Heitschmidt

A qualitative and quantitative assessment of flow of nutrients within the digestive tract of the grazing ruminant is needed. This is currently being investigated at two levels of stocking in the Rolling Plains of Texas. The stocking rates are normal (16.5 ac/au) and twice normal (8.25 ac/au) and utilize two abomasally cannulated Hereford/Simmental cross steers per treatment. Diet quality samples are being taken by hand-clipping and by esophageal techniques. Designed as a rapid rotation grazing system, clipping in each of the two replications per treatment is conducted before and after animal utilization in order to determine the amount of forage available before and after grazing. An esophageal sample is taken before and after to determine if quality changed over the 3-day grazing period. Abomasal and fecal samples are collected twice daily for nutrient analyses. Esophageal samples average 12.75 percent CP (DM Basis) for both treatments. However these samples vary greatly due to variation in percentage content of grass and succulents. To date no differences in crude protein content of fecal dry matter have been observed. Normal stocking rate shows 10.9 percent CP versus 11.4 percent CP for the twice normal stocking rate during a rapidly growing forage period.A slight increase in crude protein presented to the abomasum has occured. Normal stocking rate shows 20.1 percent CP versus 17.1 percent CP (DM Basis) for the twice normal rate. This difference may suggest less selectivity for the doubled stocking rate; but data are preliminary, and this difference may be nothing more than variation due to sampling.

PR-3825

Effect of Monensin on Rumen Microbial Turnover

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Monensin has been shown to increase the feed efficiency of cattle on both roughage and high concentrate diets. This increased performance has been attributed to monensin-mediated depressions in ruminal acetic and butyric acid concentrations with a concomitant increase in the molar percentage of propionic acid. Although it is unclear whether this shift is due to changes in microflora or metabolic pathways, any increase in propionic acid may result in increasing the efficiency with which metabolizable energy is used for maintenance and growth. Reported increases in cattle performance may not be attributed solely to increases in glucogenic substrate supply. It has been suggested and research has indicated monensin may somehow initiate a "protein sparing" effect, resulting in increased efficiency of nitrogen utilization. Whether this increase is due to a decrease in ruminal proteolysis, carbohydrate-protein interaction, or increased efficiency of microbial growth is unclear. Experiments are being conducted at Texas A&M University to evaluate what effects monensin may have on ruminal microbial synthesis/passage.

The ability of some rumen micorbes to convert sulfates to sulfides, and to incorporate these sulfides into their amino acids, permits use of radioactive (Beta) $Na_2{}^{35}SO_4$ as a microbial protein turnover marker. Approximately, 7μCi of $Na_2{}^{35}So_4$, 5 grams (gm) Ytterbium (forage bound), and 50 milliliters (mls) of .66 M CrEDTA are dosed into the rumen of eight cannulated Brahman X Jersey steers or heifers to determine the turnover of the microbial, solid and liquid fractions of the rumen, respectively. Three trials are being conducted over three stages of the grazing season (summer regrowth bermuda, winter dormant bermuda, and lush spring ryegrass). Animals were penned every 6 hours for 96 hours so duplicate rumen (upper and lower strata) and fecal samples could be collected.

In one trial (summer regrowth bermuda), turnover of liquids ($P<.002$), solids ($P<.003$) and microbial protein ($P<.009$) were increased by supplementation of 100 milligrams (mg) monensin per head per day. Also, a reduction in solid/microbial turnover was induced by monensin ($Yb/^{35}S = 1.17$ for controls *vs.* $Yb/^{35}S = .90$ for monensin) supplementation. Although analysis of the final two trials is incomplete, results appear to be compromised by within-treatment animal variations (heifer *vs.* steer). Assuming microbial equilibrium exists in the rumen (rate of passage and degradation = rate of synthesis = rate of disappearance), the disappearance of ^{35}S would represent the rate of microbial exit. Turnover rates of the various fractions were computed by applying respective dilutions with time to a single exponential model. Theoretically, this method could be used in the estimation of total microbial pool size available for incorporation of ^{35}S. However, examination of data revealed more than one rate existed in the exit of ^{35}S from the rumen. This indicates a single exponential model may not adequately describe the processes involved in microbial protein synthesis and exit. Since increased fluid dilution rates may result in increased efficiency of bacterial growth, and bacterial growth rates have profound effects on several rumen parameters (volatile fatty acid producion, deamination, etc.), the importance of any monensin induced change is unquestionable.

PR-3826

Intake, Digestibility, and Sward Characteristics of Bermudagrass-Dallisgrass Pastures

H. Lippke

In order to more accurately predict performance, a trial was conducted to provide data for the study of relationships between characteristics of the sward and intake and digestibility by grazing cattle. A 2-year-old lactating cow and a yearling heifer, both crossbreds and with ruminal and esophageal fistulas, were placed on a lightly grazed bermudagrass-dallisgrass pasture. They were allowed to graze freely during daylight but were penned at night. Fecal output was estimated using rare-earth markers. Digestibility was estimated by *in vitro* fermentation of samples collected at the esophageal fistula. Samples of the sward were also collected and analyzed. Forage available on the pasture was estimated to be 2,900 pounds/acre with a growth rate of 31 pounds/acre/day. Growth was, therefore, approximately twice the estimated utilization rate by the cattle grazing the pasture. The test animals selected diets 6 percentage points lower in fiber and 16 points higher in organic matter digestibility than the available forage. Intake and digestibility estimated for the cow were sufficient for moderate to high levels of production. Intake estimates for the heifer were only 60 percent as high on equal body weight basis. This was consistent with the flighty behavior of the heifer during the trial.

PR-3827

Diet Selection and Forage Intake of Beef Cattle and Supplemental Feeding on Native Rangeland

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A large segment of the beef cattle industry in Texas is based on the rangelands of South, Central, and West Texas. These areas are mostly non-arable but produce native vegetation consisting of an array of grasses, forbs, legumes, shrubs and trees from which animals select diets. Because of the variability in plant composition and their reactions to environmental changes, optimum management practices are difficult to predict. Questions regarding stocking rate, time, and length of breeding season and the how, when and what of supplemental feeding are complicated and the answers elusive. Basic to these questions are what and how much cattle eat under various conditions. Studies at the Texas A&M University Agricultural Research and Extension Center at San Angelo, and at satellite research ranches in McCulloch and Edward Counties, are devoted to gaining data relating to these quesions. An initial study at the Frances Hill Ranch in Edwards County compared levels and types of supplemental feed to determine effects on overall productivity of mature beef cows. Generally, conception rate increased with each increment of supplemental feed, but other factors of production (calf weights and longevity) were unaffected. The improved forage conditions that existed from April through August (weaning) allowed calves from the low-fed cows to compensate in weight gain. Facilities for individual feeding of supplements to beef cows on rangeland are being constructed at the H. D. Winters Ranch at Brady to allow greater control and accuracy in studying supplemental feed needs. This 5-year study includes measurements of diet selection and voluntary forage intake and how these are affected by season and year-to-year differences, competition from sheep and goats, and various supplemental feed mixtures. These data, combined with more basic studies at San Angelo, should assist in establishing a more predictable association between characteristics of rangeland and optimum beef cattle management.

PR-3828

Potassium Supplementation in the Rolling Plains

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Dormant forages are generally marginal in meeting a cow's nutrient requirements. Potassium, which is required by the animal, is found in extremely low concentration in dormant forages. Although clinical signs of potassium deficiency have not been apparent in cow herds, potassium supplementation under range conditions has been shown to be beneficial by researchers in several states as well as in the Coastal Plains and High Plains of Texas. A potassium supplementation program was initiated at the Texas Experimental Ranch to evaluate the effects on cow-calf performance. The program consisted of both a winter and summer supplementation period. During the 90-day winter feeding period, 50 cows in a heavy grazing treatment were fed 2 pounds per day (lbs/day) of a 20 percent crude protein range cube without additional potassium (1.05 percent K) and 50 cows were fed the same cube, but fortified with potassium (4.61 percent K). In a four-pasture, three-herd deferred rotation system, one herd (24 head) was supplemented with 2 lbs/day of potassium-fortified cubes. Actual feeding was conducted on a Monday-Wednesday-Friday schedule. The supplement provided 20 grams per day (g/day) of potassium. When the native forage entered summer dormancy, potassium chloride (KCL) was substituted for salt (NaCl) in the mineral mix that was available free choice. Based on mineral intake data, the mixture provided between 12-15 g/day of potassium to the average cow across the various grazing treatments. No differences between treatments were observed with the added potassium during the winter of 1979-80.Over the 86-day feeding period, cows in the heavy grazing treatment lost 283 pounds,including losses due to calving while cows in the four-pasture, three-herd deferred rotation lost 234 pounds. This loss represents approximately 20 percent of their mature body weight. Cow weight or calf weaning weight in August 1980 in either the heavy grazing treatment or the deferred rotation did not differ due to added potassium. Cows receiving no additional potassium averaged 962 pounds in August compared to 954 pounds for those receiving the added potassium. Calf weaning weights (unadjusted) were 529 and 525 pounds for the control and potassium treatments, respectively. Cows in the deferred rotation receiving additional potassium averaged 993 pounds while controls averaged 1,021 pounds. Calf weaning weights (unadjusted) were 616 and 596 pounds for the potassium and control groups, respectively. On the basis of one year's data, additional potassium does not seem to be beneficial to cows grazing native range in the Rolling Plains of Texas. However, the effects of additional potassium will continue to be evaluated over time.

PR-3829

Regrowth Whole Plant Grain Sorghum Silage for Stocker Calves

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Seventy-two Beefmaster steers were fed three whole plant grain sorghum silage rations during a 50-day growth trial. Whole plant silages contained either whole grain or pre-ensiled rolled grain from an initial or regrowth crop. Since the modified combine used to harvest and field-process the whole plant silage cut the stalk only a few inches above ground level, the remaining stubble was fertilized and irrigated to initiate rapid ratooning. Total dry matter yields were similar at both harvests (July or October). Average daily gain for steers was greatest ($P<.05$) for the whole grain treatment, followed by the regrowth, and rolled grain treatments. Conversion of silage, which represented 92 percent of the rations, to liveweight gain was 4.75, 5.14 and 5.50 pounds of dry matter for whole grain, rolled grain, and regrowth treatments, respectively. When these same silages were fed as 60 percent of the ration to lactating dairy cows, starch and gross energy digestibilities were highest ($P<.10$) for regrowth, followed by ground and whole grain treatments. Other measures of apparent digestibility were unaffected. These data indicate that whole plant grain sorghum silage containing whole grain was equal or superior to pre-ensiled rolled grain sorghum silage for stocker calves. Regrowth whole plant grain sorghum silage was found to be similar in nutritive value to the initial crop, identifying a method to greatly extend liveweight beef gain per acre in those regions where regrowth is feasible.

PR-3830

Short-Term Reconstitution of Grain Sorghum for Finishing Steers

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Conventional grain reconstitution consists of three primary phases, including wetting dry grain to 30-percent moisture followed by short-term aerobic and then anaerobic fermentation in oxygen-limited storage for 2 to 3 weeks. Growth, digestion and grain processing trials were established to evaluate alternative techniques for shorter term reconstitution of grain. A 138-day growth trial with 72 steers compared grain sorghum rolled prior to feeding with 88-percent grain rations prepared as follows: dry, soaked for 24 hours (hr), soaked for 24 hr plus 24 hr of aerobic fermentation, or soaked for 24 hr plus 24 hr of aerobic fermentation followed by 5 days of anaerobic fermentation.Grain sorghum in the soaked treatments contained about 35-percent moisture. One hundred thirty-eight day results indicated that steers fed any of the soaked grain treatments resulted in 12- to 15-percent improvement in conversion of grain dry matter to weight gain with similar improvements in rate of gain compared to dry rolled grain controls. The 5-day reconstituted grain treatment indicated the most favorable improvement in feed conversion. These preliminary results suggest that numerous alternatives may exist for conventional reconstitution that may require less than the usual 2-to 3-week interval.

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