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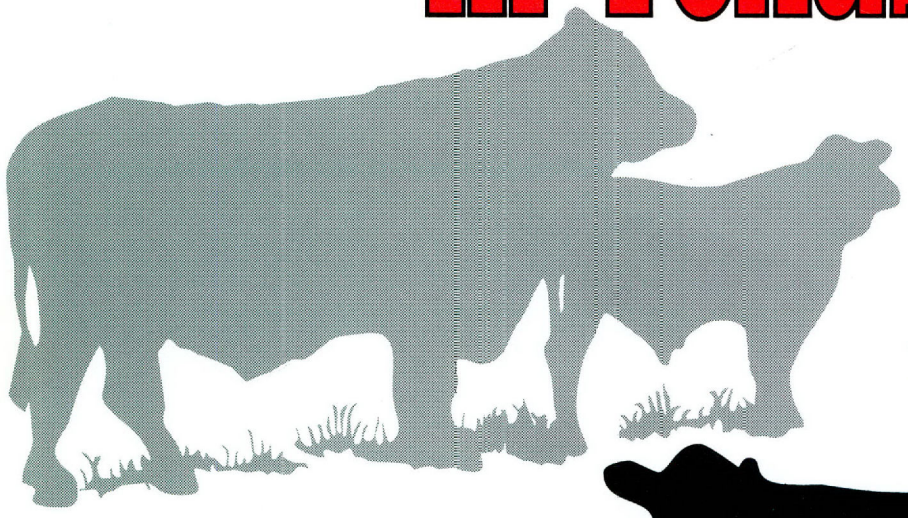
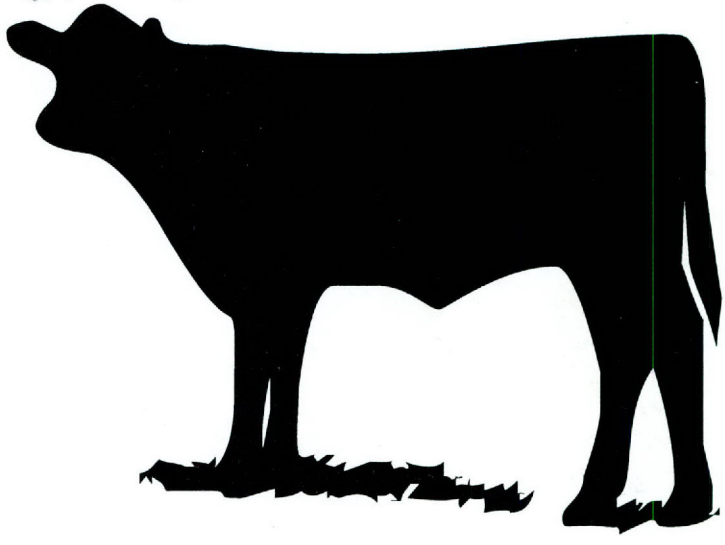
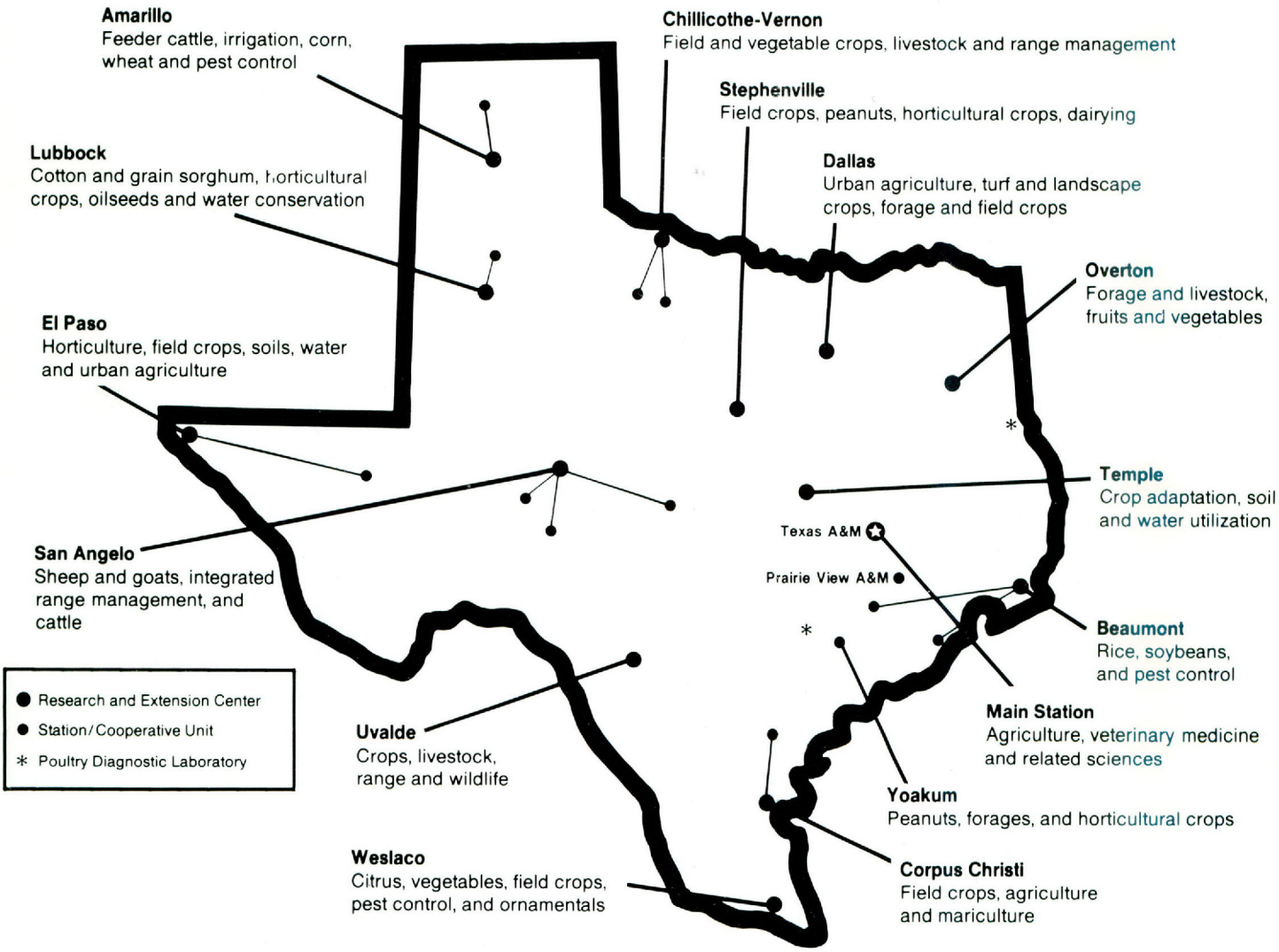
Beef Cattle Research in Texas, 1992





Texas Agricultural Experiment Station
Edward A. Hiler, Director
The Texas A&M University System
College Station, Texas

Texas Agricultural Experiment Station
Research and Extension Centers



Acknowledgments

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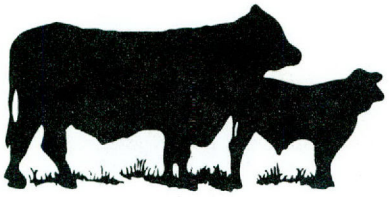
Preface

Beef Cattle Research in Texas, 1992



Texas has an approximate land area of 168.4 million acres (254 counties), or about 263,000 mi², and an 800-mi span between its east-west and north-south extremities (94 to 107 degrees west longitude; 26 to 37 degrees latitude). A wide range of climate, vegetation, and soils exists. According to similarity of soils, topography, climate, and vegetation, the state is divided into 16 land resource areas. Annual rainfall exceeds 56 in. at the Louisiana border in the east but is less than 8 in. at El Paso, the state's westernmost city. The elevation extends from sea level along the Gulf of Mexico to 3,000 - 4,000 ft on the High Plains of the Panhandle in the northwestern part of the state. The Tran-Pecos area, in the far western part, has an elevation ranging from 2,500 to 8,751 ft, the highest point in Texas (Guadalupe Peak in Culberson County). The frost-free period ranges from about 180 days at the Panhandle's north end to 340 or more days at the State's southern tip. Of the 168.4 million acres total land area, about 88 million, or 52 percent, are classified as arable, but only about 40 million acres, or 24 percent, are used for crop production. About 8 million acres, or 20 percent of the land used for crop production, are irrigated. Approximately 26 million acres are classified as forest land, which provides timber and grazing for ruminant livestock and game animals. More than 100 million acres are used as rangeland by cattle, sheep, goats, and game animals.

Texas holds a position of major responsibility in the beef industry. Despite the magnitude of the industry, there are major constraints to development of its full potential. The Texas Agricultural Experiment Station carries out a comprehensive beef cattle research program oriented toward developing technology for optimizing the conversion rate of production resources into highly nutritious, palatable beef. Research is conducted at 15 locations across the State because of the wide variations in soil, climate, elevation, and other environmental and economic conditions. Research centers and stations are located in major agricultural areas to best serve them. Work at these locations is complemented by scientists working at Texas A&M University at College Station. All research, ranging from biochemical, genetic and physiological processes at the cellular level through breeding, nutrition, and meats to feeding and management utilizing field demonstrations, is reported in this publication.

Beef Cattle Research in Texas, 1992

Foreword

Historically, the beef cattle industry has been a major contributor to the Texas agricultural economy, with the combination of cow-calf and cattle feeding operations accounting for over forty percent of Texas's agricultural cash value. The current population of cattle in Texas is estimated to be 14.3 million head. In 1992, approximately 4.8 million fed cattle were marketed in Texas, which represents 22 percent of the total fed beef in the United States. The fed cattle component of the industry has created over 19,000 jobs and has an economic impact of $11.5 million on the Texas economy.

Although the Texas beef industry will continue to face major challenges, its long-term future must be viewed optimistically. One important area for future growth of this industry is the import/export relationship with Mexico. Beef trade between Mexico and the United States is predicted to grow rapidly during the 1990s. By the end of this century, it has been predicted that Mexico will buy 500,000 metric tons of U.S. beef. The Texas beef industry will capture a major share of this market.

Beef cattle research is a major mission for the Department of Animal Science at Texas A&M University. The research is highly diversified because of the broad array of problems and issues confronting the Texas beef industry. Due to the increasing cost of production and increasing competition for beef, the department directs a major portion of its research effort toward production efficiency and product utilization. These areas include enhancement of nutritive value of forages and feeds; basic research to learn how forage and feed are converted to muscle, connective tissue and fat; and how each is deposited during the growth process.

Other researchers are investigating the reproductive process to determine causes of infertility in bulls and cows and how to detect and correct them to increase reproductive efficiency. Research to identify genetic markers for carcass merit and disease resistance is ongoing at our department's research centers at McGregor and Angleton. Health care is also necessary for an efficient production process. Extensive research is underway to maintain cattle health and fight diseases, parasites, and toxic elements in the cattle-raising and feeding environment.

Slaughter, processing, preserving, and marketing also are being studied. Finally, the end product is examined for increased nutrition, wholesomeness, and palatability in order that we continue to produce a consumer-desired product.

This report summarizes results in beef cattle research conducted during the past year.

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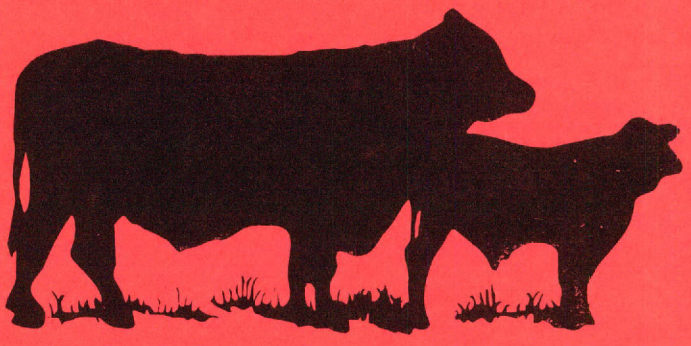
Breeding and Genetics



Evaluation of Birth and Weaning Characteristics of Halfblood and Three-quarter Blood Wagyu-Angus Calves

K.B. Smith, J.O. Sanders, and D.K. Lunt

Summary

Wagyu cattle are a Japanese breed known primarily for their marbling ability. They also tend to be smaller framed and lighter muscled than most British, Continental European, or Zebu breeds. This study was designed to evaluate the Wagyu breed in a crossbreeding program with Angus cattle. The calves used were either F_1 individuals sired by Wagyu bulls on purebred Angus dams or three-quarter blood Wagyu-Angus produced by backcrossing F_1 females to Wagyu sires. Data were collected and analyzed for birth and weaning traits.

Introduction

In 1976, four purebred Wagyu bulls (2 black and 2 brown) were imported from Japan. Following their importation, few beef producers considered the Wagyu as anything more than a novelty breed (1). However, recently, there has been increased interest in this breed; in particular, for their potential use in a crossbreeding program with the Angus breed. This study was designed to examine the differences in the performance of halfblood and three-quarter blood Wagyu-Angus calves.

Materials and Methods

Birth and weaning measurements were taken on halfblood (n=65) and three-quarter blood (n=114) Wagyu-Angus calves born at the McGregor Experiment station. The records on the McGregor calves included birth weight (n=178), cannon bone length (n=179), weaning weight (n=159), and weaning height (n=67). Birth records were also obtained on halfblood calves born in Oklahoma (n=1574). All male calves were castrated when birth records were collected. The calves born at the McGregor station were sired through artificial insemination by the six black Wagyu bulls used in the Oklahoma study. These sires include two fullblood Japanese Wagyu, three 31/32 American Wagyu, and one 15/16 American Wagyu bulls (1).

Analysis of variance was conducted for the birth and weaning characters on the McGregor calves using the General Linear Model Procedure of SAS (2). The models for birth weight and cannon bone length contained the variables gender, sire, percent Wagyu, month of birth nested within year of birth, and age of dam. The models for weaning weight and weaning height contained the same variables, except age at weaning was substituted for month of birth. Analysis of variance was then conducted for birth weight on the halfblood calves born in Oklahoma. After comparison of the two analysis of variance tables, the records for 50% Wagyu calves from the two data sets were combined and analyzed with a variable for location added.

Results and Discussion

In the McGregor study, bulls were 3.49 lbs heavier at birth than heifers, but there was no significant difference in cannon bone length due to gender (Table 1). Differences between sires were not significant for birth weight or cannon bone length. On average, calves with 50% Wagyu breeding were 7.17 lbs heavier and had a 0.24 in. longer cannon bone than calves containing 75% Wagyu. Differences due to month of birth are shown in Table 1. Calves produced by 3-year-old cows were 8.80 lbs heavier and had 0.38 in. longer cannon bones than calves produced by 2-year-old heifers. There was an average difference of 20.83 lbs in weaning weight between the steer and heifer calves; in addition the steers were 0.96 in. taller at weaning that the heifer calves. A significant difference was detected for weaning weight and weaning height due to the different sires (Table 2). The 50% Wagyu calves were also 57.42 lbs heavier and 2.15 in. taller than the 75% Wagyu

TABLE 1. LEAST SQUARE MEANS OF MCGREGOR CATTLE FOR BIRTH TRAITS.

	Birth weight (lb)	Cannon bone length (in.)
Gender		
Steers	78.49	10.91
Heifers	74.09	10.87
Sire		
Sire A	77.75	10.91
Sire B	74.58	10.63
Sire C	77.64	10.98
Sire D	76.12	11.01
Sire E	73.43	10.74
Sire F	78.17	11.08
Percent Wagyu		
50%	80.83	11.00
75%	73.64	10.78
Month of birth		
Feb 91	73.07	11.00
Mar 91	78.21	10.96
Apr 91	85.45	11.24
May 91	94.20	11.40
Sep 91	70.97	10.88
Oct 91	74.68	10.74
Feb 92	70.15	10.60
Mar 92	72.66	10.69
Apr 92	76.59	10.93
Age of dam		
2	71.88	10.70
3	80.68	11.08

TABLE 2. LEAST SQUARE MEANS OF MCGREGOR CALVES FOR WEANING TRAITS.

	Weaning Weight (lb)	Weaning Height (in)
Gender		
Steers	408.82	42.24
Heifers	387.99	41.28
Sire		
Sire A	408.31	42.35
Sire B	400.21	41.69
Sire C	395.37	41.96
Sire D	418.51	42.21
Sire E	382.93	40.56
Sire F	385.07	——
Percent Wagyu		
50%	438.97	42.83
75%	381.55	40.68

calves. As expected, the regression of weaning weight on age at weaning was found to be significant.

Next, the birth weight records from Oklahoma (n=1574) were analyzed through the General Linear Model Procedure of SAS (2). The model included the variables gender, sire, and birth month nested within birth year. Males were 6.04 lbs heavier than the females. Birth month and sire were also significant (Table 3). The birth weight records on the 50% Wagyu calves born at McGregor (n=65) were then added to the data set of the calves born in Oklahoma (n=1639). Males were 5.93 lbs. heavier than females in the combined data. Birth month, sire, and location all showed significant differences (Table 3).

TABLE 3. LEAST SQUARE MEANS OF OKLAHOMA AND COMBINED DATA FOR BIRTH WEIGHT (lb).

	Oklahoma Calves	Combined Data set
Gender		
Steers	76.53	81.31
Heifers	70.46	75.38
Sire		
Sire A	74.34	79.20
Sire B	73.45	78.25
Sire C	74.11	78.94
Sire D	71.69	76.60
Sire E	73.23	78.10
Sire F	74.16	78.97
Month of birth		
Mar 90	72.25	74.46
Apr 90	75.14	77.34
May 90	76.97	79.16
Oct 90	71.77	73.97
Sep 90	68.80	70.99
Jan 91	74.17	76.38
Feb 91	73.69	75.49
Mar 91	74.76	76.99
Apr 91	73.82	76.22
May 91	73.57	76.27
Sep 91		76.83
Feb 92		76.58
Mar 92		74.81
Apr 92		99.08
Location		
Oklahoma		76.14
McGregor		80.55

Conclusions

The three-quarter Wagyu calves were significantly smaller at both birth and weaning than the halfblood calves. The differences in size between the half and three-quarter blood calves reflect (1) differences in size between the breeds, (2) differences in the breeds for maternal traits such as milk production, (3) amount of hybrid vigor in the calf (expected to be higher in the halfbloods) and (4) amount of hybrid vigor in the dam (that is, the three-quarter bloods should have an advantage, since their dams were crossbreds). The larger size of the Angus and the higher level of hybrid vigor in the halfblood calves obviously offset any hybrid vigor advantage in the halfblood dams of the three-quarter calves. This experiment had a very low incidence of dystocia, as would be expected from the low birth weights.

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Evaluation of the Differences in Birth, Weaning, and Carcass Characteristics of Offspring of Angus Sires Available Before 1970 and Sires Born Since 1985

N.S. Fisher, J.O. Sanders, D.K. Lunt, and J.F. Baker

Summary

Calves sired by Angus bulls available before 1970 and those born since 1985 were evaluated for differences in birth, growth, and carcass characteristics. Generation of sire was found to have a significant effect on weight, cannon bone length, and heart girth at birth, weight, hip height and hip width at weaning, and carcass weight. Generation of sire was not found to have a significant effect on carcass quality grade or yield grade. Therefore, it appears that the Angus breed has made significant increases in growth, but that carcass traits have remained relatively unchanged.

Introduction

Over the past 25 years, there were significant changes in birth and growth traits as increased emphasis was placed on selection for increased frame size and faster growth rates. Recently, carcass characters have become more important as the changing lifestyle of the American consumer dictates a leaner, but still palatable product. These changes have influenced all beef breeds, and the Angus breed is no exception.

The Angus breed's genetic changes can be characterized by steady increases of birth, weaning, and yearling weight Expected Progeny Differences (EPDs) for animals born from 1972 to 1990 (4). Carcass weight EPDs increased, ribeye area EPDs increased slightly, while marbling score EPDs remained relatively constant for Angus bulls born from 1972 to 1989 (3). These trends suggest that even though large changes have been made in growth traits, other carcass characteristics have changed little.

This study was conducted to determine the degree to which birth, growth, and carcass traits have changed within the Angus breed. A similar study was conducted by the Roman L. Hruska U.S. Meat Animal Research Center at Clay Center, Nebraska, and is currently in its fifth cycle. In the fourth cycle, calves were produced that were sired by Angus bulls born from 1968-1970 and were compared to calves sired by Angus bulls born from 1982-1984 to evaluate genetic differences between the two generations of Angus cattle. The study found that progeny from modern Angus bulls were significantly heavier at birth, weaning, and final live and carcass weights. There were no significant differences between generations for fat thickness, ribeye area, or USDA marbling score, but there was a slight reduction in the current generation's fat thickness, a slight increase in ribeye area, and a small decrease in USDA marbling score (1).

Experimental Procedure

To determine differences between generations, bulls available prior to 1970 (n=18) and bulls born since 1985 (n=12) were randomly mated over 2 years to Simmental (n=67) and Hereford (n=7) cows of varying ages through artificial insemination. The old sires' semen was obtained from an earlier crossbreeding study at the Texas Agricultural Experiment Station at McGregor and the modern sires' semen was obtained through purchase and donation. Calves were born in the spring of 1989 (n=69) and 1990 (n=28). At birth, calves were weighed and measured for heart girth and cannon bone length. Date of birth, sex of calf, calving ease, calf vigor, and nursing code also were recorded.

The calves were weaned at approximately 7 months of age, immunized for respiratory and clostridial diseases, and implanted with Ralgro™. Ralgro™ was reimplanted every 90 days thereafter. A starter ration was fed for 3 weeks, followed by an intermediate ration for 2 weeks before switching to a finishing ration, which was fed until slaughter. Weights, hip heights, and body condition scores were taken approximately every 30 days and hip widths were taken every 90 days. Steers and heifers born in 1989 were fed for 217 and 202 days, while those born in 1990 were fed for 222 and 229 days, respectively. The calves were weighed before shipping and this was used as the final live weight.

Steers and heifers born in 1989 were slaughtered at three different facilities and evaluated by two different evaluators, while 1990-born steers and heifers were slaughtered at the Texas A&M Meat Science Center. After slaughter, a warm carcass weight was taken. Following chilling, lean maturity, skeletal maturity, fat thickness at the 12th rib, ribeye area, estimated percentage kidney, pelvic and heart fat, and USDA marbling scores were obtained. These measurements were then used to determine yield and quality grades.

Birth records (n=97) were analyzed using a general linear model including year of birth, sex of calf, generation of sire

(OLD vs. NEW), age of dam, breed of dam, a random sire within generation effect and date of conception as a covariate. Weaning record analysis (n=82) used the same model, except age of calf at weaning replaced date of conception as the covariate. Carcass records (n=80) were analyzed using age of calf at slaughter as the covariate (2).

Results and Discussion

The analysis of birth traits found generation of sire significant for birth weight, cannon bone length, and heart girth. Gestation length did not differ for OLD and NEW sired calves. Sire within generation, age of dam, and sex of calf were significant for birth weight, while year of birth was significant for cannon bone length. Breed of dam was significant for birth weight, cannon bone length, and heart girth. Calves sired by NEW sires had a least squares mean for birth weight 10.2 lb greater than those sired by OLD sires. This compared to a 2.3 lb increase in birth weight EPDs from Angus bulls born from 1972 to 1989 (4), and a 5.9 lb increase in the birth weight of NEW sired calves as reported by Cundiff et al. (1). Cannon bone length and heart girth of NEW sired calves exceeded those of OLD sired calves by 0.6 and 1.3 inches, respectively (Table 1). Least squares means for breed of dam showed that calves out of Simmental dams had birth weights, cannon bone lengths, and heart girths significantly greater than calves out of Hereford dams. Bull calves' least squares mean for birth weight was 6.9 lb heavier than for heifer calves.

Weaning record analysis found generation of sire, breed of dam, and year of birth significant for weaning weight, weaning hip height, and hip width. Age of dam was significant for weaning weight, hip height, hip width, and body condition score, and sex of calf was significant for weaning weight and hip width. The least squares means for NEW sired calves for weaning weight, hip height, and hip width were 50.3 lb, 2.5 in., and 0.19 in. greater than OLD sired calves (Table 2). The Spring 1990 Angus Sire Summary showed a 19.4 lb increase in weaning weight EPDs for bulls born over the 17 year period (4), while Cundiff et al. (1) reported a 29.5 lb increase in the weaning weight of NEW sired calves. Simmental cows had calves with significantly larger weaning weights, hip heights, and hip widths than calves out of Hereford cows. Least squares means for bull calves were 53.8 lb heavier for weaning weight and 0.18 in. wider for hip width than those for heifer calves.

For carcass traits, generation of sire was significant for carcass weight. Year of calf was significant for carcass weight, fat thickness, skeletal maturity, and lean maturity. Age of dam was significant for carcass weight, yield grade, and lean maturity, and sex of calf was significant for carcass weight and marbling score. Breed of dam was significant for carcass weight and ribeye area. Calves sired by NEW bulls had least squares means that were 100 lb heavier for carcass weight, 0.4 square in. larger for ribeye area, 0.03 in. more for fat thickness and 0.24 of a score lower for marbling than those sired by OLD bulls (Table 3). Carcass EPDs for bulls born from 1972 to 1988 showed that carcass weight EPDs increased 22 lb, ribeye area EPDs increased 0.09 square in., and marbling score EPDs remained relatively constant (3). Cundiff et al. reported that carcass weight of NEW sired calves was 58.6 lb heavier, ribeye area increased 0.12 square in., fat thickness decreased 0.01 in., and marbling was 0.12 of a score lower (1). To correctly assess the increase in ribeye area, the difference in carcass weights of the two generations must also be considered. Even though the NEW sired offspring had ribeyes 0.4 square in. larger, their carcasses were also 100 lb heavier. When ribeye area was examined per hundred pounds of carcass weight, the NEW sired offspring had fewer square inches of ribeye per 100 lb of carcass than OLD sired calves. Consequently, this suggests that Angus cattle have experienced a slight decrease in muscle. The least squares means for breed of dam showed that Simmental cows had calves whose carcass weights were 73.6 lb heavier and marbling scores were 0.48 lower than calves of Hereford dams. Bull calves had least squares means that were 88.8 lb heavier for carcass weight and 0.67 of a marbling score lower than heifer calves.

TABLE 1. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BIRTH TRAITS.

	Birth weight (lbs)	Cannon bone (in.)	Heart girth (in.)
Old generation	71.4 ± 2.7	10.7 ± 0.14	28.2 ± 0.39
New generation	81.6 ± 2.7	11.3 ± 0.14	29.5 ± 0.43
Male	80.0 ± 2.9	11.1 ± 0.15	29.1 ± 0.47
Female	73.1 ± 2.5	11.0 ± 0.13	28.5 ± 0.39

TABLE 2. LEAST SQUARES MEANS AND STANDARD ERRORS FOR GROWTH TRAITS.

	Weaning weight (lbs)	Weaning hip height (in.)	Weaning hip width (in.)	Weaning body condition score
Old generation	438.4 ± 18.0	41.1 ± 0.47	5.0 ± 0.08	5.3 ± 0.12
New generataion	488.7 ± 18.1	43.6 ± 0.51	5.2 ± 0.08	5.1 ± 0.12
Male	490.5 ± 19.7	42.6 ± 0.55	5.2 ± 0.09	5.1 ± 0.13
Female	436.7 ± 17.6	42.0 ± 0.47	5.0 ± 0.08	5.2 ± 0.12

TABLE 3. LEAST SQUARES MEANS AND STANDARD ERRORS FOR CARCASS TRAITS.

	Carcass weight (lbs)	Overall maturity	Adj fat thickness (in.)	Fat thickness (in.)	Ribeye area (in.^{2})	Kidney, pelvic & heart fat (%)	Marbling score[a]	Yield grade
Old generation	593.7 ± 20.7	140.9 ± 3.0	0.49 ± 0.04	0.46 ± 0.04	12.2 ± 0.37	2.46 ± 0.20	410.4 ± 21.5	2.61 ± 0.17
New generation	693.8 ± 20.5	140.3 ± 3.2	0.52 ± 0.04	0.49 ± 0.04	12.6 ± 0.37	2.61 ± 0.20	386.1 ± 21.3	2.97 ± 0.17
Male	688.1 ± 23.2	138.1 ± 4.7	0.47 ± 0.04	0.45 ± 0.05	12.8 ± 0.42	2.57 ± 0.23	364.9 ± 24.1	2.76 ± 0.19
Female	599.4 ± 20.0	143.1 ± 2.8	0.54 ± 0.04	0.50 ± 0.04	12.0 ± 0.36	2.50 ± 0.20	431.5 ± 20.8	2.82 ± 0.17

[a]300 = slight[00]; 400 = small[00]; etc.

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Comparison of Birth and Weaning Traits of F_1 Calves Sired by Tuli, Boran, and Brahman Bulls

A. D. Herring, J. O. Sanders, R. E. Knutson, and D. K. Lunt

Summary

Birth and weaning traits were evaluated on F_1 calves produced by mating Tuli, Boran, and Brahman bulls to Angus and Hereford cows. Brahman-sired calves were the heaviest at birth followed by Boran- and Tuli-sired calves. The same rank of sire breeds also was observed for cannon bone length. Although there was no statistically significant variation in gestation length accounted for by breed of sire, Boran-sired calves were carried longest followed by Brahman- and Tuli-sired calves, respectively. In regard to weaning traits, Brahman-sired calves had the heaviest average weight, tallest hip height, and greatest preweaning average daily gain compared to Boran- and Tuli-sired calves, respectively.

Introduction

An experiment was initiated in 1991 to evaluate the Tuli and Boran breeds of African cattle. Both Tuli and Boran frozen embryos were imported from Africa into Australia with the first calves being born in 1989. Semen was collected from the bulls of these two breeds and imported into the United States.

The advantages of utilizing *Bos indicus* cattle in crossbreeding systems have been shown repeatedly in studies using Brahman cattle, especially in the southern United States where cattle are subject to extreme heat and humidity as well as increased parasitic infestations (5). High levels of heterosis exist for reproductive as well as growth traits between *Bos indicus* and *Bos taurus* types of cattle (2). The increased fertility and productivity of the Brahman crossbred cow has been widely shown (4). However, there are disadvantages associated with Brahman influenced cattle in regard to carcass quality and acceptability and in the age required to reach puberty.

The Tuli breed was developed in the African country of Zimbabwe. It is a Sanga breed of cattle, meaning it has characteristics intermediate between Zebu and *Bos taurus* cattle with the hump located farther up on the neck as compared to Zebu cattle. Many are yellow "straw" colored, but dark red as well as light cream colored cattle also exist in the breed (3). Both horned and polled animals can be found in the breed.

The Boran is a Zebu (shoulder-humped) breed of cattle developed in the African country of Kenya and is a large type of East African Zebu; the majority of the animals are light gray, but the color may range to straw or red, with some animals close to black in color (1). Both polled and horned Boran cattle can be found in the breed.

The objective of this study is to compare these two newly imported African breeds of cattle to the American Brahman in regard to fertility and productivity of the crossbred females, and also to compare carcass characteristics in steers to find if they will fit into crossbreeding systems used in the southern parts of the United States.

Materials and Methods

This study is part of a collaborative project that includes the Texas Agricultural Experiment Station, the United States Meat Animal Research Center at Clay Center, Nebraska, the USDA Station in Ft. Reno, Oklahoma, and the University of Georgia. In Texas, cattle at the McGregor, Overton, and Uvalde experiment stations are being used. Artificial insemination matings were made in the spring of 1991.

At the McGregor station, both Hereford and Angus cows (all having previously calved at least once) were bred to Tuli, Boran, and Brahman bulls. Moreover, Brahman cows were also inseminated with Boran and Brahman semen. The first set of calves was born in February through April of 1992. Birth measurements were taken within 48 hours after parturition and included birth weight, cannon bone length, calving ease score, and calf vigor score. Calves were weaned in mid October, and at that time, weights, hip heights, and body condition scores were evaluated. Males were castrated shortly after being weaned. After a brief backgrounding period, the F_1 steers will be fed out and have carcass traits evaluated. The F_1 heifers will be kept to evaluate fertility, reproductive, and productivity traits. At approximately 12 months of age, the heifers will be weighed, measured for hip height, and have both internal and external pelvic dimensions evaluated.

Results and Discussion

Birth records on 156 calves out of Hereford and Angus cows were analyzed. In regard to birth weight and cannon bone length, significant differences were seen due to breed of sire (Table 1). Calves sired by Brahman bulls were the heaviest (103.7 lbs) with Boran intermediate (96.0 lbs) and Tuli-sired calves the lightest (85.1 lbs). Bull calves averaged 11 lbs more than heifers; calves out of Angus cows were 5.3 lbs lighter than those out of Hereford cows. In evaluation of cannon bone length, Brahman-sired calves were the longest (31.1 cm) followed by Boran- (29.3 cm) and Tuli-sired calves

TABLE 1. LEAST SQUARES MEANS AND ASSOCIATED STANDARD ERRORS FOR BIRTH WEIGHT, CANNON BONE LENGTH, AND GESTATION LENGTH LISTED BY BREED Of SIRE, BREED OF DAM, AND SEX OF CALF.

	N	Birth weight (lb)	Cannon bone length (cm)	Gestation (days)
Breed of Sire				
Boran	49	96.0 ± 1.8	29.3 ± 0.2	292.7 ± 0.9
Tuli	51	85.1 ± 1.6	28.3 ± 0.2	288.2 ± 0.8
Brahman	56	103.7 ± 1.6	31.1 ± 0.2	289.8 ± 0.8
Breed of Dam				
Angus	52	92.3 ± 1.6	29.9 ± 0.2	289.7 ± 0.8
Hereford	104	97.6 ± 1.1	29.2 ± 0.1	290.8 ± 0.6
Sex of Calf				
Heifers	70	89.4 ± 1.4	29.2 ± 0.1	289.2 ± 0.7
Bulls	86	100.5 ± 1.3	30.0 ± 0.1	291.3 ± 0.7
Sex by Breed of Sire				
Boran Heifers	18	88.8 ± 2.8	28.7 ± 0.3	291.7 ± 1.4
Boran Bulls	31	103.2 ± 2.0	29.9 ± 0.2	293.8 ± 1.0
Tuli Heifers	25	83.6 ± 2.3	28.2 ± 0.2	286.7 ± 1.1
Tuli Bulls	26	86.7 ± 2.3	28.4 ± 0.2	289.7 ± 1.2
Brahman Heifers	27	96.0 ± 2.2	30.6 ± 0.2	289.2 ± 1.1
Brahman Bulls	29	111.5 ± 2.2	31.5 ± 0.2	290.4 ± 1.1

(28.3 cm). Male calves had 0.8 cm longer cannon bone length than females; calves out of Angus cows had an average of 0.6 cm longer cannon bone. Boran-sired calves were carried the longest (292.7 days) followed by Brahman- (289.8) and Tuli-sired calves (288.2). There was a significant sex by breed of sire interaction for birth weight, but not for cannon bone length or gestation length. Male calves out of Brahman and Boran bulls were much heavier (14-16 lbs) at birth than females; however, male calves out of Tuli bulls weighed only 3.1 lbs more than the Tuli-sired heifer calves.

In regard to calving ease and calf survival data, two Boran-sired calves required assistance at birth, as did two Brahman sired calves; additionally, there was one Tuli-sired calf and two Brahman-sired calves that were born in a posterior position. Two of the Boran-sired calves required assistance in nursing after birth (one of which required slight assistance at birth); no Brahman- or Tuli-sired calves required nursing assistance.

In analysis of weaning traits (Table 2), Brahman-sired calves were the heaviest (545.4 lbs) followed by Boran- (512.2 lbs) and Tuli-sired calves (486.8 lbs). Bull calves weighed 46 lbs more than heifers at weaning; calves from Angus cows weighed approximately one lb more than calves out of Hereford cows. Brahman sired calves were also the tallest (116.8 cm) at weaning followed by Boran- (110.1) and Tuli-sired (109.0) calves, respectively. Bull calves were approximately 2 cm taller than heifer calves. Calves out of Angus and Hereford dams did not differ in height. Brahman-sired calves had the highest preweaning average daily gain (1.99 lb/day) followed by the Boran- (1.87 lb/day) and Tuli-sired calves (1.81 lb/day). Bull calves gained an average of 1.97 lb/day, where the heifers averaged 1.81 lb/day. Calves produced by Angus cows gained an average of 1.91 lb/day, while those produced by Hereford dams gained 1.87 lb/day.

TABLE 2. LEAST SQUARES MEANS AND ASSOCIATED STANDARD ERRORS FOR WEANING WEIGHT, HIP HEIGHT, AND PREWEANING AVERAGE DAILY GAIN LISTED BY SIRE BREED, DAM BREED, AND SEX OF CALF.

	N	Weaning weight (lb)	Hip height (cm)	Average gain (lb/day)
Breed of Sire				
Boran	43	512.2 ± 10.1	110.1 ± 0.7	1.87 ± 0.04
Tuli	48	486.8 ± 9.0	109.0 ± 0.6	1.81 ± 0.04
Brahman	53	545.4 ± 8.5	116.8 ± 0.6	1.96 ± 0.04
Breed of Dam				
Angus	50	515.3 ± 9.1	111.9 ± 0.6	1.91 ± 0.04
Hereford	94	514.2 ± 6.6	111.9 ± 0.4	1.87 ± 0.03
Sex of Calf				
Heifers	66	491.7 ± 7.9	111.0 ± 0.5	1.81 ± 0.03
Bulls	78	537.9 ± 7.4	112.9 ± 0.5	1.97 ± 0.03
Sex by Breed of Sire				
Boran Heifers	17	491.6 ± 15.3	108.5 ± 1.0	1.81 ± 0.06
Boran Bulls	26	532.9 ± 12.4	111.6 ± 0.8	1.93 ± 0.05
Tuli Heifers	23	461.6 ± 13.1	108.3 ± 0.9	1.71 ± 0.06
Tuli Bulls	25	512.0 ± 12.7	109.6 ± 0.9	1.91 ± 0.05
Brahman Heifers	26	522.0 ± 12.3	116.0 ± 0.8	1.91 ± 0.05
Brahman Bulls	27	565.8 ± 12.2	117.5 ± 0.8	2.06 ± 0.05

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Non-Mendelian Genetic Effects in Reciprocal Cross Brahman x Simmental F_1 Calves Produced by Embryo Transfer

R. M. Thallman, J. O. Sanders and J. F. Taylor

Summary

A total of 592 calves sired by Simmental bulls out of Brahman dams (SB) and 98 calves sired by Brahman bulls out of Simmental dams (BS) were produced by embryo transfer (ET) by a private seedstock producer. Embryos were assigned to Holstein or crossbred beef recipient cows at random. The effects of reciprocal cross (CROSS) and sex of calf (SEX) on birth weight (BW), gestation length (GEST), 205 day adjusted weaning weight (WW), 365 day adjusted yearling weight (YW) and 365 day adjusted yearling scrotal circumference (SC) were evaluated. BS calves had larger values than SB for all traits in both sexes. Differences between BS and SB calves were approximately twice as large in male calves as in female calves for BW, WW and YW. SB male calves were slightly lighter at birth than SB female calves. Under the usual assumptions of quantitative genetics models, CROSS is expected to have no effect. Potential explanations for the effect of CROSS on these traits are: mitochondrial inheritance, genomic imprinting, X-linked inheritance with non-random X-chromosome inactivation, Y-linked inheritance, maternal transmission of non-genetic ova cytoplasmic components and maternal effect of ovary, oviduct, and uterus of donor cow on embryo prior to transfer of the embryo on day 7.

Introduction

The Mendelian genetic model assumes that one-half of the genetic material in an individual is contributed by the male parent, the other half is contributed by the female parent, and both halves are expressed equally. This model has been applied quite successfully in breeding programs involving both quantitatively and qualitatively inherited traits. Exceptions to this model have been known for many years, most notably the differences between the X and Y chromosomes and the autosomes. As more has been learned about the molecular basis of genetics, a number of other exceptions have been found to occur in various organisms. Although the traditional model will continue to serve as the essential backbone of any widely applicable genetic model, refinements based on exceptional genetic mechanisms may render a model that is much more useful.

One of the predictions of the Mendelian genetic model is that F_1 reciprocal crosses are expected to have the same genotypic values. Phenotypic differences between Brahman (B) x Hereford (H) reciprocal crosses have been known to exist for many years (4). Traditionally, these differences have been regarded as effects of the maternal environment on the calf. Effects on BW were attributed to uterine environment and effects on WW were assumed to be due to milk production and transfer of passive immunity.

However, there is evidence that large reciprocal effects also occur in calves produced by ET. Baker et al. (3) reported that B x H ET calves were 7.4 and 11.9 kg heavier at birth and had 10 and 8 d longer gestation than H x B F_1's when the embryos were transferred to Brahman and Hereford recipients, respectively. These reciprocal effects in calves produced by ET are not due to milk production, passive immunity, or the uterine environment (after day 7), because the calves were carried and raised by unrelated recipient cows and recipients were assigned to embryos randomly.

Materials and Methods

Performance records on 592 SB and 98 BS calves were provided by Granada BioSciences, Inc., Wheelock, TX. All of the calves were produced by ET and were born from 1984 to 1987. The embryos were randomly assigned to a recipient herd consisting primarily of Holsteins with some crossbred beef recipients. The cattle were part of Granada's purebred Simbrah breeding program and were not part of any designed experiment. Consequently, selection criteria for sires and donors differed by breed and sex of parent. This could cause some bias in the estimate of the reciprocal cross effect. Birth weight, gestation length, 205 day adjusted weaning weight, 365 day adjusted yearling weight, and 365 day adjusted scrotal circumference were recorded.

The data were analyzed using an animal model with additive genetic relationships. The fixed effects in the model were CROSS by SEX subclass and contemporary groups. Contemporary groups were defined differently according to the trait.

Results and Discussion

Reciprocal Cross Differences

The BS bull calves weighed 36% (13.7 kg) more at birth than did the SB bull calves (Figure 1). The BS heifer calves were 7.7 kg heavier at birth than the SB heifer calves. Note that the effect of CROSS in the bull calves was almost twice the size of the effect in the heifer calves resulting in a CROSS by SEX interaction. Furthermore, among the SB calves, the heifers weighed 0.4±0.5 kg more at birth than the bull calves.

Figure 2 shows that gestation length was 2.3 d longer in the BS heifer calves than in the SB heifer calves. Among the bull calves, the BS were carried 1.6 d longer than the SB.

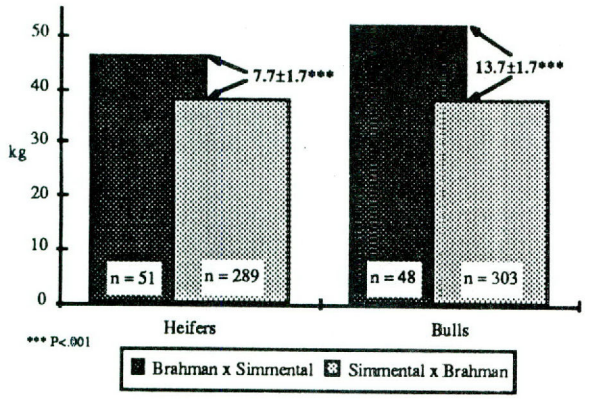

Figure 1. Birth weight in reciprocal cross embryo transfer calves.

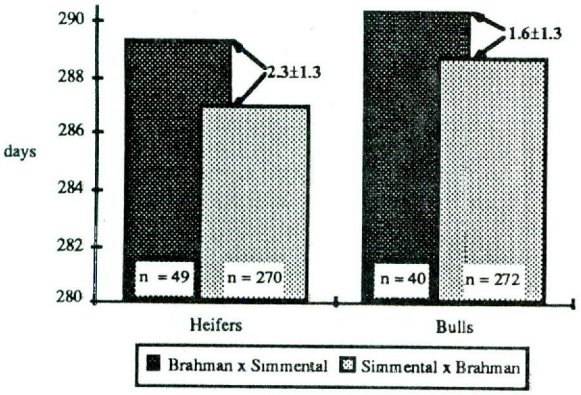

Figure 2. Gestation length in reciprocal cross embryo transfer calves.

The BS calves were also significantly heavier than the SB calves at weaning (Figure 3) and at a year of age (Figure 4). As was the case for BW, the difference between reciprocal crosses was approximately twice as large in the bulls as in the heifers. The BS bulls had 3.39 cm greater scrotal circumference than the SB bulls (Figure 5).

The CROSS by SEX interaction may be almost as important as the effect of CROSS itself. In reciprocal crosses of Brahman and Hereford produced by natural service, Roberson (14) reported a large interaction for BW between CROSS and SEX of calf. There, the reciprocal BW difference in female calves was 5.9 kg, but the reciprocal difference in BW between male calves was 11.9 kg.

Potential Genetic Mechanisms

A number of genetic mechanisms have been proposed as potential explanations for a reciprocal cross effect in ET calves.

Mitochondrial Inheritance

Mitochondrial inheritance (Figure 6) refers to the inheritance of mitochondrial DNA (mtDNA). The mitochondria is a small organelle that is responsible for energy metabolism

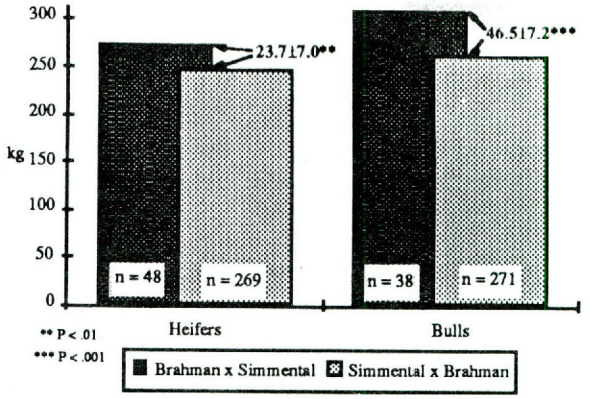

Figure 3. Weaning weight in reciprocal cross embryo transfer calves.

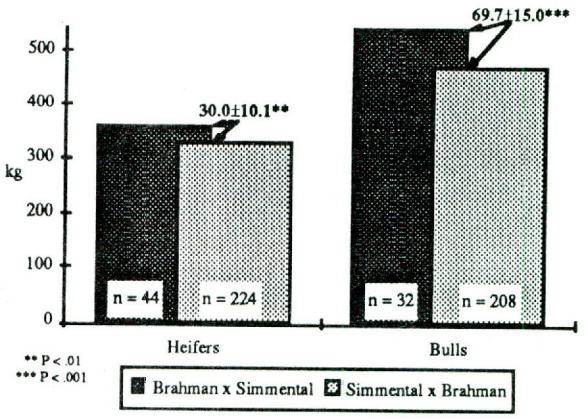

Figure 4. Yearling weight in reciprocal cross embryo transfer calves.

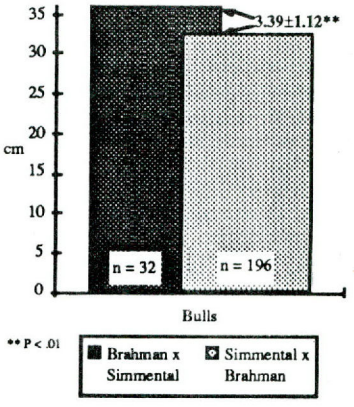

Figure 5. Yearling scrotal circumference in reciprocal cross embryo transfer bulls.

within the cell. The mitochondria contains a small, circular double-stranded DNA molecule that has 13 genes that code for protein subunits, all of which are used within the mitochondria. The bovine mitochondrial genome is 16,338 nucleotides long (2) compared with the nuclear genome which is approximately 3,000,000,000 nucleotides long and contains

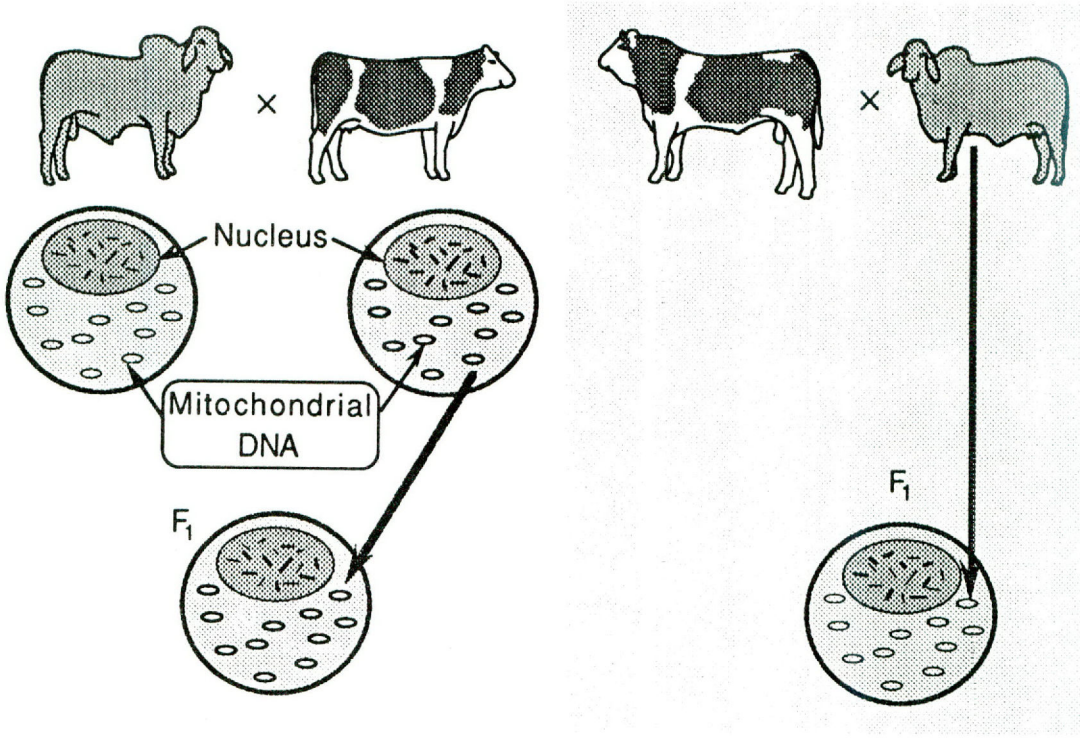

Figure 6. Mitochondrial inheritance as a potential explanation for the difference between reciprocal cross F_1 calves produced by embryo transfer.

approximately 100,000 genes. Mitochondria are inherited exclusively from the dam (7).

There has been considerable discussion in the literature on the role that mitochondrial inheritance plays in the production efficiency of livestock. Tess et al. (20) reported that mitochondrial source had a significant effect on BW, WW, average daily gain, and milk yield in Hereford cattle and accounted for 1 to 5% of the variance in these traits. However, Kennedy (10) showed that the models they used were not adequate to separate mitochondrial from additive nuclear effects. When the same data were later analyzed with the more appropriate animal model, no significant mitochondrial effect was detected for any trait (21).

Genomic Imprinting

Genomic imprinting (Figure 7) is the phenomenon in which a particular copy of a gene is expressed differently depending on whether it was inherited from the male or the female parent. Solter (18) gave an excellent review of genomic imprinting. Genomic imprinting is believed to be due to differential methylation (a form of modification that does not change the base sequence) of the DNA during gametogenesis. DNA is overmethylated during spermatogenesis and undermethylated during oogenesis. Since methylation is known to be associated with gene regulation, the paternally and maternally derived copies of a gene could be expressed differentially. Genomic imprinting has been demonstrated at the molecular level in mice and has been implicated in a variety of human diseases, including Huntington's disease (18). For some genes, the maternal chromosome is transcribed preferentially, while for others it is the paternal chromosome that is preferentially transcribed (8). Effects of genomic imprinting in livestock species have not yet been demonstrated.

X-linked Inheritance with Non-random X-inactivation

The mammalian X-chromosome (X) contains a rich variety of genes. Mammalian cells contain only one active X. In females, which are XX, one X in each cell is inactivated. The inactivation occurs relatively early in embryonic development and once one of the two X's is inactivated in a particular cell, all descendants of that cell have the same X inactive. Only the active X is expressed. In males, which are XY, no inactivation is required.

Mammalian X-inactivation is generally regarded to be a random event. However, Sharman (16) showed that the paternally derived X was preferentially inactivated in most tissues of kangaroos. Takagi and Sasaki (19) showed that the paternally derived X was preferentially inactivated in derivatives of the trophectoderm and primitive endoderm of mouse embryos, but in the derivatives of the primitive ectoderm (including the fetus and the amnion), X-inactivation was random. However, Grant and Chapman (6) reported that X-inactivation was random in the chorionic villi and some other extraembryonic components of human placentas.

Figure 8 illustrates how breed differences for loci on the X would be expected to result in differences between reciprocal cross male calves because BS calves are $Y^{B}X^{S}$ and SB calves are $Y^{S}X^{B}$ (the bold **X** indicates inheritance from the

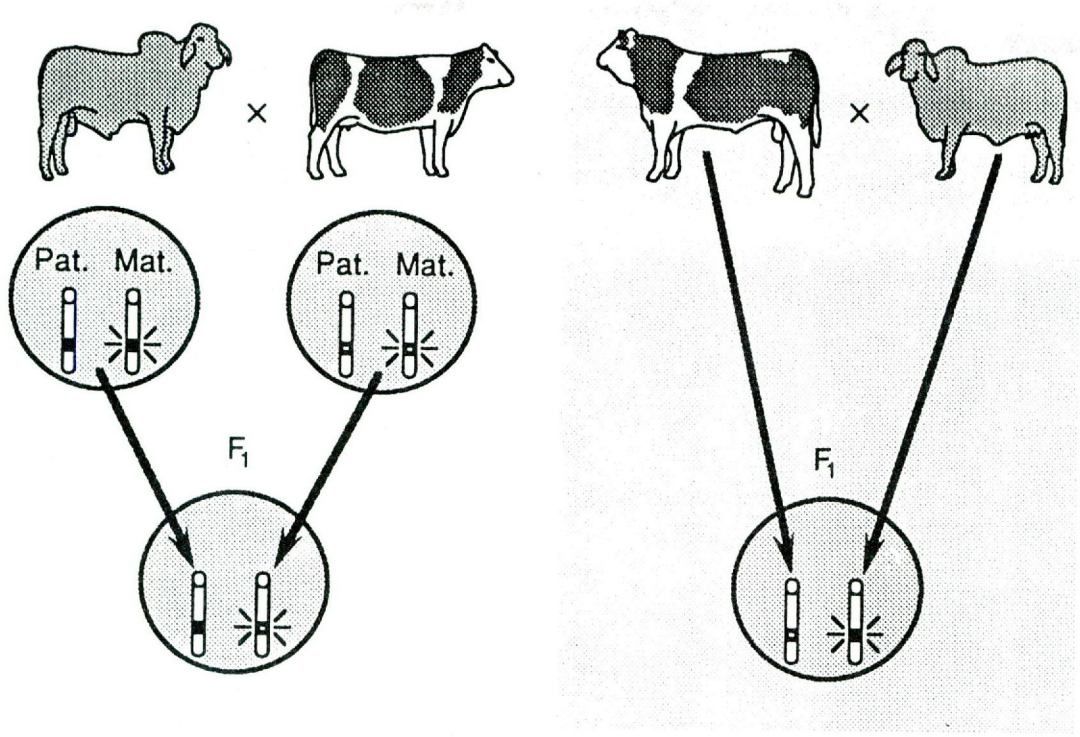

Figure 7. Genomic imprinting (with maternal expression) as a potential explanation for the difference between reciprocal cross F_1 calves produced by embryo transfer.

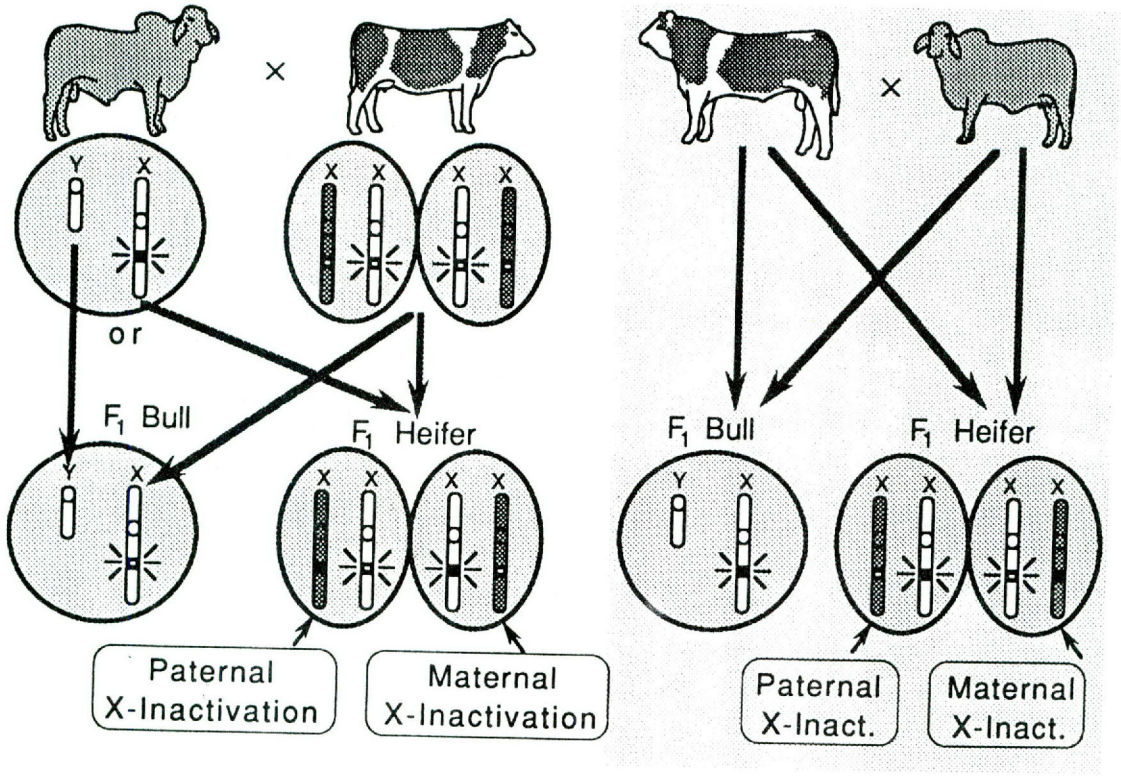

Figure 8. X-linked inheritance as a potential explanation for the difference between reciprocal cross F_1 calves produced by embryo transfer.

dam). These calves differ for source of both the X and the Y (therefore, a breed difference on the Y would also cause a reciprocal effect in male calves). In female calves, BS are X^BX^S and SB calves are X^SX^B. If X-inactivation is random, then half the cells express X^B and half express X^S in either of the reciprocal females and therefore, on average, there would be no reciprocal effect in females. (Note also that a breed difference on the Y would not cause a reciprocal effect in females). However, if the maternally derived X was preferentially expressed, then BS calves would tend to express X^S and SB calves would tend to express X^B and consequently, there would be a reciprocal difference, although it would be smaller than in the bulls unless paternal X-inactivation was complete. Since there are reciprocal differences in *B. taurus* x *B. indicus* female calves, but they are smaller than those in male calves, the issue of non-random X-inactivation is of some importance.

Y-Linked Inheritance

According to McKusick (12), the human Y chromosome contains genes for the testis determining factor (TDF) (17), a zinc-finger protein adjacent to TDF (13), the H-Y antigen, a factor affecting spermatogenesis and, perhaps, a factor affecting stature (23) and tooth size (1). Therman (22) suggested that the Y chromosome in humans seems to be devoid of genes other than those described above.

Kieffer and Cartwright (11) reported that the Y chromosome of Brahman and Santa Gertrudis bulls was acrocentric as opposed to the submetacentric Y that they found in Hereford and Holstein bulls. A number of subsequent studies have shown that most *B. indicus* bulls carry an acrocentric Y and *B. taurus* bulls carry a metacentric Y. Halnan (9) reported that the short arm of the *B. taurus* Y was equivalent to the distal segment of the long arm of the *B. indicus* Y and concluded that the difference between the two types of Y chromosome was due to a pericentric inversion. Figure 9 illustrates how a difference on the Y-chromosome could cause a reciprocal cross effect in bull calves but not in heifers.

Maternal Transmission of Non-Genetic Ova Cytoplasm Components

Oocytes contain an enormous variety of messenger RNA (mRNA) and proteins that are synthesized from the maternal DNA template. Some of them have structural or housekeeping roles in the early embryo, but many play an integral role in development. Dworkin and Dworkin-Rastl (5) gave an extensive review of maternally inherited mRNA. This mechanism is illustrated in Figure 10.

Most of these molecules are relatively short-lived and would not be expected to have a direct effect on the growth rate of the fetus. However, small differences in early development can cause permanent changes in the resulting fetus, as illustrated by the variety of maternally inherited developmental mutants in *Drosophila* (5). Although these mutations cause qualitative defects, less severe genetic differences might cause quantitative differences in fetal growth.

One example is the Oct-3 transcription factor described by Rosner et al. (15). It is expressed in maturing and ovulated oocytes, where it appears to play a role in oocyte maturation. Oct-3 mRNA, transcribed from the maternal genome and inherited through the cytoplasm, is required for the first

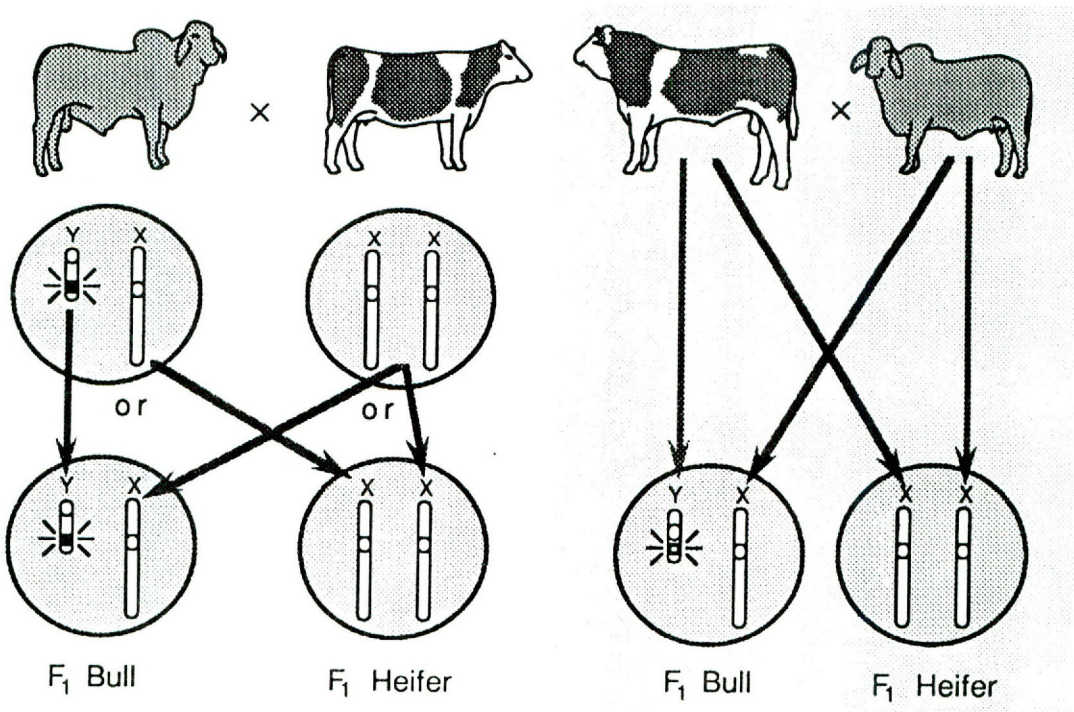

Figure 9. Y-linked inheritance as a potential explanation for the difference between reciprocal cross F_1 calves produced by embryo transfer.

embryonic division in mice. Later, it is transcribed from the embryonic genome in totipotent or pluripotent cells of the early embryo and male and female primordial germ cells, but not in differentiated cells.

Maternal Effect of Oviduct and Uterus of Donor Cow on Embryo Prior to Transfer

It is possible that the reciprocal cross effect could be due to an effect of the donor cow's oviduct and/or uterus on the embryo prior to transfer of the embryo on day 7. Although the embryo is only in the donor cow for a relatively short period of time, the first few days of gestation are quite important in the development of the embryo. This explanation is consistent with the traditional maternal effects model (Figure 11).

Implications

It is important to determine the mechanism responsible for the reciprocal cross effect in ET calves. Once it has been determined, strategies may be developed to allow exploitation of the effect. Effects of the magnitude observed in the preliminary data may provide the potential for significant improvements in production efficiency.

The models used in genetic evaluations are based on a set of assumptions regarding the ways in which genetic and environmental forces interact to yield a phenotype. Mechanisms that would cause a reciprocal cross effect in ET calves violate the assumptions upon which most current genetic evaluations are based. If we are able to determine which mechanisms are involved, we should be able to modify the analysis procedures to more accurately represent the genetic and environmental mechanisms determining phenotype.

Understanding the mechanisms responsible for the reciprocal cross effect in ET calves may lead to the design of crossbreeding programs that are optimized to take advantage of it.

Breed evaluation studies in which breeds are compared only through sires are often interpreted as providing an evaluation of the additive genetic merit of the breeds (if adjusted for differential hybrid vigor). Understanding the mechanisms responsible for the reciprocal cross effect in ET calves should allow for more meaningful interpretation of breed comparison studies.

The next step in this project will be to analyze data on backcrosses and other crosses between *B. indicus* and *B. taurus* cattle to try to determine which mechanism or combination of mechanisms is responsible for the observed reciprocal cross effect in ET calves.

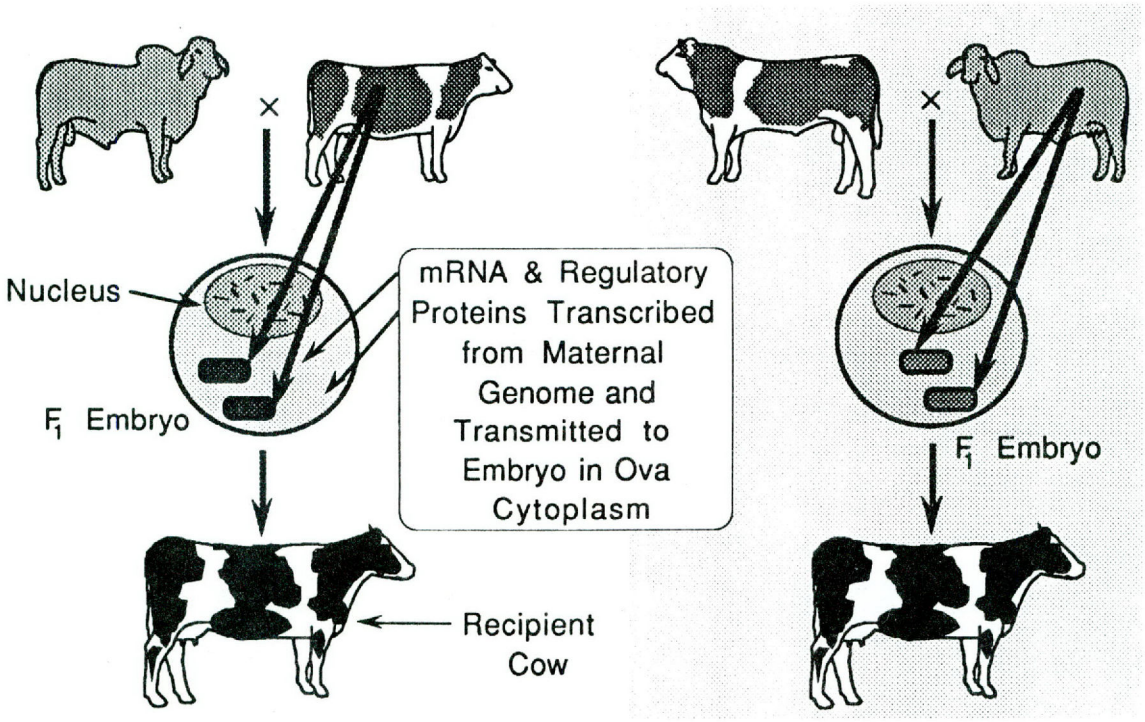

Figure 10. Maternally transcribed mRNA and regulatory proteins as a potential explanation for the difference between reciprocal cross F_1 calves produced by embryo transfer.

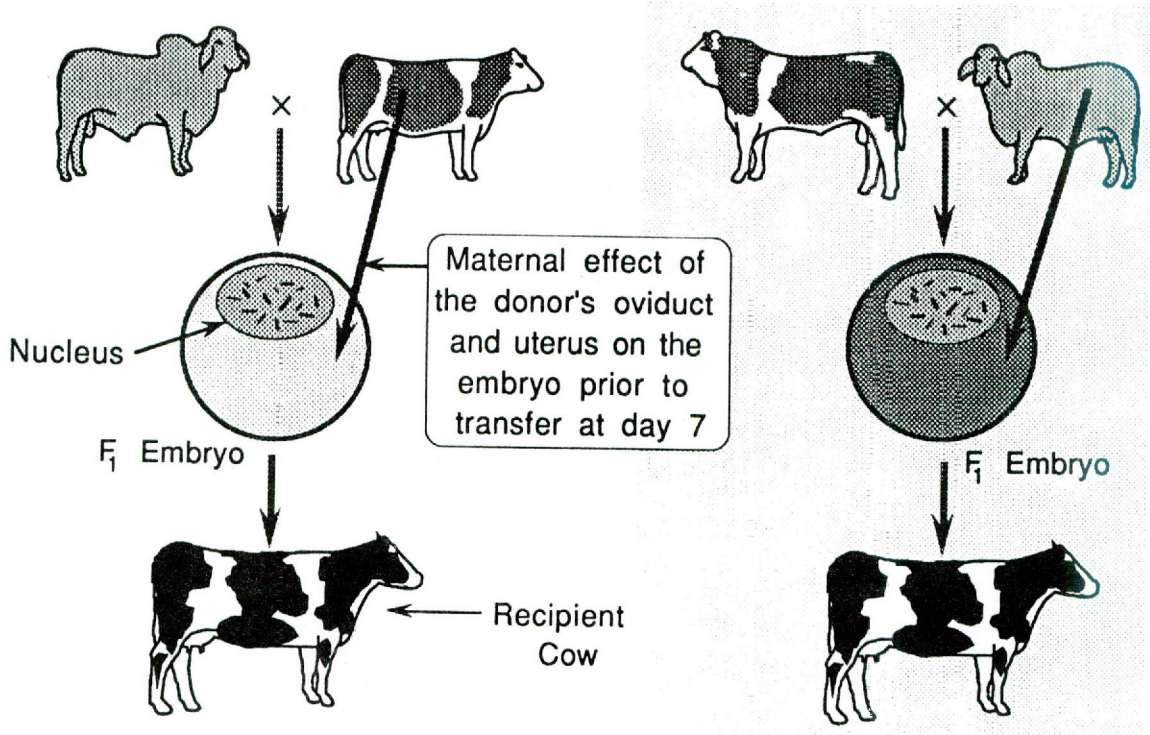

Figure 11. Early embryonic maternal effects as a potential explanation for the difference between reciprocal cross F_1 calves produced by embryo transfer.

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Nonshivering Thermogenesis in *Bos taurus* and *Bos indicus* Newborn Calves

P.C. Mostyn, G.E. Carstens, M.A. Lammoglia, R.C. Vann, J.W. Holloway, and R.D. Randel

Summary

Metabolic heat production was measured in Angus (**A**; n = 5), Brahman (**B**; n = 10), B x A (n = 8), A x B (n = 7), Tuli (**T**) x A (n = 7), and T x B (n = 9) newborn calves prior to (thermoneutral metabolic rate; **TM** rate) and following norepinephrine (**NE**) infusion (peak metabolic rate; **PM** rate). NE-induced PM rate is reflective of nonshivering thermogenesis in brown adipose tissue. At birth, calves were fed pooled colostrum, fitted with indwelling jugular catheters and placed in a temperature-controlled (37°C) water immersion system. Tympanic temperature (**TT**) was measured by inserting a resistance temperature detector probe in the ear canal in close proximity to the tympanic membrane. Metabolic heat production was determined by indirect calorimetry using a ventilated facemask to collect expired air. Mass flowrate, humidity, air and water temperatures, O_2, CO_2, and TT were measured every second and averages recorded at 30-second intervals from 2 to 5 h of age. NE was infused at 35 $\mu g \cdot kg^{-1} \cdot min^{-1}$ for 4 min, ≈ 30 min after immersing the calf in water. Weight-specific TM rate ($ca \cdot kg^{-1} \cdot min^{-1}$) was determined as the average of 10 consecutive readings prior to NE infusion and weight-specific PM rate ($cal \cdot kg^{-1} \cdot min^{-1}$) and peak TT (°C) were determined as the maximal averages of three consecutive readings following NE infusion. Calves born to B dams were 11.8% lighter than calves born to A dams. The B maternal reduction in weight-specific PM rate was greatest for T-sired calves (34.3% decrease in T x B vs T x A), intermediate for B-sired calves (15.3% decrease in B x B vs B x A) and lowest for A-sired calves (4.1% decrease in A x B vs A x A). The B maternal effects on BW and weight-specific PM rate produced even greater reductions in total PM per calf. Peak TT were lower in calves from B dams and were correlated ($P < .001$) to PM rate ($r = .46$). These results indicate that Brahman newborn calves as well as calves born to Brahman dams have lower nonshivering thermogenic capabilities than *Bos taurus* calves. Reduced nonshivering thermogenic capabilities may be one factor which contributes to higher neonatal mortality of calves of *Bos indicus* breeding.

Introduction

Neonatal calf mortality losses are second only to infertility in contributing to low reproductive rates in cattle and present a major biological constraint to improved production efficiency. Reported calf mortality losses from birth to weaning range from 8 to 14%, with most losses occurring during the neonatal period (first several weeks of life) (2, 7). One of the primary factors associated with newborn calf mortality is hypothermia caused by extremely cold ambient temperatures and(or) thermoregulatory dysfunction during the neonatal period. The newborn calf is extremely susceptible to hypothermia, as documented by Josey et al. (4) who found that neonate mortality increased from 2% when ambient temperatures were greater than 52°F (11°C) to 16% when temperatures were less than 36°F (2°C) at the time of birth.

At birth, the newborn calf encounters severe heat loss due to an abrupt change in temperature that is compounded by evaporation of fetal fluids and inclement weather. Maintenance of thermal balance in newborn calves during this period requires an acute and sustained thermogenic response, which is derived from shivering thermogenesis in muscle tissue and nonshivering thermogenesis in brown adipose tissue. Maximal thermogenic responses to cold stress (also referred to as summit metabolism) have been reported (6 and 5, respectively) to be 3.3- and 3.6-fold higher than thermoneutral basal metabolism in newborn calves. It is estimated that roughly half of the cold-induced summit metabolism is derived from nonshivering thermogenesis, therefore it is critical for newborn calves to have functional nonshivering thermogenesis during the early postnatal period to avoid hypothermia and ensure calf survival.

The incidence of neonatal calf mortality relating to cold intolerance appears to be influenced by breed type, as documented by DeRouen et al. (3) who reported neonatal mortality rates within 72 hours of birth of 5, 9 and 19% for Angus, Brangus and Brahman calves, respectively. Thus, *Bos indicus* cattle, known to be less cold tolerant, are more susceptible to neonatal calf mortality than *Bos taurus* cattle. Josey et al. (4) reported that newborn calf mortality rates increased as the percentage of *Bos indicus* breeding increased (3, 3, 8 and 21% for calves with 0, 25, 50 and 75% *Bos indicus* breeding, respectively). The objective of this experiment, therefore, was to assess breed of sire and breed of dam effects on norepinephrine-induced thermogenesis and tympanic temperature in *Bos taurus* and *Bos indicus* newborn calves

Materials and Methods

Experimental Design

Angus (**A**) females located at the Uvalde Research & Extension Center and Brahman (**B**) females located at the Overton Research & Extension Center were mated by artificial insemination to Angus, Brahman and Tuli (**T**) sires to produce the following calf

genotype x maternal breed combinations: 1) purebred A calves from A dams (n = 5), 2) B x A calves born to A dams (n = 8), 3) T x A calves born to A dams (n = 7), 4) purebred B calves born to B dams (n = 10), 5) A x B calves born to B dams (n = 7), and 6) T x B calves born to B dams (n = 9). The Tuli breed is an African *Bos taurus* breed that is subtropically adapted. These matings were made to facilitate calf breed type comparisons, as well as maternal breed (Angus vs Brahman) comparisons of physiological mechanisms associated with nonshivering thermogenesis in newborn calves.

Calf Management

Within 1 hour of birth and prior to suckling, calves were separated from their dams, weighed and fed a pooled colostrum source (30 ml/kg of body weight). At approximately 3 hours after birth, calves were fitted with jugular indwelling catheters for purposes of administering norepinephrine and then placed into a temperature-controlled water immersion system maintained at 37°C. The water level was maintained at the mid-neck of the calves by adjusting an overflow valve. Calves were gently restrained with straps in an upright position by a cradle with their heads resting on a foam-padded support.

Once positioned in the water-immersion system, a temperature probe was inserted into the right ear in close proximity to the tympanic membrane and held in place with prosthetic foam to monitor tympanic temperature changes. Calves were then fitted with a ventilated face mask to collect expired air for measurements of O_2 and CO_2 concentrations to determine metabolic heat production using an open-circuit, indirect-respiration calorimetry system (2). Tympanic and water temperatures along with O_2 and CO_2 concentrations were measured every second, and 30-second averages recorded using a computerized data acquisition system. Following 20 to 30 minutes of stable measurements in the water-immersion system to determine thermoneutral metabolic rate (**TM**), norepinephrine was infused via the jugular catheter at 35 $\mu g \cdot kg^{-1} \cdot min^{-1}$ for 4 min to determine peak metabolic rate (**PM**, $cal \cdot kg^{-1} \cdot min^{-1}$). Peak metabolic rate is proportional to nonshivering thermogenesis and thus reflects brown adipose tissue functionality in newborn animals (1).

Thermoneutral metabolic rate was determined as the average of 10 consecutive readings prior to norepinephrine infusion and PM rate was determined as the maximal average of three consecutive readings following norepinephrine infusion. Thermoneutral and peak metabolic rates were divided by calf birth weights in order to express these measurements on a weight-specific basis ($cal \cdot kg^{-1} \cdot min^{-1}$). PM rate was also expressed as total PM rate per calf ($cal \cdot calf^{-1} \cdot min^{-1}$). Peak tympanic temperature (**TT**, an indicator of hypothalamic temperature) was determined as the maximal average of 10 consecutive readings following norepinephrine infusion. An example of measurements obtained for a Tuli x Angus newborn calf is presented in Figure 1. Data were analyzed by the use of SAS (7). Two-way analysis of variance was used (the model included sire breed, dam breed, and the two-way interaction) to determine treatment differences in norepinephrine-induced metabolic rates and tympanic temperatures in newborn calves. Sex was initially included in the model but was found to be nonsignificant.

Results and Discussion

Calves born to B dams were 11.8% lighter ($P < .01$) than calves born to A dams (Table 1). Metabolic rates measured at rest in thermoneutral conditions (37°C water-immersion system) were similar for all calf breed types.

Calves born to B dams had lower ($P < .001$) weight-specific PM rates than calves born to A dams, but the magnitude of the reduction was breed-of-sire dependant. The B maternal reduction in PM rates was ($P < .001$) greatest for T-sired calves (34.3% decrease in T x B vs T x A), intermediate for B-sired calves (15.3% decrease in B vs B x A) and lowest for A-sired calves (4.1 % decrease in A x B vs A). The B maternal reduction in birth weights and weight-specific peak metabolic rates produced an even greater ($P < .001$) reduction in total PM rates ($cal \cdot calf^{-1} \cdot min^{-1}$). Thermoneutral to weight-specific peak metabolic rate ratios were highest in T x A (2.43) newborn calves (Figure 2), lowest for purebred B and T x B newborn calves (1.66 and 1.80 respectively), and intermediate for purebred A, B x A and A x B newborn calves (Table 1). Peak TT were lower in calves from B dams and were correlated with weight-specific PM rates ($r = .46$; $P < .001$; Figure 3).

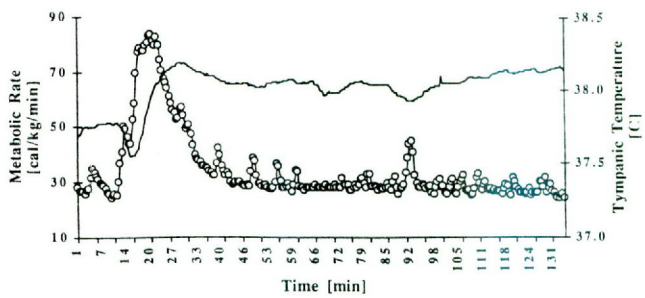

Figure 1. Thermoneutral, and norepinephrine-induced peak metabolic rates (o) and tympanic temperature (line) in a Tuli x Angus newborn calf. Norepinephrine was infused at 10 min on time line.

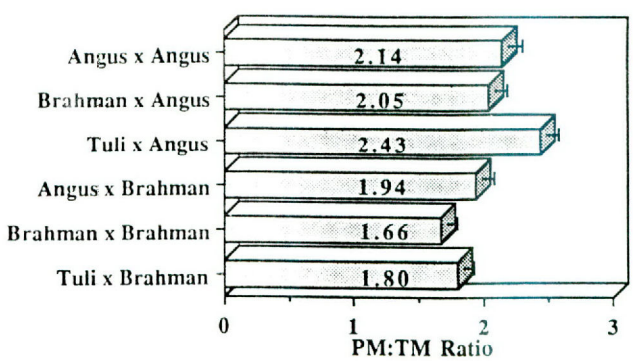

Figure 2. Peak metabolic:thermoneutral metabolic rate ratios in *Bos taurus* and *Bos indicus* newborn calves.

Collectively, these results suggest that Brahman newborn calves as well as calves born to Brahman dams have lower nonshivering thermogenic capabilities than *Bos taurus* calves. Reduced nonshivering thermogenic capabilities may be one factor which contributes to higher neonatal mortality of calves of *Bos indicus* breeding. Future research efforts will focus on quantifying brown adipose tissue in newborn calves and developing management strategies to increase survivability of neonatal calves.

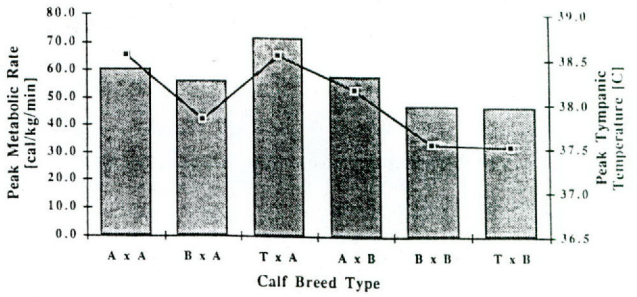

Figure 3. Peak metabolic rates (bars) and peak tympanic temperatures (line) in *Bos taurus* and *Bos indicus* newborn calves (r=.46; P<.001).

TABLE 1. THERMONEUTRAL (TM) AND PEAK METABOLIC (PM) RATES AND PEAK TYMPANIC TEMPERATURES (TT) IN NEWBORN ANGUS- (A), BRAHMAN- (B), AND TULI-SIRED (T) CALVES BORN TO ANGUS AND BRAHMAN DAMS.

	Breedtype (sire, dam breed)						P values			
	AA	BA	TA	AB	BB	TB	Dam	Sire	DxS	SE
BW, kg	34.7	38.1	33.6	32.3	31.5	30.0	0.01	0.23	0.51	2.24
TM rate[a]	28.6	27.6	29.7	30.0	28.9	26.5	0.69	0.92	0.19	1.73
PM rate[a]	60.8	56.3	71.7	58.3	47.7	47.1	0.001	0.01	0.001	3.35
PM:TM ratio	2.14	2.05	2.43	1.94	1.66	1.80	0.001	0.02	0.09	0.112
Total PM rate[b]	2110	2146	2403	1872	1494	1404	0.001	0.40	0.02	148.1
Peak TT	38.54	37.82	38.55	38.16	37.54	37.51	0.01	0.05	0.29	0.323

[a]TM and PM rates, cal•kg^{-1}•min^{-1}.
[b]Total PM rates, cal•calf^{-1}•min^{-1}.

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Carcass and Meats

Determination of Optimum Particle Size for Low-Fat, Precooked Ground Beef Patties

K.W. Lin and J.T. Keeton

Summary

Low-fat (10%) beef patties having various particle sizes, C (Comitrol® flaked), CG (mixture of flaked and ground) and G (coarse-ground) were precooked, frozen and microwave-reheated for sensory, instrumental and compositional evaluations. Treatment G had higher cooking and reheating losses resulting in higher shear values and lower final yield. Additionally, G was harder, denser, more easily fractured and less juicy than other treatments. All treatments were similar in sensory flavor attributes. Treatment C had less reheating loss, lower shear values and higher final yield; however, many of them also showed surface "puffing" and an internal air pocket after microwave reheating which could be a disadvantage. Results indicated that physical shape, size, or density of meat particles played a major role in textural traits, and for optimum yield and textural properties, low-fat, precooked beef patties targeted for the frozen market probably should be manufactured using a Comitrol®-grinding (CG) combination.

Introduction

It has been estimated (9) that by the year 2001 approximately 95% of American families will have at least one microwave oven in the home. Because of this added convenience, frozen, precooked products, such as beef patties, will likely increase in popularity. Cremer (3) found that regular beef patties reheated in a microwave oven had lower scores for appearance, flavor, and general acceptability when compared to patties heated in a convection oven. In addition, lower fat patties (5 to 10%), which are popular with today's consumer, have been shown (Cross et al., 1980) to be firmer, less juicy and less flavorful than regular beef patties containing 20 to 30% fat. Cross et al. (4) demonstrated that patties of the same grind size with 28% fat were significantly more juicy than patties containing 16 to 20% fat. Huffman and Egbert (5) on the other hand compared low-fat beef patties (10%) ground through a 0.19 or 0.13 inch plate and reported no significant differences in juiciness, texture or overall acceptability. However, the combined effects of method of particle size reduction and reduced fat level on the quality of precooked, low-fat, ground beef patties have not been studied. Therefore, this study was conducted to evaluate various means of processing to retain juiciness, tenderness and other sensory/textural characteristics in precooked, microwave-reheated, low-fat ground beef patties.

Materials and Methods

Fresh lean chuck trimmings from steers and cows were trimmed and the fat separated from the trimmed material. Lean and fat trims were ground separately through a 1.5 inch plate and blended (60/40 mix of steer/cow) for 2 min. Samples of lean and fat were taken for fat and moisture determinations using the CEM Moisture/Fat Analysis system. For flaking treatment, half of the lean and fat materials were blast frozen at -40°F, tempered to approximately 25°F and then flaked separately using an Urschel Comitrol® to produce meat flakes of 0.24 inch width. The second half of the lean/fat mix was divided into two portions and separately ground through 0.13 or 0.19 inch grinder plate. The lean/fat mix with 0.13 inch particle size was mixed with equal amounts of flaked material from the Comitrol® treatment. Three treatment combinations were coded as C = Comitrol® flaked size of 0.24 inch; CG = 50/50 mix of flaked and ground meat of 0.13 inch; G = ground meat of 0.19 inch particle size. Batches of 23 lb each were formulated to contain 10% fat, formed into 0.25 lb patties using a Hollymatic® pattymaker and then precooked on a commercial gas grill broiler at ~ 820-840°F to an internal endpoint temperature of 150 ± 2°F. Raw patties from each treatment were randomly taken, vacuum packaged and stored at -4°F for compositional analysis.

One patty for every 9 to 12 patties was randomly designated from each treatment to determine weight and diameter of raw and cooked patties and endpoint temperature. Percent cooking loss and shrinkage were calculated as the differential weight and diameter between individual raw and cooked patties. Cooked patties were individually bagged, vacuum packaged and stored at -4°F until sensory analyses and other evaluations were performed. Treatment combinations were replicated three times on three consecutive processing days.

Preweighed frozen samples were placed individually on porcelain plates covered with microwaveable Saran® wrap, but vented to allow heat ventilation and moisture evaporation. Each plate was placed on a turn table and heated at 70% of maximum power (750 watts) in two similar microwave ovens. Time settings were adjusted so that the patties were heated to a targeted internal temperature of 160 ± 2°F. Each patty was cooled for 4 to 5 min, reweighed and percent heating loss calculated. Four patties from each treatment combination were randomly selected for reheating loss and Allo-Kramer Shear determinations.

Following microwave reheating, two 0.8 x 1.6 inch strips were dissected from one patty for Allo-Kramer Shear measurement (1). Each strip was equilibrated to room temperature, weighed, loaded on to the center of Allo-Kramer Shear cell fitted to an Instron Universal Testing Machine and sheared perpendicular to the strip. Shear force was calculated as kg force/g sample.

Samples were evaluated in duplicate for texture and flavor attributes by a trained, five-member panel (6). Following microwave heating, three patties from each treatment were cut into 0.2 x 0.2 inch cubes, mixed and served to panelists. A Spectrum™ universal intensity scale with 0 = absent and 15 = extremely intense was used.

Frozen patties were thawed and homogenized in a Cuisinart® food processor prior to sampling for analyses. Proximate compositions of raw, precooked and reheated patties were determined in triplicate following AOAC procedures. Crude protein percentage was also analyzed in triplicate by the macro Kjeldahl method.

Sensory flavor/textural data, shear force values and proximate compositions were statistically analyzed as a completely randomized design using the PROC GLM of SAS procedures (8) with panelists and/or processing days (replications) being blocks. Mean separations of main effects were performed using the Duncan's Multiple Range Test method (7) for significance level at $\delta = 0.05$.

Results and Discussion

Proximate compositions of raw, precooked and reheated beef patties are shown in Table 1. The raw fat contents among treatments were close to the targeted level (10%), while treatment C (Comitrol®) contained a slightly higher ($P<0.05$) amount of fat than treatment G (ground meat) by 0.24% which was considered not to be of much practical importance. Moisture contents in raw patties were statistically higher for CG and G than for C although all treatments were numerically similar in raw moisture content. No difference in crude protein content was observed among treatments. Following cooking, fat contents in cooked patties were different ($P<0.05$) among treatments with C being highest, CG (mixture) intermediate and G lowest. On a percentage basis, the fat content of cooked patties increased in treatments C and CG, but G decreased in fat content. This was probably caused by proportionately more fat and less moisture (see cooking loss differences in Table 2) released (by approximately 3.3% on a percent moisture weight basis) during cooking for treatment G resulting in an overall dilution of the total fat content.

Protein content in cooked patties increased after cooking as a result of moisture and fat loss. Microwave reheating of frozen, precooked patties resulted in further moisture and fat (juice) loss causing an increase in both fat and protein content. Final fat content of reheated patties was different ($P<0.05$) among treatments and followed the same pattern as did the cooked patties. Treatment G had the greatest decrease in moisture content by approximately 7% and a corresponding increase in protein by 6%, while C and CG treatments showed a lesser degree of moisture decline and increase in protein content. Generally, flaking has little difference from grinding treatment regarding proximate composition that was in accordance with Chesney et al. (1978).

TABLE 1. PROXIMATE COMPOSITIONS OF LOW-FAT, PRECOOKED BEEF PATTIES AFTER VARIOUS PROCESSING TREATMENTS[a].

Treatment	C	CG	G
Raw			
Fat (%)	10.27 ± 0.36[b]	10.08 ± 0.17[bc]	10.03 ± 0.47[c]
Moisture (%)	70.32 ± 0.14[c]	70.47 ± 0.10[b]	70.58 ± 0.39[b]
Protein (%)	18.63 ± 0.54	18.89 ± 0.18	18.79 ± 0.49
Cooked			
Fat (%)	11.48 ± 0.57[b]	10.20 ± 0.38[c]	8.72 ± 0.33[d]
Moisture (%)	65.30 ± 0.63[d]	66.20 ± 0.66[c]	67.22 ± 0.54[b]
Protein (%)	23.12 ± 0.38[c]	23.50 ± 0.69[bc]	24.01 ± 0.72[b]
Reheated			
Fat (%)	11.75 ± 0.45[b]	10.36 ± 0.52[c]	9.40 ± 0.37[d]
Moisture (%)	61.57 ± 0.59[b]	61.79 ± 0.62[b]	60.30 ± 1.00[c]
Protein (%)	26.47 ± 0.81[d]	27.55 ± 0.44[c]	30.10 ± 0.79[b]

[a] C = Comitrol® of approximately 0.24 inch flake size; CG = 50/50 mix of flaked and ground meat of 0.13 inch particle size; G = ground meat of 0.19 inch particle size.

[bcd] Means ± standard deviations within the same row having unlike superscripts were different ($P<0.05$).

Physical characteristics of precooked beef patties are shown in Table 2. The treatment G had a higher ($P<0.05$) raw patty weight than CG which was also higher than treatment C, while patties of various treatments were not different in cooked patty weight. As a result, percent cooking loss was higher ($P<0.05$) for G in comparison to CG and C which were not statistically different in cooking loss. Raw patty diameter among treatments were numerically similar although statistical significances existed. Cooked patty diameter followed the similar trend as did raw diameter. The raw or cooked patty height (thickness) was not obtained because of the limited time available at the cooking facility; however, the structure of raw patties of G treatment appeared to be less dense than the other treatments. Treatment C appeared to have a more dense,

TABLE 2. PHYSICAL TRAITS OF PRECOOKED BEEF PATTIES.

Traits	C	CG	G
Raw Wt. (g)	113.47 ± 1.24[d]	115.45 ± 1.60[c]	118.01 ± 1.65[b]
Cooked Wt. (g)	88.16 ± 3.40	89.12 ± 4.03	88.35 ± 3.16
Cooking Loss (%)	22.26 ± 3.20[c]	22.83 ± 2.83[c]	25.16 ± 2.20[b]
Raw Dia. (cm)	11.5 ± 0.18[c]	11.5 ± 0.16[c]	11.6 ± 0.21[b]
Cooked Dia. (cm)	9.9 ± 0.23[c]	10.0 ± 0.21[bc]	10.1 ± 0.21[b]
Shrinkage (%)[a]	13.01 ± 2.40	12.49 ± 1.94	12.48 ± 2.61
Cooked Temp (°F)	150.0 ± 4.09	150.5 ± 3.26	151.0 ± 4.27

[a] Shrinkage (%) = [(ave. raw diameter - ave. cooked diameter) ÷ ave. raw diameter] X 100.

[bcd] Means ± standard deviations within the same row having unlike superscripts were different ($P<0.05$).

compact physical structure between the meat flakes even though it had a larger particle size (0.61 cm) than the G treatment (0.48 cm) which had more space between the globular-shaped meat particles. CG, a combination of flake (0.61 cm) and ground (0.32 cm) meat treatment, seemed to be intermediate between the other treatments for density. This could probably explain why the G treatment had a higher cooking loss, followed by CG and C, because juice was less likely to be trapped between meat particles as compared to a matrix. There were no differences in cooked endpoint temperature regardless of treatments but a broad range of standard deviation was noted. This was likely due to inherent variations in shape, density, thickness and compactness of meat particles of patties manufactured from different processes and thus led to uneven heat transfer through the patties during cooking.

Physical and instrumental analyses of precooked-reheated patties after microwave are listed in Table 3. Ground treatment (G) was found to have the greatest decrease in reheated patty weight, CG intermediate and treatment C the least. As a result, treatment C had the least percent reheating loss followed by CG and G. Differences in reheated endpoint temperature were not significant among treatments, although variations were present as explained previously. Treatment G had almost twice (6.9 vs 3.46 kg) ($P<0.05$) the shear force (kg force/g sample) of C and approximately 2.61 kg more than CG, most likely due to greater cooking and reheating losses. Treatment C had the lowest shear value. The final yield percentage was estimated from (mean reheated weight + mean raw weight) and expressed as a percent. Treatment G lost more than 40% of its original weight followed by treatments CG at 37% and C at 32%. Treatment C had the greatest final yield at 68.4% of the raw weight. Based on these results, it seems apparent that particle size, shape and density were major factors contributing to cooking loss, reheating loss and final yield of the three size treatments.

TABLE 3. PHYSICAL AND SHEAR FORCE DETERMINATIONS OF PRECOOKED BEEF PATTIES AFTER MICROWAVE REHEATING.

Measurement	C	CG	G
Cooked Wt. (g)	90.65 ± 2.45	89.94 ± 3.63	89.11 ± 1.69
Heated Wt. (g)	77.09 ± 1.97[d]	73.20 ± 2.37[e]	69.20 ± 1.64[f]
Heating Loss (%)	14.93 ± 2.31[f]	18.55 ± 2.65[e]	22.24 ± 1.84[d]
Heated Temp (°F)	160.0 ± 3.26	161.1 ± 3.85	161.0 ± 3.02
Heating Time (min:sec)	3:16 ± 0:15	3:19 ± 0:22	3:10 ± 0:10
Shear Value (kg/g)[b]	3.46 ± 0.91[f]	4.29 ± 0.35[e]	6.90 ± 0.53[d]
Final Yield (%)[c]	68.35	63.40	58.64

[a] Means of three replications (n = 12).
[b] Means of three replications calculated from the average of two strips from four patties (n = 24).
[c] Estimated Final Yield (%) = (mean reheated wt. + mean raw wt. X 100.
[def] Means ± standard deviations within the same row having unlike superscripts were different ($P<0.05$).

When some patties from treatment C were microwave reheated, the patty surface was "puffed" or raised in the center and a large air pocket was present in the center of patty when cut. Similar observations were also noted for patties processed by CG procedure. No conclusive explanation is given; however, the possibility exists that moisture in the form of ice crystals was trapped tightly within the meat flakes. When heated, the ice or water was converted rapidly to steam and caused the puffed appearance since there was a limited outlet for moisture. Other possible causes of the air pocket, however, have not been ruled out.

The mean scores for sensory texture profile analysis of precooked patties after microwave reheating are shown in Table 4. Differences in springiness scores were not significant ($P<0.05$) among treatments although G tended to be rated higher. Treatments C and CG had similar scores for cohesiveness, juiciness, hardness and fracturability, while G had higher ($P<0.05$) ratings for cohesiveness, hardness, denseness, and fracturability than treatment C. Results did not agree with Chesney et al. (1978) who reported slightly lower juiciness and cohesiveness scores for flaked products than ground product. However, they also found that flaked pork product was more acceptable than ground product. Patties from treatment C were rated juicier and less hard, dense and cohesive than patties from treatment G. Results of textural profiles among treatments were in accordance with shear force values. Overall, textural attributes of precooked patties from CG were intermediate between C and G. These observations again seem to indicate that physical shape, size or density of meat particles played a major role in textural traits of low-fat, precooked, microwave-reheated, beef patties. Results also indicated that patties processed by Comitrol® flaking or a mix of flaked and fine ground (0.32 cm) materials could produce a more acceptable low-fat, precooked beef patties destined for precooked, frozen markets.

Generally speaking, all treatments were very similar in sensory flavor traits (data not shown), even though certain attributes had significant differences in main effects. However, the magnitude of these differences (on a 0 to 15 scale) were so small to not be of practical importance.

TABLE 4. MEAN OF SENSORY TEXTURE PROFILE SCORES OF PRECOOKED BEEF PATTIES.

Attribute[ab]	C	CG	G
Springiness	4.35 ± 0.80	4.46 ± 0.84	4.70 ± 0.81
Cohesiveness	4.62 ± 0.52[d]	4.72 ± 0.54[cd]	4.93 ± 0.69[c]
Juiciness	4.25 ± 0.76[c]	4.03 ± 0.79[c]	3.67 ± 0.85[d]
Hardness	4.45 ± 0.63[d]	4.72 ± 0.55[d]	5.28 ± 1.00[c]
Denseness	5.47 ± 0.67[e]	5.78 ± 0.63[d]	6.40 ± 0.72[c]
Fracturability	2.92 ± 0.46[d]	3.08 ± 0.46[d]	3.55 ± 0.85[c]

[a] 0 = absent and 15 = extremely intense.
[b] Means of three replications from the average of five scores in duplicates (n = 30).
[cde] Means ± standard deviations within the same row having unlike superscripts were different ($P<0.05$).

Conclusion

Results of sensory texture profiles indicated that treatment G (coarse-ground) was less juicy, harder, more dense and required more force to fracture than CG (mix of ground and flaked) and C (Comitrol® flaked) treatments. All treatments were numerically similar in sensory flavor attributes. Patties of treatment CG were very similar to patties made from C treatment regarding cooking loss and sensory texture and flavor traits. Treatment C had lower reheating loss and shear force values but higher final yields; however, it also showed surface "puffing" and an internal air pocket after microwave reheating which could be a disadvantage in comparison to CG treatment. Results also suggested that physical shape, size or density of meat particles played a major role in textural traits of low-fat, precooked, microwave-heated, beef patties. For optimum yield and textural traits, low-fat, precooked beef patties targeted for the frozen market probably should be manufactured using a Comitrol®-grinding combination.

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Live Animal Ultrasound Measurements to Predict Carcass Characteristics and Selection of Optimum Feeding Period to Express Marbling Ability

R. E. Eizmendi, J. O. Sanders, and J. W. Turner

Introduction

The beef cattle industry is in a crucial stage as a dynamic industry. Between 1977 and 1985, 1 out of 7 men and 1 out of 8 women in the United States stopped eating beef (11). Several reasons for this decline are given including the competition from other sources of high quality protein. Therefore, the beef cattle industry is projected to shift form an animal oriented to a consumer or food oriented industry if it wants to remain competitive (3). As this shift takes place, a value based marketing system should be developed (3) which would translate the desires of the consumers back through the marketing chain. As a result, the carcass traits are becoming more economically important. At present, there are no objective methods to determine the value of the carcass from live cattle. Therefore, a proven system for assessing carcass merit before slaughter needs to be generated (8). Fat thickness (FAT), longissimus muscle area (REA), and marbling (MARB) are the most significant carcass traits used to estimate the value of fed cattle (8). Ultrasonography, the use of ultrasonic waves to visualize internal bodily structures and organs, has been reported as a reliable method to evaluate some carcass traits in live cattle.

The objectives of this study were: a) to develop regression models to predict carcass FAT, carcass REA, and carcass yield grade (YGRADE) using real-time ultrasonic measures in live steers; b) to evaluate the estimation of MARB and Quality Grade (QGRADE) by analyzing real-time ultrasonic images using image processing technologies; c) to evaluate the feasibility of finishing steers at the Texas A&M University (TAMU) facilities with the cooperation of the Beef Cattle Science section graduate students; and d) to select the optimum length of feeding that would allow the expression of marbling ability of Brahman cross steers.

Materials and Methods

A set of 40, long yearling steers from the Angleton Research Station was brought to the TAMU facilities at College Station. The steers were of mixed breeding, predominantly three-fourth Angus or Hereford one-fourth Brahman crosses, and represented a cross section of the commercial steer population of the Gulf Coast area (15). The steers received a high energy ration (cracked corn, 66.3%; cottonseed hulls, 15%; cottonseed meal, 10%; salt, 0.5%; Vitamin A premix, 0.25%; ionophores, 1.7%; limestone, 1.25%; molasses, 5%) provided by Producers Co-Op at a weighted average price of $142.53/ton. This ration has a Net Energy Maintenance (NEM) of .821 Mcal/lb and a Net Energy Gain (NEG) of .534 Mcal/lb. The steers were received from the Angleton Research Station on August 27, 1991. Then, the steers were hauled to a small (<5 acres) pasture located directly across from the TAMU Swine Center. The steers had access to fresh grass and water during their first days on pasture. On August 30, 1991, the feeding process started. From day 13 up to the end of the finishing period, the steers had free access to the self-feeder. Every morning and afternoon the steers were examined to identify any possible health problems.

The steers were slaughtered in 4 groups of 10 steers according to the length of the feeding periods of 130, 158, 178, and 187 days. Ultrasound measurements were taken within 8 days before slaughter. A real-time B-mode Aloka 210 (Corometrics Medical Systems, Inc., Wallingford, CT) ultrasound unit equipped with a 3 Mhz probe was used by a trained technician. The scanning area was determined by physical palpation between the 12th and 13th ribs. The variable FAT was measured at a point approximately three-fourths down the length of the ribeye muscle. The image was frozen on the screen and FAT was measured to the nearest .1 cm with an internal electronic caliper. This site was chosen because FAT between the 12th and 13th ribs is the most important measurement to determine carcass USDA yield grade.

A complete image of the longissimus muscle was recorded on standard VHS videotape and later viewed on a monitor. Ribeye muscle was traced on the screen and a planimeter was utilized to calculate REA. The videotapes containing the ultrasonic images were then sent to the Department of Agricultural Engineering (AGEN) where trained technicians used an image processing technique to estimate the amount of intramuscular fat in the longissimus muscle area of the steers.

The Texas A&M University Rosenthal Meat Science and Technology Center (RMSTC) slaughtered the steers using conventional industry procedures. The final weight (LWT) of the steers was recorded immediately before slaughter at RMSTC. The carcasses were chilled for approximately 48 hours. Then, the carcasses were ribbed, measured, and graded by trained personnel using USDA standard procedures. In addition, a steak sample of the longissimus muscle between the 12th and 13th ribs from each steer was taken and sent to the Meat Science Section laboratory for percentage of ether extractable fat (EFAT) determination.

Means (MS), standard deviations (SD), correlation coefficients (R), and Spearman rank correlation coefficients were calculated, regression models were fitted, and backward elimination procedures were used with the statistical software package Statistical Analysis System (SAS, Version 6.07).

Results and Discussion

Pearson correlation coefficients were calculated to identify associations between variables. As expected, there was a high correlation between FAT and YGRADE (r = .87) since FAT is the most important single predictor of YGRADE. Ultrasound fat thickness (USFAT) was moderately correlated with YGRADE (r = .69). Carcass fat thickness and USFAT were highly correlated (r = .81). Carcass fat thickness and USFAT were moderately correlated to final weight (LWT) (r = .55; r = .63). Carcass REA and ultrasound ribeye area (USREA) had a low correlation coefficient (r = .44). Carcass REA and USREA were lowly correlated with LWT (r = .39; r = .02).

Prediction of Carcass Fat

Terry et al. (13); May et al. (8); Turner et al. (16); Henderson-Perry et al. (6); Smith et al. (12); and Perry et al. (10) reported strong correlation coefficients between USFAT and FAT (r = .81 to .94). Smith et al. (12) reported a tendency to underestimate FAT in fatter cattle and overestimate FAT in thinner cattle. The measurements taken in this study agree with those reported by Smith et al. (12). This tendency may be caused by ultrasonic misinterpretation of connective tissue layers within fat tissue of fat animals (12). Furthermore, in the slaughtering process, skinning can modify fat deposits to deviate values from the actual fat present (4).

The simple regression of USFAT on FAT has a coefficient of determination (R^2) of .66. In an attempt to increase the accuracy of fat prediction, a multiple regression model was developed using all the variables of interest (USFAT, USREA, initial weight, LWT, DAYS on feed). Afterwards, a model including the variables USFAT and DAYS was selected as the best possible model. The negative regression coefficient associated with DAYS in the two-variable model was a result of inclement weather during the last part of the study. The inclement weather depressed the steers' feed consumption. As a result, FAT in the last two sets of steers was less than FAT on the previous two sets of steers. This model has a small Mean Square Error (MSE) of .0075 and a high coefficient of determination (r^2 = .72). Therefore, the two-variable model was selected as the most appropriate equation to predict carcass FAT. The final model has the following regression coefficients .2494 (intercept) + 1.0126xUSFAT - .0018xDAYS.

Prediction of Carcass Longissimus Muscle Area

Estimation of REA using ultrasound techniques has not been as accurate as FAT ultrasound estimation (13, 8, 16, 6, 12, 10). Smith et al. (12) reported a tendency to over predict REA for carcasses with an area <11.365 $in.^2$ and under predict REA for carcasses with areas >13.44 $in.^2$. This was observed in the ultrasound REA data collected. Cross (3) reported improper placement of the transducer by the technician, poor image resolution of deep tissues or inaccurate interpretation of the image produced as the possible causes of these low accuracy values. Furthermore, changes in muscle configuration during processing, onset of rigor mortis, and differences in muscle configuration between the standing animal and the hanging carcass may have altered the shape and size of the longissimus muscle affecting the accuracy of ultrasonic estimates (12).

The model including the independent variables USREA and LWT was selected as the best possible model for the prediction of longissimus muscle area (REA). The regression coefficients were: 2.3311(intercept) + .3999xUSREA + .0043xLWT. This final model has a coefficient of determination (R^2) of .35 and a MSE of .6787. However, the accuracy of this multiple regression equation to predict REA is lower than the accuracy of live visual estimates of REA (R^2 = .50) reported by May et al. (8).

Prediction of Carcass USDA Yield Grade

The USDA yield grade equation has been validated as a reliable equation to predict carcass composition (1). Furthermore, beef producers are paid based on USDA yield grade and USDA quality grade when cattle are sold on a carcass basis. Therefore, a regression model was developed to predict USDA yield grade (YGRADE) which included the variables USREA, USFAT, and LWT. The regression equation coefficients were: 1.1139(intercept) + 2.1614xUSFAT - .0915xUSREA + .0018xLWT. The accuracy of this model was moderately high (R^2 = .55) with a MSE of .1623. Accuracy of visual estimation of USDA yield grade (R^2 = .44) reported by May et al. (8) was lower than the accuracy of the selected model (R^2 = .55). Thus, using the model would appear to be a more efficient predictor of YGRADE.

Prediction of Level of Marbling and Quality Grade

The ultrasound images generated during this study were sent to AGEN where they have developed an ultrasound image analysis procedure to estimate the amount of intramuscular fat present in live cattle (PFAT). In order to improve image quality, image enhancement techniques were used to make an image more legible than the original for a particular procedure (14). Biological tissues are far from ideal as mediums for undistorted sound wave propagation. Therefore, an image enhancement procedure should be used to make the ultrasonic images useful for MARB estimation.

Image data analysis was done using image texture analysis procedures. The statistical measures from the image analysis process were entered in a regression model to predict the percentage of EFAT present in the longissimus muscle area. However, the values obtained using this regression

model had no real meaning as direct predictors of the percentage of EFAT present in the REA. In addition, these values were not effective predictors of MARB, EFAT, or QGRADE. However, these numbers may have been used to represent a means to rank the individual steers according to the level of MARB or EFAT.

Spearman rank correlation coefficients of the relationship between steer ranks generated using EFAT, PFAT, and MARB as the ranking variables were calculated. There was no correlation between the ranks generated using the variables EFAT and PFAT (r = -.04). Furthermore, there was no correlation between the ranks developed using the variables MARB and PFAT (r = -.07). Therefore, the application of image analysis procedures to live beef cattle cross sectional ultrasound images produced in this study did not generate reliable estimations of the MARB or EFAT present in the REA of the cattle.

The reason for these meaningless results was that a different type of ultrasound equipment was used to develop this image analysis procedure than that used to scan the steers of this study. That equipment had different image resolution capabilities than the Aloka Model 210 used with this study.

Since the PFAT values provided by AGEN with their ultrasound equipment were not useful to predict the EFAT or MARB present in the REA of the live steers, the variables USFAT, DAYS, and LWT were used to develop a regression model to predict MARB. The variable USFAT was included in the model since there is a positive correlation of r = .40 between subcutaneous fat and MARB. The regression coefficients of the independent variables included in this model were not significant (P > .15). Furthermore, the best possible model had a low coefficient of determination (R^2 = .18). Therefore, it was not possible to develop a reliable predictive model to estimate the amount of MARB in the REA of live steers. Consequently, no model could be developed to estimate QGRADE since the most important factor to determine QGRADE is the amount of MARB present in the REA.

Feeding Process

The main goal of the pilot project was to identify the marbling ability; therefore, the steers had to be fed to the point where their marbling ability was fully expressed.

Cattle finishing performance data are shown in Table 1. Overall feeding performance was slightly lower than the expected optimum industry performance. The highest group mean ADG (2.48 lb) was just .21 lb lower than the ADG reported by Mies and Summers (1980) for steers fed a ration with similar levels of processing. Yet, long yearling steers ADG is usually higher than the ADG recorded in this study (9). This was expected due to the ration with a higher level of roughage than a common feedyard ration (15% cottonseed hulls). The use of a self-feeder was dictated by management restrictions.

As shown in Table 1, Group 1 and Group 2 had the highest ADG of 2.34 lb/d and 2.48 lb/d, respectively. Group 3 and Group 4 ADG were 1.96 lb/d and 1.84 lb/d, respectively. Group 2 had the best feed conversion (FC) of 11.23 lb feed/lb gain, followed by Group 1 FC with 12.37 lb feed/lb gain, Group 4 with 14.74 lb feed/lb gain, and lastly, Group 3 with 15.05 lb feed/lb gain. A similar pattern was noted for cost of gain with G2 having the lowest ($.79/lb), followed by G1 ($.87/lb), Group 3 ($1.06/lb), and G4 the highest with ($1.08/lb).

The low performance of G3 and G4 in Table 1 can be explained by the adverse conditions existing after G2 was slaughtered. At that time, the condition of the ground surrounding the self-feeder declined due to large amounts of rainfall received and mud became a significant problem. Furthermore, due to the smaller number of steers eating from the self-feeder, as groups were slaughtered, the same feed remained exposed to the high relative humidity for longer periods of time. Consequently, microbial fermentation caused the smell and flavor of the feed to become somewhat rank. The steers refused to eat until this fermented feed was removed and new feed was put into the feed bunks. In addition, large numbers of birds were feeding off the self-feeder bunk, eating primarily the grain component of the ration. Therefore, the combination of these factors lowered feed consumption, which in turn, stopped the fattening process and reduced the body condition and finishing of the steers.

Table 2 shows the carcass traits of the steers in the different feeding periods. Carcass FAT was significantly different between groups (P<.05) with Group 2 having the most carcass FAT. Yield grade by group differed by as much as .54 of a yield grade (P<.10). Due to its carcass FAT, G2 had the highest YGRADE (3.47). The lowest average YGRADE (2.93) was found in G4.

Table 2 indicates that all the steer carcasses were classified as A maturity. Carcass QGRADE is determined by the carcass sex class, maturity, degree of MARB in the REA, and firmness of the lean. Therefore, for these carcasses, differences in QGRADE were based on the amount of MARB present in the REA. All the carcasses graded either Choice (55%) or Select (45%) with no carcasses in the Standard grade or the Prime grade. G3 had the highest percentage of Choice carcasses (70%) followed by G2 with 60%, G4 with 50%, and lastly, G1 with 40%.

The feeding performance obtained with this pilot set of steers justified the procedure of finishing the steers within

TABLE 1. FINISHING PERFORMANCE AND ECONOMICS BY GROUP.

	Steer Groups			
Item	G1	G2	G3	G4
Initial Wt (lb)	781	759	770	799
Final Wt (lb)	1,097	1,152	1,120	1,143
Days on feed	130	158	178	187
Daily Gain (lb)	2.43[a]	2.48[a]	1.96[b]	1.84[b]
Feed/Gain	12.37[ab]	11.23[b]	15.05[a]	14.74[a]
Cost/Gain ($/lb)	0.87[ab]	0.79[b]	1.08[a]	1.06[a]

[ab]Means in the same row with different superscripts differ (P < .05).

TABLE 2. CARCASS TRAITS BY GROUP.

Item	Steer Groups			
	G1	G2	G3	G4
Carcass Wt (lb)	703	744	720	748
Fat Thickness (in)	.40[a]	.58[b]	.41[a]	.41[a]
Ribeye Area (in²)	11.46	11.79	11.80	12.01
KPH (%)	2.30	2.38	2.43	2.00
Yield Grade	2.95[c]	3.47[d]	2.97[c]	2.93[c]
Marbling[e]	185	214	230	201
Maturity	A	A	A	A
Quality Grade (% Choice)	40	60	70	50
Ether extract. fat (%)	4.89	5.46	4.80	4.39

[ab]Means in the same row with different superscript differ (P < .05).
[cd]Means in the same row with different superscript differ (P < .10).
[e] 100 - 199 = Slight marbling; 200 - 299 = Small marbling.

TAMU facilities. Group 2 had the highest ADG and best FC; although they did not produce the largest number of Choice carcasses, this group had the highest percentage of EFAT. The performance, or ADG, of G2 was only slightly lower than the performance reported by Barnes and Lusby (2) for cattle of similar breeding composition (2.48 lb/d vs. 2.70 lb/d respectively). Group 3 had the highest percentage of Choice carcasses, but its cost of gain was 35% higher than G2 cost of gain ($1.08/lb vs. $.79/lb), along with G3 FC being 34% less efficient than G2 FC (15.05 lb feed/lb gain vs. 11.23 lb feed/lb gain). In addition, G3 feeding period was 12.7% longer than G2 feeding period (178 days vs. 158 days).

The feeding period of G2 (158 days) was recommended as the optimum length of feeding. The 158 day period represents the best balance between the economic feasibility and desired carcass characteristics.

Conclusion

One of the priorities in the implementation of a value based marketing system is the development of a reliable live cattle carcass assessing technique. Ultrasound scanning of live cattle is one of the most appealing live animal evaluation procedures because of ease of use, low cost, and fast application. The prediction models developed in this study accurately predicted carcass FAT (R^2 = .72) and USDA yield grade (R^2 = .55). However, prediction of REA (R^2 = .35) was not as accurate as FAT and USDA yield grade estimation. Further improvement of scanning procedures will be required to increase the accuracy of REA prediction. Estimation of MARB and EFAT content in the longissimus muscle area using the image analysis procedure was not feasible as actual data was unacceptably transformed and was not a true representation.

Feeding the pilot project steers at TAMU facilities was established to be feasible. Although the feeding performance of the steers was lower than the industry standards, the marbling ability of the steers was expressed. Furthermore, the advantage of fully controlling the feeding process and having access to the steers at any time for sampling purposes, compensated for the feeding performance. The feeding period of 158 days was selected as the optimum length of feeding. Steers fed for this period of time had the best feed conversion, highest average daily gain, and lowest cost of gain. Furthermore, 60% of their carcasses graded Choice.

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National Beef Quality Audit: I. Survey of Carcass Quality/Quantity Attributes

C.L. Lorenzen, D.S. Hale, D.B. Griffin, J.W. Savell, K.E. Belk, T.L. Frederick, M.F. Miller, T.H. Montgomery, and G.C. Smith

Summary

To assess the then-current population of fed beef cattle for quality defects, the federally inspected beef steer and heifer slaughter in 28 packing plants was surveyed during a 3-month period (October to December, 1991). Data were collected in each plant over the course of 1 day production at chain speed. Carcasses were selected randomly to include 10% of each lot in the cooler. USDA grade factors and other data were collected in the cooler. Means for the carcass traits were as follows: USDA yield grade, 3.1; hot carcass weight, 760 lb; adjusted fat thickness, .6 in; ribeye area, 12.9 in^2; kidney, pelvic, and heart fat, 2.2%; USDA quality grade, high Select; marbling score, Small-minus; and overall maturity, A^{69}.

Introduction

The National Beef Market Basket Survey (6) and the National Beef Tenderness Survey (3) documented wide variation in beef composition and palatability traits at the retail level in the United States. In addition, Savell et al. (7) found that consumers consider retail cuts with excessive external fat wasteful, low in taste and unhealthful. The last USDA Market Consist Report, which examined USDA beef grade factors, was conducted in 1973 - 1974 (9). Over the 17 yr since that study, the beef industry has seen numerous changes ranging from the influence of Continental European breeds to the diet/health concerns of consumers. The primary question exists - has beef changed significantly over this time?

Materials and Methods

The federally inspected beef steer and heifer slaughter population in 28 packing plants was surveyed over a 3-mo period (October to December, 1991). Packing plants were chosen to represent the various geographical regions of the United States, have a minimum slaughter capacity of 1,000 head/d, and to collectively encompass 80% of the federally inspected slaughter.

Approximately 10% of each slaughter lot (n = 7,375), with a minimum of two head per lot, was selected randomly and evaluated for USDA yield and quality grade factors (8) by trained and experienced carcass evaluators from Texas A&M University and Texas Tech University.

Statistical analyses were performed to generate means and frequency distributions (5). Data from the present study were compared to the 1974 USDA Market Consist Report using a t-test in which the error terms were pooled (4).

Results and Discussion

Means for USDA yield grade (YG) traits were as follows: USDA Yield Grade, 3.1; carcass weight, 760 lb; adjusted fat thickness, .6 in; ribeye area, 12.9 in^2; and kidney, pelvic, and heart fat percentage, 2.2 (Table 1). When compared with data from the USDA Market Consist Report of 1974, these data indicated a numerical decrease ($P < .05$) of .3 in USDA Yield Grade, .03 in. less adjusted fat thickness and .8% less kidney, pelvic, and heart fat. In addition, ribeye area increased by 1.1 in^2 and hot carcass weight increased by 81.1 lb ($P < .05$).

Of the carcasses sampled, 10.0% were YG 1, 33.9% were YG 2, 39.6% were YG 3, 13.6% were YG 4, and 2.9% were YG 5. According to Abraham et al. (1), adjusted fat thickness accounted for 67% of the variation in the yield of boneless, closely trimmed retail beef cuts. May et al. (2) found that 12th-rib fat thickness was one of two traits having the greatest impact on boneless subprimal yield and the production of trimmable fat. Savell et al. (7) concluded that consumers in the United States find external fat to be undesirable and prefer closely-trimmed beef cuts at the retail level. The National Beef Market Basket Survey (6) documented the mean external fat cover on retail cuts to be .12 in; according to the current

TABLE 1. MEANS, STANDARD DEVIATIONS, AND MINIMUM AND MAXIMUM VALUES FOR USDA CARCASS GRADE TRAITS.

Trait	Mean	S.D.	Minimum	Maximum
USDA Yield Grade	3.1	0.9	-0.8	7.2
USDA Quality Grade[a]	686	60	213	900
Adjusted Fat Thickness (in)	0.6	0.2	0.0	1.8
Carcass Weight (lb)	760.0	94.4	382.3	1196.0
Ribeye Area (in^2)	12.9	1.6	7.3	22.7
Kidney, Pelvic, and Heart Fat (%)	2.2	0.7	0.0	6.0
Marbling Score[b]	424	106	140	1000
Lean Maturity[c]	163	19	110	330
Skeletal Maturity[c]	175	29	100	470
Overall Maturity[c]	169	21	110	430

[a] 100 = Canner^{00} and 800 = Prime^{00}
[b] 100 = Practically Devoid^{00} and 900 = Abundant^{00}
[c] 100 = A^{00} and 400 = D^{00}

study, only 11.0% of the carcasses had <.31 in. 12th rib fat thickness. Thus, the current slaughter cattle population is still too fat.

Mean USDA Quality Grade traits were as follows (Table 2): Quality Grade, Select[86]; marbling score, Small[24]; lean maturity, A[63]; skeletal maturity, A[75]; and overall maturity; A[69]. A statistical comparison between this study and the USDA (1974) consist study showed a reduction ($P < .05$) in marbling score from Small-plus to Small-minus. There was a 5% incidence of dark-cutting carcasses that partially explained the difference between the mean marbling score (Small[24]), which corresponds to the minimum marbling requirement for low choice, and the Select[86] grade observed in this study.

The frequency distribution for Quality Grades (data not shown) was as follows: Prime, 2.3%; Choice, 52.7%; Select, 36.9%; Standard, 7.6%; Commercial, .2%; Utility, .1%; and Canner, .2%; in the sampled population. Marbling scores of Small and Slight, as shown in Table 3, comprised 73.6% of the sample. Of the cattle in the USDA Choice grade, 67.6% had a marbling score of Small (Table 3). When compared to the 1974 quality grade data, the percentage of carcasses graded USDA Prime and Choice has declined by 20%, 54% in 1991, versus 74% in 1974.

Distribution of carcasses across USDA quality and yield grades in 1991 is depicted in Table 4. The majority of the carcasses were of Choice, YG-2; Choice, YG-3; Select, YG-2, and Select, YG-3. Close to one-fourth (24.2%) of the carcasses in this study were YG-4 and YG-5 or had Standard or lower USDA Quality Grades.

Change in population distribution since 1974 is presented in tables 3 and 4. The trend has been an increase in YG-1 and YG-2 with a decrease in Prime and Choice carcasses. In addition, carcass weights have increased over the past 17 yr.

Cattle have increased in size, remained equal in mean 12th rib fatness, but have not maintained marbling levels indicating shifted growth patterns in the cattle population over the last 17 yr. The shift in distribution of USDA yield grades, quality grades and hot carcass weight since 1974 reflect a shift in the genetic base.

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TABLE 2. PERCENT DISTRIBUTION OF CARCASSES; STRATIFIED BY USDA QUALITY AND YIELD GRADES.[a]

	Prime	Choice	Select	Standard	Commercial	Utility	Cutter
YG 1	0.05	2.44	4.60	2.12	0.01	0.01	0.00
YG 2	0.47	16.15	14.40	3.03	0.04	0.04	0.01
YG 3	0.99	22.93	13.76	2.14	0.08	0.10	0.00
YG 4	0.56	9.24	3.60	0.30	0.00	0.30	0.00
YG 5	0.19	2.11	0.57	0.05	0.00	0.05	0.00

[a]Carcasses with missing values for USDA Quality or Yield Grades are not included.

TABLE 3. FREQUENCY DISTRIBUTION (%) OF USDA YIELD GRADE IN 1974 VS 1991.

USDA Yield Grade	1974	1991	Net Change
1	4.1	10.0	+ 5.9
2	25.7	33.9	+ 8.2
3	43.9	39.6	- 4.3
4	20.5	13.6	- 6.9
5	5.8	2.9	- 2.9

TABLE 4. FREQUENCY DISTRIBUTION (%) OF USDA QUALITY GRADE IN 1974 VS 1991.

USDA Yield Grade	1974	1991	Net Change
Prime	6.6	2.3	- 4.3
Choice	68.0	52.7	- 15.3
Select	21.3	36.9	- 15.6
Standard	3.9	7.6	+ 3.7

National Beef Quality Audit: II. Survey of Livestock-Related Defects at Slaughter

C.L. Lorenzen, D.S. Hale, D. B. Griffin, J.W. Savell, K.E. Belk, T.L. Frederick, M.F. Miller, T.H. Montgomery, and G.C. Smith

Summary

To assess the then-current population of fed beef cattle for quality defects, the federally inspected beef steer and heifer slaughter in 28 packing plants was surveyed during a 3-month period (October to December, 1991). Data were collected in each plant over the course of 1 day of production at chain speed. Carcasses were selected randomly to include 50% of each lot as it was processed on the slaughter floor. Slaughter floor defects evaluated were brand location and size; degree of bruising, grubs and injection sites; condemnation of offal; and the presence of mud and horns. The distribution of hot-iron brand scars on the hide for the sample was as follows: cattle with no brand, 55.0%; cattle with butt brands, 29.9%; cattle with side brands, 13.8%; and cattle with shoulder brands, .8%. In addition, 83.3, 85.6, 76.6, 97.3, 99.9, and 99.8% of the carcasses had no superficial bruising in the chuck, rib, loin, round, brisket and other areas of the carcass, respectively. The incidence of viscera condemnations for livers, lungs, tripe and total viscera were 19.2, 5.1, 3.5, and 0.1%, respectively.

Introduction

The 1991 National Beef Quality Audit was conducted to serve as a benchmark as to what kind of product the beef industry is producing and identify quality defects that occur because of producer-related management decisions and practices. This phase of the audit dealt with in-plant surveys of the quality attributes associated with livestock and their conversion to carcass form.

Materials and Methods

The federally inspected beef steer and heifer slaughter population in 28 packing plants was surveyed over a 3-mo period (October to December, 1991). Packing plants were chosen to represent the various geographical regions of the United States, have a minimum slaughter capacity of 1,000 head/d, and collectively encompass 80% of the federally inspected slaughter.

Approximately 50% of each slaughter lot was evaluated separately for hide defects (n = 32,265), viscera condemnation (n = 37,925), head and tongue condemnation (n = 30,646), and bruising (n = 37,002). To quantify hide defects, the approximate size and location of hot-iron brand scars on the hide were recorded by primal region on the animal as it was hanging in the exsanguination area. Additionally, the presence of horns and mud was determined. Mud scores were evaluated on a four-point scale: 0 = no mud, 1 = minimal, 2 = some, and 3 = heavy mud.

Viscera (liver, lung, tripe and total viscera), head and tongue condemnations were recorded along with the reason for condemnation provided by USDA Food Safety and Inspection Service personnel within each plant. The occurrence of fetuses also was noted. Severity of bruising, obvious injection-site blemishes, and grub damage were scored on a scale of 0 to 9 where: 0 = no defect, 1 = minor $^{-}$, 5 = major^{o}, and 9 = critical^{+} defects.

Statistical analyses were performed to generate means and frequency distributions (2).

Results and Discussion

Branding scars occurred as follows: cattle with no brands, 55.0%; cattle with butt brands, 29.9%; cattle with side brands, 13.8%; and cattle with shoulder brands, .8%; (Table 1). More than one brand per animal was found in 2.1% of the population (data not shown). Data in Table 1 provide mean brand size for cattle with brands and illustrate the wide variation in branding techniques currently used in the United States. Side brands tended to be the largest brands observed and would cause the greatest amount of the hide to be downgraded due to both reduced size of unaffected hide, and particularly location (1). In addition to brands, 31.1% of the cattle surveyed had horns (which could contribute to bruising and must be removed before the hide can be pulled over the head) and 6.8% received a mud score (mud contributes to increased contamination during slaughter/dressing and to decreased dressing percentage) of ≥ 1.

TABLE 1. CHARACTERISTICS OF BRANDED HIDES.

Brand Site	Brand Size				
	% of Sample[a]	Mean (in^2)	SD	Minimum (in^2)	Maximum (in^2)
Shoulder	0.8	22.5	18.4	1.0	146.0
Side	13.8	47.2	43.5	3.0	450.0
Butt	29.9	17.2	16.5	2.0	200.0

[a]55.0% of the sample had no brand.

The incidence of viscera condemnations for livers, lungs, tripe and total viscera were 19.2, 5.1, 3.5, and 0.1%, respectively. The incidence of liver condemnations in this study agreed with the 19.3% reported by the USDA in its 1989 Statistical Summary (4). Abscesses accounted for 72.7% of condemned livers, 53.6% of condemned lungs, and 87.6% of condemned tripe. Among heifers studied, there was a 2.7% incidence of fetuses. For all carcasses, 1.1% of the heads and 2.7% of the tongues were condemned. Fourteen out of 37,002 carcasses (.04%) observed were condemned for reasons of pathology (example: pneumonia, toxemia, etc.).

Mean bruise severity (data not reported in tabular form) in the chuck and loin was "minor-minus," with the means for rib, round, brisket, and other carcass locations equal to "no bruise" (< 1). Occurrence of none, one, two, three, or four bruises was 60.8, 25.0, 10.6, 3.5, and .2%, respectively. In addition, of all cattle reviewed; 83.3, 85.6, 76.6, 97.3, 99.9, and 99.8% of the carcasses had no superficial bruising in the chuck, rib, loin, round, brisket, and other areas of the carcass, respectively. Superficial grub and visible injection-site damage (data not shown) had means equal to "no defect" (< 1). Grub damage was noted in the rib, loin, and chuck at a rate of .5, 3.4, and .1%, respectively. Grub damage was not detected in other areas of the carcass. Koeppen (1) documented increased grub damage to hides (from 3 to 7%) since 1988 and suggested that much of the down-grading of hides is due to insect- and parasite-inflicted damages. Surface detection of injection-site blemish damage was noted at a frequency of .3% in the chuck, but was not detected in other areas of the carcass (data not presented in tabular form). Smith (3) reported a 14 to 22% incidence of injection-site blemishes in the top sirloin; therefore, it would seem that visual inspection of carcass surfaces for injection-site blemishes is ineffective.

In conclusion, it would appear that the beef cattle industry potentially can recoup value loses that result because of producer related management decisions. For example, significant economical savings would result if cattle producers relocated their brand from the side of the animal to the shoulder or butt area.

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Obtaining Nutrient Composition Data for Those Beef Retail Cuts Not Presently in USDA Agriculture Handbook 8-13

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Summary

Nutrient composition data were collected for 10 beef retail cuts. The cuts included Chuck Clod Roast, Chuck Clod Steak, Chuck Tender Steak, Chuck Top Blade, Inside Skirt Steak, Outside Skirt Steak, Tri-tip Roast, Tri-tip Steak, T-Bone Steak, and Porterhouse Steak. These cuts were not included in earlier versions of the Agriculture Handbook 8-13 and were selected from the newer variations of traditional cuts as having the highest priority for nutrient analyses by representatives of the National Live Stock and Meat Board, USDA, and Texas A&M University. Nutrient composition was not available for these cuts; therefore, proximate, fatty acid, cholesterol, and mineral analyses were conducted.

For many of the cuts, a 3 1/2 oz (100 g) portion has fewer than 200 total calories. Select cuts were generally lower in fat than Choice cuts, and removing external fat before cooking usually decreased total fat. This is extremely valuable information since USDA will be incorporating this data into the Agriculture Handbook, which will be used as the database for nutrition labeling.

Introduction

With up-to-date nutrition composition data, the beef industry will be able to show its continued efforts to provide retail cuts that meet consumer demands as well as health professionals' recommendations. It is imperative that the beef industry have information available for dietitians, nutritionists, government agencies, and other users of nutrient information. The USDA recently updated the Agriculture Handbook 8-13 (4) to include data that reveals beef is leaner than offered previously. However, the 1990 handbook only includes 22 retail cuts. According to data collected in the National Beef Market Basket Survey (3) and in the National Beef Tenderness Survey (2), there are some new retail cuts available in today's marketplace. The new cuts have been developed to help remove unwanted intermuscular fat and to help provide leaner and more closely trimmed beef retail cuts to consumers. The evolution of these new retail cuts has provided a greater number of retail cuts for consumers to choose from, but it also has limited the usefulness of the present Agricultural Handbook 8-13. Therefore, the handbook must be revised to include all retail cuts that are available in the marketplace today. These retail cuts include: Chuck Clod Roast, Chuck Clod Steak, Chuck Tender Steak, Chuck Top Blade, Inside Skirt Steak, Outside Skirt Steak, Tri-tip Roast, and Tri-tip Steak. The T-Bone Steak and Porterhouse Steak are included in the 1990 Handbook 8-13, but there are insufficient data for these cuts with 1/4 inch or less external fat trim.

Material and Methods

Nutrient composition data for Chuck Clod Roast, Chuck Clod Steak, Chuck Tender Steak, Chuck Top Blade, Inside Skirt Steak, Outside Skirt Steak, Tri-tip Roast, Tri-tip Steak, T-Bone Steak, and Porterhouse Steak were analyzed to update the USDA Agriculture Handbook 8-13. Cattle used to obtain the retail cuts were from Colorado and Texas, were representative of the market, and included Choice and Select, Moderate through low Slight marbling scores, and Steers and Heifers of Yield grades 2 and 3 (Table 1).

The cuts were assigned to one of the following treatments: (1) raw, trimmed to 1/4 inch; (2) trimmed to 1/4 inch external fat, then cooked; and (3) trimmed to 0 inch external fat, then cooked. All dissection was done by trained personnel to produce data for separable lean, separable fat, and heavy connective tissue and bone. The cuts assigned to cooking were prepared according to the methods prescribed in the American Meat Science Association (1) guidelines. Cooking yields were obtained.

The following nutrients were analyzed and the results are presented in tabular form for each retail cut (and for quality grade when the particular cut is normally sold as Choice or Select): (1) Proximate—Protein, Total Lipid, Food Energy, Moisture, and Ash; (2) Cholesterol, (3) Fatty Acids—Saturated (12:0-18:0), Monounsaturated (14:1, 16:1, 18:1), and Polyunsaturated (18:2, 18:3, and 20:4), and (4) Minerals—Calcium, Copper, Iron, Magnesium, Phosphorus, Potassium, Selenium, Sodium and Zinc (Table 2).

Results and Discussion

For many of the cuts, total calories were lower than 200 per 100 grams (3 1/2 ounces). In general, Select cuts were lower in fat and had less calories than Choice cuts. Cooking cuts such as the T-bone and Porterhouse with the external fat removed caused a slight decrease in fat content and total calories compared to cooking cuts with the fat still attached (Table 3).

USDA will now have this information so they can update the Agriculture Handbook 8-13 to reflect the variety of cuts available in the marketplace.

TABLE 1. BEEF RETAIL CUT COMPOSITION (3 1/2 OZ COOKED PORTION), SEPARABLE LEAN ONLY, USDA CHOICE.

	Water g	Food Energy kcal	Protein g	Total Lipid g	Saturated Fatty Acids g	Monounstaurated Fatty Acids g	Polyunsaturated Fatty Acids g	Cholesterol mg
Chuck Tender Steak, Broiled, Trimmed 0"	65.59	161.23	25.74	5.69	1.71	2.71	0.40	65.44
Chuck Top Blade, Broiled, Trimmed 0"	61.63	216.57	26.11	11.65	3.62	5.73	0.41	56.70
Clod Steak, Broiled, Trimmed 0"	59.42	192.98	29.52	7.42	2.12	3.56	0.28	63.19
Clod Steak, Broiled, Trimmed 1/4"	58.47	199.63	29.62	8.11	6.88	4.08	0.30	63.48
Clod Roast, Braised, Trimmed 0"	64.39	171.15	25.95	6.69	1.96	3.51	0.25	63.81
Clod Roast, Braised, Trimmed 1/4"	64.95	178.29	26.10	7.41	2.38	3.90	0.29	55.55
Porterhouse Steak, Broiled, Trimmed 0"	59.13	224.38	25.51	12.80	4.93	7.60	0.41	65.12
Porterhouse Steak, Broiled, Trimmed 1/4"	60.36	213.91	24.98	11.89	4.52	6.79	0.41	66.26
T-Bone Steak, Broiled, Trimmed 0"	62.50	197.62	25.98	9.61	3.27	4.67	0.32	59.58
T-Bone Steak, Broiled, Trimmed 1/4"	62.05	200.75	26.10	9.90	3.80	5.41	0.31	53.38

TABLE 2. BEEF RETAIL CUT COMPOSITION (3 1/2 OZ COOKED PORTION), SEPARABLE LEAN ONLY, USDA SELECT.

	Water g	Food Energy kcal	Protein g	Total Lipid g	Saturated Fatty Acids g	Monounstaurated Fatty Acids g	Polyunsaturated Fatty Acids g	Cholesterol mg
Chuck Tender steak, Broiled, Trimmed 0"	67.26	156.86	26.13	5.02	2.00	2.46	0.28	59.38
Chuck Top Blade, Broiled, Trimmed 0"	64.32	183.86	26.16	8.00	2.71	3.33	0.31	65.74
Clod Steak, Broiled, Trimmed 0"	60.29	191.38	30.37	6.84	2.48	3.20	0.32	65.28
Clod Steak, Broiled, Trimmed 1/4"	60.89	182.71	29.08	6.49	2.49	3.29	0.35	56.04
Clod Roast, Braised, Trimmed 0"	64.21	172.44	28.09	5.82	2.15	2.92	0.34	72.19
Clod Roast, Braised, Trimmed 1/4"	64.87	166.36	26.75	5.78	1.80	2.41	0.29	63.59
Porterhouse Steak, Broiled, Trimmed 0"	62.19	194.29	26.89	8.81	3.28	3.76	0.37	58.28
Porterhouse Steak, Broiled, Trimmed 1/4"	60.65	203.19	27.20	9.65	4.23	4.81	0.55	58.07
T-Bone Steak, Broiled, Trimmed 0"	63.73	177.41	26.00	7.36	2.95	3.48	0.39	54.86
T-Bone Steak, Broiled, Trimmed 1/4"	61.54	197.51	27.35	8.95	3.34	3.91	0.33	54.92

TABLE 3. BEEF RETAIL CUT COMPOSITION (3 1/2 OZ COOKED PORTION), SEPARABLE LEAN ONLY, ALL GRADES.

	Water g	Food Energy kcal	Protein g	Total Lipid g	Saturated Fatty Acids g	Monounstaurated Fatty Acids g	Polyunsaturated Fatty Acids g	Cholesterol mg
Inside Skirt Steak, Broiled, Trimmed 0"	61.77	199.44	26.66	9.49	3.85	5.22	0.36	59.03
Outside Skirt Steak, Broiled, Trimmed 0"	59.17	232.87	24.18	14.37	5.97	7.38	0.60	57.61
Tri-tip Steak, Broiled, Trimmed 0"	51.67	249.71	30.68	13.16	4.87	6.93	0.46	67.23
Tri-tip Roast, Braised, Trimmed 0"	61.80	207.72	28.24	9.66	3.54	4.96	0.30	56.27

Acknowledgments

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Relationship Between USDA and Japanese Beef Grades

J. J. Harris, D. K. Lunt, J. W. Savell, E. W. Hawkins, and L. E. Orme

Summary

Angus steers (n=78) were feedlot finished to approximately 1,550 lbs live weight. This scheme of finishing the steers was chosen to simulate what might be done in Japan or what could be done to produce carcass beef for Japan. The finished steers were slaughtered at a commercial packing plant, chilled and evaluated for USDA and Japanese yield and quality grade characteristics. The resulting carcasses were excessively heavy and fat for the domestic (U.S.) beef industry. Over 70% of the carcasses were U.S. Yield Grade 5, and almost 40% were Japanese Yield Score 'C'. Although excessively fat externally, less than 50% of the carcasses qualified for U.S. Prime, and none of the carcasses qualified for Japanese Meat Quality Score 5. Moderate to high correlations were observed between U.S. 12th rib carcass traits and Japanese sixth rib traits; however, multiple regression equations based upon USDA carcass characteristics explained only 46% and 25% of the observed variation in Japanese marbling score and estimated percent wholesale cut yield, respectively.

Introduction

The United States beef industry has experienced dramatic growth in export sales during the past 10 years, largely as a result of liberalization of the Japanese market. This has led many U.S. producers to target specific cattle and (or) carcasses for the Japanese market. Carcasses sold to Japanese companies, generally are shipped to Japan as quartered beef, separated between the 12th and 13th ribs. However, carcass value to the Japanese customer is determined by grade data — primarily marbling score — determined at the sixth-seventh rib interface. Therefore, unless the relationship between 12th rib grade data (USDA) and sixth rib data is known, an equitable pricing system is impossible.

Japanese customers place a high value on marbling and often are willing to accept excess external fat to obtain it. With this in mind, cattle destined for Japanese markets routinely are fed a high concentrate diet in a confinement setting for long periods of time relative to common domestic practices. It is not unusual for these cattle to be fed for well over one year and to reach live weights of over 1,500 lbs. With this much time and money being spent to produce a carcass, it is imperative that the producer have some knowledge of how that carcass will be viewed by Japanese customers. Carcasses are graded at the 12th rib by USDA graders and shipped to Japan with the hope that a high marbling score in the ribeye at the 12th rib will translate into a high marbling score at the sixth rib when the carcass arrives in Japan. Currently, the specific relationship between these evaluation locations is not clearly defined. Therefore, the objective of this study was to provide a comparison of Japanese and USDA beef quality and yield grades and to determine if it is possible to predict Japanese grade based on 12th rib evaluation.

Materials and Methods

Angus steers (n = 78) were placed on feedlot finishing diets at approximately 1,230 lbs live weight and remained on this diet until reaching approximately 1,550 lbs. This feeding regimen was used to somewhat simulate feeding conditions in Japan. Upon reaching finished weight, the steers were slaughtered in a commercial packing plant and chilled for 48 h under typical industry chilling conditions (approx. 28°F, no spray chill). After chilling, the carcasses were transferred to a holding cooler (34°F), ribbed between the 12th and 13th ribs, and USDA (6) grade data were collected by two trained evaluators. Lighting (incandescent) in the grading area was maintained at a constant level of 30 footcandles. After collection of USDA grade data, the carcasses were shipped by refrigerated truck to a fabrication facility where they would ultimately be fabricated and the subprimals exported to Japan. Upon arrival at the fabrication facility, the carcasses were placed in a holding cooler (34°F) and ribbed between the sixth and seventh ribs. After ribbing, Japanese grade data were collected by two evaluators trained in the Japanese grading system. In this facility lighting was provided by fluorescent lights, but was maintained at a constant 30 footcandles as before. Due to the time required to load and ship the carcasses to the fabrication plant, the Japanese grade data (3) were collected approximately 36 h after the collection of the USDA data. This delay was unavoidable because the slaughterer was selling the carcasses on a hanging basis to the fabricator and would not allow ribbing in both locations before shipment. However, this situation would not be different from carcasses being graded in the U.S. (12th rib) and then shipped to Japan where they would be ribbed at the sixth rib some weeks later. Japanese grade data collected included: marbling score, lean color score, lean brightness score, firmness score, texture score, fat color score, fat luster and quality score, ribeye area at the 6th rib, rib thickness, external fat thickness and yield score. Japanese Yield Score is classified into three grades (A, B, and C) based on estimated (via multiple regression) percentage yield of boneless, trimmed wholesale cuts (3). Carcasses with an estimated yield ≥72.0% qualify for Yield Score A (YS 'A'), those estimated ≥69.0% and <72.0 qualify for YS 'B', and those <69.0% would be YS 'C'.

Means were calculated and correlations and regression analyses were conducted using SAS (5). Regression models were developed to predict the Japanese estimated yield and

marbling score, since these are the two most important value-determining components of the Japanese beef grades. Independent variables were selected from carcass characteristics evaluated at the 12th rib.

Results and Discussion

Not surprisingly, the steers fed in this study became excessively fat and heavy for the U.S. beef industry by the end of the feeding period. The mean external fat thickness was 1.17 in. at the 12th rib (Table 1), with a mean hot carcass weight of 1016 lbs. This led to USDA yield grades which were far beyond what is considered acceptable in the U.S. (Figure 1). Over 70% of the carcasses were Yield Grade 5, with an additional 22% Yield Grade 4. Even with the large amount of external fat on the carcasses, less than 50% had sufficient marbling to grade USDA Prime (Figure 2), which is the typical target quality grade for export to Japan. It also is important to keep in mind here that these steers are from a breed (Angus) known for its ability to deposit marbling. Therefore, from this group of steers, it appears that it would not be efficient to use this type of production system to produce desirable carcasses for domestic or export markets. Any economic advantage gained from the carcasses that were of sufficient quality for export to Japan would be far exceeded by the discounts received in the U.S. for those which did not meet Japanese specifications.

Characteristics evaluated at the sixth rib for Japanese grade determination indicated that, although they were fed similarly to Japanese cattle, these steers did not produce carcasses of high quality (Table 2). The mean marbling score was only 3.50 on the 12-point Japanese scale where 1 is the least amount of marbling and 12 is the most. This would be sufficient marbling for Meat

TABLE 1. MEAN USDA CARCASS CHARACTERISTICS.

Characteristic	Mean	CV
Live weight, lbs.	1,500.00	NA[d]
Dressing percent	67.74	NA[d]
Skeletal maturity[a]	171	12.53
Lean maturity[a]	160	9.29
Overall maturity[a]	166	10.15
Marbling score[b]	686	20.94
Quality grade[c]	395	12.11
Actual fat thickness, in.	1.17	24.14
Adjusted fat thickness, in.	1.22	24.20
Ribeye area, in.^{2}	13.72	11.40
Kidney, pelvic and heart fat, %	2.53	26.29
Hot carcass weight, lbs	1,016	7.03
Yield grade	5.53	19.45

[a]100 = A[00] and 500 = E[00].
[b]300 = Slight[00] and 900 = Abundant[00].
[c]100 = Standard[00] and 400 = Prime[00].
[d]Measures of variability were not available because packer only provided total live weight for the entire lot.

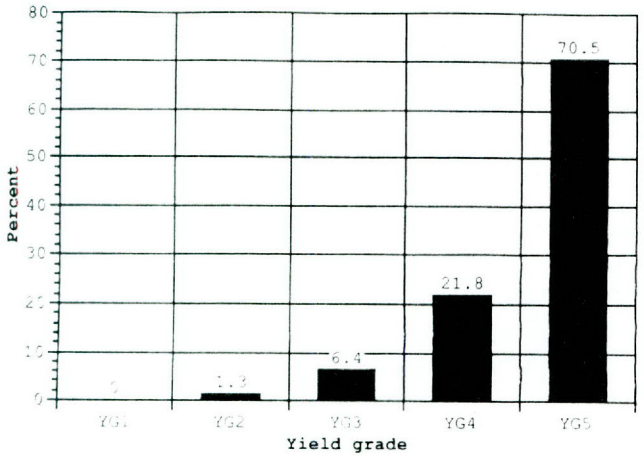

Figure 1. Percentage distribution of USDA Yield Grades.

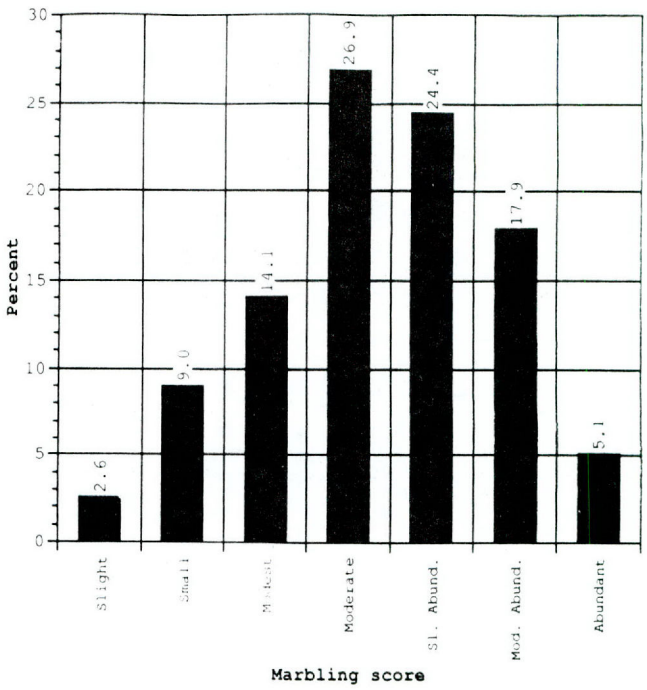

Figure 2. Percentage distribution of USDA marbling scores.

TABLE 2. MEAN JAPANESE CARCASS CHARACTERISTICS.

Characteristic	Mean	CV
Marbling score[a]	3.50	35.89
Lean color score[b]	2.65	24.16
Brightness score[b]	2.95	18.85
Firmness score[c]	2.82	25.39
Texture score[c]	2.79	21.85
Fat color score[b]	3.45	14.52
Fat luster and quality score[c]	2.91	18.52
Ribeye area, in.^{2}	7.00	12.63
Rib thickness, in.	2.92	14.98
External fat thickness, in.	1.38	20.14
Intermuscular fat thickness, in.	2.51	13.84
Estimated yield, %[d]	69.32	1.4

[a]Based on 12-point scale with 1 being the least amount and 12 being the most as represented by standard plastic models manufactured by the Japan Meat Grading Association.
[b]Based on 7-point scale with 1 being most desirable and 7 being least desirable as represented by standard plastic models manufactured by the Japan Meat Grading Association.
[c]Based on 5-point scale with 1 being most desirable and 5 being least desirable as represented by standard plastic models manufactured by the Japan Meat Grading Association.
[d]Calculated from three-variable regression equation as published by Japan Meat Grading Association (3).

Quality Score (MQS) 3 (midpoint of the Japanese quality scale). Less than 22% of the carcasses would qualify for MQS 4, and none would qualify for the highest quality score, MQS 5 (Figure 3). It is interesting to note that even Black Wagyu cattle fed in Japan average only about 50% MQS 4 or 5.

The mean Japanese estimated yield of the carcasses in this study was 69.3% (Table 2), which would qualify for YS 'B'; however, only 3.8% of the carcasses would qualify for YS 'A' while 38.5% would be in YS 'C'. Thus, when evaluated based upon the Japanese grading system, most of these carcasses were only marginally acceptable with respect to quality, and many were excessively fat even by Japanese standards. Currently, cutability is of little concern to Japanese customers; however, as more beef becomes available in the Japanese market, it is likely that cutability will begin to receive more emphasis in the pricing scheme.

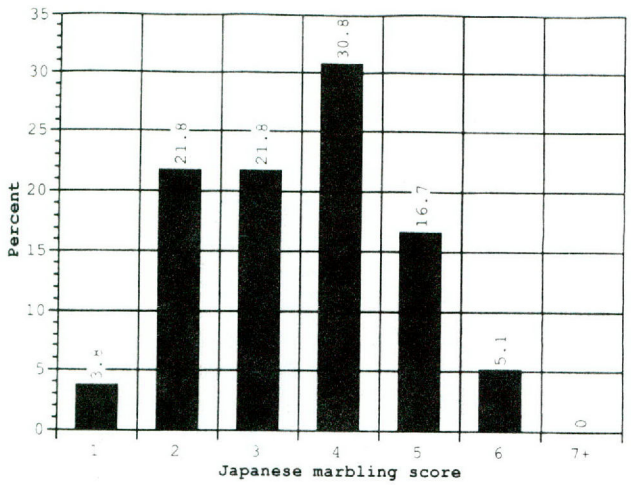

Figure 3. Percentage distribution of Japanese marbling score.

Simple correlation coefficients between various traits evaluated in this experiment (Table 3) indicate that some USDA traits are somewhat highly correlated to the sixth-rib Japanese traits of major concern (marbling and estimated yield). Not surprisingly, USDA marbling score and quality grade are the only 12th rib traits significantly correlated to Japanese marbling score (r = .64). Actual fat thickness, adjusted fat thickness, ribeye area and yield grade all were closely related (P < .01) to Japanese estimated yield (r = -.32, -.31, .32 and -.42, respectively).

Regression equations were generated to predict Japanese marbling score and estimated yield using 12th rib USDA carcass traits (Table 4). The 1, 2, 3 and 4-variable equations presented are the "best" equations based upon

TABLE 3. SIMPLE CORRELATION COEFFICIENTS FOR USDA AND JAPANESE CARCASS TRAITS.

	1	2	3	4	5	6	7	8	9	10	11	12
1. US marb		.99**	.03	.02	.02	.01	.01	.64**	-.22*	.15	.15	-.14
2. US QG	.99**		.03	.01	.02	.01	.01	.64**	-.22*	.15	.15	-.14
3. Act. fat	.03	.03		.98**	-.24*	.26*	.91**	.12	-.16	.35**	.58**	-.32**
4. Adj. fat	.02	.01	.98**		-.21	.28*	.92**	.08	-.16	.39**	.59**	-.31**
5. US REA	.02	.02	-.24*	-.22		.11	-.50**	-.14	.41**	.26*	-.09	.32**
6. KPH, %	.01	.01	.26*	.28*	.11		.36**	-.05	-.18	.37**	.29*	-.17
7. US YG	.01	.01	.91**	.92**	-.50**	.36**		.12	-.29*	.33**	.58**	-.42**
8. Jap marb	.64**	.64**	.12	.08	-.14	-.05	.12		-.16	-.03	.23*	-.28*
9. Jap REA	-.22*	-.22*	-.16	-.16	.41**	-.18	-.29*	-.16		.10	-.20	.78**
10. Rib thk	.15	.15	.35**	.39**	.26*	.37**	.33**	-.04	.10		.48**	.25*
11. Jap fat	.15	.15	.58**	.59**	-.09	.29*	.58**	.23*	-.20	.48**		-.52**
12. Jap yld	-.14	-.14	-.32**	-.31**	.35**	-.17	-.42**	-.28*	.78**	.25*	-.52**	

* P < .05
** P < .01

TABLE 4. REGRESSION EQUATION (1, 2, 3 AND 4-VARIABLE) COEFFICIENTS PREDICTING JAPANESE PERCENT YIELD AND MARBLING SCORE.

Dependent variable	Intercept	Actual fat thick., in.	Adj. fat thick., in.	U.S. quality grade	U.S. marbling score	U.S. ribeye area, in.²	U.S. yield grade	R^2	RMSE[a]
Japanese estimated yield:									
1 variable	71.81						-.449	.18	1.03
2 variable	72.12		.724				-.911	.22	1.02
3 variable	73.47		.735	-.003			-.917	.24	1.01
4 variable	94.84		.726	-.131	.042		-.931	.25	1.01
Japanese marbling score:									
1 variable	-3.12			.017				.41	.97
2 variable	1.35				.006	-.019		.43	.96
3 variable	-3.41	1.523	-1.319	.016				.44	.96
4 variable	.81	1.391	-1.24		.005	-.016		.46	.95

[a]Root mean square error

maximization of the coefficient of determination (R^2) and the minimization of the root mean square error (RMSE). The best 1- and 2-variable equations for predicting Japanese estimated yield contained USDA yield grade alone or in combination with adjusted fat thickness, respectively. When additional variables were added, USDA quality factors began to enter the equation; however, even the best 4-variable equation only accounted for 25% of the variation in estimated yield. Although Japanese marbling was much more predictable than estimated yield, the best regression equation developed still accounted for only 46% of the variation in marbling score. As expected, all equations contained some measure of marbling at the 12th rib (either marbling score or quality grade). As variables were added to the equations, USDA measures of fat thickness and ribeye area began to enter. The fact that quality factors were useful in equations predicting yield, and yield factors were found in quality prediction equations is in agreement with previous researchers (1,2,4).

Implications

Currently there appears to be little opportunity for equitable price discovery for carcasses intended for export to Japan if only 12th-rib carcass information is available. Some method for reconciliation of 12th-rib and sixth-rib carcass measures must be devised to bridge the gap between carcass values obtained from the two sets of value-determining criteria.

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Shelflife Characteristics of Beef from Steers Assigned to Various Forage Utilization-Grain Feeding Regimens

S. F. Kelley, F. M. Rouquette, Jr., J. W. Savell, and J. W. Turner

Summary

A 2-year study was conducted at the Texas A&M University Agricultural Research and Extension Center at Overton to ascertain the influence of forage utilization strategies and grain feeding regimens on shelflife characteristics of the beef produced. Data were compiled from sixty-eight 1/2 Simmental X 1/4 Hereford X 1/4 Brahman steers born in 1981 and 1982 during the late winter to early spring of both years. Within each treatment year, all steers began the post-weaning trial on the same date; whereas, slaughter dates varied by treatment and year. Beef cuts were displayed under retail conditions and evaluated over a 3-d period. As the fat differentiation increased between carcasses from the forage- and grain-feeding regimens, large differences ($P < .05$) were evident in the initial evaluation of selected shelflife characteristics of the displayed lean.

Muscle color evaluations favored the grain-fed treatments on the initial day of evaluation, but by d 3 similar scores were recorded for samples from the grain-fed and forage-fed treatments. Sampled lean from the grain-fed treatments had superior fat color scores throughout the entire display period. Yet, for all of the evaluated traits, the 98-d grain-fed treatments had the most rapid deterioration rate when compared to any of the forage-finished and(or) grain-finished treatments. Beef from the forage treatments exhibited comparable retail evaluations with grain-fed beef as the display period progressed. The utilization of electrical stimulation as a post-slaughter treatment enhanced ($P < .05$) the shelflife of the beef by improving muscle color of the lean during the display period.

Introduction

Forages, the most widely available digestible source of nutrients for grazing ruminants, have been researched many times as a possible management alternative for slaughter beef production (2, 6, 10, 17). Numerous researchers have reported superior carcasses from grain-fed cattle, while others (1, 11) have concluded that forage-finished cattle exhibit comparable traits when compared to their grain-fed contemporaries. Additional data by Reagan et al. (12) investigated the stability of forage-fed beef and its utility in a boxed beef packaging program. With the acceptance of boxed beef and the increasing trend of beef exportation, the primary objective of this study was to evaluate various forage utilization strategies, days on feed, and the impact these strategies had on the physical shelflife characteristics of beef cuts evaluated under retail display conditions. Furthermore, electrical stimulation, utilized as a post-slaughter treatment, was considered to ascertain the influence of electricity on the shelflife of retail cuts.

Experimental Procedure

The Texas A&M University Agricultural Research and Extension Center at Overton uses highly productive Brahman X Hereford (F-1) cows and their Simmental-sired calves to evaluate various forage-animal grazing systems. Two successive experiments were conducted during the years 1981-83 (Trial 1) and 1982-84 (Trial 2) using 68 Simmental-sired steers. All offspring were sired by embryo twins and born during late winter to early spring. Within each treatment year, all steers began the trial on the same date; yet, slaughter dates varied by treatment and year. The feedlot diet (Table 1) was comprised of 95% whole shelled corn and 5% premix with an 88.35% dry matter content for both trials. Net energy for maintenance was 2.07 Mcal/kg and NE_g was 1.36 Mcal/kg. Upon slaughter, carcasses were longitudinally split with one side receiving electrical stimulation. This post-slaughter treatment allowed each carcass side to be analyzed for the effects of electrical stimulation on various shelflife traits of the retail beef cuts. Retail cuts were evaluated for muscle color, surface discoloration, and fat color over a 3-d retail display period by trained evaluators.

Forage utilization is a major factor of consideration in grazing management due to the growth cycle of winter forages and pasture costs ranging from $ 187.50 to 312.50/ha. The winter grazing strategies used in this study were selected as diverse methods to evaluate the predominant forges used for

TABLE 1. RATION COMPOSITION FOR TRIALS 1 AND 2.

Ingredient	Percentage
Whole, Shelled Corn	95.0000
Premix	5.0000
Alfalfa, dehydrated	2.2500
Rice Mill	0.6000
$CaCO_3$	1.3000
NaCl	0.5000
$AmSo_4$	0.3125
Monensin 60	0.0175
Trace Mineral #1	0.0100
Vitamin A	0.0100

winter pasture grazing. Hay and protein were provided to supplement the steers during the early establishment and growing phases and later discontinued when the clover-ryegrass pastures were able to be grazed in early spring. The rye-ryegrass pastures were intermittently (2 h/d) grazed at a 2 X stocking rate during the initial growing phase to prevent over-grazing and forage damage. The pastures were later grazed full-time in the spring to efficiently harvest the available forage.

Trial 1

Forty-one steers were stratified by weight and randomly assigned to the following wintering treatments which began November 12, 1981, and terminated June 15, 1982 (215-d): (1) Hay ad libitum (ad lib) plus .225 kg cottonseed meal (CSM) per head/d (116 d) followed by full-time, continuous grazing of 'Yuchi' arrowleaf clover (*Trifolium vesiculosum*) and 'Gulf' ryegrass (*Lolium multiflorum*) for 99 d; (2) Hay ad lib plus 2 h/d (intermittent) grazing of 'Elbon' rye (*Secale cereale*) and ryegrass (116 d) followed by full-time, continuous grazing of the rye-ryegrass pastures (99 d); (3) Full-time, continuous grazing of rye-ryegrass pastures (215 d). Following the winter pasture grazing period, steers were randomly stratified into various summer pastures 'Tifton-44' bermudagrass (*Cynodon dactylon*) and(or) feedlot regimens (Table 2). Steers previously assigned to the winter treatments consisting of hay plus CSM, and hay plus intermittent grazing of rye-ryegrass pastures were allocated to one of the following finishing treatments: (1) Feedlot for 147 d; (2) Tifton-44 bermudagrass plus 1% BW of whole corn for 147 d; (3) Tifton-44 bermudagrass alone followed by a feedlot period of 98 d. Steers assigned to the full-time rye-ryegrass wintering strategy were allocated to the following treatments: (1) Direct slaughter off winter pasture; (2) Feedlot for 85 d; (3) Feedlot for 147 d; (4) Full-time, continuous grazing of Tifton-44 bermudagrass for 147 d.

Trial 2

Twenty-seven steers were stratified by weight into the following winter grazing strategies beginning November 4, 1982, and terminating on June 3, 1983 (211-d): (1) Hay ad lib plus .225 kg CSM per head/d (113 d) followed by full-time, continuous grazing of Yuchi arrowleaf clover and Gulf ryegrass for 98 d; (2) Hay ad lib plus 2 h/d (intermittent) grazing of Elbon rye and ryegrass (113 d) followed by full-time, continuous grazing of the rye-ryegrass pastures for 98 d; (3) Full-time, continuous grazing of rye-ryegrass pastures (211 d). With the conclusion of the winter grazing period, steers were randomly assigned to various summer grazing strategies utilizing Tifton-44 bermudagrass and(or) feedlot regimens (Table 3). Steers originally assigned to the winter treatments of hay plus CSM, and intermittent grazing of rye-ryegrass were allocated to the following finishing strategies: (1) Full-time, continuous grazing of Tifton-44 bermudagrass (139 d) followed by a 97-d feedlot period; (2) Tifton-44 bermudagrass plus 1% BW of whole corn for 139 d. Steers assigned to the winter treatments

TABLE 2. DATES AND TREATMENT DESCRIPTION OF FEEDING REGIMENS FOR TRIAL 1.

	Treatment Dates[a]					
	Winter Phase		Finishing Phase			
Trt.	Nov. 12 to Mar. 8 (116 d)	Mar. 8 to June 15 (99 d)	June 15 to Sept. 8 (85 d)	Sept. 8 to Nov. 9 (62 d)	Nov. 9 to Feb. 15 (98 d)	Trt. Days
1	Hay + CSM	Full time Clover-Ryegrass	Feedlot	Feedlot		362
2	Hay + CSM	Full time Clover-Ryegrass	Tifton-44 + 1% BW of Corn	Tifton-44 + 1% BW of Corn		362
3	Hay + CSM	Full time Clover-Ryegrass	Full time Tifton-44	Full time Tifton-44	Feedlot	460
4	Hay + 2 h/d Rye-Ryegrass	Full time Rye-Ryegrass	Feedlot	Feedlot		362
5	Hay + 2 h/d Rye-Ryegrass	Full time Rye-Ryegrass	Tifton-44 + 1% BW of Corn	Tifton-44 + 1% BW of Corn		362
6	Hay + 2 h/d Rye-Ryegrass	Full time Rye-Ryegrass	Full time Tifton-44	Full time Tifton-44	Feedlot	460
7	Full time Rye-Ryegrass	Full time Rye-Ryegrass				215
8	Full time Rye-Ryegrass	Full time Rye-Ryegrass	Feedlot			300
9	Full time Rye-Ryegrass	Full time Rye-Ryegrass	Feedlot	Feedlot		362
10	Full time Rye-Ryegrass	Full time Rye-Ryegrass	Full time Tifton-44	Full time Tifton-44		362

[a]Steers were slaughtered at the completion of each treatment.

TABLE 3. DATES AND TREATMENT DESCRIPTION OF FEEDING REGIMENS FOR TRIAL 2.

Trt	Treatment Dates[a]					Trt Days
	Winter Phase		Finishing Phase			
	Nov. 4 to Feb. 25 (113 d)	Feb. 25 to June 3 (98 d)	June 3 to Aug. 25 (82 d)	Aug. 25 to Oct. 20 (57 d)	Oct. 20 to Jan. 26 (97 d)	
11	Hay + CSM	Full Time Clover-Ryegrass	Full Time Tifton-44	Full Time Tifton-44	Feedlot	447
12	Hay + CSM	Full Time Clover-Ryegrass	Tifton-44 + 1% BW of Corn	Tifton-44 + 1% BW of Corn		350
13	Hay + 2 h/d Rye-Ryegrass	Full Time Rye-Ryegrass	Full Time Tifton-44	Full Time Tifton-44	Feedlot	447
14	Hay + 2 h/d Rye-Ryegrass	Full Time Rye-Ryegrass	Tifton-44 + 1% BW of Corn	Tifton-44 + 1% BW of Corn		350
15	Full Time Rye-Ryegrass	Full Time Rye-Ryegrass				211
16	Full Time Rye-Ryegrass	Full Time Rye-Ryegrass	Feedlot			293

[a]Steers were slaughtered at the completion of each treatment.

with full-time grazing of rye-ryegrass pastures were either slaughter directly off of winter pasture or finished in a feedlot for 82 d.

Statistical Analyses

Shelflife scores from the 68 steers were edited and formed into three independent data sets for statistical analysis by Mixed Model Least-Squares procedures for fixed effects as described by Harvey (7). Animal was identified as nested within treatment, while the fixed effect day represented the day observations were made and the number of days in the display cooler. Data Set 1 using Trials 1 and 2 (256 records) was created to ascertain the differences in shelflife characteristics between steers slaughtered upon the completion of the finishing strategies, as described in Tables 2 and 3, of either full-time grazing of Tifton-44 bermudagrass plus 1% BW of corn (Treatments 2, 5, 12, 14) or Tifton-44 bermudagrass alone followed by 98-d in the feedlot (Treatments 3, 6, 11, 13). Differences were also analyzed according to the two wintering strategies. One hundred and ninety-two records comprised Data Set 2 which evaluated shelflife characteristics of steers from Trial 1 which were slaughtered after either grazing Tifton-44 bermudagrass plus 1% BW of whole shelled corn (Treatments 2 and 5), Tifton-44 bermudagrass followed by a 98-d feedlot period (Treatments 3 and 6), or an exclusive feedlot period of 147 d (Treatments 1 and 4). Data Set 3 used Trials 1 and 2 (224 records) and determined the variation between the evaluated traits attributed by steers assigned to the wintering strategy of full-time rye-ryegrass pastures (Treatments 7, 8, 9, 10, 15, 16) and various finishing strategies: feedlot for 85 d, feedlot for 147 d, winter pasture for 215 d, or a combination of winter pasture and summer pasture for a total of 362 d.

Results and Discussion

Data Set 1

Even though there were no real categorical differentiation, retail cuts from cattle receiving hay ad lib plus .225 kg of CSM followed by full-time grazing of clover-ryegrass had more desirable ($P < .01$) muscle color and total desirability scores than beef from the intermittent grazing strategy when evaluating shelflife traits (Table 4). Similar to Schroeder et al. (16), the grain-finished steers had more desirable ($P < .001$) evaluation scores for muscle color and fat color than displayed meat samples from the forage-finished steers. Retail cuts from the grain-fed treatments reported traits of creamy tinted fat, while samples from the forage-fed strategies had creamy yellow fat. Surface discoloration scores favored ($P < .001$) the forage-fed strategy, which maintained less than a 10% discoloration of lean, over the grain-fed strategy through the second day of display. Electrical stimulation improved ($P < .001$) muscle color and total desirability over the non-stimulated cuts. This enhancement in shelflife is in agreement with Rouquette et al. (14) even though we observed both treatments to have slightly dark red lean and considered them to be slightly desirable when total desirability was evaluated.

Muscle color values from the grain-fed treatment had a more desirable ($P < .05$) lean color upon the initial day of evaluation; however, after d 1 and d 2, no difference between the grain- or forage-finishing strategies was evident (Table 5). Contradicting Craig et al. (4), and Cross and Smith (5), our study clearly showed a more rapid deterioration of lean samples from the 98-d grain-fed treatment than from the forage-fed treatment. Samples from the forage-fed treatment had characteristics of deteriorating at a slower ($P < .05$) rate than samples from the grain-fed treatment when evaluating

TABLE 4. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SHELFLIFE TRAITS FROM DATA SET 1.

		Winter Strategy		Finishing Strategy			Electrical Stimulation	
Trait	SE	Hay + CSM[a]	Intermittent Grazing[b]	Tifton-44 + 1% BW Corn[c]	Tifton-44 + 98d Feedlot[d]	SE	NS[e]	ES[f]
No. of Observations		64	64	64	64		128	128
Muscle Color[g]	0.15	5.46[k]	5.31[l]	5.26[k]	5.51[l]	0.11	5.20[k]	5.58[l]
Surface Discoloration[h]	0.09	6.16	6.13	6.29[k]	5.99[l]	0.07	6.14	6.14
Total Desirability[i]	0.16	5.45[k]	5.22[l]	5.38	5.28	0.12	5.23[k]	5.44[l]
Fat Color[j]	0.10	5.86	5.90	5.69[k]	6.07[l]	0.08	5.90	5.87

[a] Hay ad libitum plus .225 kg of cottonseed meal per head/d followed by full-time clover-ryegrass.
[b] Intermittent grazing of Rye-ryegrass plus ad libitum hay followed by full-time Rye-ryegrass.
[c] Tifton-44 bermudagrass plus 1% corn for 147 d.
[d] Tifton-44 bermudagrass for 147 d followed by 98 d in the feedlot.
[e] Carcass sides not receiving electrical stimulation.
[f] Carcass sides receiving electrical stimulation.
[g] Based on a 9 point scale; where 3=dark red, 4=moderately dark cherry red, 5=slightly dark red and 6=cherry red.
[h] Based on a 7 point scale; where 4=25 to 50% discolored, 5=10 to 25% discolored and 6=less than 10% discolored.
[i] Based on an 8 point scale; where 4=slightly undesirable, 5=slightly desirable and 6=desirable.
[j] Based on an 8 point scale; where 4=yellow, 5=creamy yellow and 6=cream.
[k,l] Subclass means in the same row with different superscripts differ (P < .05).

TABLE 5. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SHELFLIFE TRAITS BY RETAIL DISPLAY DAY FROM DATA SET 1.

		Winter Strategy		Finishing Strategy	
Trait	No. of Days on Display	Hay + CSM[a]	Intermittent Grazing[b]	Tifton-44 + 1% BW Corn[c]	Tifton-44 + 98 d Feedlot[d]
Muscle Color[e]					
SE		0.16	0.16	0.16	0.16
	0[i]	5.93	5.78	5.49[m]	6.22[n]
	1[j]	5.61	5.45	5.31	5.74
	2[k]	5.32	5.15	5.20	5.26
	3[l]	5.00	4.88	5.04	4.83
Surface Discoloration[f]					
SE		0.12	0.12	0.11	0.11
	0[i]	6.89	6.95	6.92	6.92
	1[j]	6.42	6.32	6.46	6.28
	2[k]	5.85	5.88	6.04[m]	5.69[n]
	3[l]	5.46	5.36	5.74[m]	5.08[n]
Total Desirability[g]					
SE		0.17	0.17	0.16	0.16
	0[i]	6.37	6.22	6.07	6.52
	1[j]	5.72	5.46	5.54	5.64
	2[k]	4.96	4.76	5.11[m]	4.62[n]
	3[l]	4.73	4.45	4.83[m]	4.36[n]
Fat Color[h]					
SE		0.11	0.11	0.10	0.10
	0[i]	6.22	6.23	5.91[m]	6.53[n]
	1[j]	5.80	5.94	5.71[m]	6.03[n]
	2[k]	6.00	6.06	5.68[m]	6.37[n]
	3[l]	5.43	5.38	5.45	5.36

[a] Hay ad libitum plus .225 kg of cottonseed meal per head/d followed by full-time clover-ryegrass.
[b] Intermittent grazing of Rye-ryegrass plus ad libitum hay followed by full-time Rye-ryegrass.
[c] Tifton-44 bermudagrass plus 1% corn for 147 d.
[d] Tifton-44 bermudagrass for 147 d followed by 98 d in the feedlot.
[e] Based on a 9 point scale; where 4=moderately dark cherry red, 5=slightly dark red and 6=cherry red.
[f] Based on a 7 point scale; where 5=10 to 25% discolored and 6=less than 10% discolored.
[g] Based on an 8 point scale; where 4=slightly undesirable, 5=slightly desirable and 6=desirable.
[h] Based on an 8 point scale; where 5=creamy yellow and 6=cream.
[i,j,k,l] Subclass means in the same column with different superscripts differ (P < .001).
[m,n] Subclass means in the same row with different superscripts differ (P ≤ .05).

for surface discoloration. These factors, favoring the forage-fed beef, contradict the conclusions established by Schroeder et al. (16). Day 2 evaluations reported desirability scores equivalent to slightly desirable and slightly undesirable for the forage-fed and grain-fed treatments, respectively. Statistical differences occurred through d 3; however, categorical differences between the samples were not evident since both samples were slightly undesirable at the conclusion of the evaluation period. Differences in fat color, favoring the 98-d grain-fed strategy, occurred through the second day of display but by d 3, both forage and grain treatments had similar scores and were evaluated as having creamy yellow fat. For all evaluated traits, the 98-d grain-fed beef tended to deteriorate at a faster rate through the retail evaluation period, this rate of deterioration contradicts data from studies by Wanderstock and Miller (17), and Wheeling et al. (18).

Data Set 2

Differences ($P < .001$) in muscle color and total desirability were detected when analyzing the winter grazing strategies; however, both strategies had slightly dark red muscle color and were only slightly desirable when the values were translated (Table 6). The three finishing regimens, however, had distinct differences ($P < .001$) in muscle color and fat color. In agreement with Schroeder et al. (16), the 147-d feedlot steers had more desirable ($P < .001$) muscle color scores than the 98-d feedlot or the 147-d forage-finished steers. Beef from the two grain-finished treatments had superior ($P < .001$) fat color over the forage-fed treatment, which was recorded as having creamy yellow fat.

There was no difference in surface discoloration between the displayed samples from the forage-fed or 147-d grain-fed steers; yet, retail cuts from the 98-d grain-fed steers had the least ($P < .001$) desirable surface discoloration evaluation score (10 to 25% discolored) than the other two groups which had less than 10% of their lean surface discolored. In a similar sense, cuts from the forage and 98-d grain treatment did not differ in total desirability, but the 147-d grain-fed beef was more ($P < .001$) desirable with a higher desirability score. Electrical stimulation improved ($P < .001$) the muscle color evaluation during the retail display even though lean from both treatments was evaluated as having a slight dark red color.

A noticeable decrease ($P < .001$) in scores of all evaluated traits was evident after remaining on display for 24 h (Table 7). Moreover, this deterioration trend continued through the third day of display. Fat color was the only characteristic that did not have any physical color alteration between the first and second day of display. Distinct differences ($P < .001$) were evident in muscle color on d 0 and d 1 between carcasses from the hay ad lib plus .225 kg of CSM followed by full-time grazing of clover-ryegrass treatment and the intermittent winter grazing strategy; however, by d 2 and d 3 the differences had subsided. Corresponding to Schroeder et al. (16), the grain-fed beef had cherry red muscle color and, as expected, the 147-d forage treatment had a darker red lean color when entering the display case. Maintaining this advantage throughout the evaluation period, the 147-d grain-fed beef completed the display with a more desirable muscle color score. However, contrary to popular studies (4, 5, 17), samples

TABLE 6. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SHELFLIFE TRAITS FROM DATA SET 2.

		Winter Strategy			Finishing Strategy				Electrical Stimulation	
Trait	SE	Hay + CSM[a]	Intermittent Grazing[b]	SE	Tifton-44 + 1% BW Corn[c]	Tifton-44 + 98 d Feedlot[d]	Feedlot for 147 d[e]	SE	NS[f]	ES[g]
No. of Observations		96	96		64	64	64		96	96
Muscle Color[h]	0.16	5.27[l]	5.90[m]	0.24	5.02[l]	5.68[m]	6.05[n]	0.20	5.40[l]	5.77[m]
Surface Discoloration[i]	0.07	6.08	6.05	0.10	6.21[l]	5.65[m]	6.33[l]	0.09	6.12	6.01
Total Desirability[j]	0.16	5.17[l]	5.68[m]	0.24	5.11[l]	5.23[l]	5.94[m]	0.20	5.41	5.44
Fat Color[k]	0.07	6.12	6.14	0.11	5.54[l]	6.07[m]	6.79[n]	0.09	6.16	6.11

[a] Hay ad libitum plus .225 kg of cottonseed meal per head/d followed by full-time clover-ryegrass.
[b] Intermittent grazing of Rye-ryegrass plus ad libitum hay followed by full-time Rye-ryegrass.
[c] Tifton-44 bermudagrass plus 1% corn for 147 d.
[d] Tifton-44 bermudagrass for 147 d followed by 98 d in the feedlot.
[e] Feedlot for 147 d.
[f] Carcass sides not receiving electrical stimulation.
[g] Carcass sides receiving electrical stimulation.
[h] Based on a 9 point scale; where 4=moderately dark cherry red, 5=slightly dark red and 6=cherry red.
[i] Based on a 7 point scale; where 4=25 to 50% discolored, 5=10 to 25% discolored and 6=less than 10% discolored.
[j] Based on an 8 point scale; where 4=slightly undesirable, 5=slightly desirable and 6=desirable.
[k] Based on an 8 point scale; where 4=yellow, 5=creamy yellow and 6=cream.
[l,m,n] Subclass means in the same row with different superscripts differ ($P < .001$).

TABLE 7. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SHELFLIFE TRAITS BY RETAIL DISPLAY DAY FROM DATA SET 2.

Trait	No. of Days on Display	Winter Strategy		Finishing Strategy		
		Hay + CSM[a]	Intermittent Grazing[b]	Tifton-44 + 1% BW Corn[c]	Tifton-44 + 98 d Feedlot[d]	Feedlot for 147 d[e]
Muscle Color[f]						
SE		0.24	0.24	0.28	0.28	0.28
	0[i]	5.93[n]	6.60[o]	5.40[n]	6.91[o]	6.49[o]
	1[k]	5.42[n]	6.18[o]	5.20[n]	5.91[n,o]	6.29[o]
	2[l]	5.08	5.70	4.84[n]	5.29[n,o]	6.04[o]
	3[m]	4.65	5.10	4.63[n,o]	4.61[o]	5.39[n]
Surface Discoloration[g]						
SE		0.14	0.14	0.15	0.15	0.15
	0[i]	6.93	6.96	6.97	6.86	7.00
	1[k]	6.35	6.27	6.35	6.14	6.43
	2[l]	5.84	5.76	6.01[n]	5.16[o]	6.23[n]
	3[m]	5.20	5.23	5.52[n]	4.45[o]	5.66[n]
Total Desirability[h]						
SE		0.24	0.24	0.26	0.26	0.26
	0[i]	6.30	6.87	5.86[n]	7.13[o]	6.78[o]
	1[k]	5.59	5.99	5.27[n]	5.87[n,o]	6.23[o]
	2[l]	4.65[n]	5.36[o]	4.83[n]	4.25[n]	5.94[o]
	3[m]	4.15	4.50	4.49[n]	3.68[o]	4.80[n]
Fat Color[i]						
SE		0.16	0.16	0.13	0.13	0.13
	0[i]	6.69	6.64	5.88[n]	6.88[o]	7.24[o]
	1[k]	6.16	6.29	5.61[n]	6.13[o]	6.94[p]
	2[k]	6.30	6.38	5.51[n]	6.58[o]	6.93[o]
	3[l]	5.33	5.26	5.14[n]	4.69[o]	6.05[p]

[a] Hay ad libitum plus .225 kg of cottonseed meal per head/d followed by full-time clover-ryegrass.
[b] Intermittent grazing of Rye-ryegrass plus ad libitum hay followed by full-time Rye-ryegrass.
[c] Tifton-44 bermudagrass plus 1% corn for 147 d.
[d] Tifton-44 bermudagrass for 147 d followed by 98 d in the feedlot.
[e] Feedlot for 147 d.
[f] Based on a 9 point scale; where 4=moderately dark cherry red, 5=slightly dark red and 6=cherry red.
[g] Based on a 7 point scale; where 4=25 to 50% discolored; 5=10 to 25% discolored, 6=less than 10% discolored and 7=no discoloration.
[h] Based on an 8 point scale; where 4=slightly undesirable, 5=slightly desirable, 6=desirable and 7=very desirable.
[i] Based on an 8 point scale; where 5=creamy yellow, 6=cream and 7=creamy white.
[j,k,l,m] Subclass means in the same column with different superscripts differ ($P < .001$).
[n,o,p] Subclass means in the same row with different superscripts differ ($P \leq .05$).

from the 98-d feedlot treatments deteriorated at a more rapid rate than cuts from the 147-d forage-finished treatments.

No difference in surface discoloration was evident between the 147-d forage-fed or the 147-d grain-fed treatments, by d 2 and d 3, however, carcasses from the 98-d grain-fed treatment were distinctly lower and had the least desirable ($P < .05$) score at the conclusion of the evaluation period. Desirability characteristics for the grain-fed treatments were superior over the forage-fed steers and after the second day of display, beef from the 147-d grain-fed treatment had strongly maintained an advantage in total desirability and was evaluated as desirable. Nonetheless, when the evaluation was terminated, both the 147-d grain-fed and the 147-d forage treatments were only slightly desirable and did not differ significantly. The 98-d grain-fed samples, on the other hand, were undesirable by d 3 and showed evidence of having the fastest deterioration rate.

The grain-fed treatments had more desirable ($P < .05$) fat color scores up to d 3 of the display at which time fat on the samples from the 98-d grain-fed treatment turned yellow. At the completion of the evaluation, cuts from the forage treatment had fat color scores equivalent to creamy yellow, while samples from the 147-d grain-fed steers had creamy colored fat. Contrary to the rapid deterioration rate of forage-fed beef reported by Schroeder et al. (16), the 98-d grain-fed samples deteriorated at a much faster rate for all of the evaluated shelflife traits than samples from the 147-d grain-fed or the 147-d forage treatments.

Data Set 3

In accordance with Schroeder et al. (16) and Kelly (8), retail cuts from the grain-fed treatments had brighter muscle color evaluation scores than the forage-fed groups (Table 8). Retail cuts from the 85- and 147-d feedlot treatments were more ($P <$

TABLE 8. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SHELFLIFE TRAITS FROM DATA SET 3.

	Treatment					Electrical Stimulation	
Trait	Rye-ryegrass for 215 d[a]	Rye-ryegrass + Tifton-44 for 362 d[b]	Rye-ryegrass + 85 d Feedlot[c]	Rye-ryegrass + 147 d Feedlot[d]	SE	NS[e]	ES[f]
No. of Observations	64	40	88	32		112	112
Muscle Color[g]	4.90 ± 0.31[k]	4.78 ± 0.39[k]	5.61 ± 0.26[l]	5.59 ± 0.43[l]	0.18	4.98[k]	5.46[l]
Surface Discoloration[h]	5.90 ± 0.14[k]	6.15 ± 0.17[l]	6.28 ± 0.12[l]	6.12 ±0 .19[l]	0.08	6.12	6.10
Total Desirability[i]	4.98 ± 0.21[k]	4.57 ± 0.26[l]	5.76 ± 0.18[m]	5.58 ± 0.29[m]	0.13	5.11[k]	5.33[l]
Fat Color[j]	5.44 ± 0.14[k]	4.93 ± 0.17[l]	5.91 ± 0.12[m]	6.47 ± 0.19[n]	0.08	5.65	5.72

[a] Steers grazing Rye-ryegrass pastures full-time for 215 d.
[b] Steers grazing Rye-ryegrass pastures full-time for 215 d followed by grazing Tifton-44 pastures for 147 d.
[c] Steers grazing Rye-ryegrass pastures full-time for 215 d followed by 82 or 85 d in the feedlot.
[d] Steers grazing Rye-ryegrass pastures full-time for 215 d followed by 147 d in the feedlot.
[e] Carcass sides not receiving electrical stimulation.
[f] Carcass sides receiving electrical stimulation.
[g] Based on a 9 point scale; where 4=moderately dark cherry red, 5=slightly dark red and 6=cherry red.
[h] Based on a 7 point scale; where 5=10 to 25% discolored, 6=less than 10% discolored and 7=no discoloration.
[i] Based on an 8 point scale; where 4=slightly undesirable, 5=slightly desirable and 6=desirable.
[j] Based on an 8 point scale; where 4=yellow, 5=creamy yellow, 6=cream and 7=creamy white.
[k,l,m,n] Subclass means in the same row with different superscripts differ (P ≤ .05).

.05) desirable than the two forage-fed treatments when evaluating the cuts for total desirability. In fact, the 215-d and 362-d forage-fed treatments were slightly undesirable while on display in the retail case. This disadvantage in product desirability for the forage-fed treatments corresponds with the study conducted by Schroeder et al. (16). Fat color favored the grain-fed treatments with samples from the 147-d grain-fed steers having the whitest, most desirable (P < .05) fat color of the cuts from the compared feeding regimens. Contradicting reports published by Craig et al. (4), Kemp (9), and Bidner et al. (1), there were no real detectable differences in fat color between the 85-d grain-fed or the forage feeding treatments, since all were evaluated has having creamy yellow fat.

Retail cuts from the electrically stimulated carcasses had slightly dark red lean, while the non-stimulated cuts were moderately dark cherry red. A difference (P < .05) in total desirability was also detected between samples from the two treatments; however, both treatments were slightly desirable when their mean desirability scores were translated. These increased values of muscle color and desirability parallel studies by Savell et al. (15) and Rouquette (13).

Table 9 specifically describes the affects of feeding regimen on shelflife traits by retail display day. Between d 0 and d 1, no difference occurred in the deterioration of muscle color; however, after d 1, large differences (P < .001) occurred between the display days. Similarly, fat color did not deteriorate between d 0 and d 1, nor between d 2 and d 3. However, rapid deterioration of the lean occurred when evaluating for surface discoloration and total desirability.

The grain-fed treatments differed (P < .05) from the forage-finished treatments and had more desirable muscle color scores on the initial day of display. By d 1, samples of lean from the 85-d grain treatment had maintained their cherry red color; whereas, the two forage treatments and the 147-d grain-fed treatment began to show evidence of color deterioration. Day 2 and 3 evaluations revealed no difference in muscle color scores between the feeding regimens due to rapid deterioration of the 85-d grain-fed treatment. Supporting research by Wheeling et al. (18), Bowling et al. (3), and Schroeder et al. (16), retail cuts from the 147-d grain treatment had a slight advantage in muscle color with only slightly dark red lean by the end of the display period. However, contrary to previous documentation (4, 5, 16, 17) the grain-fed treatments provided evidence of deteriorating at a faster rate while under the retail display conditions.

No difference in surface discoloration was visible between the four feeding regimens when the retail cuts were initially placed into the display case; yet, after 24 h, differences occurred and remained through out the 3 d period. The 215-d forage-fed treatment had the most surface discoloration with 25 to 50% of the visible lean surface showing evidence of discoloration while these samples also showed evidence of a more rapid change of their surface, supporting conclusions documented by Schroeder et al. (16).

The initial evaluation of the retail cuts for total desirability favored (P < .001) the grain-fed treatments and after 24 h the 85-d feedlot treatment had maintained its desirable traits, while desirability scores from the 147-d grain treatment decreased and were not different from the 215-d forage-fed treatment. This trend continued through out the display period and by d 3 the 215-d forage-fed and the 147-d feedlot treatment did not differ and had traits of being slightly undesirable when the evaluation was finalized. Samples from the 362-d forage treatment had the lowest desirability evaluation score

TABLE 9. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SHELFLIFE TRAITS BY RETAIL DISPLAY DAY FROM DATA SET 3.

Trait	No. of Days on Display	Treatment			
		Rye-ryegrass for 215 d[a]	Rye-ryegrass +Tifton-44 for 362 d[b]	Rye-ryegrass + 85 d Feedlot[c]	Rye-ryegrass + 147 d Feedlot[d]
Muscle Color[e]					
SE		0.24	0.31	0.21	0.34
	0	4.96[m]	5.02[m]	6.05[n]	5.95[n]
	1	5.24[m]	4.97[m]	6.12[n]	5.70[m,n]
	2	4.83	4.69	5.32	5.50
	3	4.56	4.43	4.95	5.19
Surface Discoloration[f]					
SE		0.14	0.18	0.12	0.20
	0	7.00	6.98	6.91	6.88
	1	6.24[m]	6.07[m]	6.70[n]	6.38[m,n]
	2	5.46[m]	6.06[n]	6.18[n]	5.94[n]
	3	4.92[m]	5.49[n]	5.33[n]	5.30[m,n]
Total Desirability[g]					
SE		0.19	0.24	0.16	0.27
	0	5.39[m]	5.44[m]	6.56[n]	6.55[n]
	1	5.40[m,o]	4.83[m]	6.26[n]	5.91[n,o]
	2	5.03[m]	4.07[n]	5.58[o]	5.28[m,o]
	3	4.09[m]	3.94[m]	4.65[n]	4.56[m,n]
Fat Color[h]					
SE		0.12	0.15	0.10	0.17
	0	5.49[m]	5.32[m]	6.06[n]	6.95[o]
	1	5.55[m]	5.29[m]	6.15[n]	6.56[o]
	2	5.39[m]	4.48[n]	5.74[o]	6.44[p]
	3	5.34[m]	4.61[n]	5.69[o]	5.91[o]

[a] Steers grazing Rye-ryegrass pastures full-time for 215 d.
[b] Steers grazing Rye-ryegrass pastures full-time for 215 d followed by Tifton-44 pastures for 147 d.
[c] Steers grazing Rye-ryegrass pastures full-time for 215 d followed by 82 or 85 d in the feedlot.
[d] Steers grazing Rye-ryegrass pastures full-time for 215 d followed by 147 d in the feedlot.
[e] Based on a 9 point scale; where 4=moderately dark cherry red, 5=slightly dark red and 6=cherry red.
[f] Based on a 7 point scale; where 4=25 to 50% discolored; 5=10 to 25% discolored, 6=less than 10% discolored and 7=no discoloration.
[g] Based on an 8 point scale; where 3=undesirable, 4=slightly undesirable, 5=slightly desirable and 6=desirable.
[h] Based on an 8 point scale; where 4=yellow, 5=creamy yellow and 6=cream.
[i,j,k,l] Subclass means in the same column with different superscripts differ ($P \leq .001$).
[m,n,o,p] Subclass means in the same row with different superscripts differ ($P < .05$).

and was undesirable when removed from the display case, yet did not differ from the 147-d grain-fed treatment. Corresponding to Schroeder et al. (16), carcasses from the grain-fed treatments had superior ($P < .05$) fat color scores over the forage-fed treatments at the beginning of the display period and these superior scores were maintained throughout the display period.

Implications

This study indicates that forage-finished beef could be a possible alternative for markets with extended shelflife and(or) a contender for niche marketing or exportation. Although muscle color favored the grain-fed treatments at the initiation of the shelflife evaluation period, all treatments had similar lean beef display scores at the completion of the 3-d test. Our data would also imply that once the retail cuts were trimmed to the current 6.35 mm standard, visual detection of pre-slaughter feeding regimens would not be easily detected. Yet for effective marketability, shelflife presentation must also be accompanied by acceptable sensory traits to ensure consumer appeal of any lean or trimmed beef cut.

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Using Cloned Steers to Investigate Carcass Composition and the Mechanism of Marbling Development

J.J. Harris, J.W. Savell, S.B. Smith, and D.K. Lunt

Nuclear transfer clones (Brangus steers) are being utilized in parallel experiments to document the mechanistic effects of calf-feeding and yearling-feeding on carcass quality and composition, meat palatability and the role of preadipocyte proliferation in marbling development. The use of clones allows us to do research in which all of the experimental cattle have the same genotype, which can largely eliminate the normal animal-to-animal genetic variation that clouds many studies. Although genetic variation is not the only source of variation (environment also plays a major role) between cattle, it usually is the largest single source of variation. In the first experiment, cloned steers (n = 8) are being calf- or yearling-fed to a constant age of 15 months, allowing the composition to vary between the two feeding regimes.

It should be noted that in this first experiment, two genotypes are equally represented (all steers are from the same sire with four each from two dams). In the other experiment, cloned steers (n = 10) are being calf- or yearling-fed to a constant fat thickness of 0.5 inch, regardless of animal age. In both experiments, the calves are going on feed at 8 months of age and the yearlings at 12 months. Therefore, we have simultaneous experiments in which one maintains constant slaughter age (allowing composition to vary), and the other maintains constant external fat thickness (varying age). In this way, possible interactions between animal age, feeding regimen, and carcass composition can be evaluated.

At slaughter, samples of subcutaneous and marbling adipose tissue will be obtained by dissection, and preadipocyte proliferation during explant culture will be measured. The calpain protease system, as a measure of muscle growth impetus and postmortem proteolysis, and sarcomere length also will be measured. Additionally, quality and yield grade, meat palatability (sensory and shear force) and carcass composition (via dissection) will be measured. At present, the first group of steers (age constant) have been fed and slaughtered, with laboratory analyses on-going. The average weaning weights of the calf- and yearling-fed steers in this experiment were 540 and 548 lbs., respectively. The calves were on feed 214 d and the yearlings were fed 91 d. There was a substantial difference in the slaughter weights between the calf- and yearling-fed steers (1,130 vs 976 lbs., respectively). The fat constant steers all have been weaned, with the yearlings having been on oat pasture, and all currently are on feed, having expected slaughter dates between June and September 1993.

This experiment offers a very unique opportunity to investigate changes in marbling and carcass composition and palatability as impacted by animal age and management. By using clones, true mechanisms (at least within the genotypes represented by these steers) of fat deposition, muscle growth, palatability and other financially important traits to cattle producers can be studied without the usual animal-to-animal genetic variation that has plagued our ability to address these issues in the past.

Feeding and Nutrition

Effects of Zeranol on Bulls and Forage Versus Concentrate Feeding Regimens on Performance and Carcass Characteristics of Bulls and Steers

D.M. Polser, F.M. Rouquette, Jr., and J.W. Turner

Summary

The effects of zeranol and forage versus grain-based feeding systems were experimentally evaluated using information obtained at the Texas A&M University Research and Extension Center at Overton, Texas. A total of 74 1/2 Simmental X 1/4 Hereford X 1/4 Brahman bulls and steers born during 1983 and 1984 were used to create individual data sets for analysis. Animals were stratified according to treatment and sex and randomly assigned to either pasture plus supplementation, pasture alone or drylot nutritional strategies. Results indicated that implanting bulls did not significantly affect ($P > .05$) gain or carcass traits. Concentrate feeding produced both heavier and fatter carcasses ($P < .05$), larger *longissimus* muscle areas with more marbling and increased kidney, pelvic, and heart fat. Sex differences existed ($P < .05$) only when an adequate amount of nutrition was available.

Introduction

Throughout recent history, producers in the beef industry have sought to improve their production methods. It is no longer a matter of simply raising and selling calves. Rather, it is a matter of utilizing current technology and other methods to produce beef in a manner that provides a positive economic return to the producer. Growth implants have emerged as powerful tools that, when used properly, can increase gain and improve feed efficiency of steers and heifers. The popularity of implants among cattle feeders can be attributed to the following reasons: first, implants generally provide a sound economic investment, second, response to implantation is generally positive and third, their use is fairly simple.

There are numerous implants that are cleared for use in beef cattle, among them is one containing the compound zeranol. This compound is not an endogenous hormone, but instead is classified as a protein anabolic agent. Zeranol's mode of action appears to affect the release of certain hormones in the animal's body. Historically, research has shown that growth promotants produce differing results as there are numerous variables that can affect an animal's response to implantation.

Materials and Methods

The Texas A&M University Research and Extension Center located in Overton, Texas, utilizes F-1 (Brahman X Hereford) cows and Simmental bulls in order to conduct research in the areas of beef production and forage utilization. For this study, two groups of 1/2 Simmental X 1/4 Brahman X 1/4 Hereford bulls were used to study the effects of zeranol, sex, and forage versus concentrate nutritional regimens on animal performance and carcass characteristics. Another two groups of steers of the same breeding were utilized to determine the effects of diet and sex upon the same performance characteristics.

Data were collected on bull and steer calves for the periods of 1983-84 (Trial 1) and 1984-85 (Trial 2). Initially, calves were allotted to their respective trials, however, preliminary analysis indicated that there were no statistically significant differences in the traits measured, therefore, the data sets were combined. Having done this, it became evident that not all animals received the same treatment. Subsequently, the data were edited to create subsets containing data on like animals that received the same treatment and nutritional strategies. Therefore, comparison consisted of four independent analyses.

Several comparisons could not be made as feeding regimens were not consistent across sex, and there was no control group for steers. Likewise, carcass data was not available for several subsets, thus limiting the scope of this report. A more detailed description of the experiment follows.

Bull performance analysis

Data from a total of 42 implanted and nonimplanted bulls from each of the two trials, representing two treatments (implant versus nonimplant), three nutritional regimens (grazing of Elbon rye (*Secale cereale*) - Gulf ryegrass (*Lolium multiflorum*) pastures plus .90 kg whole shelled corn per head per day, pasture alone, and feedlot ration, and the interaction of the above terms were edited to form a data set. A contrast was performed to detect any possible differences between the forage based systems. No significant difference ($P > .4$) was found and, as a result, data from the two forage systems were combined. Average daily gain (ADG) served as the response variable.

Bull carcass analysis

The 22 observations that made up this data set were used to analyze the effects of implantation, nutrition, and their interaction upon the carcass traits of bulls. The carcass traits

used for comparison included: fat color (FCOL); hot carcass weight (HOTWT); fat thickness (FTHK) opposite the twelfth rib; ribeye area (REA); kidney, pelvic, and heart fat (KPH) percentage; skeletal maturity (SKMAT); lean maturity (LMAT); marbling (MARB); lean color (LCOL); lean firmness (LFIRM); and lean texture (LTXT).

Steer performance analysis

The effect of nutrition upon ADG was measured using 32 steers from both trials. Independent variables representing pasture plus grain supplement, feedlot, and full pasture alone were represented by 16, 10, and 6 observations, respectively. Since all steers were implanted, no comparison could be made for the effect of treatment. Similarly, nutritional regimens were different for the two trials and, as a result, the effects of a year X nutrition interaction were not possible.

A contrast was performed to detect any differences among the three nutritional systems. Pasture plus grain did not differ from pasture alone ($P > .5$); however, the concentrate based feeding system was significantly different ($P < .001$) from the forage based systems. The pasture based systems were not pooled in order to obtain more independent variables for analysis.

Bull and steer performance analysis

A total of 30 observations, comprised entirely of implanted animals and numbering 10 bulls and 20 steers, were utilized to determine the effects of nutrition, sex, and their interaction upon ADG. Fifteen animals from each sex received either pasture or feedlot diets.

Results and Discussion

Bull performance analysis

Average daily gain was statistically analyzed using the following independent variables: year, treatment, nutrition, and all subsequent interactions. Least-squares mean values (LSM) for ADG are contained in Table 1. Bulls measured during Trial 2 gained .17 kg more ($P < .005$) than bulls in Trial 1. The nutritional strategy was significant ($P < .0001$) with bulls receiving concentrate ration or pasture plus grain supplementation gaining 1.27 and .72 kg per day, respectively. Other reports (4) have indicated like differences between forage-fed and grain-fed cattle. The interaction of treatment and nutrition had tendencies ($P < .06$) towards significance suggesting that when provided with adequate nutrition, bull performance may be enhanced. Treatment was not significant at any level and this result is consistent with other findings (2).

Bull carcass analysis

A series of carcass traits was analyzed to determine the effects of treatment and nutrition. Treatment was not statistically significant for any of the dependent variables, however a treatment X nutrition interaction was detected ($P < .05$) for

TABLE 1. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR ADG OF BULLS (kg/d).

	Year		Treatment		Nutrition	
Variable	Trial 1	Trial 2	Implant[a]	Control	Pasture[b]	Feedlot[c]
LSM	.91[d]	1.08[e]	1.02	.97	.72[f]	1.27[g]
SE	.03	.03	.03	.03	.03	.03
n	22	20	21	21	20	22

[a] Implanted with 36 mg zeranol.
[b] Grazing Rye-ryegrass pasture or Ryegrass pasture plus .90 kg whole corn/hd/d.
[c] Ad libitum access to whole corn plus protein premix containing monensin and 4.5 kg Coastal bermudagrass/hd/d.
[d,e,f,g] Means within a row with no common superscript differ ($P < .005$) for a given effect.

LTXT. The effects of nutrition were significant for many of the dependent variables including: HOTWT ($P < .0001$), FTHK ($P < .005$), REA ($P < .001$), KPH ($P < .05$), SKMAT ($P < .005$) and MARB ($P < .005$). Least-squares means for the various carcass traits are listed in Table 2. Carcass weights were 130.2 kg heavier and had .45 cm more external fat for bulls receiving a feedlot ration compared to pasture fed bulls. This is in agreement with other findings (1), which reported that higher levels of energy intake produced heavier and fatter carcasses.

Least-squares mean values for REA differed by 6.29 cm^2 in favor of the concentrate-based diet. Other studies (3) have also reported that feeding of concentrate-based diets increased REA. Percent kidney, pelvic and heart fat estimates were 1.79 and 1.15 for grain-fed and forage-fed systems, respectively. Skeletal maturity was detected as being significantly affected by nutrition, however, LSM values indicate they are within the A maturity range. Lean maturity tended to be significant ($P < .06$) and LSM values for nutritional effects indicated that forage-based diets produced carcasses that fit into the B maturity category whereas grain-fed carcasses fell into the A classification. Least-squares means values for marbling indicated that forage-fed and grain-fed bulls should be graded as Low Standard and Standard, respectively. Lean color and firmness were not affected by any treatment or treatment combination.

Steer performance analysis

Animal performance, as measured by ADG, was analyzed using nutrition as the independent variable. Nutrition was categorized as either full time grazing of Elbon rye- Gulf ryegrass pastures alone, grazing the same types of pastures with .90 kg supplementation of whole corn/hd/d, or feedlot rations. The effects of nutrition were significant ($P < .0001$) and LSM values revealed that concentrate fed steers gained .57 kg more than steers grazing pasture plus grain, which in turn, gained .02 kg more than steers on pasture alone (Table 3).

Bull and steer performance analysis

Sex, nutrition and their interaction were analyzed to detect their effects upon ADG in bulls and steers. Nutrition

TABLE 2. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR CARCASS TRAITS OF BULLS.

	Implant[a]	Control	Pasture[b]	Feedlot[c]
n	11	11	10	12
FCOL[d]	3.08	2.73	2.90	2.92
HOTWT[e]	264.8	282.3	208.5[o]	338.7[p]
FTHK[f]	.39	.33	.14[o]	.59[p]
REA[g]	74.57	76.48	67.54[o]	83.51[p]
KPH[h]	1.67	1.26	1.15[o]	1.79[p]
SKMAT[i]	150.92	146.83	139.00[o]	157.75[p]
LMAT[i]	202	239	243	199
MARB[k]	254	226	186[o]	294[p]
LCOL[l]	5.00	4.18	4.10	5.08
LFIRM[m]	5.65	5.33	5.40	5.58
LTXT[n]	5.30	5.03	5.00	5.33

[a] Implant consisted of 36 mg zeranol.
[b] Rye-ryegrass grazing alone or Rye-ryegrass grazing plus .90 kg corn/h/d. Pasture treatments did not differ (P > .4).
[c] Ad libitum access to whole corn plus protein premix and 4.5 kg Coastal bermudagrass/h/d.
[d] Fat color based on a 5 point scale; where 1 = white, 5 = yellow.
[e] Hot carcass weight, kg.
[f] Fat thickness measured at the twelfth rib, cm.
[g] Ribeye area, cm^2.
[h] Percent kidney, pelvic and heart fat.
[i] Skeletal maturity based on a 200 point scale; where 100 = A maturity, 200 = B maturity.
[j] Lean maturity based on a 200 point scale; where 100 = A maturity, 200 = B maturity.
[k] Marbling score based on a 300 point scale; where 100 = Practically devoid, 200 = Traces, 300 = Slight.
[l] Lean color based on an 8 point scale; where 4 = Slightly dark red, 5 = Slightly bright red.
[m] Lean firmness based on an 8 point scale; where 4 = Slightly soft, 5 = Slightly firm.
[n] Lean texture based on an 8 point scale; where 4 = Slightly coarse, 5 = Slightly fine.
[o,p] Means in the same row with no common superscript differ (P < .05) for a given effect.

alone was significant (P < .0001) but sex was not significant (P > .09). However, an interaction of the above terms was detected (P < .05). Least-square mean values indicated that although there were not large differences between the sexes while grazing forages, .76 kg and .79 kg for bulls and steers, respectively, larger amounts of variation existed when the animals were placed on feed, 1.54 kg bulls versus 1.33 kg steers (Table 4). This suggests that animal performance was limited by forage quantity and quality and approached a "ceiling ADG", (5). However, when provided with an adequate plane of nutrition, bulls performed better than steers.

Conclusion

This study has related the effectiveness of growth implants in bulls as measured in average daily gain and its effects upon carcass traits, the differences in performance between bulls and steers, and the effects of forage or grain feeding systems upon performance characteristics.

The effects of the implantation of bulls were statistically nonsignificant for all of the traits measured. However, it appears that when provided with an increased plane of nutrition, implanting bulls can improve performance compared to nonimplanted bulls. Contrastingly, if nutrition is limited to forage based systems alone, implanting does not appear to offer any increased benefits.

TABLE 3. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR ADG OF STEERS (kg/d).

Strategy	Number of observations	Least-squares mean	Standard error
Pasture plus grain[a]	16	.76[d]	.02
Feedlot[b]	10	1.33[e]	.03
Pasture alone[c]	6	.74[d]	.04

[a] Rye-ryegrass plus .90 kg corn /hd/d.
[b] Ad libitum access to corn, protein premix and 4.5 kg Coastal bermudagrass hay/hd/d.
[c] Rye-ryegrass alone for 57 d and supplemented with corn and hay for 133 d.
[d,e] Means within the same column with no common superscript differ (P < .05).

TABLE 4. LEAST-SQUARES MEANS AND STANDARD ERRORS FOR ADG OF BULLS AND STEERS (kg/d).

	Strategy	Number of observations	Least-squares means	Standard error
Main effects	Pasture (P)[a]	15	.77[c]	.03
	Feedlot (F)[b]	15	1.43[d]	.03
	Bull (B)	10	1.15	.04
	Steer (S)	20	1.06	.02
Interactions	P*B	5	.76	.05
	P*S	10	.79	.04
	F*B	5	1.53	.05
	F*S	10	1.33	.04

[a] Rye-ryegrass alone.
[b] Ad libitum access to whole corn, protein premix and 4.5 kg Coastal bermudagrass hay/hd/d.
[c,d] Means within the same column with no common superscripts differ (P < .05) for a given trait.

There does not appear to be any sex differences between implanted bulls and steers as both groups gained similarly on both pasture and feed. This would indicate an advantage to feeding steers because of the behavior related problems often associated with bulls.

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Metabolic Indices for Growth: Endocrine Profile of Steers on Different Nutritional and Growth Regulation Regimens

C. D. Reinhardt, F. M. Byers, N. D. Turner, G. E. Carstens and D. C. Kenison

Summary

Thirty-six Angus x Hereford steers (mean weight = 275 kg) were used in a 56-d experiment examining endocrine influences on empty body gain (DEBG), protein gain (DPG), fat gain (DFG), retained energy (RE), and energy density of gain (RE/G). Animals were individually fed daily at one of three levels (9.1, 7.3, or 5.5 kg/d) and treated with 36 mg zeranol, 600 µg/d zeranol (delivered from a mini-osmotic pump) or no growth regulator. Endocrine analyses included IGF-1, thyroxine (T4), triiodothyronine (T3), and the ratio of T3:T4. Plasma glucose and plasma urea nitrogen were also analyzed. For each sample day, the endocrine factors which were statistically determined to be linked to the calculated growth measures were regressed against the respective growth functions. IGF-1, T3, the ratio of T3:T4 and plasma glucose were related to gain, composition of gain, and energy density of gain. Also plasma urea nitrogen varied with respect to both nutritional level and growth regulators, indicating an alteration in nitrogen balance. Zeranol delivered via implants and mini-osmotic pumps increased plasma IGF-1 and glucose, and decreased plasma urea nitrogen for a 56-d period. Prediction models were generated for DEBG (R^2 = .56), DPG (R^2 = .47), DFG (R^2 = .58), RE (R^2 = .74), and RE/G (R^2 = .52). DPG was predicted by initial T3, d2 glucose and DEBG. Prediction of DRE included d 16 IGF-1, d 1 and 56 T3, and DEBG. The model for RE/G included d 2 T3:T4, and d 32 and 56 glucose. These indices should be useful tools to estimate short-term growth patterns in animals treated with growth regulators.

Introduction

Hormones of potential use for estimating body composition changes are IGF-1, thyroxine (T4), and tri-iodothyronine (T3). IGF-1 has been associated with increased growth in pigs (11), and lean deposition in cattle (1). Thyroid hormones are suspected to stimulate protein degradation and turnover, and to inhibit muscle fiber growth. Previous research demonstrated that zeranol repartitions nutrients away from fat deposition toward protein deposition (8) thereby altering body composition, and reduces T4 levels (12).

The objectives of this research were to: 1) determine which of the described hormones and(or) metabolites could be statistically linked to changes in composition of growth, and 2) what sampling strategy would be most effective to predict the composition of growth.

Materials and Methods

Thirty-six feeder steers were stratified by weight (mean = 275 kg) in a 3 X 3 factorial design with three zeranol treatments (0, 36 mg implant, or 600 µg/d Alzet osmotic pump) and three intake levels (low, 5.5 kg/d; medium, 7.3 kg/d; or high, 9.1 kg/d). Animals were individually fed a concentrate diet (66% whole shelled corn, 18% cottonseed meal, 10% cottonseed hulls, 4% dried molasses and 2% vitamin-mineral premix) for 12 d prior to sampling at 80% of ad libitum intake, during which time initial body composition was estimated by two-pool D_2O dilution (4). Following d 56, final composition was estimated. Protein and fat accretion were determined by the difference between initial and final composition.

The experiment began when treatments were applied (d 0). Zeranol implants (36 mg) were placed in the standard subcutaneous location on the back side of the ear. Alza mini-osmotic pumps were prepared using the following preparation and surgical procedures to deliver 600 µg of zeranol per day.

Zeranol was completely dissolved in DMSO. To this solution PEG 300 was added, with thorough, continuous mixing. This yielded a solution that would deliver 600 µg/d, considering an estimated pump delivery rate of .051 ml/d. Solutions were filtered through a Nalgene disposable filter (.45 µm pore size) for sterilization. The sterile solution was added to the pumps, with both volume and weight of solution noted.

The pumps were placed into test tubes along with just enough saline to come close to the top of the pump, but not contact the flow moderator. This prevented saline from entering the pumps, which would have precipitated zeranol out of solution. The tubes were placed into a 37°C water bath for 4 hours. After that time, the tubes were removed, the pumps removed from the tubes and the saline poured off. The pumps were placed back into the tubes for transportation to the work site.

To implant the pumps, an incision was made at the base of the recipient's ear in a loose fold of skin after application of a local anesthetic. Blunt dissection was used to open a small pouch that was 1.5 times the pump length (4.4 cm). The Alzet was placed in the incision, with the delivery port in the dorsolateral position (away from incision), and the incision was then sutured closed. After 28 d the incision was re-opened, the pump was removed, and the incision was re-sutured.

After removal from the animal, pumps were cut at the base to expose the internal compartment, a needle was inserted into the compartment and all the remaining solution was extracted with a syringe. The volume and weight of

solution recovered was recorded. Rates of delivery were determined by changes in volume and weight of solution from preparation to recovery. These procedures were developed based on the published protocol from Alza Corporation and discussions with their technical staff.

After completion of the experiment, blood samples taken prior to feeding in the morning on day -7, -3, -1, 0, 1, 2, 4, 8, 16, 32 and 56 were analyzed for serum IGF-1 (Rabbit anti-IGF-1 courtesy of National Institute of Diabetes and Digestive and Kidney Diseases through the National Hormone and Pituitary Program), T3 and T4, and plasma glucose and urea nitrogen. IGF-1 was determined using our validated assay, T3 and T4 were determined using commercial RIA kits, and plasma urea nitrogen and glucose were measured using auto-analyzer methods that are routinely conducted in our Nutrition and Growth laboratories. The pre- and post-treatment values of all blood analytes were regressed (10) against DEBG, DPG, DFG, RE, and RE/G. The sample day or two sampling days for each hormone and metabolite, which were most closely linked to the growth functions, were included in general linear models with growth as the dependent variable. The backward stepwise regression procedure was performed, with those variables not significantly contributing ($P > .25$) to each model being eliminated. If elimination of a variable resulted in a R2 drop of .02 or greater, that variable and each subsequently removed variable were retained in the final model.

Results and Discussion

The experiment was designed to produce a range in DEBG, DPG, DFG, and RE (Table 1). The means for DEBG and DPG were similar to those reported by Lemieux et al. (8), but mean DFG was slightly higher than reported by those researchers.

Growth regulator treatments increased several of the endocrine factors and metabolites. Across day and intake level, the treatments induced an 11.9% increase in serum IGF-1 concentration. At d 32, animals receiving Alzet and implant treatments had 43.1 and 48.8% greater ($P < .05$) IGF-1 levels than controls (Figure 1). IGF-1 concentration for d 16 through 56 was 31.4 and 36.2% higher ($P < .05$) for steers receiving the Alzet and implant treatments than controls (Figure 1). These results are consistent with Breier et al. (3) who reported an increased IGF-1 concentration in estradiol-treated steers. While not affecting T4 levels (Figure 2), the Alzet treatment increased ($P < .10$) T3 concentrations across day and intake level (11.2%) over controls (Figure 3), and tended ($P > .10$) to increase T3 (7.5%) across the final 3 sampling days over controls. The lack of T4 response in this study is consistent with results of Bowman and Ellersieck (2), but contrary to a reduction reported by Wiggins et al. (12). Due to T3 increases, the ratio of T3:T4 for Alzet treated steers was also 20% higher ($P < .10$) across all days and 74.7% higher ($P < .05$) on d 4 than controls (Figure 4).

Alzet and implant treatments induced decreases in plasma urea nitrogen of 15.7 and 14.8% across d 1 through 56 ($P < .01$), 27.4 and 25.3% at d 8 ($P < .05$), and 19.8 and 13.0% across d 16, 32, and 56 ($P < .05$). This response was consistent with Loy et al. (9) who reported a reduction in plasma urea nitrogen levels following zeranol treatment. In the current study, the effect of growth regulation on urea nitrogen concentrations is not initiated until after d 4 and is sustained from d 8 through 56 (Figure 5). Reduced urea nitrogen concentrations indicate zeranol reduced protein degradation or turnover.

Alzet and implant treatments induced 21.0 and 18.9% increases in glucose over controls across all sampling days ($P < .001$). At d 8 the Alzet and implant treatments caused 36.0 and 28.8% increases in glucose over controls ($P < .05$) and across d 16, 32 and 56 treated animals had 14.2 and 14.8% higher ($P < .10$) glucose levels than controls (Figure 6). A similar effect of growth regulators on glucose levels was observed by Loy et al. (9).

TABLE 1. MEAN, RANGE AND STANDARD ERROR FOR EACH MEASURED GROWTH FUNCTION.

Growth component	Mean	Range	SEM
Daily empty body gain (kg/d)	1.06	-.04-1.85	.066
Protein gain (kg/d)	.083	-.023-.211	.010
Fat gain (kg/d)	.680	-.16-1.49	.056
Retained energy (Mcal/d)	6.845	-1.35-14.42	.521
Retained energy/gain (Mcal/kg)	7.527	2.22-11.4	.335

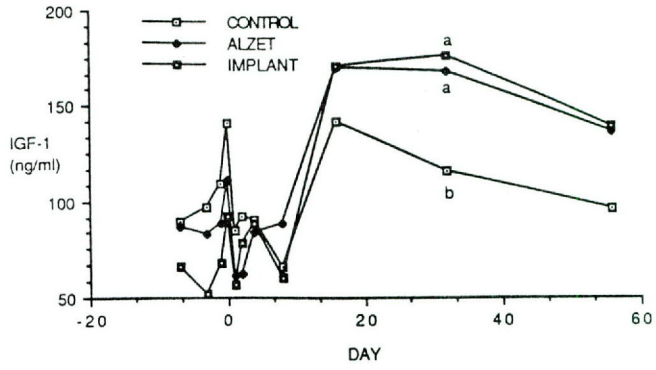

Figure 1. IGF-1 concentrations by day as affected by zeranol treatment (a,b $P < .05$; SEM = 8.0).

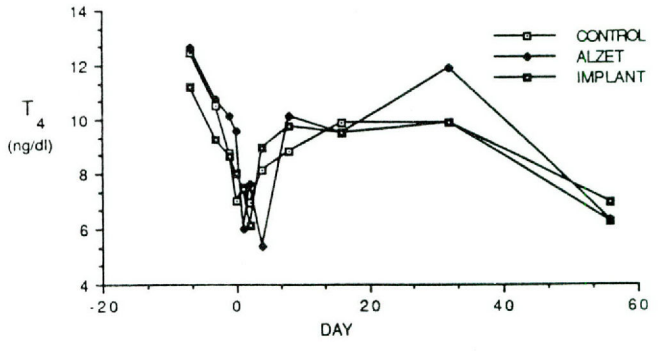

Figure 2. Thyroxine (T4) concentrations by day as affected by zeranol treatment (SEM = .39).

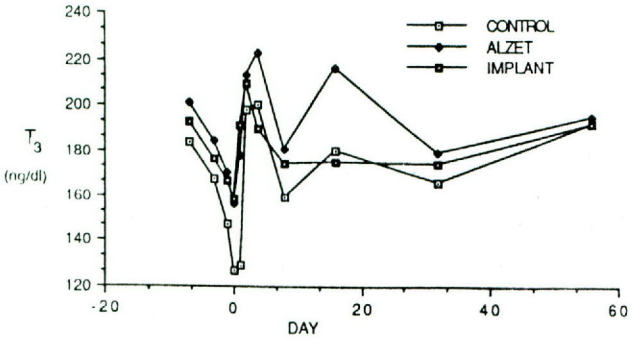

Figure 3. Tri-Iodothyronine (T3) concentrations by day as affected by zeranol treatment (SEM = 7.5).

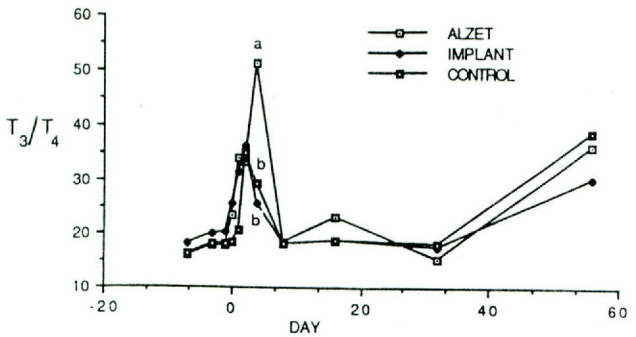

Figure 4. Triiodothyronine:thyroxine (T3:T4) ratios by day as affected by zeranol treatment (a,b P<.001; SEM=1.9).

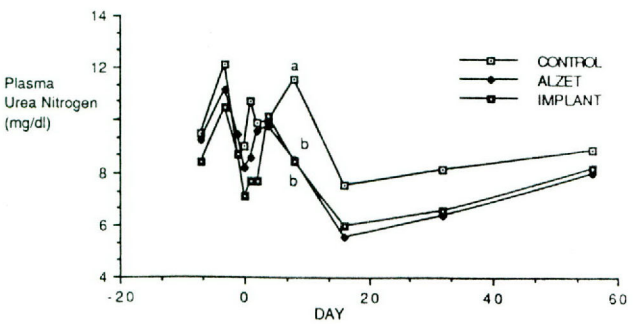

Figure 5. Plasma urea nitrogen concentrations by day as affected by zeranol treatment (a,b P < .05; SEM = .32).

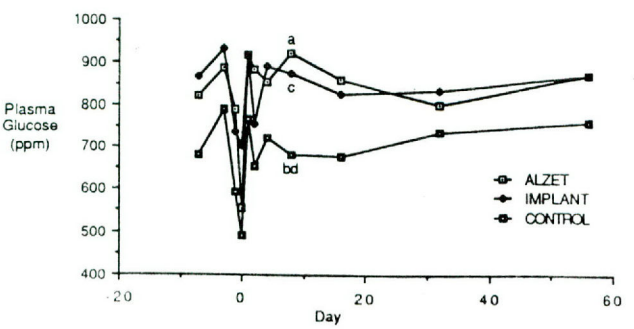

Figure 6. Plasma glucose concentrations by day as affected by zeranol treatment (a,b P < .05; c,d P < .10; SEM = 29.7).

Means (from d 1 to 56) by intake groups of the analytes measured are in Table 2. The highest intake level resulted in increased (P < .05) serum T3 and plasma urea nitrogen concentrations and slightly elevated (n.s.) IGF-1 concentrations. The medium intake level resulted in an intermediate depression in urea nitrogen concentrations. The greatest reduction in plasma urea nitrogen and IGF-1 concentration was observed with the low intake level. On d 16, serum IGF-1 concentrations were 35% greater (P < .05) in the high intake group compared to the other groups (Table 3). T3 concentrations were also 32% greater (P < .05) in the high intake group compared to the other groups on d 56. The increase (52%) in plasma urea nitrogen for cattle in the high intake group was only different (P < .05) from the low intake group.

Final prediction models and R^2 values for each are presented in Table 4. IGF-1 was positively related to DEBG, DPG, DFG, and the natural log of RE. These results are consistent with Hizuka et al. (7) who reported increased growth rates in hypophysectomized rats following IGF-1 administration. Disteldorf et al. (5) found greater rates of protein synthesis and reduced protein degradation in rat smooth muscle cells treated with IGF-1.

Level of T3 was negatively related to RE and the ratio of T3:T4 was positively related to DEBG and RE/G, and negatively related to DFG. These results are in agreement with those of Wiggins et al. (12) who found reduced T4 levels in sheep implanted with zeranol. Plasma glucose was positively related to DPG, and negatively related to DEBG and RE/G.

The relationship between IGF-1 and growth presented in this study may be explained by the obvious links between growth and nutritional status (6) where IGF-1 increases paralleled compensatory weight gain. The glucose-growth relationships reported in this study were expected based on intake differences. Ellenberger et al. (6) found 10% glucose reductions during 50% intake restriction.

Sampling days of greatest importance in predicting responses to growth regulators were as follows. The sampling days and predictors retained in the final model for DEBG were d 16 IGF-1, d 8 T3:T4, and d 4 and 56 for plasma glucose. Variables retained for DPG were initial T3, d 2 plasma glucose, and DEBG. DFG was predicted using d 2 and 16 IGF-1, d 1 and 2 T3:T4, and d 0 plasma glucose. Sampling days and predictors retained for DRE were d 16 IGF-1, d 1 and 56 T3, and DEBG. The model for RE/G included d 2 T3:T4, and d 32 and 56 plasma glucose.

Implications

IGF-1, T3, the ratio of T3:T4, and plasma glucose have shown relationships to gain, composition of gain, and energy density of gain. This study has shown that certain circulating factors are associated with changes in animal development. In addition to these factors, plasma urea nitrogen has been shown to respond to growth regulation and dietary restriction, indicating an alteration of nitrogen balance.

TABLE 2. INTAKE GROUP MEANS FOR ENDOCRINE AND METABOLITE LEVELS (d1 TO 56).

Intake group	Intake (kg/d)	Serum IGF-I (ng/ml)	Serum T3[a] (ng/ml)	Serum T4[b] (ng/dl)	T3/T4	Plasma urea nitrogen(mg/dl)	Plasma glucose (mg/dl)
High	8.5	113.3	197.5[c]	8.4	27.6	9.2[c]	83.5
Medium	6.8	100.3	174.4[d]	8.1	24.8	8.5[cd]	77.9
Low	5.5	104.2	186.0[d]	8.3	28.5	7.8[d]	82.9
SEM	.49	7.97	7.48	.394	1.93	.32	2.87

[a] T3 = tri-iodothyronine.
[b] T4 = thyroxine.
[c,d] Means in a column without a common superscript differ (P<.05).

TABLE 3. MEAN ENDOCRINE AND METOBOLITE LEVELS BY INTAKE FOR DAYS IN WHICH DIFFERENCES WERE OBSERVED.

Intake group	Serum IGF-I d 16 (ng/ml)	Serum T3 d 56 (ng/ml)	Plasma urea nitrogen d 16 (mg/dl)
High	195.5[a]	230.6[a]	7.9[a]
Medium	138.7[b]	166.9[b]	6.1[a,b]
Low	151.1[b]	181.8[b]	5.2[b]
SEM	10.71	11.01	.50

[a,b] Means in a column without a common superscript differ (P<.05).

Changes in composition can now be identified by measuring the specified hormones and metabolites on the appropriate days post-treatment, and applying the values to metabolic index equations generated in this study. Using these indices, empty body gain, protein gain, fat gain, daily retained energy, and energy density of gain can be estimated.

TABLE 4. FINAL LINEAR PREDICTION MODELS.

Dependent variable[a]		Model statement and R^2 coefficients for each model
DEBG	=	.56+IGF1 (d 16)* .0034+T3:T4 (d 8)* .0164-Glucose (d4 & 56)* .00042, R^2=.56
DPG	=	-100.15+Glucose (d 2)* .0654 + Initial T3* .0327 + DEBG* 73.765, R^2 = .47
DFG	=	.932 + IGF1 (d 2 & 16)* .0029 - T3:T4 (d 1 & 2)* .0099 - Initial glucose* .00034, R^2 = .58
LnDRE	=	1.649 + IFG1 (d 16)* .0022 - T3(d 1 & 56)* .0037 + DEBG* .476, R^2 = .74
RE/G	=	-6.003 + T3:T4(d 2)* .125- Glucose (d 32 & 56)* .0115, R^2 = .52

[a] DEGB = daily empty body gain, DPG = daily protein gain, DFG = daily fat gain, DRE = daily retained energy, RE/G - retained energy per unit gain.

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Growth and Reproduction

Acetaldehyde as a Possible Marker and Predictor of Bovine Estrus

W. R. Klemm

Summary

As cows near the stage of estrus, they give off volatile chemical signals (pheromones) that bulls respond to with preparatory mating behaviors. We have shown that these pheromones are present in cervico-vaginal mucus and in the secretions of certain vulvar skin glands. As an approach to the chemical identification of such compounds, we used gas chromatography to analyze the volatile compounds present in blood and their changes with various stages of the estrous cycle. We found several distinguishable volatile components in blood, one of which was correlated with the stage of estrus. We confirmed that this component was acetaldehyde. Fluctuations in acetaldehyde levels in blood, and perhaps in other body fluids such as milk, saliva, or sweat, or even in breath air, may serve as indicators and predictors of bovine estrus.

Introduction

We (4) and others have shown that cervico-vaginal mucus at the time of estrus is a very potent aphrodisiac for bulls (3,9,14), thus, indicating that this body fluid contains volatile compounds that are markers of estrus and ovulation. We also observed that cervico-vaginal mucus contains many unusual and interesting chemicals (4), but could not establish which if any compound could predict estrus because the mucus itself is only secreted in large amounts around the time of estrus. Also, it is difficult to collect the mucus without getting it contaminated by feces and other organic matter. Urine is a potential source of estrus-predicting volatile compounds, but collection of urine from cows requires tedious catheterization. Also, urine contents are notoriously variable, affected by diet, metabolic changes, and probably a host of other difficult-to-control variables. Moreover, urine contains an abundance of compounds, which magnifies the problems of chemical isolation and identification.1

For these reasons, we decided to test other body fluids. Because attractant pheromone is contained in both urine and cervico-vaginal mucus, we postulated that it might be carried also in other body fluids, particularly blood. Tests of serum from near-estrous females confirmed this suspicion. Positive attraction and sexual arousal responses could be seen by putting 10 ml of blood in a dish in an open outdoor pen of bulls, with no females present (11,12,13).

Chemical analysis of low-molecular weight volatile compounds has special technical difficulties, not the least of which is that the compounds of interest are readily lost to evaporation during handling. Also, it is not, for example, very feasible to extract the sample with various organic solvents and then try to concentrate the compounds of interest by evaporating the solvents - the sample would also evaporate. We therefore chose to examine the volatile components of blood with head-space gas chromatography (HSCG), which does not require prior extraction. In essence, head-space gases above the blood were trapped, pulled into a heated, gas-tight syringe, and directly injected onto a capillary gas chromatographic column

Materials and Methods[1]

HSGC

Ten ml of citrated blood were put in 30 ml injection vials, sealed with a teflon septum. One ml of the headspace in a vial was drawn into a heated, gas-tight syringe and injected into the splitless port of an Hewlett-Packard HP-5 gas chromatograph.

Eriching Headspace Yield

In order to increase the yield of volatile compounds in the head space, we tested six procedures: 1) shaking the sample, 2) heating sample to 100°C, 3) varying the equilibration time of heated samples, 4) varying the amount of blood in the injection vial, 5) altering the water content of blood, and 6) adding various salts to precipitate blood proteins.

Derivatization

In order to confirm the identity of one of the volatile compounds that was found to correlate with estrus, we first derivatized the blood headspace through an acidified solution of reagent (2,4-dinitrophenylhydrazine - DNPH).

Mass Spectral Analysis

GC/MS analysis was performed on a Hewlett-Packard Model 5970 GC/quadrupole mass spectrometer coupled to a HP model 5890 GC fitted with a HP Ultra-1 cross-linked methyl silicone microbore capillary column (12.5 m, 0.30 mm O.D., 0.20 mm I.D.).

Results and Discussion

Here, we can only summarize out latest findings. Complete results are presented elsewhere (5).

[1]Complete details are being published elsewhere (5).

Our initial studies of whole blood showed that the HSGC profile of early eluting components differed with the stage of estrus cycle. One peak in this profile, peak #3 (arrow in Figure 1), increased dramatically just prior to the day of estrus. This peak eluted from the column quite rapidly, even at room temperature, indicating that it was of very low molecular weight.

As the first step in identifying peak #3, we tested several low-molecular weight compounds and found that acetaldehyde co-eluted with peak #3. Initially, our procedures yielded amounts of peak #3 that were too small to permit mass spectral identification. Of the various enrichment procedures tested, heating and adding potassium carbonate were the most effective in increasing the release of bound acetaldehyde into the blood head space.

Chemical derivatization of blood head space and mass spectral identification showed that peak #3 was acetaldehyde (Figure 2).

Measurement of acetaldehyde at various stages of 24 estrous cycles of seven cows revealed that in every cycle, the relative amounts of acetaldehyde increased a few days before behavioral signs of estrus (as confirmed by rectal palpation of the ovaries) and decreased markedly on the day of estrous or shortly thereafter (see example in Figure 3). This was true whether the estrus occurred as a result of a super-ovulation pre-treatment hormone regimen or was a naturally occurring cycle ("N" in the Figures).

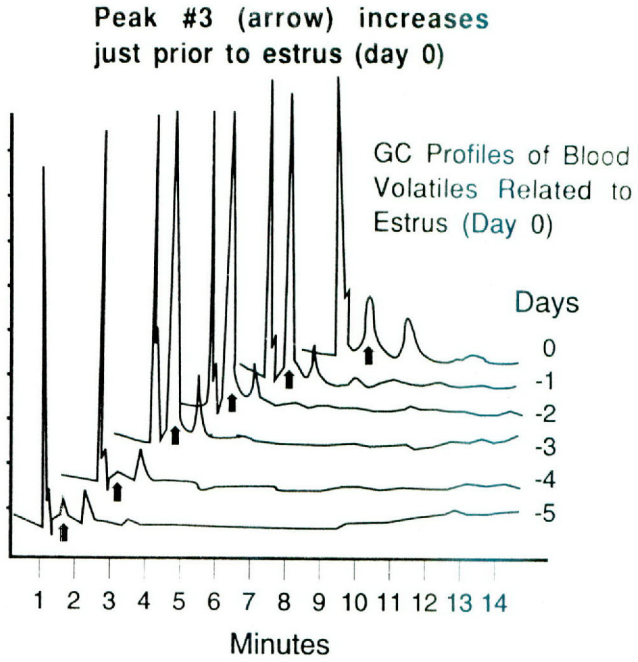

Figure 1. GC profiles from the headspacegas of the same cow in various stages of the estrous cycle (day 0 = day when cow stood for mating, which is the typical behavioral sign of bovine estrus; day 0 was also confirmed by rectal palpation of ovaries). The third peak (arrow) conspicuously increases on days-3 to -1. Run profile began at 300C, holding for 10 min, and 40C/min, terminating at 1100. Injector temperature was 1800C and FID detector temperature was 2000C. Flow rate of helium carrier gas was 4 ml/min. Peak asrea were calculated with the PC software "Chromperfect" (Justice Innovations, Inc.).

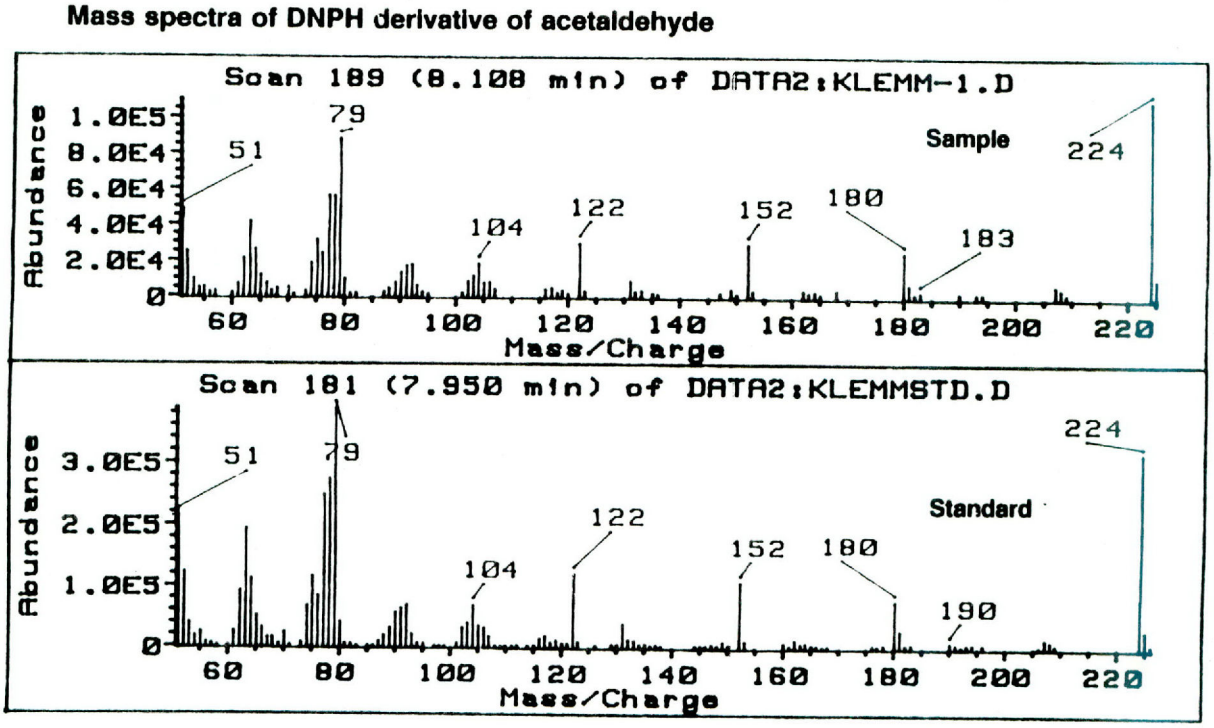

Figure 2. Spectra of blood head space that was derivatized with DNPH (sample) and a comparably prepared acetaldehyde standard. The 224 molecular ion is the sum of the mass of DNP (198) and acetaldehyde (44), minus the mass of water, which is eliminated in the reaction. These spectra provide definitive proof that the compound of interest is acetaldehyde.

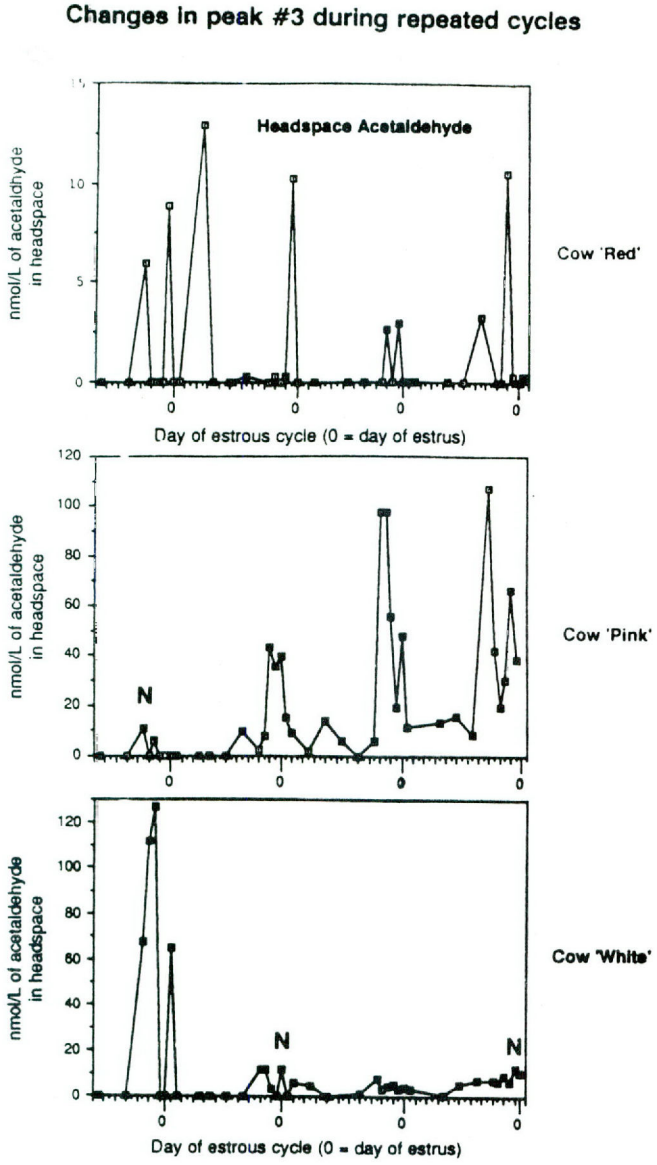

Figure 3. Changes in blook head-space acetaldehyde during four estrous cycles in a representative cow. In every cycle the relative amounts of acetaldehyde increased and then suddenly decreased at or near estrus. "N" signifies that the estrus was natural and not preceded by FSH and prostaglandin injections.

This discovery seems to be important for two reasons. First, the changes in acetaldehyde are probably occurring because of some unknown metabolic consequence of the changes in sex hormone levels that occur during the estrous cycle. Future research needs to examine the possibility that the ovarian follicle itself is the origin of the build-up of blood acetaldehyde that occurs just prior to estrus.

Secondly, the common practices of visual monitoring and measuring blood progesterone as indexes of stage of estrus might be improved, and perhaps even replaced, by a more accurate method that could measure levels of acetaldehyde in body fluids that are in equilibrium with blood. Candidate sources include milk, saliva, skin gland secretions, or perhaps even breath air.

If acetaldehyde were an attractant pheromone, it could be used to evaluate and stimulate libido in bulls. However, our preliminary studies indicate that acetaldehyde alone, in concentrations that approximate what is found in blood head space, does not reliably attract bulls (9). The estrous attractant could be a mixture of low-molecular weight compounds, even though only one was seen to correlate with estrus. Mammals commonly use mixtures of compounds as intraspecific signals (2,6,7,8).

Acknowledgments

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Colostral Immunoglobulins and Their Absorption by Newborn Beef Calves

R. C. Vann, M. A. Lammoglia, D. A. Neuendorff, J. W. Holloway, G. E. Carstens, and R. D. Randel

Summary

Calf morbidity is one problem facing the Beef Industry today. The results from this experiment provide some interesting and potentially useful information for the cow/calf producer. Twenty Brahman and 20 Angus cows were bred to produce 10 calves of each of the following breed types: AxA, AxB, BxA and BxB to determine the effect of breed of sire and dam on calf serum immunoglobulin (Ig) concentrations and colostral Ig concentrations. The principle class of Ig in bovine serum is IgG. In colostrum, IgG and IgG_1 are the most abundant immunoglobulins. Brahman (B) cows had greater availability of Ig compared with Angus (A) cows due to increased production of colostrum. Cows producing crossbred calves had increased colostral Ig concentrations over cows producing purebred calves. These data suggest that heterosis of the fetus may have an affect on colostral Ig concentrations. Breed of service sire, breed of dam and sex of calf all influence colostral Ig concentrations in cattle. Total colostral Ig concentrations decreased over time.

Serum total Ig in the calves was not affected by their sex or the breed of sire or dam. However, crossbred (AxB and BxA) calves had higher serum total Ig concentrations which correlates with dams of crossbred calves producing higher colostral Ig concentrations. It has been suggested that hybrid vigor may influence the calf's ability to absorb immunoglobulins (7). The crossbred calf usually tries to suckle the dam more quickly, thus receiving immunoglobulins in a more timely fashion. Perhaps this is one reason why crossbred calves tend to perform more efficiently than purebred calves. Serum Ig concentrations in the calves increase from negligible quantities at birth to higher values soon after ingesting colostrum. Serum Ig concentrations usually reach a peak around 24 to 48 h. Overall efficiency of absorption was similar for all breed types. Absorption efficiency for total Ig was not affected by sex of calf or the breed of sire or dam. Calves with higher serum Ig concentrations tended to be more resistant to disease challenge compared to calves with lower serum Ig concentrations. Calves with higher serum Ig concentrations at 24 and 48 h tended to be sick for shorter periods of time compared to calves with lower serum Ig concentrations. In relation to the amount of Ig available in colostrum from the cow, the calf absorbs only a small quantity which then appears as serum Ig concentration. However, there is a positive linear relationship between the amount of colostrum consumed and the corresponding serum Ig concentration in the calf. Management of cows and calves can have an influence on the calf's ability to resist disease challenge. One important factor in increasing immune protection is to make sure the calf receives adequate colostrum soon after birth.

Introduction

The calf is born with negligible levels of immune protection (3). The ruminant's transfer of maternal immunoglobulins (Ig) to the neonate occurs exclusively through the colostrum (4). Passive acquisition of immunity in the neonatal bovine is dependent upon intestinal absorption of colostral Ig during the first 24 h after birth (14, 15). The neonate must absorb Ig's to build up an adequate antibody titre which, in turn, provides resistance against disease organisms. Often neonatal calf mortality is associated with failure of passive transfer, as reflected by low serum Ig concentrations (6).

The term Ig is general and applies to a family of high molecular-weight proteins (1). Several classes of Ig exist; however, IgG, IgG_1, IgG_2, IgM, and IgA are the primary classes of Ig that are found in cattle. The objectives of this project were to: 1) determine factors affecting immunoglobulins available in the dam's colostrum, 2) determine factors affecting absorption efficiency of immunoglobulins by newborn beef calves, and 3) evaluate immunoglobulin serum concentrations and absorption efficiency in relation to calf sickness.

Materials and Methods

Twenty Brahman and 20 Angus cows were bred to Brahman (B) and Angus (A) sires to produce 10 calves of each of the following breed types: AxA, AxB, BxB and BxA over a 75 d spring calving season. The Brahman and Angus cows were maintained separately on rye and ryegrass pastures, supplemented with a 4:1 corn:soybean meal concentrate (4 lb/hd/d plus ad libitum hay). Cows were allowed to calve naturally on pasture unless assistance was indicated due to dystocia. After parturition, the calves were left with the dam for approximately 30 to 45 minutes or until they attempted to stand and suckle. At this time, the cow and calf were separated, and the calf was placed in a temperature-controlled water bath in order to conduct a concurrent experiment. A presuckling blood sample was collected by jugular venipuncture. Subsequent blood samples were collected at 6, 12, 24 and 48 h after parturition. Serum was harvested and frozen at -20C until

analyzed for Ig using radial immunodiffusion (RID) assay techniques (VMRD, Pullman, WA.).

Each calf was fed pooled colostrum at 14 cc/lb birth weight after the presuckling and 6 h blood samples were collected. In addition, an E. Coli preventive packet was given after the presuckling blood sample. The calf was removed from the water bath and then placed in a wooden box to allow interaction with the dam yet prevent the calf from suckling. The calf was removed from the box 12 h after birth, fed it's dam's colostrum and returned to her side. The dam was hand-milked at 1 and 12 h after parturition. The colostrum yield was then weighed (g). An injection of oxytocin was administered (30 IU i.v.) to induce milk letdown. Samples of each dam's colostrum and the colostrum pools were collected and stored at -20C until analyzed for Ig using the RID assay.

Data were statistically analyzed using repeated measures analysis of variance of the General Linear Models procedure of SAS (13). Means were compared using the PDIFF options of the General Linear Models procedure for SAS (13).

Results and Discussion

Birth weight was affected by breed of dam ($P < .05$) and tended to be affected by sex of calf ($P < .08$). Angus cows had heavier calves than B cows (80.5 ± 3.1 vs 71.7 ± 2.9 lb, respectively). Bull calves tended to be heavier than heifer calves (80.1 ± 3.3 vs 72.2 ± 2.6 lb, respectively).

Brahman cows produced a greater ($P < .001$) volume of colostrum at 1 (4.98 ± .453 vs 1.30 ± .498 ℓ, respectively) and 12 h (3.41 ± .224 vs 1.12 ± .246 ℓ, respectively) compared to Angus cows. This is in agreement with Roberson et al. (11), who reported that Brahman heifers significantly exceed Hereford heifers in milk production. Angus cows produced colostrum with a greater density ($P < .02$) at 1 (1.06 ± .004 vs 1.05 ± .003 g/cc, respectively) and 12 h (1.04 ± .003 vs 1.03 ± .003 g/cc, respectively) compared to Brahman cows.

Cows producing crossbred (BxA and AxB) calves had higher ($P < .003$) total colostral Ig concentrations at 1 h compared to cows producing purebred (AxA and BxB) calves (Figure 1). At 12 h, cows producing crossbred (BxA and AxB) calves tended ($P < .09$) to have higher total colostral Ig concentrations compared to cows producing purebred (AxA and BxB) calves (Figure 1). Additionally, cows producing crossbred (BxA and AxB) bull calves had higher total Ig ($P < .02$) colostral concentrations at 1 and 12 h compared to cows producing crossbred (AxB and BxA) heifer calves (Figure 2). However, cows with purebred (AxA and BxB) heifer calves had higher total colostral Ig concentrations compared to cows producing purebred (AxA and BxB) bull calves (Figure 2).

Higher Ig concentrations could be the result of heterosis from the cow producing a crossbred calf. Reynolds et al. (10) reported that, based on the average of two milk yield samples, crossbred calves obtained 1.1 lbs ($P < .01$) more milk from Angus and Brahman dams than straightbred calves, representing a 16% increase. In the present study, Angus cows had higher total Ig concentrations in colostrum as a result of

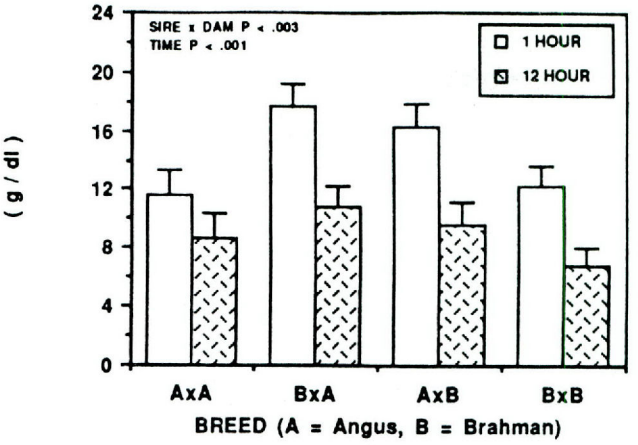

Figure 1. Total Ig concentration in colostrum as affected by breed of sire and dam at 1 and 12 hours after calving.

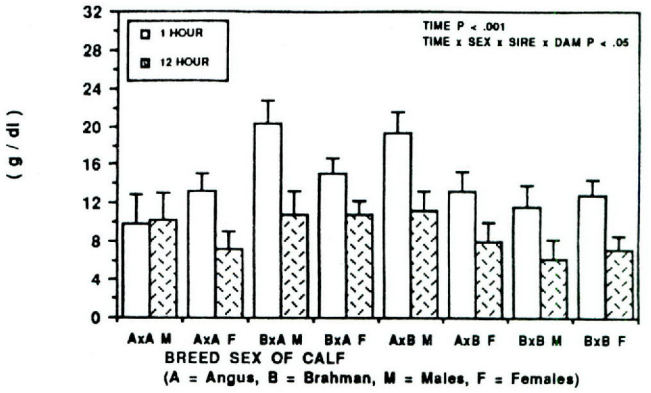

Figure 2. Total Ig concentration in colostrum as affected by breed of sire and dam and sex of calf at 1 and 12 hours after calving.

greater density of colostrum compared to the Brahman cows. Brahman cows had more total Ig ($P < .001$) available in colostrum compared to Angus cows. Brahman cows producing bull and heifer calves had more total Ig available in colostrum compared to Angus producing bull and heifer calves.

Serum concentrations of total Ig in calves were not affected ($P > .10$) by sex of calf, breed of dam, breed of sire or the interaction between any of these traits. However, crossbred (AxB and BxA) calves had higher serum total Ig concentrations compared to purebred calves. This is related to higher colostral Ig concentrations from cows producing crossbred (AxB and BxA) calves, although calves from B dams had the most colostral Ig available to them. O'Kelley (8) reported that the Africander-cross calves had higher Ig concentrations at 24 and 48 h, followed by Brahman-cross calves and Shorthorn x Hereford calves, respectively.

Efficiency of Ig absorption by the calf at 6 and 12 h was not affected ($P > .10$) by sex of calf, breed of sire or dam, or any interaction. Overall efficiency was similar for all breed combinations and averaged 22.03 ± 3.3% at 6 h and 19.2 ± 1.89% at 12 h for total Ig absorption of that available in the dam's colostrum.

Healthier calves (calves sick for less than 10 days with E. coli) had higher ($P < .05$) serum Ig concentrations compared to the less healthy calves (calves sick greater than 10 days with E. coli). The two breeds of cows (B and A) were managed differently, however calves with higher serum Ig concentrations tended to be more resistant to disease challenge than calves with lower serum Ig concentrations. Norman et al. (7) reported that increased survivability of crossbred animals may be due to higher serum immunoglobulin concentrations. Conversely, poorer survivability of inbred animals may be due to lower calf serum IgG_1 concentrations resulting from less efficient or later-developing immunoglobulin production. McGuire et al. (6) emphasized that most calves that die of infections failed to absorb adequate amounts of maternal immunoglobulins. Logan (5) stated that poor husbandry did not have any apparent influence on Ig concentrations but did have a profound effect on colostrum yield and thus total Ig available.

Implications

Cows producing crossbred (AxB and BxA) calves had greater total Ig concentrations in colostrum than cows producing purebred (AxA and BxB) calves. In addition, Brahman cows had more Ig available in colostrum as a result of the greater volume of colostrum produced compared to Angus cows. Crossbred calves tended to have higher serum Ig concentrations compared to purebred calves. The tendency for higher serum Ig concentrations in crossbred calves could be the result of the cows producing crossbred calves having greater Ig concentrations in colostrum. Calves appear to be equal in their ability to absorb immunoglobulins. It is of primary importance that each calf receives colostrum as soon after birth as possible and receives adequate levels of high quality colostrum (6, 3, 15, 16).

Acknowledgments

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Efficacy of Syncro-Mate-B as a Primer in Postpartum Cattle

M.D. Fanning, B.B. Carpenter, and L.R. Sprott

Crossbred first-calf heifers (n=24) and mature cows (n=37) were utilized in an experiment to examine the efficacy of Syncro-Mate-B (SMB) to initiate cyclicity in postpartum cattle prior to the breeding season. Some inductions of estrus with SMB are not accompanied by a fertile ovulation in postpartum cattle. Therefore, the hypothesis is that SMB treatment 30 days prior to the start of the breeding season would allow an animal to exhibit an estrus (with or without an ovulation) and be prepared to exhibit estrus, ovulate, and be inseminated early in the breeding season. Animals were stratified by body condition, calving date, and parity.

Thirty days before the start of the breeding season (x = 31 and 40 days postpartum for first-calf heifers and mature cows, respectively) the animals were either administered the 6-mg norgestomet ear implant (s.c.) and a 2 ml injection (i.m.) consisting of 5 mg estradiol valerate and 3 mg norgestomet (SMB) or served as a control. All animals were maintained on an adequate plane of nutrition and in the same pasture together. Nine days after treatment, the implants were removed and calves left with their dam. Fourteen days after implant removal, two bulls were placed with the females for a 90 day breeding season. Rectal palpation was performed 170 days after the end of the breeding season.

Pregnancy rates for the first-calf heifers were 90.9 and 92.3%, respectively, for the control and SMB-treated animals. Pregnancy rates for the mature cows were 68.4 and 77.7%, respectively, for the control and SMB-treated animals. These data indicate that SMB treatment does not influence overall pregnancy rate. However, the influence of SMB treatment on postpartum cattle on pregnancy rates early and throughout the breeding season needs to be examined.

Gonadotropin-Releasing, Hormone-Induced, Luteinizing Hormone Secretion as Affected by a Progestin or a Progestin and Estradiol

M.D. Fanning, P.G. Harms, L.R. Sprott, and D.W. Forrest

Sixteen ovariectomized, Brahman-cross heifers (mean body weight = 673 lb) were utilized in an experiment (5 months post-surgery) to determine steroid influence on gonadotropin-releasing hormone (GnRH)-induced luteinizing hormone (LH) secretion. We hypothesized that a progestin (norgestomet) would suppress GnRH-induced LH release while the combination of norgestomet and estradiol would result in an increase in GnRH-induced LH release when compared to norgestomet treatment. Heifers were stratified by body condition and body weight and were assigned randomly to one of three treatments: control (CON; n=5), two 6 mg norgestomet (NOR; n=5) ear implants (s.c.), or two norgestomet implants and one-half of a Compudose® implant that contained approximately 12 mg of estradiol (NOR+E; n=6).

Blood samples were collected every 15 minutes for 8 hours via an indwelling jugular catheter to quantify the magnitude of LH peaks in response to GnRH on day 5 of treatment. After 2 hours of blood collection to determine basal LH concentration, heifers were administered a physiological dose of GnRH (22 ng/lb of body weight over three injections) at 2-hour intervals. The effects of treatment on basal LH concentration were analyzed using preplanned orthogonal contrasts of NOR compared to either CON or NOR+E. The statistical model for analysis of LH peak concentration included treatment and time of GnRH administration as the main effects with basal LH concentration as a covariate.

Mean basal LH concentration, prior to GnRH administration, was .86, 1.43 and .75 (pooled standard error + 0.66) ng/ml, respectively, for CON, NOR and NOR+E heifers (P>.10). Mean peak LH concentration did not differ (P>.10) in response to each of the three injections of GnRH, and there was no interaction (P>.10) between treatment and time of GnRH administration. Mean peak LH concentration (average of the three peaks) in response to GnRH was 6.19, 3.78 and 12.80 (pooled standard error + 2.03) ng/ml, respectively, for CON, NOR and NOR+E heifers (NOR vs NOR+E, P<.05). These data indicate that NOR failed to suppress basal or GnRH-induced LH release as compared to CON; however, NOR in combination with E did increase the quantity of LH secreted in response to GnRH administration as compared to NOR. Therefore, the hypothesis that NOR inhibits GnRH-stimulated LH release is rejected, while the effects of E are consistent with the hypothesis that E enhances release of LH from the pituitary in response to GnRH.

Metabolic and Hormonal Changes Occurring in Response to Level and Pattern of Zeranol Delivered to Steers

N. D. Turner, F. M. Byers, and D. C. Kenison

Summary

These experiments included a range of zeranol doses delivered through implants or osmotic pumps. Average daily gain, feed efficiency, and IGF-1 concentrations were increased with zeranol treatment. Animals receiving zeranol had reduced plasma urea nitrogen. A dose of 600 µg/d appears to be adequate to produce the desired metabolic responses which are necessary to achieve an improved composition of gain. IGF-I concentrations were elevated to a greater degree and for a longer time with increasing duration of a zeranol pulse. Plasma urea nitrogen was reduced by increased level of zeranol, but length of pulse did not affect the response. When the pulse was repeated, similar results were achieved, except for a lesser dose response. These studies support a dose response between plasma zeranol and regulation of growth and indices thereof in beef cattle.

Introduction

There is no known documentation in the literature concerning the relationship between variable zeranol doses delivered in various patterns and metabolite or metabolic hormone patterns. Attempts to increase lean and reduce fat in beef have included exogenous growth regulators such as zeranol. However, the mechanisms whereby the changes occur have not been determined. Effectiveness of repartitioning dietary nutrients away from fat to protein deposition needs to be improved by developing new compounds, or administering currently available compounds at optimal levels and/or patterns. Long-term studies are currently capable of predicting composition changes using either serial slaughter or body composition estimators. More reliable indices of protein deposition in short-term studies would facilitate these efforts. Reinhardt et al. (3) developed a metabolic indices model including IGF-1, T3, T4, plasma urea nitrogen and plasma glucose to predict growth, composition of growth, and energy density of growth.

The overall objectives of these experiments were to define the relationship between zeranol dose and the indices developed by Reinhardt et al. (3) to assess the level and pattern of growth regulator delivery to optimize animal response. Specifically the objectives were to: 1) define the response of indices to different zeranol doses and/or delivery patterns; 2) determine the plasma levels that may generate optimal animal responses; and 3) identify the impact of amplitude and duration of growth regulator pulses on modification of metabolic indices of growth, in order to assess the importance of pattern of delivery on animal response to growth regulators.

Experimental Procedures

This study included a series of three experiments. Angus x Hereford steers were adjusted to the diet (66% whole shelled corn, 18% cottonseed meal, 10% cottonseed hulls, 4% dried molasses and 2% vitamin and mineral premix) prior to starting the experiments. In all experiments, intake was maintained at 80% of ad libitum and feed was withheld on sampling days until body weights and blood samples were taken. Steers always had free access to water. In all experiments, blood samples were taken on days -7, -3, -1 and 0 to establish baseline data for each steer.

In Experiment I, the objective was to establish the relationship between serum IGF-I and circulating metabolites to zeranol dose in an implant or administered at a constant rate with mini-osmotic pumps. Steers were assigned to treatments such that the mean weight of each treatment group (287 kg) was similar. Blood samples were taken from the jugular vein ipsilateral to the implant sites for plasma and serum on days 1, 2, 4, 8, 16 and 32. Steers were weighed on days -7, 0, 14, 28, 42 and 56. Feed was provided at 0700 and 1900, and refusals were collected and weighed. Treatments included a control (0 mg zeranol), 12 mg, 24 mg, 36 mg or 48 mg of zeranol in an implant, or 400 or 800 µg/d of zeranol from a mini-osmotic pump. A brief description of pump preparation and use can be found in Reinhardt et al. (3). Implants and pumps were put in place on day 0 of the experiment.

The objectives of Experiment II were to establish the relationship of serum IGF-I and metabolites to various levels of zeranol delivered in a constant infusion pattern, and to determine the time sequence of IGF-I and metabolic responses to zeranol dose. Steers (average weight = 422 kg) were housed in paddocks and provided feed at 0700 daily.

Blood samples were collected on day 1, 2, 4, 6, 8, 12, 16, 20, 24, and 28. Steers were weighed on days -7, 0 and 28. Treatments included a control (0 mg zeranol), 150, 300, 450, 600, 750, 900, or 1000 µg/d of zeranol delivered by Alza mini-osmotic pumps.

The objective of Experiment III was to establish the relationship between IGF-I and metabolites to amplitude and duration of a zeranol pulse in order to assess their impact on initiation of metabolic responses. Animal (average weight = 404 kg) handling and feeding was as described for Exp. I. This experiment was conducted in two phases to assess the response to a repeated pulse. Alzet pumps were prepared to deliver .5, 1.0, or 2.0 mg/d zeranol in a pulse of 1, 2, 4, or 8 d duration, at which time the pumps were removed. Each dose x time treatment combination group contained three animals.

Blood samples were collected on days 1, 2, 4, 6, 8, 12, 16, 20, 24, 28, and 56. Collection of baseline samples for the second pulse began on day 49. The same pattern of blood sampling and weighing was used for the second pulse period, which started on day 56.

Hormonal and Metabolite Analyses

Serum IGF-1 was measured using an RIA assay previously validated in our laboratories. Plasma glucose and urea nitrogen were measured using automated spectrophotometric procedures.

Statistical Analyses

All data were statistically analyzed using SAS GLM (4) and regression procedures. A repeated measures model was used which included treatment, time, and a treatment x time interaction. In Exp. III, the effect of pulse length and its potential interactions with other main effects were tested.

Results

Experiment I

Daily feed intakes (6.88 kg) were similar for all treatments. Daily gain from day 0 to 56 was greater ($P < .05$) for the 36 mg treatment group than the controls (Table 1). Less feed per unit gain (n.s.) was required for animals receiving 36 or 48 mg of zeranol (a 7.3 to 32.9% reduction, respectively) or zeranol delivered via Alzet pumps (a 11.0 to 23.2% reduction for the 400 and 800 µg/d treatments) than controls.

Time after initiating treatment explained 52% of the variation in IGF-1 concentrations ($P = .0001$), which increased from day 0 (18.9 ng/ml) to a high of 143.8 ng/ml on day 16 (Figure 1). Concentrations of IGF-1 increased only after terminating the period of intensive sampling. Although there was no effect of individual treatment, the data indicate that as implant dose increased there was a tendency ($P > .10$) for increased circulating IGF-1 concentrations. These results are similar to those of Breier et al. (1) who found elevated IGF-1 concentrations in estradiol treated steers.

Circulating glucose concentrations changed with time after initiating treatment ($P = .0062$). On day 0 the average glucose concentration was 79.3 mg/dl, whereas it was elevated to 97.0 mg/dl across treatments by day 16. In contrast to glucose, plasma urea nitrogen was affected by treatment ($P = .0530$), time after initiating treatment ($P = .0001$) and their interaction ($P = .0031$). Plasma urea nitrogen was reduced, as compared to the control, for all treatments except for animals receiving 400 µg/d of zeranol from the Alzet pumps (Figure 2). The reduction in plasma urea nitrogen ranged from 13 to 32%. Loy et al. (2) also reported reduced plasma urea nitrogen in zeranol treated steers.

Experiment II

Individual intakes were not measured in this experiment; an average of 10.64 kg of feed was supplied to each animal daily. There was no effect of treatment on daily gain (Table 2). Animal variability during the short experimental time period precluded detection of any differences and reflects the difficulty of using either gain or efficiency as measures of implant effectiveness during short-term experiments.

Analysis of IGF-1 data from this experiment resulted in a significant main effect of time. Although nearly all animals treated with zeranol had elevated IGF-1 concentrations, only those that received 450, 600, and 900 µg/d had significantly greater overall circulating IGF-1 than the control animals (Figure 3). The elevation in IGF-1 observed over time was cyclical, with the peak concentrations found for days 6, 12 and 28. In contrast, the IGF-1 concentration of control animals

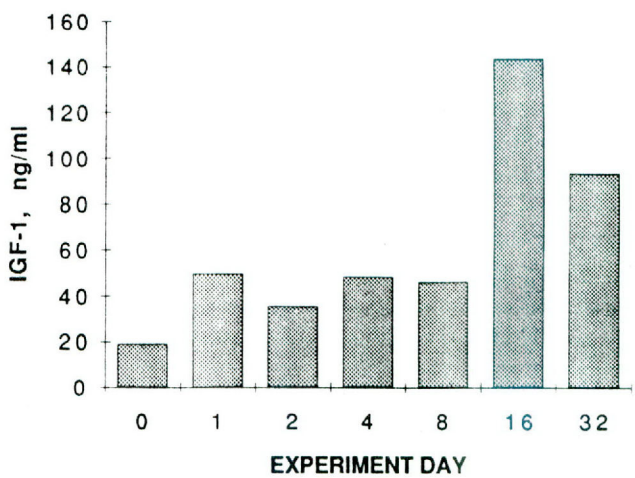

Figure 1. Mean serum IGF-1 concentrations during Experiment I.

TABLE 1. DAILY GAIN AND FEED EFFICIENCY IN EXPERIMENT I.

	Treatment groups							
		Implant mg				Alzet. µg/d		
Item	Control	12	24	36	48	400	800	SEM
Feed intake, kg/d	6.86	7.01	6.84	6.80	6.87	6.88	6.85	.18
Daily gain, kg/d								
Day 0 - 28	1.00	1.56	1.25	1.06	1.07	1.36	.84	.25
Day 0 - 56	.90	.92	.86	1.29	1.01	1.12	.95	.13
Day 28 - 56	.81	.50	.47	1.15	.95	.81	1.07	.29
Feed/gain								
Day 0 - 28	8.1	4.7	5.7	3.2	11.9	5.1	13.6	5.1
Day) - 56	8.2	8.3	8.5	5.5	7.6	6.3	7.3	1.1

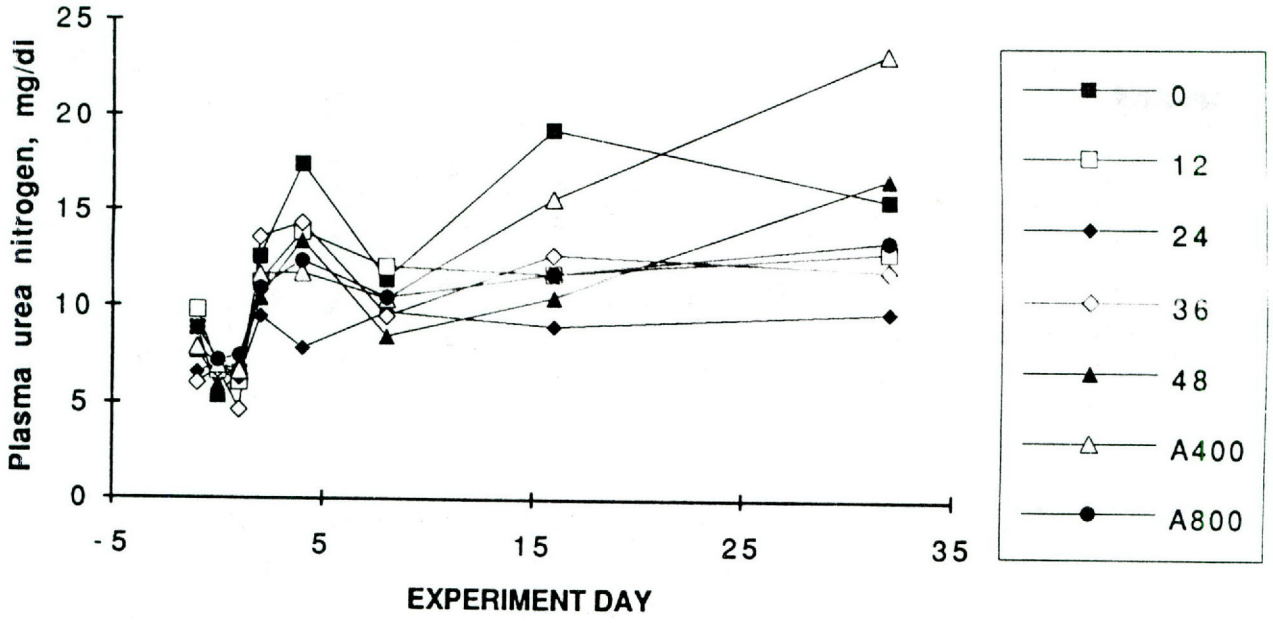

Figure 2. Plasma urea nitrogen concentrations in Experiment I.

TABLE 2. DAILY GAIN, FEED EFFICIENCY, SERUM IGF-1 AND PLASMA GLUCOSE IN EXPERIMENT II.

	Treatment groups								
Item[b]	Control	150	300	450	600	750	900	1000	SEM
Daily gain, kg/d	1.14	.84	1.03	1.06	1.41	1.50	1.26	1.08	.24
Serum IGF-1, ng/ml	61.8	65.7	61.1	92.7	84.4	69.4	94.2	75.3	7.8
Plasma glucose, mg/dl	90.4	77.8	86.2	78.2	85.4	80.3	88.1	78.3	2.1

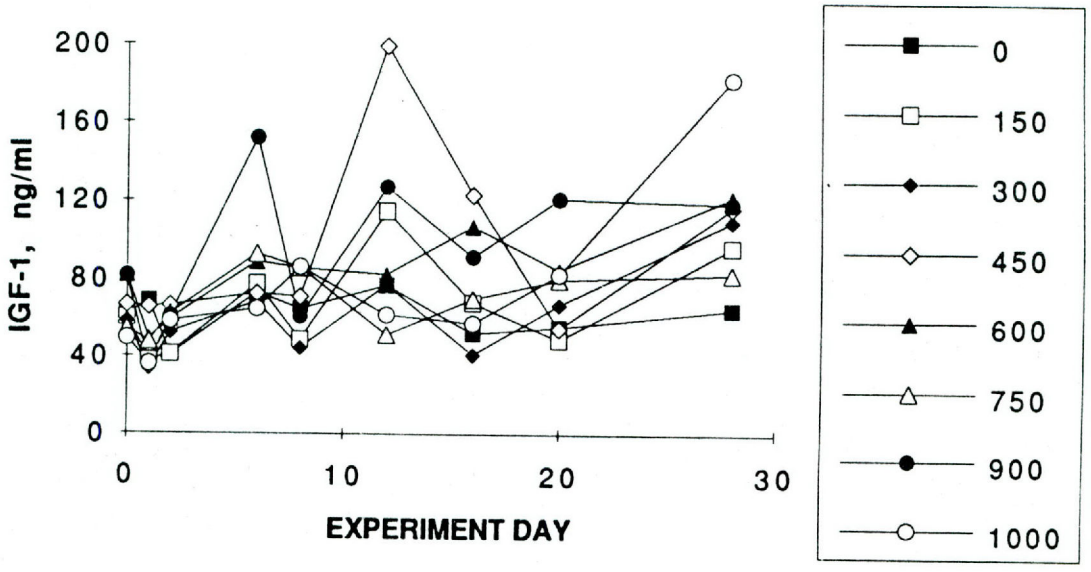

Figure 3. Serum IGF-1 concentrations by treatment during Experiment II.

was not different on any experimental day when compared to baseline values.

Glucose changed over time after treatment (P = .0154), however, treatment effects were not significant. The main effect of time after treatment and its interaction with treatment were the only significant factors affecting plasma urea nitrogen. Zeranol levels below 600 µg/d produced quite variable results, however, those above 600 caused a reduction in plasma urea nitrogen that began by day 2 after treatment (Figure 4). Zeranol also reduced plasma urea nitrogen in a study by Loy et al. (2).

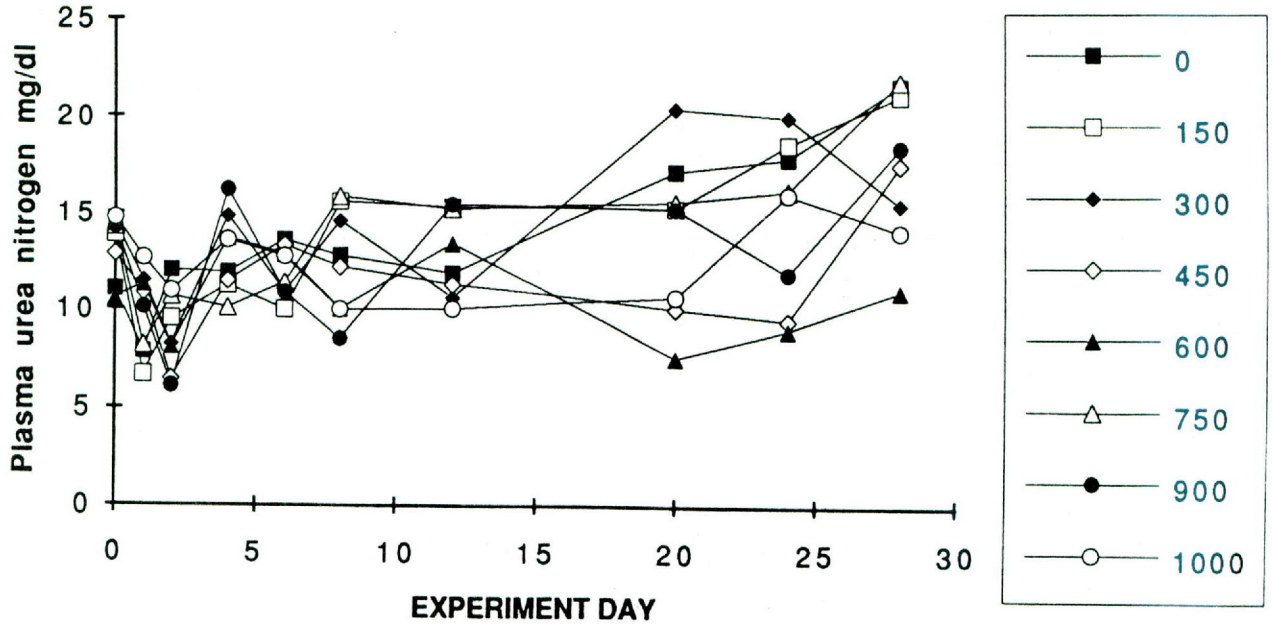

Figure 4. Plasma urea nitrogen concentrations in Experiment II.

Experiment III

Analyzing these data with a model containing treatment and length of zeranol delivery as main effects and their interaction produced no significant differences, however, it explained more variation than a model without interactions. Gain during the first 56 d was not affected (P > .25) by treatment, time or the interaction of treatment x time (Table 3). Gain during the second pulse was generally less than that observed in the first 56 d. However, animals receiving 2 mg/d of zeranol in a pulse for 4 or 8 d had increased gain relative to controls, resulting in a higher 84-d gain than during the first 56 d.

Time after treatment (P = .0104) affected IGF-1 concentrations. The variation in response to treatment is demonstrated in Table 3. Over all treatment groups, IGF-1 concentrations were increased (P < .05) in samples taken after day 0 (Figure 5).

Glucose differed with time after treatment (P = .0001). Animals in all three treatments had generally lower glucose concentrations after the treatments were initiated. In general, those animals receiving longer pulses of zeranol had higher glucose concentrations (Table 3).

In the complete model used to analyze plasma urea nitrogen, the three-way interaction between treatment, length of pulse and time after initiating treatment approached significance (P = .0945). An interaction between treatment and length of pulse was not observed, however, an interaction

TABLE 3. DAILY GAIN (PHASE I AND II), AND IFG-1 AND GLUCOSE (PHASE I) IN EXPERIMENT III.

Treatment	Pulse length	Gain (kg) 0-56	Gain (kg) 0-84	Serum IGF-1 (ng/ml)	Plasma glucose (ng/ml)
.5	1	.90	.96	80.0	78.1
.5	2	.91	.78	62.8	76.2
.5	4	.47	.57	64.5	98.6
.5	8	.81	.75	90.4	83.3
1.0	1	.87	.83	62.8	73.7
1.0	2	.68	.67	60.8	84.4
1.0	4	.84	.82	58.7	78.6
1.0	8	.97	.81	64.8	89.7
2.0	1	.66	.56	63.3	79.0
2.0	2	.64	.56	60.6	87.3
2.0	4	.65	.82	86.5	87.1
2.0	8	.86	1.01	70.2	78.7
SEM		.15	.12	8.3	2.2

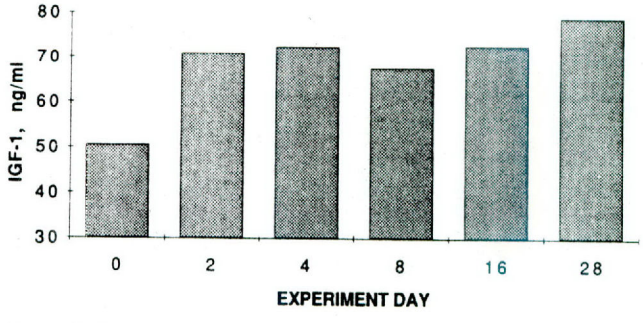

Figure 5. Mean serum IGF-I concentrations during Experiment III, Phase I.

between treatment and time after initiating treatment was found (P = .0087). This would indicate that the reduction in plasma urea nitrogen was similar whether a short or long pulse was used (Table 4).

During the second phase, IGF-1 concentrations responded only to time after treatment (Figure 6). The highest concentration of IGF-1 was observed on day 8. In general those animals which received a pulse of zeranol for 4 or 8 d had higher (n.s.) concentrations of IGF-1 (Table 5).

The effect of time after initiating treatment was the only significant factor (P = .0001) in analysis of plasma urea nitrogen. In this phase of Exp. III, as in the other experiments, plasma urea nitrogen decreased after the animals started receiving zeranol (Table 5). Level of zeranol had no impact on plasma urea nitrogen; mean = 10.41 mg/dl, standard error of mean = .20. A pulse of 1 d generated similar urea nitrogen concentrations, regardless of dose. However for other pulse lengths, circulating concentrations of urea nitrogen were usually reduced.

Time after treatment initiation (Table 5) significantly altered plasma glucose. A peak in glucose (94.7 mg/dl) occurred on day 6. The baseline glucose concentration was 79.6 mg/dl. From day 0 through 6, all plasma glucose values were increased over baseline. After day 6 plasma glucose declined to baseline levels or below.

Discussion

Zeranol has previously been shown to affect growth by influencing some of the endocrine factors and metabolites associated with growth and development. From the current research it can be concluded that IGF-1, plasma urea nitrogen and glucose concentrations are all affected by the presence of zeranol. Hormones and metabolites responded at different times following treatment, presumably because of their differing roles in growth mediation or reflecting the actions of growth regulators prior to sampling times. When provided in appropriate form and sufficient dose, zeranol can induce repartitioning of feed nutrients from fat to lean growth as predicted by the indices models.

Certain conclusions can be drawn from the present and previous research regarding the key hormones in growth stimulation. With knowledge of the relationships between hormones and tissue development, changes in the hormones can ultimately be used to infer changes in growth status of animals.

The responses observed in Exp. II indicated that an inconsistent response to dose resulted, except that IGF-1 concentrations continued to increase up to the highest implant dose. Plasma urea nitrogen was also decreased for all doses. A test of the affect of incremental plateau doses indicated that

TABLE 4. TREATMENT X TIME INTERACTION MEANS[c] FOR PLASMA UREA NITROGEN LEVELS IN EXPERIMENT III, PHASE I.

	Dose			
Day	.5	1.0	2.0	SEM
-7	19.2	17.3	25.6	.75
-3	13.8	12.9	18.0	.75
-1	13.7	10.6	13.8	.69
0	13.3	11.0	18.0	.69
1	15.7	11.9	12.8	.72
2	11.1	9.7	13.9	.70
4	13.4	10.6	12.8	.69
6	10.4	12.0	12.7	.69
8	9.9	8.1	10.5	.70
12	10.6	10.4	12.6	.69
16	11.1	11.2	10.4	.75
20	16.3	13.7	15.1	.72
24	14.9	17.1	15.8	.70
28	11.7	10.3	12.8	.70

[a] Linear effect of treatment (P = .0382).
[b] Linear effect of time after initiating treatment (P = .0064).
[c] Interaction of time and time after initiation (P = .0087).

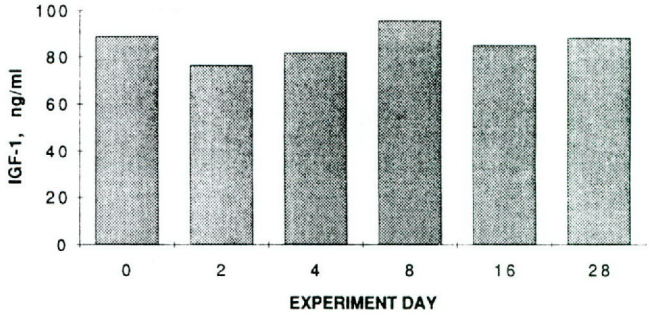

Figure 6. Mean serum IGF-1 concentrations during Experiment III, Phase II.

TABLE 5. GROWTH REGULATOR TREATMENT MEANS FOR IGF-1 AND METABOLITE LEVELS IN EXPERIMENT III, PHASE II.

Treatment	Pulse time	Serum IGF-1 (ng/ml)	Plasma urea nitrogen (mg/dl)	Plasma glucose (mg/dl)
.5	1	80.7	11.0	78.2
.5	2	91.4	9.7	78.3
.5	4	92.0	10.1	99.9
.5	8	102.7	11.1	75.3
1.0	1	73.6	11.0	81.4
1.0	2	69.9	10.1	77.6
1.0	4	(76.2)	10.7	74.2
1.0	8	97.1	8.9	85.4
2.0	1	73.8	11.2	78.3
2.0	2	61.1	11.1	81.2
2.0	4	99.6	10.0	79.7
2.0	8	77.7	10.1	73.8
SEM		8.5	.42	3.7

Least squares mean for the number in parentheses was non-estimable.

600 to 900 µg/d produced elevated IGF-I concentrations, decreased urea nitrogen levels, and increased gain. A pulse of zeranol, whether 2 to 8 d in length, produced the same response for either .5 or 2.0 mg/d doses. However of the pulse doses used, a 1.0 mg/d dose generated the best performance. When the pulse was repeated 56 d after the first pulse, there was a lower dose response, and no effect of pulse length.

The data from Exp. I through III indicate that plateau levels of zeranol above 900 µg/d would not produce any additional increases in performance, and that doses below 600 µg/d were less effective. A single, short duration pulse was as effective as a longer pulse of zeranol in changing performance. However, IGF-1 concentrations were elevated more and remained elevated longer with increasing length of pulse. Any subsequent pulse duration was as effective as another, however, these data tend to indicate that the dose level for a second pulse may need to be higher to be as effective as the first pulse.

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Plasma Kinetics of Zeranol in Steers Receiving Variable Doses in Implant or Mini-Osmotic Pump Form

N. D. Turner, F. M. Byers, and D. C. Kenison

Summary

Plasma concentrations of zeranol were determined in steers using a monoclonal RIA assay kit. Delivery of zeranol from commercial implants and mini-osmotic pumps was tested. Rate of release and elimination from plasma after a pulse were determined. The pumps and(or) tissue site of implantation provided variable release and resulted in considerable variation in plasma zeranol. With the caveat that variation exists because of Alza pump variability, the overall results indicate the pumps simulated the doses delivered by Ralgro implants. Our previous work suggested that the Ralgro implants delivered approximately 600 µg/d of zeranol; these experiments support that calculation. However, there is apparently a limit to the quantity of zeranol that can be absorbed at the delivery site which is dependent, at least in part, on body size; thus a larger dose may be required in yearling-feedlot cattle or larger-frame animals. A near linear increase in plasma zeranol was achieved when a linear increase in dose was delivered; however, a plateau in plasma zeranol concentration occurred with doses above 750 µg/d. Spikes of zeranol were easily generated using high delivery doses for short periods of time. Some animals had zeranol peaks after pumps were removed suggesting the existence of an inducible metabolic pathway, which required at least 2 d to become fully activated or that transfer of zeranol from the implant site was not immediate.

Introduction

Most attempts to increase lean and reduce fat in beef include exogenous growth regulators such as zeranol. Success in repartitioning dietary nutrients away from fat and toward protein deposition may improve with new compounds, or administering currently available compounds at optimal levels and(or) patterns. If the effectiveness of repartitioning by zeranol is to be improved, an understanding of the pattern of delivery and circulating concentrations must be developed. An effective means of simulating implant delivery of zeranol would eliminate the variability inherent with implanted pellets and would assist in correctly determining zeranol kinetics.

The overall objectives of this series of experiments were to assess the validity of using Alza implants to model implant delivery of zeranol and to assess the rate and pattern of release from both implants and mini-osmotic pumps. Specifically the objectives were to: 1) compare plasma levels of zeranol in animals receiving similar doses of zeranol but delivered via an implant or mini-osmotic pump; 2) determine the minimum dose that generates a plateau in plasma levels; and 3) determine the time after initiation of treatment that a spike in plasma zeranol concentration is observed, and how long zeranol remains in blood after removal of the source.

Experimental Procedures

Experiments

In all experiments, blood samples were taken on day -7, -3, -1, and 0 to determine basal levels of any compounds that would react with the RIA antibody and therefore would be detected as zeranol in the post-treatment samples. Blood samples were always taken from the jugular vein ipsilateral to the implant site. Steers were fed at 80% ad libitum of a feedlot type diet in all experiments, except for Experiment I in which feeding levels varied.

In Experiment I, 36 Angus x Hereford steers (average weight = 297 kg) were adjusted to 80% ad libitum intake of a feedlot-type diet. The animals were then placed on a set intake level for the experimental period; the levels were full feed (ad libitum), 80 or 60% of ad libitum. Twelve animals received each feeding level. Within a feeding level, four animals were assigned (equal weight basis) to one of the following treatments: no implant, a 36 mg Ralgro implant, or an Alza pump containing a solution that was prepared to deliver 605.5 µg/d of zeranol. The approximate 600 µg/d dose of zeranol was chosen based on calculated estimates of normal delivery from zeranol implants. Pump preparation and surgical procedures are presented elsewhere (4). The second set of pumps were filled with a solution that had an expected delivery rate of 599.3 µg of zeranol/d.

On d 28 the first Alzet was removed, and a replacement pump was placed in a new site on the opposite side of the animal. The second pumps were removed on d 56. Blood samples were taken on days 2, 4, 8, 16, 32, and 56 following initial implantation.

Experiment II included five implant levels of zeranol and two Alza treatment levels of zeranol. The implant levels used were 0, 12, 24, 36, and 48 mg of zeranol. Solutions for the pumps were prepared to deliver approximately 400 or 800 µg/d of zeranol. These concentrations were chosen so that they would simulate the expected delivery from implant doses (24 to 48 mg) used in this study. For this experiment, blood samples were taken from 42 steers (average weight = 287 kg) on days 2, 8, 16, and 32 after initial treatment.

In Experiment III, 32 steers (average weight = 422 kg) were fed in paddocks. Only Alza pumps were used in this experiment. Pumps were designed to deliver approximately 0, 150, 300, 450, 600, 750, 900, and 1000 µg/d of zeranol. Alza pumps were used to deliver zeranol at a constant level throughout the study period. Levels were chosen to provide a linear dose titration that would include the levels delivered by standard Ralgro implants. Four animals were assigned to each treatment. Blood samples were collected on days 1, 2, 4, 6, 12, 16, and 28 after initiation of treatment.

In Experiment IV 36 steers (average weight = 404 kg) were used to determine the effect of a pulse dose of varying lengths and concentrations. Solutions were prepared to deliver 500, 1000 and 2000 µg/d of zeranol. Pumps were placed in animals on day 0 of the experiment. Twelve animals were assigned randomly to each dose level, and for each dose three pumps were removed on day 1, 2, 4, and 8. This generated a 3 X 4 factorial design with three animals in each treatment group. This design allowed the assessment of circulating plasma zeranol that resulted from short pulses of three zeranol doses that should have simulated the normal release from implants containing three levels of zeranol. Blood samples were taken on days 2, 4, 8, 16, and 28. Pumps were replaced on day 56 after initial implantation and the experiment was replicated. The same doses and removal schedule were used. Blood samples for the second phase were taken on day -7 (relative to day 56 of the first phase), 0, 2, 4, 8, and 16.

Radioimmunoassay

The RIA procedure used for analysis of zeranol in plasma was an adaptation (8) of an assay developed by Dixon in 1980 (1). Prior studies using this RIA detected zeranol and zearalanone in muscle, kidney, and liver (150 pg/g; 7), urine (2.5 ng/ml; 3), and feces (1 ng/g; 2) from cattle.

Statistical Analysis

Data were analyzed using repeated measures techniques of SAS (5). Least squares means with standard error of the means of the treatment for each sampling day are presented. To better understand the relationships developed, data also are presented graphically.

Results and Discussion

Experiment I

Mean zeranol concentrations are presented in Figure 1. The main effects of treatment, time after treatment, and their interaction were significant in the model ($P < .0001$). Steers receiving implants did not exhibit as large a peak (.86 ng/ml) in zeranol as those receiving zeranol from pumps (1.57 ng/ml). However, implanted animals had elevated ($P < .0001$) zeranol levels as compared to controls. The highest concentration of zeranol for implanted steers was in day 8 samples. Animals that received zeranol from pumps also had a zeranol peak on day 8, with concentrations similar to implants on days 4, 16, and 32. All animals had increased zeranol levels in samples taken on day 56; one potential explanation would be that the corn contained mycotoxins or nonspecific binding. The corn was produced in a year when very high mycotoxin levels were observed throughout Texas and the antibody in the RIA cross-reacts with zearalenone.

To remove the effect of possible feed contaminants, the mean level for control animals at each sampling date was subtracted from the implanted and Alza treatment groups. These data are presented in Figure 2. This illustrated there was a decline in plasma zeranol in the implanted animals and a stable level in the Alza group at the end of the trial.

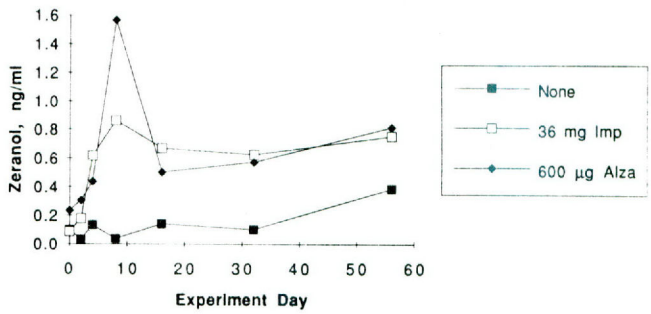

Figure 1. Plasma zeranol in steers receiving no zeranol, zeranol from a 36 mg commercial implant or 600 µg/d of zeranol delivered via a mini-osmotic pump in Experiment I.

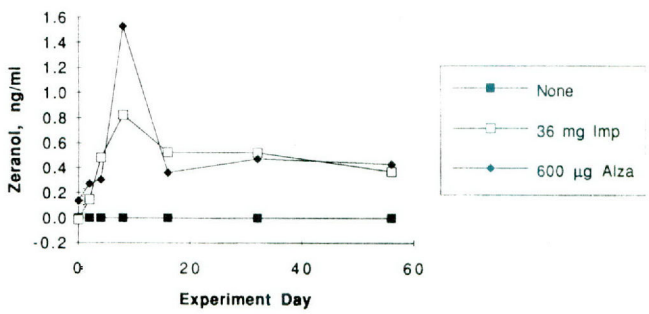

Figure 2. Plasma zeranol in steers receiving no zeranol, zeranol from a 36 mg commercial implant or 600 µg/d of zeranol delivered via a mini-osmotic pump in Experiment I. Mean level of controls have been subtracted from treatment group means.

Experiment II

In this experiment, treatment ($P < .0001$) and time after treatment ($P < .0002$) were significant. Levels of zeranol for control animals appeared to be relatively stable throughout the study, ranging from .24 to .58 ng/ml (Figure 3). Animals receiving 12 mg of zeranol had higher plasma concentrations than the controls; levels peaked on days 2 and 8 and then decreased. Animals implanted with 24 mg of zeranol had greater zeranol concentrations than those receiving only 12 mg. Peak levels (3.6 ng/ml) for the 24 mg treatment occurred on day 8. Plasma concentrations were similar in steers implanted with 36 mg or had pumps that delivered 400 µg/d of zeranol (Figure 3). Peak concentrations (4.2 ng/ml) occurred on day 8 for both the 36 mg and 400 µg/d treatments. Plasma

levels were similar for animals in the 48 mg and 800 µg/d zeranol treatment groups. A peak concentration of approximately 4.9 ng/ml was observed on day 8 for both these groups.

Experiment III

Analysis of data for Experiment III resulted in a significant treatment effect (P = .0264). Overall, plasma levels observed are consistent with respect to level delivered and the time after insertion of the pumps (Figure 4).

For this study, peak (1.4 to 2.8 ng/ml) concentrations were observed on days 4 or 6. Even though Alza pumps were intended to deliver zeranol at a constant rate, the data indicate that: 1) the rate of delivery was not constant, 2) the solution did not readily diffuse away from the implant site and therefore did not enter the circulation, or 3) the animals were capable of rapid metabolism and removal of zeranol from blood once a key enzyme or metabolic system was up-regulated. If stimulation of a metabolic pathway was the explanation, the time of peak concentration would correspond with the time required for the pathway to be maximally activated.

Experiment IV

Data from Phase I of Experiment IV are presented in Figure 5. The interaction of treatment with time after treatment was significant (P < .0002), and treatment (P = .0001), days of exposure (P = .0517) and time after treatment (P = .0001) were all significant main effects in the model. Plasma patterns of zeranol were similar to those in the previous trials.

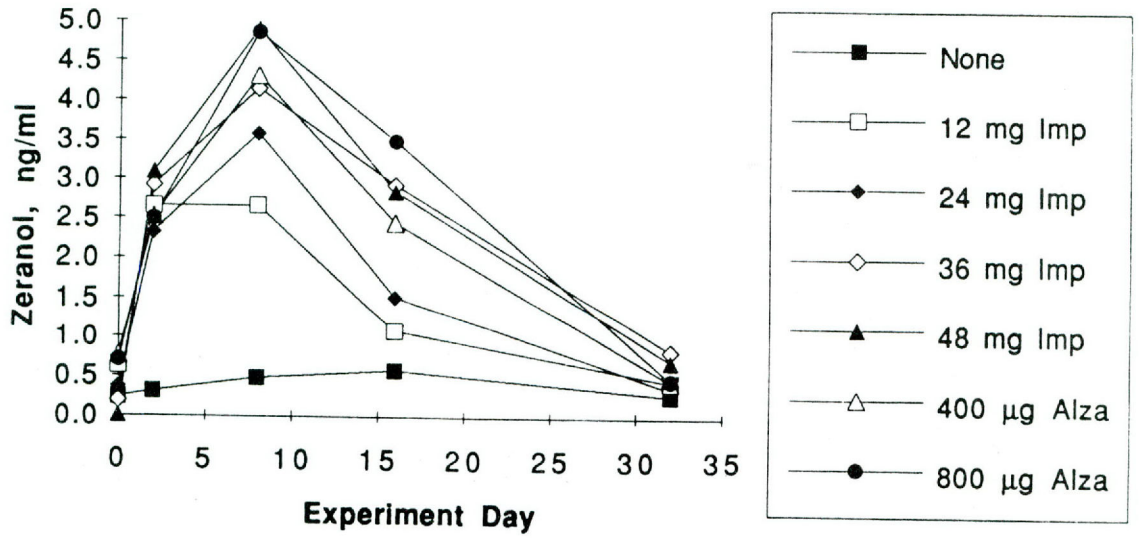

Figure 3. Plasma zeranol in steers receiving no zeranol, either 12, 24, 36, or 48 mg of zeranol from a commercial implant, or either 400 or 800 µg/d of zeranol delivered via a mini-osmotic pump in Experiment II.

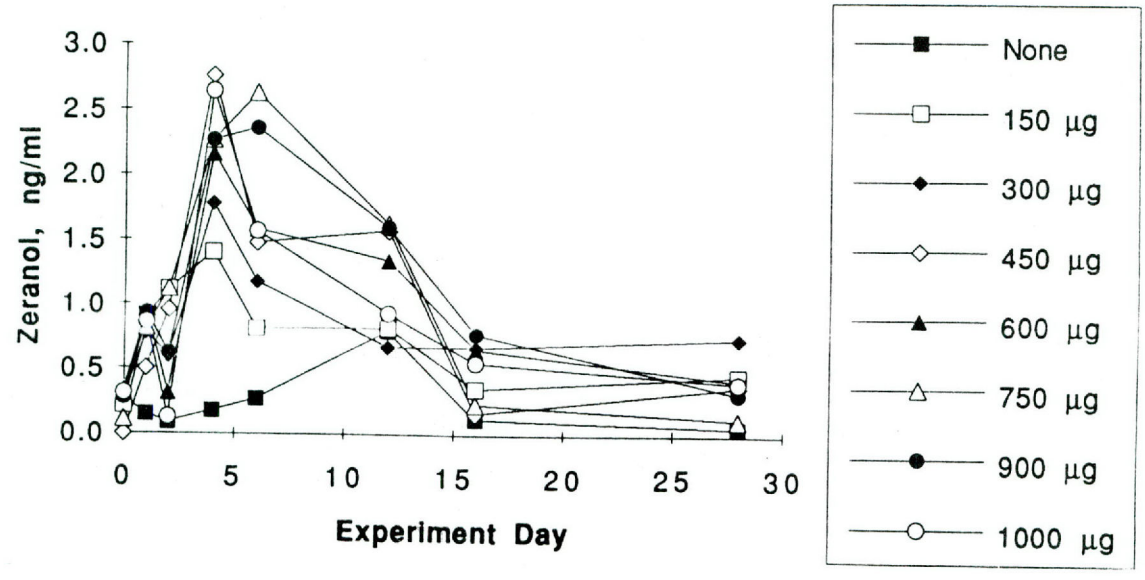

Figure 4. Plasma zeranol in steers receiving no zeranol, or either 150, 300, 450, 600, 750, 900, or 1000 µg/d of zeranol via a mini-osmotic pump in Experiment III.

In this experiment, peak concentrations were generally observed on the days pumps were removed. The main exception was for pumps removed after only 1 d. It is possible that the pathway which metabolizes zeranol may not be stimulated until at least 2 d after exposure, or that uptake from the tissue site is delayed. Animals receiving the 2 mg/d dose, in general, had higher levels of plasma zeranol than those receiving only .5 mg/d, with the 1 mg/d dose resulting in intermediate concentrations. Fluctuation in this pattern was primarily due to length of time prior to pump removal.

Variability in plasma zeranol for the second phase of this experiment was significant (Figure 6). The only significant main effect was time after treatment ($P < .0001$). However, the

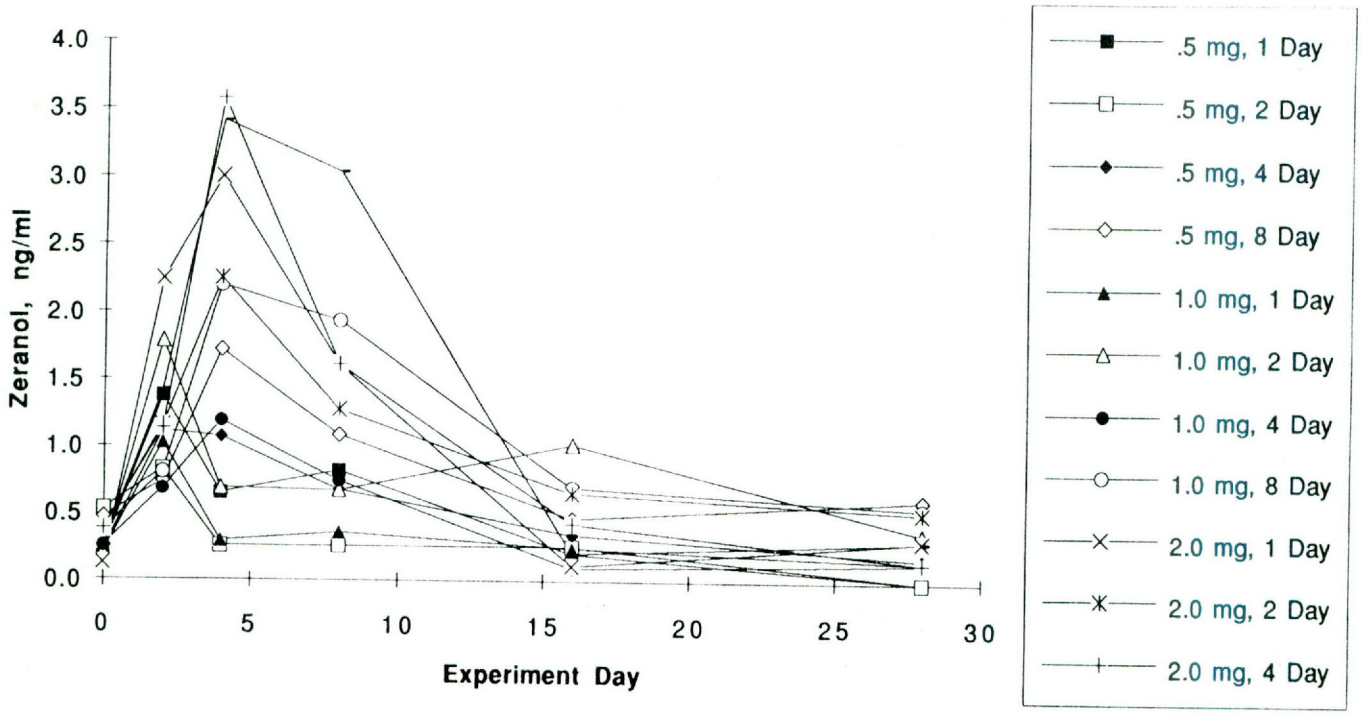

Figure 5. Plasma zeranol in steers receiving either .5, 1.0, or 2.0 mg/d of zeranol via a mini-osmotic pump for 1, 2, 4, or 8 day in Phase I of Experiment IV.

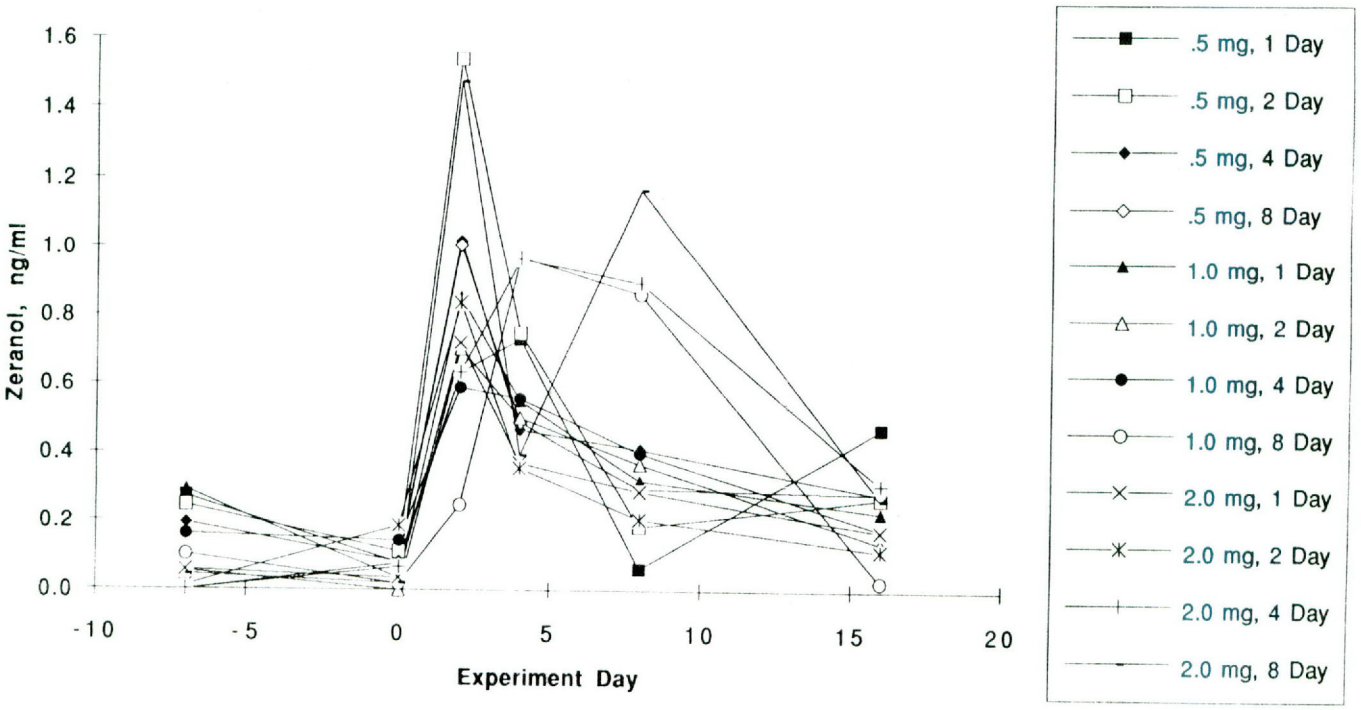

Figure 6. Plasma zeranol in steers receiving either .5, 1.0, or 2.0 mg/d of zeranol via a mini-osmotic pump for 1, 2, 4, or 8 d in Phase II of Experiment IV.

same overall pattern observed during Phase I was found, except that peaks occurred earlier. This may reflect the fact that these animals had already been stimulated to synthesize the enzymes necessary for zeranol metabolism. Zeranol concentrations at the end of this trial increased in treated and control animals, as noted in some of the other experiments.

The lower concentrations of plasma zeranol observed during Experiment IV probably are a result of the increased animal size. The volume of blood passing through the implant sites would be greater in larger animals, and the mass of tissue that could take up zeranol, metabolize zeranol or excrete zeranol (bile) would be much greater in larger animals.

Conclusions

Alza mini-osmotic pumps were used to control variability and to effectively deliver a continuous dose of zeranol. The pumps and(or) carrier solution did not perform as expected, resulting in considerable variation in plasma zeranol concentrations when animals were given zeranol using Alza pumps. It is possible that due to the insolubility of zeranol in water, precipitates of zeranol formed at the opening of the pumps and continuous delivery to the general circulation was not achieved.

With the caveat that variation exists because of Alza pump variability, the overall results indicate that pumps did simulate doses predicted to be delivered by the Ralgro formulation implants. Previous work had suggested that the implants deliver approximately 600 µg/d of zeranol. These experiments support that observation. However, it appears there is a limit to the quantity of zeranol absorbed at the delivery site by animals depending at least in part on their body size. Therefore, a smaller implant dose may be effective in younger, smaller animals, and a larger dose may be required in feedlot-sized or larger-frame animals. This hypothesis supports research which has indicated larger-frame and yearling animals require more than 36 mg of zeranol for an effective shift in nutrient usage to protein synthesis and muscle protein deposition (6).

Plasma zeranol increased with level delivered through 450 µg/d, with wide variability beyond this level. This supports the concept of a size/delivery rate relationship up to some level. Spikes of zeranol were easily generated using high delivery doses for short periods of time. However, it appeared that deposits of zeranol were formed at a site outside the pump because some animals had peaks of zeranol after pumps were removed.

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"Prospro E-9": A New Estrous Synchronization Program - II

J.S. Bluntzer, M.D. Fanning, M.R. Flake, D.W. Forrest, P.G. Harms, R.K. Knutson, D.K. Lunt, and F. Ruvuna

Summary

This is a progress report on the second in a series of studies on a novel combination of synchronization products for a breeding program. The program is now entitled "Prospro E-9" where "Pros" stands for the prostaglandin (Bovilene) injection, "pro" represents the progestogen (norgestomet implant), "E" represents the estradiol valerate and norgestomet intramuscular injection and "9" represents the norgestomet treatment duration. This treatment consists of administering 1 mg of Bovilene (B) on day 0 of the standard 9-day Syncro-Mate-B (SMB) regime. Prospro E-9 in experiment I increased pregnancy rates 29% over SMB alone in pre- and post-pubertal Jersey heifers (1). Furthermore, 83 vs 60% of the heifers were pregnant in the Prospro E-9 vs SMB treated heifers ($P<.05$) at the end of the 52 day breeding season (1). In the present study, 135 purebred and crossbred beef heifers were used to determine if the 9 day treatment period could be shortened to 7 or 8 days (Prospro E-7 and Prospro E-8, respectively), using SMB as the control group breeding program. The first-service pregnancy rates for Prospro E-7, Prospro E-8, and SMB were 30, 50, and 40%, respectively. Since treatment differences for fixed-time breeding pregnancy rates were statistically non-significant ($P>0.16$). A future experiment will repeat the previous studies and minimize heifer breed type and A.I. sire effects that were significant in this study ($P<0.001$, $P<0.05$, respectively). Overall pregnancy rates for the 57-day breeding season for Prospro E-7, Prospro E-8, and SMB were 91, 84, and 75%, respectively ($P>0.13$). Second service or repeat breeding results from this study were 69, 41, and 33% pregnant for Prospro E-7, Prospro E-8, and SMB, respectively ($P<0.016$). This implies that these novel treatments induced a higher pregnancy rate than SMB alone during the repeat A.I. breeding period.

Introduction

The justification of the Prospro E-9 breeding program design was documented in the report of Experiment I with a novel combination of Bovilene plus Syncro-Mate-B (1). Briefly, the major advantages of adding B to the SMB treatment are to enhance a weak luteolytic effect of estradiol valerate (2), to shorten the total time the heifer is under the influence of progesterone (3), and to act as a therapeutic agent for postpartum cattle. The major disadvantages of adding B, besides the additional cost involved, is the fact that prostaglandins will abort any unknown pregnancy that the SMB treatment alone will not affect.

The objective of experiment II, therefore, was to determine if the norgestomet implant period could be shortened to seven (Prospro E-7) or eight (Prospro E-8) days due to the addition of a strong long acting luteolytic agent on initial SMB treatment day.

Materials and Methods

The 135 females in this study were beef heifers raised on the McGregor Research Station, and included 40 Angus, 27 Hereford x Brahman, 37 Hereford, 10 Salers, and 21 Simmental. These females were randomly assigned to treatment based on their weight and breed type. On March 31, 1992, the average weight of the Prospro E-7, Prospro E-8, and SMB only groups were 641, 634, and 627 pounds, respectively. On weigh date, the age range for each of the treatment groups on almost all heifers was 10 to 14 months with a few heifers (≤3 hd) in each group being approximately 17 months of age. On April 23, 1992, Prospro E-7, Prospro E-8, and SMB synchronized breeding treatments were initiated. On May 2, 3, and 4, 1992, Prospro E-9, Prospro E-8, and SMB groups were bred, respectively, via A.I. by the same technician. Four A.I. sires were randomly assigned to the heifers in this study and these same sires were used to breed the heifers that returned to estrus.

Results and Discussion

Table 1 shows that there was not a statistical difference in pregnancy rates resulting from the treatments for fixed-time A.I., cumulative 5 day, 25 day, or overall pregnancy rate. The 10% greater first-service pregnancy rate of the Prospro E-8 treatment over standard SMB treatment, and last year's 29% Prospro E-9 significant pregnancy rate increase over SMB, is encouraging for future research with this novel approach. The percent change for Prospro E-7 and Prospro E-8 from fixed time A.I. through 25 days was 48 and 20%, respectively,

TABLE 1. FIXED-TIME A.I., 5-DAY A.I., 25-DAY A.I. AND 57-DAY PREGNANCY RATE PERCENTAGES BY SYNCHRONIZATION TREATMENT OF BEEF HEIFERS.

		Percent pregnant			
Treatment	n	F.A.I.	5-d A.I.	25-d A.I.	57-d a.i. and bull
Prospro E-7[a]	46	30	39	78	91
Prospro E-8	44	50	52	70	84
SMB Only	45	40	42	60	75

[a] "Pros" for prostaglandin Bovilene; "pro" for norgestomet; "E" for estradiol valerate; 7 for 7 day implant duration.

leaving one to speculate whether heifers were being induced to cycle by the treatment or whether they were attaining puberty during this brief time period. Since the SMB group also had a 20% increase during the repeat breeding period, perhaps what we were seeing for the Prospro E-7 group was a 28% additional increase caused by the combination of the B with SMB. To clarify this large increase in pregnancy rate after fixed-time A.I., Table 2 indicates second service results. This table indicates a definite advantage of increased pregnancy rate with Prospro E-7 and E-8 over SMB alone. Looking at each treatment individually vs the SMB control group, we find that Prospro E-7 during the repeat breeding period had a significant pregnancy rate increase vs SMB alone (P<0.007). Since Prospro E-7 and E-8 both have B, with only a difference in day length of norgestomet treatment, we decided to pool their data for second service and compare the results to SMB results. The lower part of Table 2 depicts a greater pregnancy rate (57 vs 33 %) for the novel treatments of adding B (P< 0.041) over SMB alone.

TABLE 2. SECOND SERVICE A.I. PREGNANCY RATE BY SYNCHRONIZATION TREATMENT OF BEEF HEIFERS.

Treatment	n	Percent pregnant
Prospro E-7	32	69[a]
Prospro E-8	22	41[b]
SMB only	27	33[b]
Prospro E-7 and E-8	54	57[c]
SMB only	27	33[d]

[a,b] (P<.01)
[c,d] Values in the same column with different superscripts differ (P<.041)

Table 3 indicates that after 25 days of A.I. breeding there was an effect of breed type on the percentage pregnant (P< 0.001) with pregnancy rates of 84, 81 and 81% for Hereford, Hereford x Brahman and Simmental heifers compared to 50 and 40% for Angus and Salers, respectively.

TABLE 3. FIXED-TIME A.I., 5-DAY A.I., 25-DAY A.I. AND 57-DAY PREGNANCY RATE PERCENTAGES BY BEEF HEIFER BREED TYPE.

		Percent pregnant			
Breed type	n	F.A.I.	5-d A.I.	25-d A.I.[a]	57-d A.I. and bull
Angus	40	28	28	50	75
Hereford x Brahman	27	44	44	81	81
Hereford	37	41	54	84	92
Salers	10	30	30	40	80
Simmental	21	62	66	81	90

[a] (P<0.001)

Table 4 indicates that after 25 days A.I. there was an effect of sire on percent pregnant, with one Angus sire (Shoshone Sampson) performing with lower pregnancy rates than the other 3 A.I. sires (P<0.01). The effect carried over through the 57-day breeding season and the clean up sire was unable to make up for this difference.

The implications of this study are that the novel treatments did not significantly improve fixed-time synchronized pregnancy rate to a high enough degree to be statistically significant, however heifer breed type and A.I. sire variation may have contributed to the lack of significance.

Table 4. Fixed-time A.I., 5-day A.I., 25-day A.I., and 57-day pregnancy rate percentages by beef A.I. sire.

		Percent pregnant			
	n	F.A.I.	5-d A.I.	25-d A.I.[a]	57-d A.I. and bull[a]
Wagyu					
01	33	42	55	88	97
107	34	44	44	71	91
Angus					
P.I.	34	53	53	71	85
S.S.	34	21	26	50	62

[a] (P<0.01)

Acknowledgments

The authors wish to express appreciation to Syntex Animal Health for providing the Bovilene used in this study.

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Regulation of Adrenocorticotrophin (ACTH) in Cattle

J.A. Carroll and T.H. Welsh, Jr.

Introduction

Environmental and (or) management factors which induce stress in cattle are detrimental to efficient production of milk and meat. In order to control the negative factors associated with stress, we must first understand how animals respond hormonally to stress.

In response to a stressor, the hypothalamic portion of the brain releases corticotrophin releasing factor (CRF) which stimulates the release of ACTH from the anterior pituitary gland. ACTH acts at the level of the adrenal cortex to enhance the release of cortisol, the steroid hormone that is often referred to as the stress hormone. By reducing an animal's exposure to sustained supraphysiologic levels of cortisol, one may be able to combat the detrimental effects of stress on growth, reproduction, and the immune systems in livestock and thus improve animal productivity.

In addition to CRF, the hypothalamic neurohormone vasopressin stimulates release of ACTH in rats, humans, pigs, and sheep. Ironically in sheep, vasopressin has been shown to be a more potent stimulus *in vivo* and *in vitro* of ACTH secretion than CRF. In contrast, our data with cattle, however, have demonstrated that CRF is a more potent stimulator of ACTH release than vasopressin. The focus of our project is to determine whether and how vasopressin and CRF interact to control ACTH and cortisol release in cattle. In addition, we are examining the negative feedback mechanism whereby cortisol blocks 1) hypothalamic secretion of CRF and vasopressin and 2) CRF- and vasopressin-stimulated synthesis and secretion of ACTH in cattle. The following series of *in vivo* and *in vitro* experiments were designed (some of which are still in progress) to accomplish these objectives.

Materials and Methods

In Vitro Experiment

Bovine anterior pituitary glands collected from steers at the Rosenthal Meat Science and Technology Center were enzymatically dispersed to yield corticotrophs for cell culture experiments. The cells were cultured in humidified, water-jacketed CO_2 incubators for five days (medium changed each day). On the fifth day, cells were challenged for a 3-hour period with either medium alone (Control) or various doses of either bovine CRF, vasopressin, an analog of vasopressin, or/and Dexamethasone (a synthetic glucocorticoid). Media were collected and frozen until assayed for content of ACTH.

In Vivo Experiment

Eight Jersey cows that were previously exposed to long periods of halter restraint and handling were selected for this experiment due to their docile disposition. Two cows were randomly assigned to one of four treatment groups (Group A-saline, Group B-bCRF, Group C-vasopressin, or Group D-bCRF+vasopressin) and this process was repeated on each of the 4 days of hormone challenge/blood collection. Each cow received two intramuscular injections of Lutalyse (prostaglandin) at an interval of 10 days in order to have the cows in the follicular phase of their estrous cycle at the time of the experiment. Each animal was fitted with an indwelling jugular catheter 24 hours prior to initiation of blood sampling and hormone challenges. On bleeding day 1, blood samples were collected at 15-min intervals for 4 hours, and then each group was immediately challenged with the appropriate treatment. Blood samples were then collected at 1, 5, 10, and 15 min post-treatment. Blood sampling then continued at 15-min intervals for the remainder of the 6-hour post-treatment sampling period. The animals were then given a 14-hour rest period and randomly assigned to one of the four treatments which they had not previously been subjected. The blood sampling protocol of day 1 was again used for days 2, 3 and 4. All cows received additional injections of prostaglandin to synchronize their estrous cycles for bleeding days 3 and 4 at which time they were subjected to a similar hormone challenge/bleeding protocol as previously described. Plasma samples will be assayed to determine concentration of ACTH and cortisol.

Results and Discussion

Treatment with bovine CRF significantly increased ($p<.05$) the cell culture medium concentration of ACTH 3.76-fold over Control (cells treated with medium alone). We did not see a significant difference between the two neurohormones in our cell cultures. The medium concentration of ACTH for cells challenged with vasopressin and the vasopressin analog increased 2.65- and 2.77-fold relative to Control, respectively. In a previous experiment with sheep, this same vasopressin analog has been demonstrated to be only 1/36 as potent as vasopressin. Moreover, these compounds did not elicit a greater response than CRF, as reported for sheep. As expected, dexamethasone proved to be a potent inhibitor of ACTH secretion. Specifically, when cultured cells were treated with combinations of dexamethasone with either CRF, vasopressin, or the vasopressin analog, the medium concentration of ACTH remained similar to that of the Control group.

Blood samples for the in vivo experiment are currently being analyzed for ACTH and cortisol. It is anticipated that CRF will be a more potent stimulator of ACTH secretion than vasopressin. We hypothesize that vasopressin and CRF will be synergistic in stimulating the release of ACTH and cortisol.

Extension and Progress Reports

The Effect of Implanting Suckling Calves Grazed on Native South Texas Pasture

T. R. Troxel and C. L. Gasch

This study was designed to ascertain the cost effectiveness of implanting suckling calves grazing South Texas native pasture. In today's cow/calf industry, efficiency of production is extremely important. Employing cost effective beef cattle management practices has become necessary for all types of beef cow/calf producers.

One hundred twenty-six suckling calves approximately 60 days old were randomly assigned to a 2 x 2 factorial treatment design. The main effects were implanting (no implant or Synovex-C) and sex of the calf (heifers or steers). At the time of treatment (implanting), calves were tagged, weighed, bulls were castrated and calves assigned to the Synovex-C treatment were implanted. Following treatment and weighing, all calves were allowed to return to their dams. All cows and calves were similarly managed on native pasture. The pasture consisted of pink pappusgrass (*Pappophorm bicolor*), hooded windmillgrass (*Chloris cucullata*), plains bristlegrass (*Setaria leucophila*), and Wright threeawn (*Aristida Wrightii*). The brush was a mixed population with the dominant brush being mesquite (*Prosopis glandulosa*), guajillo (*Acacia berlandieri*), black brush (*Acacia rigidula*), and twisted acacia (*Acacia schaffneri*).

The calves in the implant group received Synovex-C implants (10 mg of estradiol benzoate and 100 mg of progesterone - Syntex Animal Health, Inc.). The implants were inserted between the skin and the cartilage in the middle third of the ear. Calves were weaned 203 days after treatment.

The main effects of implanting and sex of calf were significant ($P < .005$). There were no significant interactions ($P > .10$). This data indicates that regardless of the sex of calf (steers or heifers), Synovex-C increased average daily gains. The average daily gain for the implanted calves was 2.33 lbs. per day whereas the average daily gain for the control or non-implanted calves was 2.11 lbs. per day. This 10.4 percent increase in average daily gain resulted in an additional 44.7 lbs. at weaning and is supported by other South Texas implant demonstrations (1).

In order to evaluate the economics of implanting calves, an adjustment in price for heavier calves must be considered. Therefore, the additional 44.7 pounds gained due to implanting was valued at $.50 per pound ($22.35 per head). With a $2.05 implanting cost, the net return from implanting calves was $20.30 per head. Steers outgained heifers by 20.8 percent (2.44 vs. 2.02 lbs. per day). Because of this additional gain, steers had an increased gross income of $43.65 over heifers.

The results of this field trial support the cost effectiveness of implanting suckling calves grazing native South Texas pastures. Producing the most product per dollar investment has become a major factor in ranch survival. In this field trial, the cost and return analysis of implanting suckling calves was positive.

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Total Quality Management in the Beef Cattle Industry

N. C. Tipton and W. L. Mies

Introduction

Recent developments in the beef cattle industry have been, at times, almost overwhelming. Government regulation, environmental threats, animal welfare, the increasing cost of doing business, and the ever present and changing consumer preference leave the beef cattle industry wondering if there is any way to turn. On the other hand, such technological advancements as computerization, newer and better drug treatments, satellite marketing and information systems, and sophisticated production and genetic models leave us wondering which way to turn.

How then does the beef cattle industry progress into the nineties and beyond? In any consumer driven and competitive free market, it would seem that recent examples from various industries (the automotive, home entertainment, and especially our competitors - the swine and poultry industry) dictate that consumer's preference is for a consistent, low cost, and high quality product. It would, therefore, make sense for those of us in the beef cattle industry to provide such a product. How then do we achieve such a goal?

The answer is simple, but the implementation is anything but simple. If the beef cattle industry hopes to stay competitive it must produce a quality product at a reasonable price. It must identify to the cow/calf producer those animals that are capable of maximum efficiency and profitability in a given environment, as well as a specified consumer quality preference. Furthermore, the feeding industry must then cultivate from cow/calf and stocker producers a client base that will consistently supply high quality cattle. The feeding industry must then give suppliers feedback that will allow them to continue to consistently supply high quality cattle.

Additionally, packers and retailers, must receive a consistent high quality product, and, in turn, packers and retailers must provide feeders with feedback that will allow them to continue to produce a consistent high quality product. The only way such a system of quality can work is through mutual trust and open communication between producer and supplier, along with a willingness to proactively implement consumer dictated changes. Only then will we be able to maintain a long term stake in the maturing beef cattle industry.

Before we can look specifically at Total Quality Management within the beef cattle industry we must first look at the history of Quality Management. Historically, quality has been one of the fundamental attributes of U.S. workmanship. Throughout the first 160 years of our existence a culture pervaded in this country that was based on pride in quality of the finished product. Handmade and custom products made up the bulk of our nations output at this time. Workers had a vital stake in all parts of the manufacturing process, and took great pride in the finished product. Even during the first years of Fredrick Taylor and Henry Ford's Scientific Management and mass production era, quality was still ingrained in the work force from the days of individual craftsmanship.

After World War II, however, the negative affects from Taylor's scientific management system began to emerge. Jobs became increasingly monotonous and mass production fueled by production quotas ruled the day. Under Taylor's management ideas, workers were no longer encouraged to be free thinkers. It was thought that anything the worker did to the production process, other than his specific job, was detrimental to the end profit of the company. Quality began to suffer, but that was overlooked because economic times were good, and many companies were making record short run profits using Scientific Management principals. Long term survival, during this time period, seemed assured, but an increasingly global economy would soon teach the United States the value of Quality Management.

During the post World War II period, Japan began marketing international with their own mass production products. In the beginning Japan's products were inferior and not well accepted in the international market, and Japanese industry suffered accordingly. Japan, however, quickly recognized the inferiority of their products, and immediately set about the process of revamping their industrial capabilities. Japan's long history of pride along with the assistance of U.S. statistician Dr. J. Edward Deming soon changed Japan's manufacturing industry into a quality based system. As a result Japan's international reputation eventually became synonymous with the highest quality products. At first Japan paid dearly for its commitment to quality as hundreds of thousands of their products sat idle in world ports. Japan, nevertheless, stuck to their vision of a future driven by quality instead of quantity, and within thirty years Japan had become a dominant force in the international trade community.

Japan's vision was one based on quality. Japanese manufacturers lead by Dr. Deming realized that the future of the industrialized world would be a fast paced society having little time for delays caused by inferior products. Quality at a reasonable price would be the driving force of the future. No longer would the vision of a '57 Chevy rag-top out for a Sunday drive be able to compete with a Toyota truck that ran economically for two hundred thousand plus miles.

Japan's lesson in Quality Management and a vision of the future compared to America's archaic mass production and short term profit driven industry are similar to the current competitive situation between the poultry and beef cattle industries. Today's beef cattle industry is still far behind in

effective production and quality competitiveness with the poultry industry as well as other high quality protein sources.

While it might be suggested by some that the poultry industry's recent boom is the result of bad press and misleading reports about the cholesterol, fat, cancer, and heart disease aspects of beef. The reality of the situation is quite different. The poultry industry's boom is in no way a recent development. Over the past 60 years, the price of poultry has gone from more than twice the price of beef to less than half the price of beef (2, 14). During that same time period, gross profits in the poultry industry increased by 325 times, and over the last 30 years consumer consumption of broilers has tripled (1).

The dramatic increases seen in the Poultry Industry are, more than anything else, a result of technology adoption, creative marketing, and a commitment to both present and future Total Quality Management. Feed conversions for four pound broiler chickens are two-thirds of what they were in 1950, and today it takes half the amount of time as it did in 1950 to grow a four pound broiler. Ninety-nine percent of broilers production in the United States is done under contract to fully integrated broiler firms. Profits in these integrated firms essentially stay within the company from egg production all the way to the wholesale marketing of the broilers to retail chains (1).

In contrast to the poultry industry, the beef cattle industry is a complex and segmented industry that takes individual short term profits out of the overall products profit potential at several different production levels. Additionally, the majority of the beef cattle industry operates under a marketing system that emphasizes short term profitability. A large number of fed and feeder cattle are still marketed on a liveweight basis that encourages producers to group low and high quality cattle together. Such a marketing system only creates skepticism between packers, feeders, and producers, since there is an incentive on all sides to get by with what you can in the way of short term profits at the expense of overall profitability. This, in turn, creates a system where producers have little profit incentive to produce quality calves, feedyards have little incentive to buy quality cattle, unless they are the most profitable cattle, and furthermore, packers have little profit incentive to pay the true value for fed cattle.

Commitment to long term quality, and, therefore, long term profits, would be hard to achieve in a system like the beef cattle industry's current marketing system. To become competitive again, the beef cattle industry must shift its marketing system to a profit for a consumer driven carcass quality system instead of the ambiguous marketing system currently in place (6). Doing so will bring with it both increased short and long term profits through increased quality of the end product (10). To do this, we must set up a system that emphasizes profitability through the sale of a quality product, along with an emphasis on the proactive free flow of quality information between supplier, consumer, and producer.

The beef cattle industry can no longer allow itself to be driven by short term profit at the different levels of production in an industry that can take years to change the composition of its product. Vertical integration from a quality and profitability standpoint is the only way the industry can hope to compete long term with the ownership integrated poultry industry (6). This is because it is economically unfeasible to vertically integrate from the ownership side in the beef cattle industry. (Simple math shows it would take twelve and one-half 30,000 head feedyards, at 2.6 turns per year, and over 10,000, one hundred head cow calf operations just to run IBP's Amarillo plant.)

The beef cattle industry, which must deal with an animal that is at least twice as expensive per pound to produce as broilers (1), must commit itself to the long term Total Quality Management of its end product or suffer the same fate the sheep industry has over the past two decades. The reason why is simple. As cost of production increases so does the resulting wholesale and retail price, and as retail cost increases so does customer quality requirements. Additionally, as quality increases so does market share, productivity, profit on sales, and return on investment (4). Instead of trying to defend and justify the current and archaic cattle marketing system, the beef cattle industry must embrace the idea of proactive change toward quality. Petty excuses, squabbling, and accusations between supplier and producer over segmented profits only creates inefficiency, and spells long term industry decline (7).

Management of Quality Process

Total Quality Management to increase profits is the rule rather than the exception in almost all of today's industries. More and more the consumer is making it known that their preference is for the highest quality product at the most affordable price (11). When consumers were recently polled in the United States, Germany, and Japan, the majority of those consumers rated quality and price as the two most important contributing factors in purchasing a product (12).

At the heart of any industries attempt at the Total Quality Management Process is commitment from management. Management must realize that in today's global economy quantity produced means nothing without quality standards that are built into the manufacturing process (9). Additionally, management must realize that current quality management standards will soon be outdated in today's constantly changing global business community. Therefore, management must embrace the idea and implement the process of change and innovation, evaluated from a practical as well as a quality management standpoint, if industry is to be competitive in the long run. (5).

To achieve long term Total Quality Management through customer satisfaction Feigenbaum (8) discussed three different areas industries of the future must consider:

1. **Customers have been and will continue to increase their quality requirements sharply.**
2. **As a result of this increased customer demand for higher quality products, present quality practices and techniques will soon be outmoded.**

3. **The costs of inferior quality have become very high. For many companies, they may be much too high for these companies to continue their manufacturing operations and improve their competitive position over the long run.**

With these thoughts in mind, companies of today must constantly update their Total Quality Management process through the Management of Quality process.

Management of Quality is the organizational function that has as its main responsibility the prevention of product defects. In the case of the beef cattle industry, defects would be defined as those cattle that are undesirable to the cow/calf producer, the stocker producer, the feeder, and the packer. To eliminate defective products, quality must be managed by the Management of Quality Process which encompasses Quality Engineering, Strategic Management of Quality, and Management Programs for Quality (3).

Quality Engineering, the first step in the Management of Quality Process, is described by Feigenbaum (8) as the process by which policy is formulated and analysis and planning of the product quality is performed in order to implement a Total Quality Management process that will yield maximum customer satisfaction at minimal cost. The process involves the preparation of a quality policy, product quality analysis, and quality operations planning (3).

The preparation of a quality policy is the process by which the companies quality objectives will be established. In the case of the beef cattle industry, this might include the kind of cattle performance that will be tolerated at a given time; tolerance levels in feed production and feed performance at a given time; and minimal quality levels for carcass characteristics at a given time.

Product quality analysis includes techniques for isolating and identifying factors that affect the quality of the product. This section of Total Quality Management is perhaps the hardest to perfect as far as beef cattle are concerned. This is, of course, due to the uncertainty involved in so many of the factors associated with cattle. Processing procedures, cattle origin, grazing practices, weather factors, carcass factors, control of genetics, and feed factors are all included in this section.

Quality operations planning consists of emphasizing the development of a proposed course of action and methods for obtaining a desired outcome. Included in this section might be such things as how to properly raise feeder calves, how to properly market cattle, how to feed, process, ship and receive feeder cattle, and how to properly purchase and slaughter fed cattle. The main purpose of this part of the Total Quality Management process is to deliver a specified quality product to the consumer at minimal cost.

The Activities of the Quality Engineer were defined by Simmons (13) as the following:

1. **Training** - Preparation of educational material for conducting training programs in Total Quality Management. Train all employees to keep abreast of new developments for the purpose of future training.
2. **Quality Standards** - Develop, implement, and train employees to use quality standards where needed in the company.
3. **Measurements and Analytical Facilities** - Determine, recommend, and/or design measurements and analytical facilities required to evaluate product quality and reliability.
4. **Methods and Procedures** - Develop forms and instructions for the proper collection and dissemination of data on quality.
5. **Non-Conforming Products** - Establish and implement clear and concise procedures for disposition of non-conforming products or materials.
6. **Audit of the Quality Program** - Provide methods and arrange for auditing and reporting the progress of the implementation stage, as well as the effectiveness, cost, and savings of the quality process.

The second step in the Management of Quality Process is the Strategic Management of Quality. This step might be thought of as the way decisions are made, communicated, and implemented in the Total Quality Management process. It is the vital point where quality is implemented and communicated within the actual day-to-day process of production. Included in this step in the Total Quality Management process are what have become known as the fourteen steps of the Deming Method. These fourteen steps are discussed in depth by Gitlow and Gitlow (9). They include such ideas as consistency of purpose toward improved products, improving the quality of incoming product through use of select suppliers, adopting the new philosophy of the ever evolving economic age, and the elimination of fear among employees to name a few of the points.

Also included in the Strategic Management of Quality steps are the processes of product appraisal, failure analysis, and quality education and training. It is in this portion of the process that end product quality is appraised to determine if it did indeed meet quality standards. Carcass, performance, and production traits are a good example of this in the beef cattle industry. If the product failed, the reason is determined, and used for future reference to the quality management process. Also closely associated with product failure and appraisal is the quality education process. Employees must be positively taught about proper quality roles and responsibilities to be able to know what quality is and why a product might fail (3).

The last three parts of the Strategic Management of Quality step are consumer affairs, product safety, and product liability. Consumer affairs deals with reactions of management to the complaints of the customer about the products quality. Management must then decide how or if it is necessary to modify the product so the customer, who in reality has the final say, will be satisfied. This point is of paramount importance to the beef cattle industry as we have all seen in recent times.

Product safety and product liability go hand-in-hand when it comes to quality. Failure of the company to properly handle the product from a quality standpoint can often lead to liability problems (3). This is of special importance to the beef cattle industry when it comes to drug use, withdrawal periods, and residue levels. Government regulations, whether popular or not, must be adhered to if the quality of beef wishes to remain beyond reproach.

The last remaining steps in the Management of Quality Process are the Management Programs for Quality. Included in these steps are both motivation of the employees toward the quality process, as well as the organization of the Total Quality Management function within the company. These two steps are essentially self explanatory. In order for the Management of Quality Process to exist and function properly, management must not only motivate all employees to accept and implement Total Quality Management, management must also organize Total Quality Management personnel into an accountable, responsible, and communicative organization (3).

Conclusion

The beef cattle industry, along with the entire industrialized world, is today in the middle of a new age of operation. Society and technology have continued and will continue to change at astronomical rates. If today's beef cattle industry wishes to be a viable industrial force into the next century, the idea of proactive Total Quality Management must motivate our industry's future. The reason why is critical to our existence. Production for productions sake is no longer a profitable part of today's competitive global economy. Quality is the guiding force throughout the industrialized world. To compromise cost conscious quality in turn compromises profitability which ultimately compromises long term viability.

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The Value of a Protein Supplement and Elevated Levels of Phosphorus, Other Minerals, and Ruminally Undegraded Protein on Adult Beef Cows on Rangeland

J. E. Huston, K. W. Bales, P. V. Thompson, and D. Spiller

Summary

One-hundred-five adult beef cows at two locations (Edwards and McCulloch Counties) received winter supplemental feed treatments during a 1-yr study. Body weight and body condition score changes in cows and calf weaning weights were evaluated. Treatments included (1) control (no supplemental feed), (2) protein-energy supplement, (3) treatment 2 plus additional phosphorus, (4) treatment 3 plus additional minerals, and (5) treatment 4 plus additional ruminally undegraded protein. The treatments were applied between December 1, 1991, and March 20, 1992, using Calan individual animal feeding gates (American Calan Inc., Northwood, NH). The cows were weighed and condition scored at the beginning and end of the feeding period and at weaning (October) at which time pregnancy was determined. Analyses were performed on the pooled data for effects of treatment and location. Cows receiving supplements lost less weight and condition during the winter feeding period and gained less weight the subsequent growing season than the control cows. Additional nutrients did not show benefits. No differences were noted for conception or calf weaning weights. Body weight losses were greater at the Edwards County location. These data demonstrate the need for protein supplements in adult beef cows grazing range vegetation.

Introduction

Typically, the nutrient content of range vegetation drops below animal requirements during the winter months (1), and if not supplemented with protein, beef cows will not utilize dormant forage effectively (3) and will lose ruinous amounts of weight and body condition. Although protein generally is considered to be the first limiting nutrient in cattle grazing dormant range forage (2), the importance of supplementation of other nutrients is often questioned. This study was conducted to determine whether additional nutrients would improve the value of a protein supplement for beef cows grazing dormant rangeland.

Materials And Methods

This study was conducted at the Frances Hill (Edwards County) and H.D. Winters (McCulloch County) ranches in the Edwards Plateau region of Texas. At the Hill Ranch site, 15 Brangus cows grazed in four pastures (60 cows total), and Calan gates were used in each pasture to supply supplemental feed to three cows per treatment. Three cows in each pasture were designated as controls and did not receive supplemental feed although all cows had free access to white salt. Procedures were similar at the Winters Ranch site with Hereford X Brangus cows. Treatments are described in Table 1 for control (NC), protein-energy supplement (PC), and elevated phosphorus (PHOS), trace minerals (TM) and ruminally undegraded protein (UDP). Feeding began in early December, 1991, and continued through mid March, 1992. The cows were weighed and body condition scored at the beginning and end of the feeding period and at weaning (October). Calf birth dates and weaning weights were recorded, and adjusted weaning weights were calculated. Pregnancy was determined at weaning. Nu-

TABLE 1. EXPERIMENTAL RATIONS AND TARGET FEEDING LEVELS IN A STUDY OF THE EFFECTS OF PROTEIN, PHOSPHORUS, TRACE MINERALS, AND EXTRA RUMINALLY UNDEGRADED PROTEIN ON ADULT BEEF COWS GRAZING EDWARDS PLATEAU RANGELAND.

	Treatments				
Item	1 NC	2 PC	3 PHOS	4 TM	5 UDP
Ingredients:	----------	----------	%	----------	----------
Milo		32.8	32.8	32.8	0.0
CSM					62.8
SBM		53	53	53	0.0
Urea		2.2	2.2	2.2	1.3
Molasses		4	4	4	4
Feather meal					15.9
Fish meal					8
CA-PO4			2.8	2.8	
TM salt				5.2	5
Salt		8	5.2	0	3
		100	100	100	100
Target Feeding Levels:					
DM, g/d		1200	1200	1200	1200
CP, g/d		400	400	400	600
RDP, g/d		300	300	300	300
UDP, g/d		100	100	100	300
DE, Mcal/d		3.5	3.5	3.5	3.5
P, g/d		5.3	12	12	13
K, g/d		14.8	14.8	45	45
Cu, mg/d		19.8	19.8	70	70
Zn, mg/d		35.6	35.6	566	610
Mn, mg/d		20.1	20.1	282	289

merical scores were assigned for fetal age from zero (open) to three to indicate time from conception.

Results and Discussion

Data were pooled for analysis and are shown in Tables 2 and 3 for treatment and location effects, respectively. Cows that did not consume supplements at or near the prescribed level or, for any reason did not wean calves, were excluded from the data. Although the 1991 to 1992 winter season was considerably less severe than the average, supplemental feeding reduced the weight and condition losses between fall and spring. The NC cows gained more weight during the subsequent growing season, and over the total experimental period (fall to weaning) weight changes among treatments did not differ. No additional benefits were observed as a result of any of the elevated nutrients. Pregnancy scores and adjusted calf weaning weights did not differ among treatment groups. Differences were detected between locations for fall to spring and fall to weaning weight changes, for all periods of condition score changes, and for adjusted calf weaning weights. Cattle at the Hill Ranch were heavier and in higher body condition at the beginning of the study, and due to local conditions, lost more weight and body condition during the study periods.

TABLE 2. EFFECTS OF SUPPLEMENTAL FEEDS ON PERFORMANCE OF ADULT COWS GRAZING RANGELAND AT TWO LOCATIONS IN THE EDWARDS PLATEAU REGION OF TEXAS.

	Treatments				
Item	NC	PC	PHOS	TM	UDP
Number of cows	20	16	20	15	15
Cow weights, lb					
Fall, 1991	1149	1152	1174	1179	1169
Spring, 1992	940	998	1035	1022	1010
Weaning, Oct.	1010	1005	1035	1063	1039
Cow weight changes, %					
Fall to spring	-18.2[a]	-13.4[b]	-11.8[b]	-13.3[b]	-13.6[b]
Spring to weaning	6.0[a]	0.5[b]	0.0[b]	3.5[ab]	2.3[ab]
Fall to weaning	-12.2	-12.9	-11.8	-9.8	-11.3
Cow condition scores (CS)					
Fall, 1991	4.94	4.75	4.88	4.90	4.83
Spring, 1992	3.70	4.04	4.28	4.13	4.03
Weaning, Oct.	4.22	4.15	4.29	4.77	4.38
Cow CS changes					
Fall to spring	-1.24[a]	-0.71[b]	-0.60[b]	-0.77[b]	-0.80[b]
Spring to weaning	.52[a]	0.11[b]	0.01[b]	0.64[a]	0.35[ab]
Fall to weaning	-0.72[a]	-0.56[ab]	-0.59[ab]	-0.13[b]	-0.45[ab]
Pregnancy score	1.8	1.5	2.2	2.1	1.9
Adjusted calf weaning weight, lb	601	596	607	604	601

[ab]Means not sharing a common superscript differ (P <.05).

TABLE 3. PERFORMANCE OF ADULT BEEF COWS GRAZING RANGELAND AT TWO LOCATIONS IN THE EDWARDS PLATEAU REGION OF TEXAS.

	Locations	
Item	Edwards County	McCulloch County
Number of cows	43	43
Cow weights, lb		
Fall, 1991	1219.05[b]	1109.05[b]
Spring, 1992	1029	969
Weaning, Oct.	1053	1003
Cow weight changes, %		
Fall to spring	-15.6[a]	-12.6[b]
Spring to weaning	2.1	3.0
Fall to weaning	-13.5[a]	-9.6[b]
Cow condition scores (CS)		
Fall, 1991	5.30	4.43
Spring, 1992	4.32	3.74
Weaning, Oct.	4.33	3.38
Cow CS changes		
Fall to spring	-0.98[a]	-0.69[b]
Spring to weaning	0.01[a]	-0.64[b]
Fall to weaning	-0.97[a]	-0.05[b]
Pregnancy score	1.77	2.02
Adjustsed calf weaning weight, lb	613[a]	591[b]

[ab] Means not sharing a common superscript differ (P <.05).

These results demonstrate the need for supplemental protein but fail to show any benefit from other nutrients provided at elevated levels. Variation due to location was demonstrated.

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1991-1992 Texas A&M Ranch to Rail Summary Report

J.W. McNeill, W.L. Mies, W.W. Morgan, and S.F. Kelley

Summary

Six hundred sixty-six steers were consigned to the 1991-92 Texas A&M Ranch to Rail Program. This program gave 74 producers the opportunity to learn more about the feedyard performance and carcass traits of their calf crop. The program also familiarized producers with retained ownership as a marketing alternative and the factors that influence value beyond the weaned calf phase of production. Over 90% of the ranches recorded a profit from retained ownership. However, there was considerable variation between entries and among individual steers within ranch entries for most of the traits measured. Evaluation of the 666 head showed that 31.7% of the individual steers failed to meet arbitrary standards set to measure the level of industry acceptance. Most of the deficiencies can be corrected through cost effective management changes (particularly by enhanced health programs to boost immunization prior to shipment), whereas others can be achieved only by modifying the genetic base of their herd. Due to its success, the program is being continued and expanded to allow producers to determine if management changes implemented as a result of what was learned helped them meet individual ranch goals and to allow others to participate.

Introduction

The beef industry has traditionally been known as a segmented industry. Each segment takes the cattle to a given point and then sells them to the next segment. Although this is still the primary method of marketing today, there are inherent inefficiencies caused by such a scheme due to lack of feedback on whether or not cattle produced are acceptable through all phases of production. It is important to identify those beef production systems that supply the type of cattle that are productive under their environmental conditions, but still produce acceptable carcasses. The Texas A&M Ranch to Rail Program was designed to help provide such feedback to commercial ranchers and purebred breeders. This was not a contest to compare breeds or breeders, but an information exchange between the commercial producer, feeder, and packer segments of the beef industry. The information gained from the program can be utilized by the individual producers to determine the types of cattle that can be raised in their given environmental constraints, while meeting acceptable standards in terms of their feedlot performance and carcasses.

The first objective of the program was to provide commercial cow/calf producers, purebred breeders, stocker operators and cattle feeders the opportunity to determine the feedyard performance and carcass characteristics of cattle they are producing and the factors influencing value. The second objective was to familiarize producers with cattle feeding and retained ownership as an alternative marketing method. Through education of the total beef industry, efficiency can be enhanced at all levels of production.

Procedures

Seventy-four producers delivered 666 head of cattle to Randall County Feed Yard in Amarillo, Texas on November 18, 1991. All entries were required to pay a nomination fee of $10.00 per head. The steers were to weigh between 500 and 700 pounds upon delivery to the yard. Upon arrival at the feedyards, the steers were ear tagged, individually weighed, photographed, and processed. Although there was no required preconditioning regime, it was recommended that calves be weaned, castrated, and vaccinated at least 30 days prior to arrival at the feedyard. It was determined to mass medicate all steers for three days since the cattle, as a group, appeared stressed and bad weather was forecasted. After this, individual animals were treated as prescribed by the feedyard veterinarian. Medical records and all costs were kept on each individual animal.

Upon arrival at the feedyard, each animal was assigned a per hundred weight value based upon current market conditions. These values were used to calculate theoretical breakevens and profitability of the feeding venture. The cattle were then sorted into feeding groups based on weight, frame size, and flesh condition. The cattle were placed on a starter ration, and then gradually stepped up to a finisher ration. Feed consumption was calculated at the end of the feeding period. Cattle were slaughtered at 186 days and 211 days, which was when each outcome group reached the weight and condition regarded as acceptable by the feedyard manager and the Texas A&M Ranch to Rail management team. The cattle were sold on a carcass basis, with premiums and discounts for quality grades, yield grades, and carcass weights being established prior to slaughter. Each producer had all fees deducted and was paid the balance. The feedyard performance information that was reported include: average daily gain, feed efficiency, total cost of gain, breakeven, and net return. Carcass information collected was: carcass weight, dressing percentage, ribeye area, adjusted fat thickness, yield grade, and quality grade.

Discussion

During the 186 and 211 day feeding periods, performance data and carcass information were collected for each animal and were made available to each participating producer. Ideally, the information would be used to allow the producers to understand how their cattle performed, both individually and as a group, and indicate how the consigned cattle fit the needs of the beef industry.

Performance Data

The daily gain of the group entries averaged 3.03 pounds per day with a range of 1.71 to 3.56 pounds per day (Figure 1). Thirty-two percent of the cattle fell within the 3.00 to 3.25 pounds per day category with only 4% of the group gaining over 3.50 pounds a day. Gains were calculated based upon arrival weight at the feedyard to final pay-weight (4% pencil shrink) after 186 or 211 days on feed. The range in off-truck weight upon arrival to the feedyard was 424 to 858 pounds and the calves averaged 594 pounds for the entire 666 head.

Since feed costs accounted for a majority of the production costs during the feeding period, feed efficiency is a very important performance trait for consideration. Feed intake was calculated based upon pounds of feed consumed per head day in each pen; therefore, cattle that had higher daily gains had more desirable calculated feed efficiencies. The fastest gaining steer in the entire feeding program gained 4.28 pounds per day, while the average feed/gain for the entire group was 8.08 with a range of 6.75 to 15.79 pounds of calculated feed per pound of gain (Figure 2).

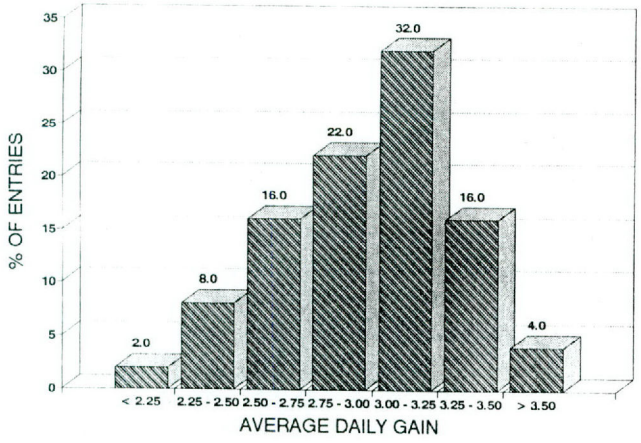

Figure 1. Distribution of average daily gain.

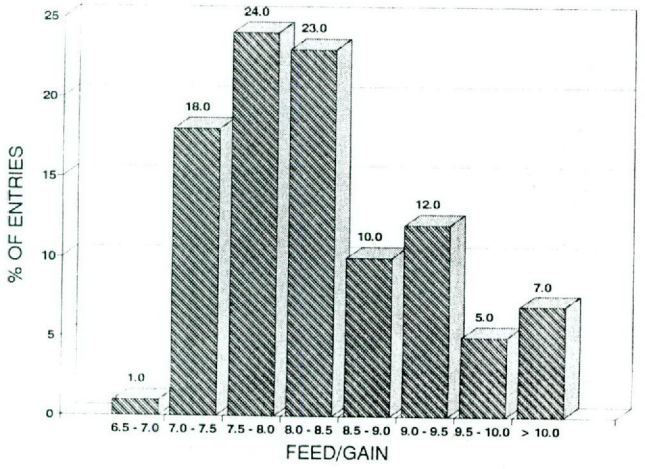

Figure 2. Distribution of feed/gain.

Carcass Data

Upon completion of the feeding period, the cattle were sold "grade and yield" based upon United States Department of Agriculture Yield and Quality Grade standards. Figure 3 describes the distribution in carcass weight. Specifically, twelve carcasses were discounted due to weight constraints. Eleven of these carcasses weighed over 950 pounds with only one carcass weighing less than 550 pounds. Carcasses not complying to the carcass weight constraints of 550 to 950 pounds were discounted $13.00 per hundred weight. Dressing percentage ranged from 55.7 to 71.8% and averaged 65.5% for the two combined kill groups.

Over 44% of the cattle had between a 13.0 and 14.9 square inch ribeye area (REA) when measured at the 12th rib. Ribeye area was distributed (Figure 4) between 9.0 and 21.5 square inches with an average of 13.5 square inches. In a similar distribution, the amount of external fat when measured at the 12th rib was centered between .30 and .59 inches of fat (58%) (Figure 5). The thinnest carcass measured .10 inch of fat while the fattest was carrying 1.15 inches of fat over the 12th rib. The average fat thickness for the group was .48 inches.

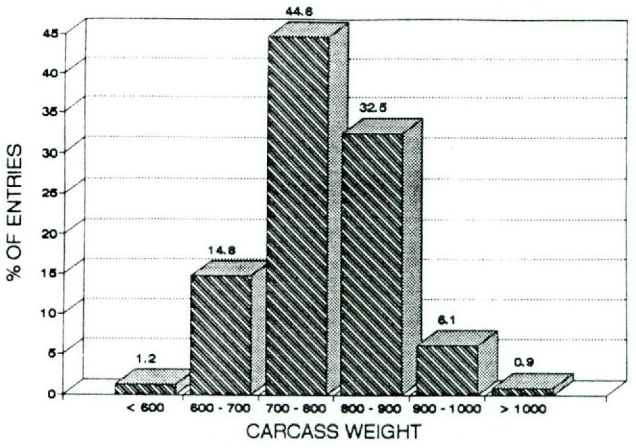

Figure 3. Distribution of carcass weight.

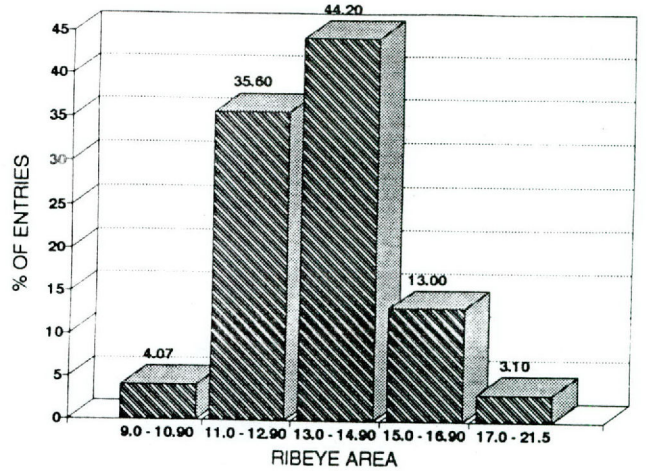

Figure 4. Distribution of ribeye area.

Over 31% of the carcasses graded Choice with 62.8% and 5.4% grading Select and Standard, respectively (Figure 6). Over-all, the carcasses had exceptional yield grades with 60.9% of the carcasses Yield Grading 1 or 2 (Figure 7). Only 8.3% of the carcasses were discounted for being Yield Grade 4 or 5.

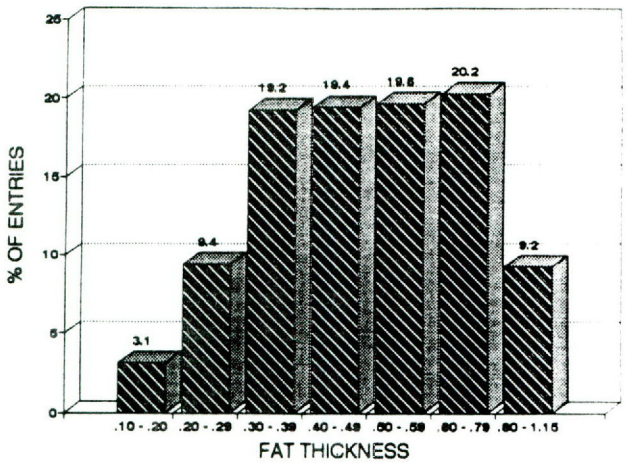

Figure 5. Distribution of fat thickness.

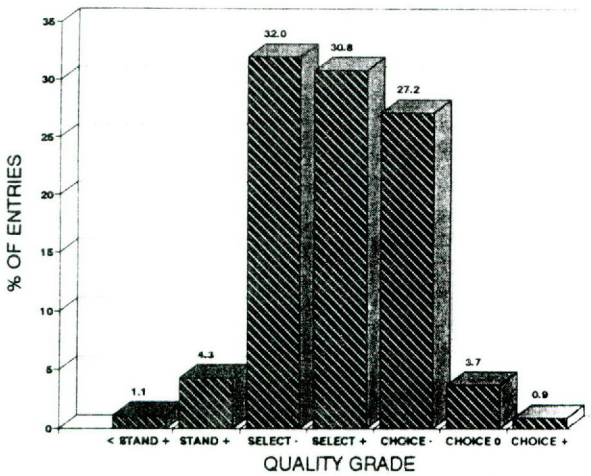

Figure 6. Distribution of quality grade.

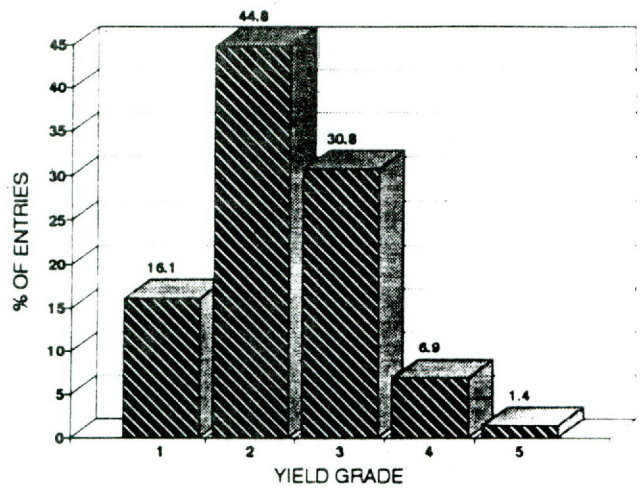

Figure 7. Distribution of yield grade.

The prices received for both kill groups were very similar and the average carcass price by quality grade for each yield grade is reflected in Table 1. Yield Grade 3 carcasses grading Choice and weighing between 550 and 950 pounds served as the basis for the price determination. Yield Grade 1 and 2 carcasses received a $1.50 per hundred weight premium while Yield Grade 4's and 5's were discounted $11.75 and $16.50 per hundred weight, respectively. Select carcasses were discounted $8.50 per hundred weight less than Choice while Standards were worth $24.00 less per hundred weight.

TABLE 1. AVERAGE CARCASS PRICES PER HUNDRED WEIGHT.[a]

Quality Grade	Yield Grade	Price
Choice	1 and 2	$123.50
Choice	3	122.00
Choice	4	110.25
Choice	5	105.50
Select	1 and 2	115.50
Select	3	113.50
Select	4	101.75
Standard		98.00

[a] Carcasses weighing under 550 and over 950 pounds were discounted $13.00.

Cost Analysis

Figure 8 illustrates the main expenses incurred during the feeding period. Excluding the cost of the cattle, feed cost amounted to 83.5% of the total production expenses while medicine costs were secondary in total cost and accounted for 9.2% of the expenses. Medicine costs averaged $19.11, excluding the standard mass medication treatment each animal received upon arrival at the feedyard. The cost of medication per ranch entry ranged from $0.00 to $72.39 per head (Figure 9). These figures dramatically illustrate the importance of feed efficiency and health status on the production cost of cattle in the feedyard. Deficiencies in these areas, undoubtedly, have direct effects on the profitability of the cattle.

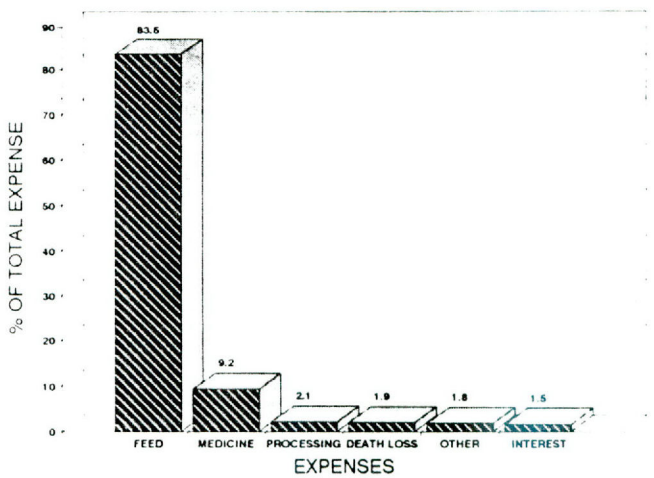

Figure 8. Production expenses.

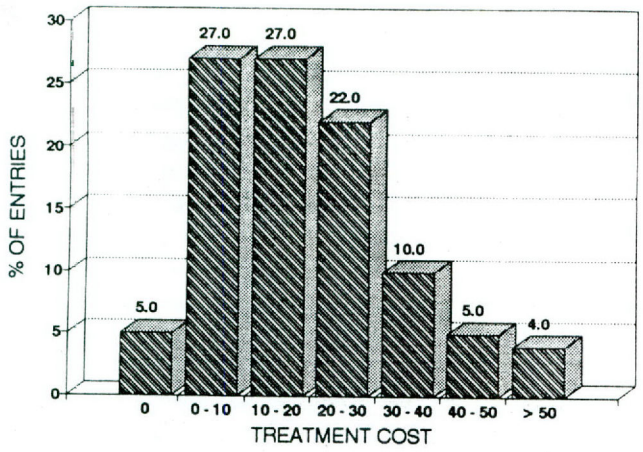

Figure 9. Distribution of treatment cost post-mass medication.

Table 2 (Ranch A) depicts a scenario in which specific cattle got sick, responded to medical treatment, recovered, gained well and produced acceptable carcasses. However, the expense incurred for the medical treatment detracted from the over-all profits of the cattle. Several of the cattle listed in Table 2 made money but could have made 4.5 times as much if they had not incurred such large medicine costs.

TABLE 2. THE IMPACT MEDICINE COST HAS ON NET PROFIT.

Tag No.	ADG	F/G	QG	YG	Other Medicine Cost	Net Profit
Ranch A						
176	2.98	7.92	Ch-	2	$76.47	$50.17
178	3.33	6.58	Sel+	3	75.07	58.54
177	2.32	10.26	Ch-	3	76.47	-30.97
166	2.63	8.72	Ch-	3	75.15	-9.33
168	3.13	7.72	Sel-	2	58.80	33.12
Avg	2.87	8.09	Sel+	2.6	72.39	20.19
Ranch B						
504	2.01	11.72	Sel-	1	76.66	-88.87
492	2.99	8.41	Ch-	1		208.40
466	1.87	13.18	Sel-	1	29.91	-19.71
526	2.29	10.73	Sel-	1	33.59	-16.68
*472	2.52	9.56	Sel+	1	58.80	-195.71
508	2.27	10.82	Sel	1	31.02	15.30
Avg	2.33	10.51	Sel	1	38.33	-16.21

* Blood splash

Cattle that get sick not only incur more expense, but they also generally lag behind their pen mates with respect to gain, efficiency, and quality grade. A good example of this is illustrated in Table 2 (Ranch B). Steer 492 was the only animal in this group that did not require hospital treatment or medicine costs. This steer gained faster, was more efficient, had a higher quality grade and made over $200.00. However on the other end of the spectrum, steer 472 lost almost as much ($192.71). Yet, the total loss can not be solely attributed to poor performance. The carcass was discounted to $89.00 per hundred weight due to "blood splash" in the lean which is caused by the rupturing of capillaries due to high blood pressure or by violent muscle contractions upon slaughter. This phenomenon generally occurs in "wilder", more excitable type cattle.

Profit/Loss

The cattle performed reasonably well resulting in an average profit of $92.42. Most producers that did not realize a profit could attribute their loss to death of an animal, which had to be absorbed by the relatively small number of head remaining for that individual owner. As seen in Table 3, disregarding initial value, feed cost was the primary expense as would be expected in such a venture. There was a wide range in net profit per head marketed. The most profitable ranch entry had a net profit of $186.39 per head, while the other end of the spectrum saw a net loss of -$108.42 per head. Figure 10 illustrates the distribution of profit/loss per head. While many factors affected the profitability of the cattle, the major contributors were medicine cost, rate of gain, feed efficiency, and sale value, as influenced by quality and yield grades.

Although the primary objective in this program was to identify those practices and systems that yielded the most acceptable end-product, one must not forget that beef production is a business. Therefore, profit and losses must be considered for each aspect of beef production in order to

TABLE 3. BUDGET PER STEER SOLD.

Income	$903.89
Expenses	
Initial Value	$493.98
Processing	6.80
Mass Medication	10.15
Other Medication	19.11
Feed	265.20
Death Loss	6.01
Other (TCFA, Check Off, Insurance, Freight)	5.61
Interest	4.61
	$811.47
Net	$92.42

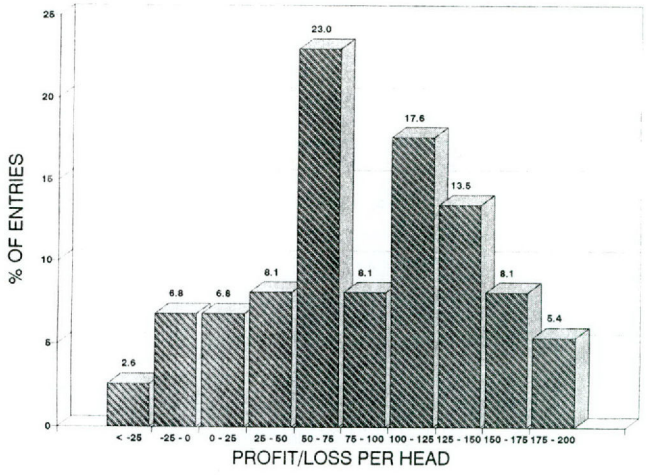

Figure 10. Distribution of profit/loss.

correct inefficiencies that decrease total return on investment. The average total expense per steer was $811.47. A profit of $25.00 from the feedyard phase of production would be an annualized return of 5.7%. Using this figure as a minimal level of financial productivity, coupled with Table 4, which shows some arbitrary established standards which cattle should meet in order to fit the needs of the total industry, one can determine what corrective measures need to be taken to produce cattle that will be acceptable. While 68.3% of the total 666 individual steers that were included in this program met these standards, there were 209 that fell short in at least one category. Table 5 identifies the reasons the animals did not measure up to the performance standards that were prescribed for acceptability. Some of these deficiencies can be corrected with only minor managerial adjustments. As previously mentioned, an effective health program at the ranch level can greatly reduce sickness and associated cost, while promoting enhanced performance, therefore resulting in increased profits. Other deficiencies may only be modified through genetics, such as changing biological types. The top 10% of the ranch entries, based on net return per head, were compared with the bottom 10% of the entries (Table 6). Even though these two groups were similar in terms of beginning weights and values per pound, the more profitable group excelled in rate of gain, cost of gain, health status, quality grade, and sale value. This indicates that even though animals appear similar in the beginning, more information about the animals is needed to identify those which are going to be more profitable.

TABLE 4. MINIMAL STANDARDS.[a]

Profit	$25.00/Head
Average Daily Gain	2.25
Feed/Gain	10.5
Quality Grade	Select-
Yield Grade	3.0
Carcass Weight	550 - 950 lbs.

[a] Plus not die or have to be sold prematurely due to poor performance (railed).

TABLE 5. REASON(S) ANIMALS DID NOT FIT THE INDUSTRY.

Reason(s)	Head	Percentage
Profit	76	11.4
Gain; Feed Efficiency; Profit	37	5.6
Yield Grade	21	3.2
Quality Grade	20	3.0
Carcass Weight	11	1.7
Yield Grade; Profit	10	1.5
Died	8	1.2
Gain; Feed Efficiency	7	1.1
Gain; Feed Efficiency; Quality Grade	7	1.1
Railed	3	.5
Feed Efficiency	2	.3
Feed Efficiency; Profit	2	.3
Gain; Profit	2	.3
Quality Grade; Profit	2	.3
Quality Grade; Weight	1	.2
	209	31.7

TABLE 6. COMPARISON OF TOP 10% AND BOTTOM 10% OF ENTRIES BASED ON NET RETURN PER HEAD.

	Top 10	Bottom 10%
In Weight	565	565
In Value/cwt	$81.45	$82.92
Out Weight	1,220.00	1,050.00
Out Weight/cwt	$77.14	$75.00
Average Daily Gain	3.37	2.43
Cost of Gain/cwt	$40.71	$67.15
Breakeven/cwt	$59.57	$75.67
Net/Head	$173.53	-$7.03
Hospital Days/Head	3.6	9.1
Medicine Cost/Head	$15.79	$30.14
Quality Grade		
% Choice	40%	12%
% Select	57%	75%
% Standard	3%	13%

Acknowledgments

Special thanks is extended to the Meat Science Section graduate students for their assistance in carcass evaluation. All Extension Livestock Specialists are commended for promoting this program and helping coordinate arrangements.

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