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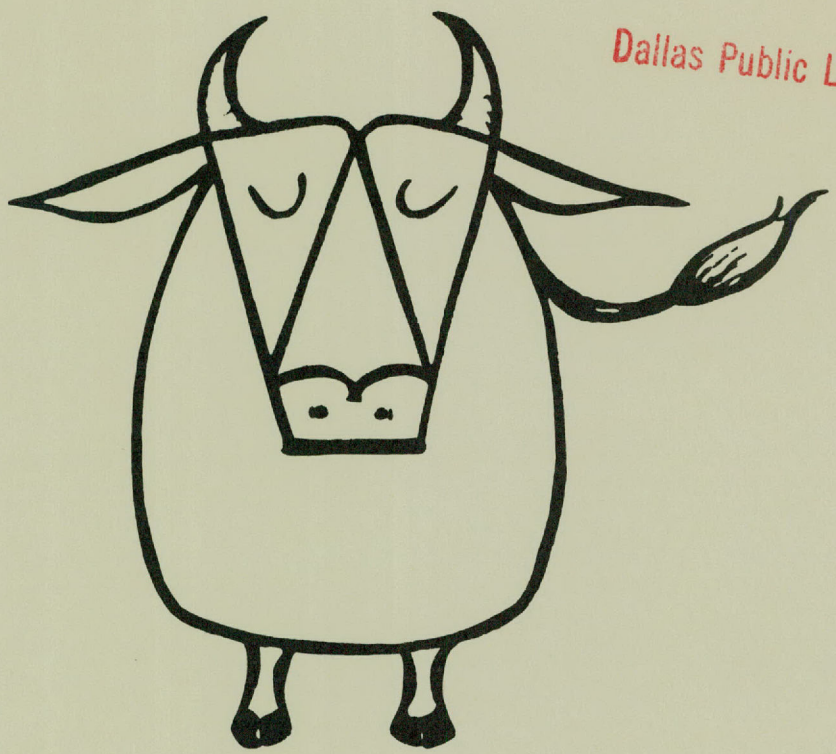
Beef Cattle Research in Texas, 1986



The Texas Agricultural Experiment Station
Neville P. Clarke, Director, College Station, Texas
The Texas A&M University System

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Metric Units — English Equivalents

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

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Foreword

On January 1, 1986, Texas beef herds totaled 13.6 million cows and calves, or 12.9 percent of the U.S. total. Beef cows in Texas numbered 5.2 million head, 15.4 percent of the U.S. beef cow population. Texas feedlots accounted for 11.1 percent of U.S. fed cattle marketings during 1985, and Texas produced 15.0 percent of the beef slaughtered in the U.S. during 1985. Beef cattle are the single most important contributor to agricultural cash receipts in Texas. Cash paid for beef cattle in 1985 totaled $4.5 billion, or 47.9% of Texas' $9.4 billion in agricultural cash receipts. The Texas beef cattle industry is land-based and provides an effective means of harvesting range and pasture resources, while using harvested roughage, by-product feeds, and feed grains.

The beef cattle research program of the Texas Agricultural Experiment Station focuses on biological, physical, and economic phenomena to provide the technology needed to enhance beef cattle production, processing, and distribution. The TAES beef cattle research program emphasizes integration of science, technology, and economics to improve the profitability of beef cattle enterprises. In addition, the TAES beef cattle research program is oriented toward developing new science and technology to improve the utilization of resources for efficient production of palatable, lean, and highly nutritious beef. TAES beef cattle research can be viewed as a balanced continuum extending from "basic" to "applied." Specific priority areas include growth and reproductive efficiency, production and management systems, marketing options, disease and parasite control, and beef in human nutrition.

The 1986-1990 Five-Year Plan for the Texas Agricultural Experiment Station includes the following prioritized statements of need:

1. Develop efficient production/marketing strategies to produce economically marketable beef.
2. Evaluate the potential of molecular and conventional genetics to improve beef production.
3. Develop systems to reduce fatness of beef without reducing quality.
4. Improve reproductive efficiency in beef herds.
5. Enhance growth efficiency in beef cattle.
6. Assess the role of beef in the diet and assess consumer concerns for nutrition, quality, and safety of foods.
7. Develop efficient and accurate price-reporting and price-discovery systems for the beef industry.
8. Diagnose and prevent infectious and noninfectious diseases of beef cattle.
9. Assess, integrate, and utilize biological technology in beef-production systems.
10. Improve feedstuff utilization and supply.
11. Develop integrated pest-management strategies to control cattle parasites.

The beef industry currently faces increasing costs of production and increasing competition. To compete in the marketplace, the beef industry must become more efficient. The Texas Agricultural Experiment Station has targeted its research to increase production efficiency and to improve product utilization. Research goals include development of improved feeding practices and enhancement of nutritive value of forages and feeds; basic research is being conducted to determine how forage and feed are converted to muscle and fat, how muscle and fat are deposited during the growth and development processes, and how the ratio of that deposition relates to consumer acceptance.

Other TAES scientists are investigating the reproductive process to determine causes of infertility in bulls and cows and how to detect and correct these causes to increase reproductive efficiency. Breeding and genetics research focuses on use of conventional and molecular means for using heredity to improve productivity of beef cattle. 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. Management studies are directed toward development of computerized decision aids and development of ways to improve prices for feeder cattle. Slaughtering, processing, preserving, packaging, and marketing of cattle and beef are also being studied. Finally, the product is being examined for ways to increase nutrition, wholesomeness, and palatability for consumers.

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

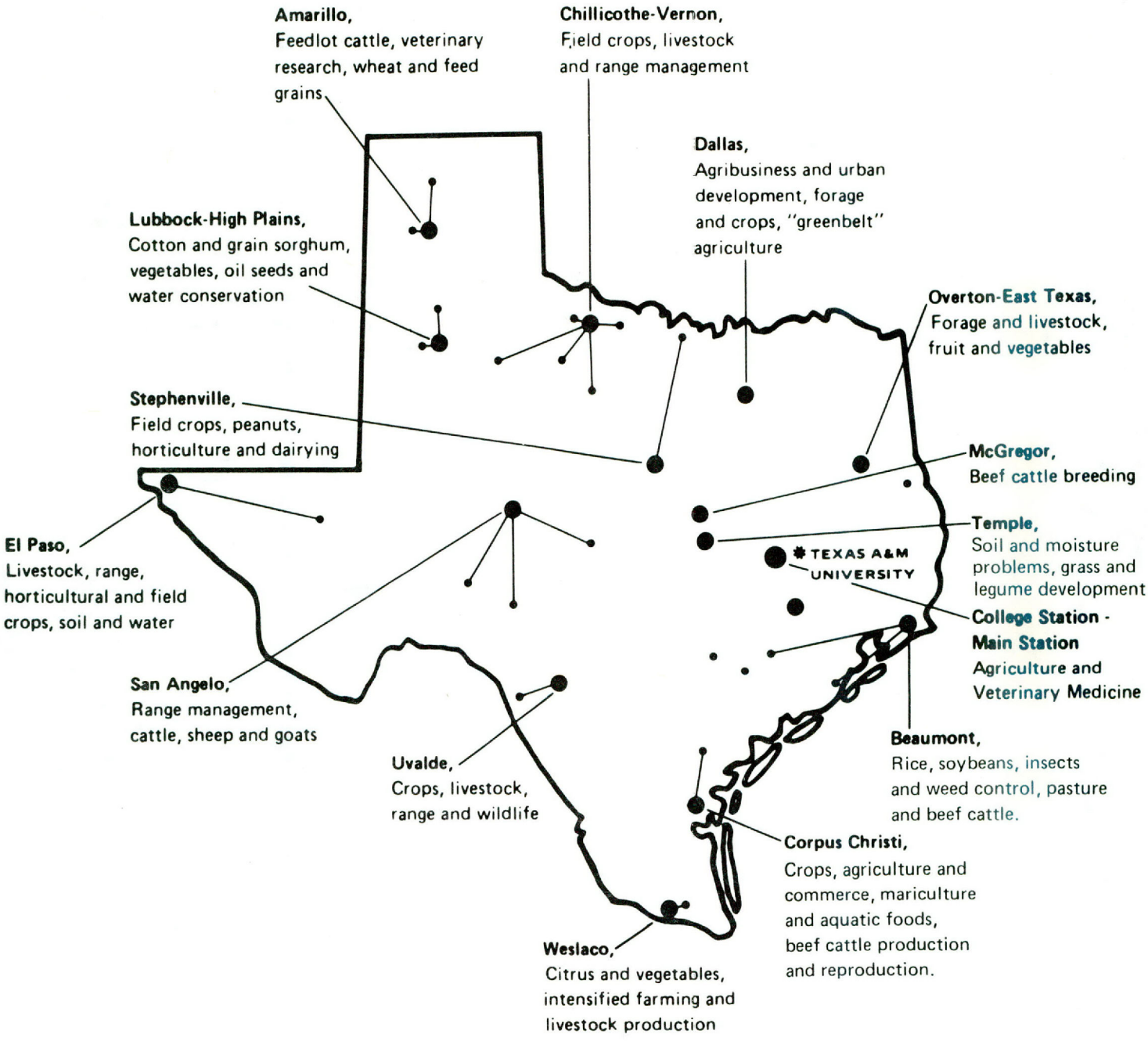
Neville P. Clarke, Director

Preface

Texas has an approximate land area of 168.4 million acres (254 counties), or about 263,000 mi^2, 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 Trans-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 corp 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. The research is conducted at 15 locations. Because broadly different problems are brought about by the wide variations in soil, climate, elevation, and other environmental and economic conditions in the 16 land resource areas, research centers and stations are located in major agricultural areas to serve them. Work at these locations is complemented by that of a staff of scientists working in the laboratories of Texas A&M University at College Station. The work encompasses basic, adaptive, and applied research, ranging from biochemical, genetic, and physiological processes at the cellular level through breeding, nutrition, and meats to feeding and management under practical production conditions. The multidisciplinary nature of this research is obvious.

THE TEXAS A&M UNIVERSITY SYSTEM
RESEARCH AND EXTENSION CENTERS



Beef Cattle Research in Texas, 1986

Reproduction

PR-4461

Effects of New Spaying Techniques and Implanting of Heifers

D.K. Lunt, T.H. Welsh, Jr., G.P. Rupp, R.W. Field, H.R. Cross, H.A. Recio, and G.C. Smith

Pregnant heifers in feedlots cause costly reductions in profitability through prolapsed uteri, retained placentas, hemorrhaging, reduced dressing percentage, and increased incidence of torn visceras at the time of slaughter. One method of avoiding these losses is the practice of injecting heifers with abortion-inducing drugs. These drugs are not 100 percent effective, however—especially in the later stages of gestation. Possible side effects and post-abortion complications also influence the decision to use these drugs.

Another approach to this problem is spaying of heifers. Because the ovaries are removed, the heifers will neither continue a pregnancy nor become pregnant while grazing or while in feedlots. New techniques for spaying—vaginal spaying and autografting—have recently been developed and are growing in popularity. A study was conducted to evaluate these new techniques and to assess their relative merits.

Sixty crossbred heifers were divided by breed type, frame size, and weight into four treatments: (a) vaginal spay plus implant with Synovex H®, (b) autograft plus implant, (c) autograft without implant, and (d) ovaries left intact plus implant. Vaginal spaying was performed by a veterinarian using a Kimberling-Rupo spaying instrument. Autografts were performed by removing the ovaries through an incision in the flank and then inserting a small slice of one ovary underneath the lining (serosa) of the rumen. The heifers were fed a finishing diet until they weighed approximately 432 kg (950 lb).

Autografted, spayed, and intact heifers that had been implanted gained faster than the autografted heifers that had not been implanted. Feed efficiency tended to favor the autografted-implanted and spayed-implanted heifers over the intact-implanted and autografted-only heifers. Because the nonimplanted autografted heifers did not have the effects of testosterone from the implants that the other heifers had and because the grafts may have produced estrogen, they had higher quality grades than did the spayed-implanted heifers. Heifers from all four treatments had similar lean color, texture, and firmness ratings. The autografted heifers that were not implanted had higher (less desirable) USDA yield grades. These data indicate that feedlot heifers may be spayed or autografted without sacrificing performance if they are im-

planted. With all the advantages of spaying, such as the unrestricted movement of cattle across state lines, a guarantee that heifers are open, the avoidance of losses associated with pregnant feeder cattle, and the ease of management, this seems to be a sound management tool that may be used to make feeding and handling feedlot heifers more profitable. However, this study does not support claims that autografting results in increased feedlot performance in heifers above that observed in heifers spayed via other techniques or in heifers that are not spayed.

PR-4462

Changes in Brain Chemistry Associated with Alterations in Reproductive Status in Calves

M.S. Amoss, Jr., L.A. Rund, and D.C. DeLuca

During the past two decades, investigations into the control of reproductive phenomena have moved from the steroid hormones of the gonads to the gonadotrophins (LH and FSH) of the pituitary gland to the releasing hormones of the hypothalamus to the neurotransmitters of the brain that activate the neurons that synthesize the peptides of the hypothalamus. Many neurotransmitters have been identified in the central nervous system (CNS), but the best known are dopamine and norepinephrine, which are catecholamines, and serotonin, an indolamine. The release of LH is regulated by the hypothalamic peptide gonadotrophin-releasing hormone (GnRH). Control of the release of GnRH appears to be a result of the activities of the neurotransmitters listed above. Changes in neural activity are associated with the differential release of the various neurotransmitters. This is ultimately reflected in changes in the pattern of LH release.

In earlier reports, our laboratory provided evidence of exogenously administered serotonin decreasing the frequency of the release of LH. The current report provides data concerning the concentration of the neurotransmitters and their various metabolites in cerebrospinal fluid (CSF) following castration of young bull calves. We thought that serum levels of LH would increase following castration and that if neurotransmitters are involved in the regulation of LH release, changes in the CSF concentration of specific neurotransmitters could be expected. We assumed that the concentration of neurotransmitters in the CSF would more closely mimic the metabolic activity of the brain than that of blood because the brain is bathed by CSF. A serious caveat to this approach is that total brain activity is represented in CSF and not just that involved in the release of LH.

Each of four 150-kg bull calves were implanted with a permanent indwelling third ventricular cannula from which CSF samples could be taken with no discomfort to the animal. Both blood and CSF samples were collected every 10 min for 4 hr on the day before castration (which served as the control) and at days 2, 4, 6, 13, 20, and 27 post-castration. The serum LH concentration was analyzed by radioimmunoassay (RIA), and the CSF biogenic amine levels by high-pressure liquid chromatography (HPLC) coupled to an electrochemical detector.

The mean serum LH concentration increased fivefold by day 6, as expected. This increase was due primarily to the change in pulse frequency, which increased to an average of six pulses per 4 hr from less than one pulse during the same time span before castration.

Although the HPLC technique developed was sufficiently discriminatory to detect nine biogenic amines, only a metabolite of serotonin, 5-hydroxyindole acetic acid (5-HIAA), and a metabolite of dopamine, homovanillic acid (HVA), were quantifiable. The mean 5-HIAA levels over a 4-hr period ranged from 80.28 ng/ml to 242.66 ng/ml, and the HVA levels ranged from 63.38 ng/ml to 550.61 ng/ml. The variation of both of these amines was unusually high within and between animals. Although the mean levels of 5-HIAA and HVA changed between days, neither a consistent pattern to the variation nor a significant correlation to the increase in mean LH concentration or to the increase in LH pulse frequency was observed.

The increase in LH pulse frequency associated with the post-castration rise in LH has been attributed to an increase in the activity of a putative hypothalamic pulse generator. This increase in activity should have resulted in an alteration in the synthesis, release, and/or metabolism of the biogenic amines. The sensitivity and specificity of the HPLC technique should have been adequate to detect any changes had they occurred. One explanation for the lack of any consistent pattern or correlation with the increased LH release may be that the background of neural activity may be so great that the changes resulting from hormone release were undetectable. Various stresses, including changes in temperature, handlers, noises, etc., may produce a variety of changes that are ultimately observed as changes in CSF biogenic amine levels. It may be necessary to construct environmentally controlled isolation chambers in which to perform these types of experiments if we are to determine the relationships between the brain and the endocrine system. (Supported by USDA Grant No. 82-CRSR-2-1043.)

PR-4463

Electron Microscopic Analysis of Mid-Cycle Bovine Luteal Cells

J.G. Betts, D.W. Forrest, T. Caceci, and G.L. Williams

Summary

Healthy corpora lutea (CL) were removed from four cows on day 11 of the estrous cycle. Portions of each CL were prepared for electron microscopy. Sixteen cells were photographed and analyzed by microcomputer. Cellular and nuclear diameters and estimated volumes were determined as well as number of lipid droplets observed in the plane of the section. Nuclear diameter and estimated volume were related to cellular diameter and nuclear volume. The number of lipid droplets observed was not related to cell size.

Introduction

Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) and its analogs are widely used in the beef cattle industry to synchronize estrus and, thereby, facilitate artificial insemination. These products induce premature regression of the corpus luteum (CL) when administered during the mid-luteal phase of the estrous cycle. The mechanism and site of action, however, remain to be elucidated. One requirement for elucidating the mechanism whereby $PGF_{2\alpha}$ induces regression is to have a better understanding of the ultrastructural features of the healthy luteal cell. This would necessarily be followed by ultrastructural studies of bovine luteal cells during the time immediately following $PGF_{2\alpha}$ injection.

The density of luteal cells has been reported to increase following $PGF_{2\alpha}$ analog injection (1). This suggests that luteal cells may decrease in size during regression. Studies documenting cell and organelle size in healthy and regressing CL are crucial in elucidating the mechanism of regression. The objective of this study, therefore, was to characterize the ultrastructure of individual healthy luteal cells on day 11 of the 21-day estrous cycle. Characteristics measured included cell diameter, estimated cell volume, nuclear volume, and number of lipid droplets in the plane of section.

Experimental Procedures

Four lactating, multiparous Brahman-cross cows were synchronized with Syncro-Mate B®. Eleven days after observed estrus, the ovary bearing the CL was excised per vagina. The CL was excised from the ovary, and a section was diced into pieces of less than 1 mm^3. These pieces were fixed overnight at room temperature in 2.5 percent glutaraldehyde prepared in 0.1 M cacodylate buffer followed by post-fixation in 2 percent OsO_4 for 2 hr. Pieces were mounted in Epon-Araldite, and gold to silver sections were cut on a Sorval MT-2B ultramicrotome. Sections were picked up on bare 300-mesh copper grids and stained for 3 and 10 min in uranyl acetate and lead citrate, respectively. Photomicrographs of 16 randomly selected cells (two to six cells per animal) were taken on a Zeiss EM-10 CAS electron microscope at 40 kv. Final prints were made at 3,000—15,000 X for analysis. Prints were analyzed on a Zeiss Videoplan Image Analysis System. A print of an individual luteal cell was placed on a magnetic digitizer tablet connected to a microcomputer. A digitizer pen was then used to trace the outline of the cell and its intracellular organelles. Digital data produced was converted by themicrocomputer into estimates of cell and organelle sizes.

Results and Discussion

Nuclear diameter increased with increasing cell diameter ($r = 0.78$; $P < .01$). The number of lipid droplets observed in the plane of the section was not related to the diameter of the cell ($P > .1$). Cell nuclei composed 12.8 ± 1.56 percent, and lipid droplets composed 4.21 ± 1.08 percent of the cell area observed in all cells.

Two size classifications of luteal cells have been identified in the cow and sheep. In the sheep, small cells of thecal origin were described as being less than 22 μm in diameter, and large cells of granulosal origin were described as being greater than 22 μm in diameter (2). In the present study, 11 of the 16 cells were classified as large. These cells had greater diameters and estimated volumes than did small cells (Table 1). Large cell nuclei were also larger than small cell nuclei. However, the nuclear to cytoplasmic ratio was greater in small cells. The number of lipid droplets seen in the area of section was not greater in large than small cells. In conclusion, in healthy luteal cells not treated with $PGF_{2\alpha}$, the number of lipid droplets does not relate to cell size, and nuclear size increases with cell size but may not increase proportionately with cell size.

TABLE 1. SIZES OF LARGE AND SMALL CELLS AND NUCLEI

Item	Cell Class	
	Large	Small
Cell diameter (micrometers)	35.4±2.9	17.5±1.1**
Cell volume (picoliters)	28.1±7.2	2.9±0.5*
Nuclear diameter (micrometers)	10.8±0.7	7.3±0.7**
Nuclear volume (picoliters)	0.74±0.12	0.22±0.49*
Lipid droplets (number)	60.4±16.8	11.4±1.8
Ratio of nuclear to cytoplasmic percentages	3.69±0.83	7.76±1.66*

*Means in the same row differ ($P< .05$).
**Means in the same row differ ($P< .01$).

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PR-4464

The Role of Calcium and Sodium in the Action of Gonadotropin-Releasing Hormone in Calf Pituitary Cells

J. P. Kile and M. S. Amoss, Jr.

Introduction

The need for a basic understanding of how GnRH works at the cellular level is important for the future synthesis of longer acting and more potent synthetic hormones to be used in reproduction and to understand how other agents may affect the action of hormones such as GnRH. Calcium (Ca^{++}) has been found to be an absolute requirement for the proper functioning of any cell, and this is particularly true for hormone-responsive cells (2). Therapeutic drugs, such as the growth promoter monesin and the antibiotic miconazole, exert their effects by acting either to increase intracellular levels of both Na^{+} and Ca^{++} or possibly to interfere with the actions of intracellular proteins (3). Many antispasmodic and antiarrhythmic drugs block the entry of Ca^{++} into muscle cells (1). Therefore, it is important to know how a particular drug may be altering the actions of GnRH and other hormones.

Although it is known that Ca^{++} is required for GnRH-induced luteinizing hormone (LH) secretion from both rat and bovine pituitary cells, little work has been done to study the role of calcium in the release of LH from bovine pituitary cells. Therefore, a study was done to compare the effects of agents that alter sodium (Na^{+}) and Ca^{++} entry into cells on LH release from cultured calf anterior pituitary cells. Experiments were also performed to determine if the intracellular Ca^{++}-binding protein calmodulin is involved in GnRH-induced LH release. Drugs that act as calmodulin antagonists were tested in the presence and absence of GnRH.

Materials and Methods

Dependency of GnRH-Induced LH Release on Extracellular Calcium

To determine if GnRH-induced LH release from bovine anterior pituitary cells is Ca^{++} dependent, Ca^{++} was removed from primary cell culture ($3x10^5$ cells/container) by washing them vigorously with Ca-free salt solution. Following the washings, the cells then were treated with 1-ml salt solution at the desired Ca^{++} concentration with or without 100 ng/ml GnRH and incubated for 6 hr at 37°C.

Effects of Ion Channel Blocking Agents and Calmodulin Antagonists on Luteinizing Hormone Release

Cells were pretreated for 15 to 30 min with either Ca^{++} channel blockers (verapamil, nifedipine, or cobalt) or the Na^{+} channel blocker tetrodotoxin to block plasma membrane calcium or sodium channels. Cells were then challenged with or without GnRH 100 ng/ml to determine if blocking calcium or sodium channels would reduce basal and/or GnRH-induced LH secretion.

In a separate experiment, cells were pretreated with three different calmodulin antagonists, 1 ml HBSS/HEPES for 15 to 30 min and then challenged with GnRH (100 ng/ml) to determine if inhibiting calmodulin activity would also interfere with the ability of GnRH to release LH.

Results

Dependency of GnRH-Induced LH Release on Extracellular Ca^{++}

The calf pituitary cells used in this study were found to release LH in response to GnRH in a linear fashion between 25 and 250 ng/ml, a maximal response occurring at 250 ng/ml GnRH ($P < 0.01$). The GnRH-stimulated LH release was found to be calcium dependent. Cells vigorously washed to reduce intracellular calcium and incubated in "Ca^{++}-free" medium gave little response to GnRH (100 ng/ml). As little as 16 μM Ca^{++} in the medium permitted a threefold increase in LH release; normal Ca^{++} concentration in blood plasma is 1000 times this amount. Furthermore, increasing the amount of calcium (using ionophore A23187) or sodium (using ouabain) in the pituitary cells produced dramatic increases in LH release (see Figure 1).

On the other hand, if calcium in the medium was prevented by Ca^{++} channel blocking drugs from entering the cells, both nifedipine and verapamil as well as cobalt caused linear reductions in GnRH-induced LH release (Figures 2 and 3). A similar inhibition of LH secretion was produced by tetrodotoxin (TTX), which blocks Na channels (Figure 4).

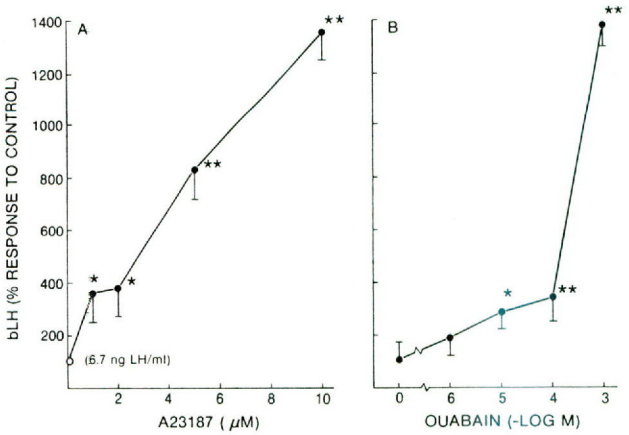

Figure 1. Effect of Ca^{++} ionophore A23187 (panel A) and Na^{+}/K^{+} ATPase inactivator ouabain (panel B) on LH release from calf anterior pituitary cells. Values represent mean ± S.E. ($n = 12$) of four trials and reflect LH as a percentage of the response to HBSS/HEPES control.

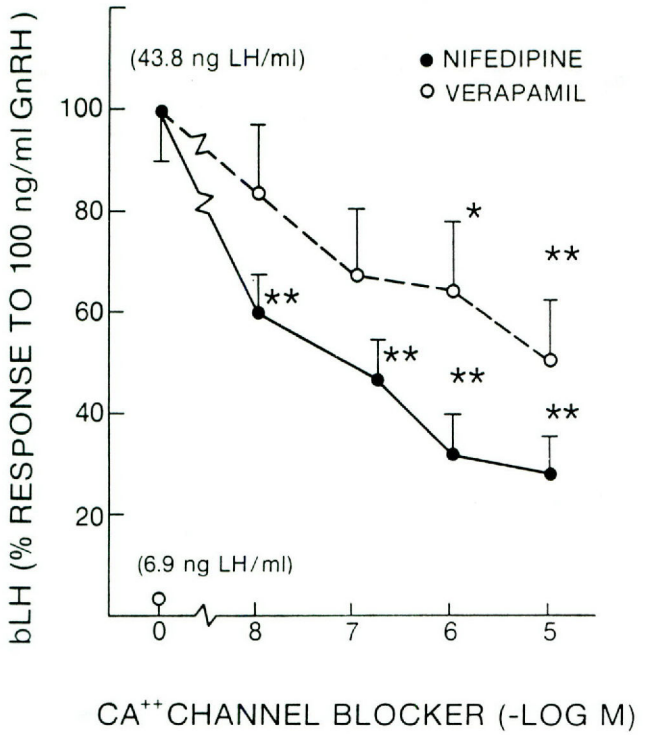

Figure 2. Inhibition of GnRH-stimulated LH release by Ca^{++} channel blockers nifedipine (closed circles) or verapamil (open circles). Cells were preincubated 15 min in the Ca^{++} blocker before stimulation with GnRH (100 ng/ml). Values represent mean ± S.E. for three trials (n = 9) and reflect LH values as percentage of the reponse to GnRH.

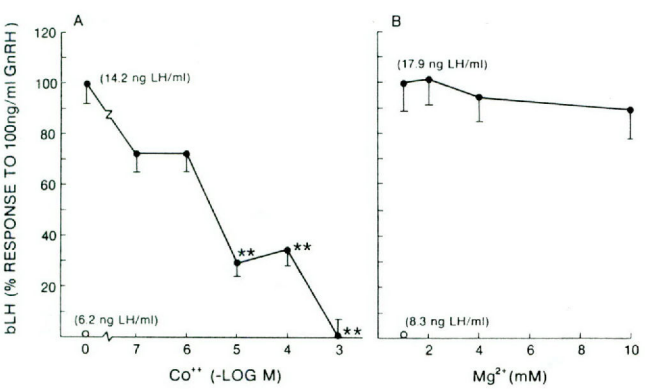

Figure 3. Inhibition of GnRH-stimulated LH release by divalent cations Co^{++} (panel A) or Mg^{++} (panel B). Cells were preincubated 15 min before stimulation with GnRH (100 ng/ml). Values represent mean ± S.E. for four trials (n = 12) and reflect LH as a percentage of the response to GnRH.

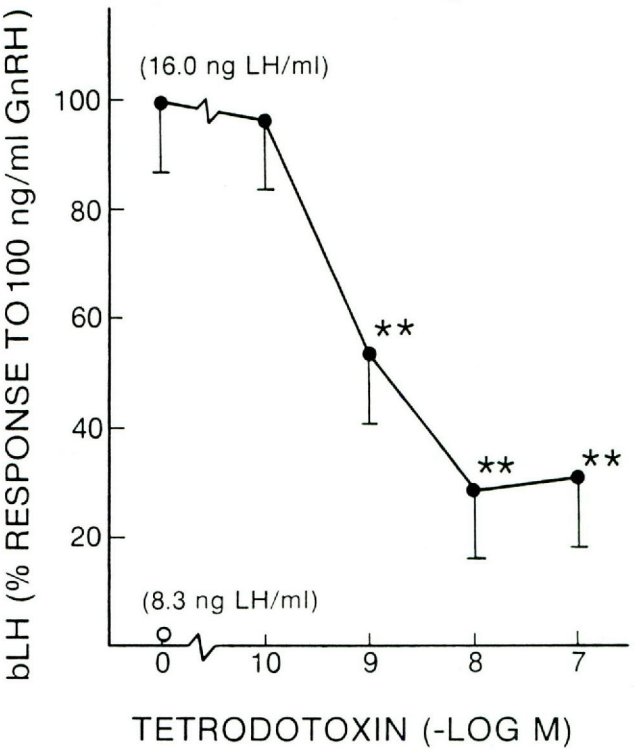

Figure 4. Inhibition of GnRH-stimulated LH release by Na^{+} channel blocker tetrodotoxin. Values represent mean ± S.E. (n = 9) of three trials.

Inhibition of GnRH-Induced LH Release by Most Calmodulin Antagonists

Pretreatment of the pituitary cells with either calmidazolium (CMZ) or W7 significantly reduced GnRH-induced LH release. IC_{50} (dose at which GnRH-induced LH release was inhibited to 50 percent) determinations from four separate experiments yielded values of 1.1 to 4.3 nM, which when combined gave an average IC_{50} for CMZ of 2.0 nM. The naphthalenesulfonamide, W7, also significantly reduced LH release with IC_{50} values from two separate experiments ranging from 0.93 to 3.17 μM and yielding an average IC_{50} for W7 of 2.3 μM. Surprisingly, though, another calmodulin inhibitor, trifluoperazine, had absolutely no effect on either basal or GnRH-induced LH release.

Discussion

These data show that GnRH-induced LH release from calf pituitary cells is indeed a Ca^{++}-dependent process. Preventing calcium from entering the calf pituitary cells was shown to reduce GnRH-stimulated LH release, while agents that increased Ca^{++} entry into the pituitary cells were found to stimulate LH release. Finally, the results of this study suggest that activation of calmodulin (CM) by Ca^{++} may be one mechanism by which GnRH stimulates LH release in cattle. Two structurally unre-

lated CM antagonists, calmidazolium and W7, were potent inhibitors of GnRH-induced LH secretion. The results also demonstrate a lack of effect by trifluoperazine on LH release, suggesting that trifluoperazine may have completely different sites of action than do CMZ and W7 in calf pituitary cells.

The data, however, underscore two apparent differences between the pituitary gonadotroph cell in rats and cattle: (1) The release of LH from the bovine pituitary relies on the influx of both Na^+ and Ca^{++} into the gonadotroph, whereas the rat gonadotroph depends mostly on Ca^{++}. (2) Phenothiazines such as trifluoperazine have little effect on LH release in cattle, in contrast to other calmodulin antagonists (calmidazolium, a miconazole derivative, and W7, a napthalene sulfonamide) that inhibit GnRH-stimulated LH release. These facts may be important when making decisions regarding appropriate drug therapy for ailing cattle, particularly with respect to ionophore antibiotics (Monensin, Ionomycin) or miconazole-containing derivatives. (Supported by USDA Grant No. 82-CRSR-2-1043, Organized Research Reserve 5-83.)

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PR-4465

Biological Activity of Luteinizing Hormone in Postnatal Heifers

T. A. Norris, G. D. Weesner, W. J. Anderson, P. G. Harms, and D. W. Forrest

The total number of calves produced during the reproductive lifespan of a cow is directly affected by the age at which puberty is attained. Techniques to maximize the reproductive lifespan would clearly benefit the livestock producer's profit. To develop methods by which the onset of puberty can be successfully regulated, a thorough understanding of the endocrine mechanisms involved is required.

Numerous investigators have examined the pattern of luteinizing hormone (LH) secretion in prepubertal heifers. In the cycling female, a surge of LH, which initiates ovulation, is released from the pituitary gland. The release of LH is regulated through a feedback mechanism of steroids and possibly other factors produced by the ovaries. It is thought that, at the time of puberty, ovarian feedback on the pituitary is altered. The studies conducted to determine the levels of LH during sexual maturation have utilized radioimmunoassay techniques. While radioimmunoassay provides quantitative information on LH, it does not indicate the biological potency of the hormone. Therefore, the purpose of this study was to determine the biological activity of LH in Holstein heifers that were ovariectomized at 3, 6, and 9 weeks of age. Blood samples were collected through jugular cannulae 1 week before (pre) and 4 weeks after (post) ovariectomy. Blood was collected during each sampling period for 4 hr at 10-min intervals. Bioactive LH (BioLH) was determined by an assay that utilizes a dose-response production of testosterone by Leydig cells from rat testes. Immunoactive LH (ImmunoLH) was also determined by radioimmunoassay. The data obtained from these two assays are listed in Table 1.

The results of this study demonstrate that removal of ovarian feedback effects will cause a significant increase in the levels of both ImmunoLH and BioLH by 4 weeks after ovariectomy. The mean ImmunoLH levels were significantly greater than mean BioLH levels in both the pre- and post-ovariectomy periods. Yet, the pattern of secretion of both ImmunoLH and BioLH was similar, and ImmunoLH and BioLH peaks occurred simultaneously. The ratio of BioLH to ImmunoLH, presented in Table 2, represents the relative potency of the molecule.

The BioLH to ImmunoLH ratio neither changed from the pre- to post-ovariectomy periods nor differed among the three age groups. Thus, the biological activity of LH in postnatal heifers remains low although the feedback effects of the ovary are absent. To supplement this information, our lab is in the process of determining the bioactivity of luteinizing hormone in prepubertal Holstein heifers.

TABLE 1. BIOACTIVE (BIO) AND IMMUNOACTIVE (IMMUNO) LUTEINIZING HORMONE CONCENTRATIONS IN HOLSTEIN HEIFERS OVARIECTOMIZED AT 3, 6, AND 9 WEEKS

	Mean Luteinizing Hormone ± SEM (ng/ml)			
	BIO		IMMUNO	
Age	PRE-OVX	POST-OVX	PRE-OVX	POST-OVX
3	0.15 ± 0.0[a]	0.67 ± .29[b]	0.79 ± .10[b]	4.92 ± .72[c]
6	0.15 ± .07[a]	0.83 ± .22[b]	0.73 ± .05[b]	4.86 ± 1.3[c]
9	0.26 ± .05[a]	0.92 ± .14[b]	1.30 ± .28[b]	4.93 ± .67[c]

[a,b,c]Mean BIO or IMMUNO values within row are different ($P < .05$).

TABLE 2. BIOLOGICAL TO IMMUNOLOGICAL LUTEINIZING HORMONE (B:I) RATIO IN HOLSTEIN HEIFERS OVARIECTOMIZED AT 3, 6, AND 9 WEEKS

	Mean B:I ratio ± SEM	
Age	PRE	POST
3	.20 ± .03	.18 ± .03
6	.22 ± .02	.18 ± .01
9	.23 ± .03	.21 ± .02

PR-4466

The Potential Role of Insulin-Like Growth Factor I/Somatomedin-C (IGF-I) in Maturation and Ovulation of Bovine Follicles

Ann M. Miller, David K. Lunt, David W. Forrest, and Thomas H. Welsh, Jr.

Numerous hormonal factors control the processes of follicle maturation, ovulation, and luteinization (formation of the corpus luteum, CL) in the bovine. A more thorough understanding of the complex interactive roles of these hormonal factors must be acquired. This information would assist in the development and implementation of more precise, reliable hormonal methods to induce puberty, synchronize estrus, and induce superovulation in cattle.

Tissue growth factors, e.g., insulin-like growth factor I/Somatomedin-C (IGF-I), have been postulated to interact with pituitary gonadotropins (e.g., follicle-stimulating hormone, FSH) in directing follicle development. *In vitro* data indicate that IGF-I is present in ovarian granulosa cells (which line the inner wall of the follicle). Moreover, IGF-I synergizes with FSH to promote (a) progestin and estrogen biosynthesis and (b) induction of luteinizing hormone (LH) receptor formation in cultured rat granulosa cells. These reports on *in vitro* studies suggest that IGF-I may be involved in the control of intraovarian events that regulate follicle growth, ovulation, and luteinization.

Therefore, a study was conducted to determine whether these *in vitro* observations could be extended to the *in vivo* state. We examined whether alterations in plasma and follicular fluid levels of IGF-I are temporally associated with induction and maturation of bovine preovulatory follicles. In the first study, exogenous prostaglandin $F_{2\alpha}$ was used to lyse a day-10 corpus luteum and synchronize follicle recruitment and onset of estrus in 43 heifers. At 24 (n = 15), 48 (n = 16), and 72 (n = 12) hr after $PGF_{2\alpha}$ treatment, blood samples were collected and ovaries were obtained for measurement of follicle size and aspiration of follicular fluid. Concentrations of IGF- I, progesterone, and total estrogens were determined by radioimmunoassay (RIA). Plasma progesterone decreased over time after $PGF_{2\alpha}$ injection, indicating regression of an existent CL. Mean follicle diameter increased over time although follicular fluid volume did not change. Plasma estrogen increased over time, indicating induced synchronous follicular growth. Plasma IGF-I was identical at 24 hr and 48 hr (0.19 ± 0.03 U/ml) and increased slightly by 72 hr (0.23 ± 0.04 U/ml). As follicular maturation proceeded, IGF-I concentration increased in the fluid of the preovulatory follicle (24 hr: 0.64 ± 0.21 U/ml; 48 hr: 0.75 ± 0.35 U/ml; and 72 hr: 1.42 ± 0.51 U/ml).

In a second study, six mature cows were subjected to a superovulation regimen. Days 8 through 22 of the estrous cycle were divided into five periods (P) dependent on treatments given or on physiological or endocrine events: P1—time before exogenous FSH treatment; P2—initial 3 days of FSH treatment; P3—time of (a) $PGF_{2\alpha}$ induced preovulatory estrogen and LH peaks and (b) occurrence of ovulations; P4—time postovulation when plasma progesterone exceeded 1 ng/ml; P5—time postovulation when progesterone exceeded 5 ng/ml. Changes in ovarian structures were monitored by ultrasonography.

Mean plasma IGF-I concentration (range from .39 to .44 U/ml) did not vary during the three periods before ovulation. However, IGF-I level (.65 ± 0.06 U/ml) during P4 was greater than during P1, P2, or P3. Plasma IGF-I in P5 (.52 ± 0.09 U/ml) was greater ($P < .05$) than in P1. Plasma IGF-I level in P4 was positively correlated with LH peak concentration ($r = .85$, $P < .05$) and total number of ovulations ($r = .91$, $P < .01$) and postovulatory plasma progesterone concentrations ($r = .89$, $P < .05$).

In summary, increases in plasma and follicular fluid concentrations of IGF-I were temporally associated with increases in both follicle size and estrogen secretion during a period of induced follicular maturation. A higher concentration of IGF-I in the follicular fluid than in the peripheral circulation of proestrus-estrus cows suggests that IGF-I may be synthesized/sequestered by the ovary. *In vivo* observations of temporal increases in plasma levels of IGF-I levels with number of ovulations and postovulatory plasma progesterone levels suggest a possible luteotrophic role for IGF-I. These findings should assist in developing more precise methods to control ovarian functions in cattle.

PR-4467

Use of Ultrasound for Determining Ovarian Dimensions and the Relationship of Body Condition Score to Luteal Function in Beef Cows

J.G. Betts, D.W. Forrest, J.W. Holloway, and L.W. Varner

Summary

Ultrasound (high-frequency sound waves) was evaluated as a method to measure ovarian and luteal

dimensions in the beef cow. Additionally, body condition scores were evaluated as an indicator of luteal function. Ultrasound was determined to be an accurate method for measuring ovarian size but was less accurate in measuring luteal dimensions. Based on serum progesterone concentrations, body condition score was not an accurate predictor of luteal function.

Introduction

The value of high-frequency sound waves (ultrasound) is well established in the field of human reproductive medicine. Ultrasound has been used to measure subcutaneous fat thickness in cattle and is currently being investigated for use as a way to analyze the reproductive status of the cow. Numerous studies indicate that the body condition of the cow is related to subsequent reproductive efficiency. Cows on a high-energy diet exhibited a shorter postpartum anestrous period than those on a low-energy diet (3). Cows on a low-energy diet also had lower serum progesterone levels (1), suggesting impaired function of the corpus luteum (CL). Therefore, the objectives of the present study were to determine the accuracy of real-time linear array ultrasound in measuring ovarian and luteal dimensions and to determine the relationship between body condition score and luteal function.

Experimental Procedure

Seventy-two multiparous, nonlactating Brahman-cross cows were injected twice at 14-day intervals with prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) to synchronize estrus. Cows were slaughtered 14 days after the second injection (mid-luteal phase). Condition scores (CS) on a scale of 1 (extremely thin) to 9 (extremely fat) were assigned at slaughter. Serum samples were obtained from all cows at each $PGF_{2\alpha}$ injection and again at slaughter for determination of progesterone concentration by radioimmunoassay.

Ultrasound scanning of ovarian structures was performed on 40 cows immediately before slaughter. Ultrasonic images were recorded on videotape for subsequent evaluation. Scanning of each ovary was performed transrectally, and images were analyzed for ovarian length, width, and depth, and corpus luteum diameter. Ovaries were excised at slaughter, and these same dimensions were measured with calipers.

Results and Discussion

In 8 of the 40 cows, a CL was not readily discernible during evaluation by ultrasound. Two of these eight cows did not have a CL at slaughter. The difficulty of ultrasonically identifying corpora lutea has been observed previously in human studies (2) and was attributed primarily to operator inexperience or to analysis utilizing single ultrasound scans. Therefore, it appears that operator experience and/or multiple scans may be required for reliable ultrasound analysis of corpora lutea in cows.

Ultrasonic measurements of corpora lutea in the remaining 32 cows and ovarian dimensions in all 40 cows were highly correlated with those measurements obtained from excised ovaries (Table 1). Little information has previously been available on the relationship between progesterone concentrations and ultrasonic measurements of the CL. Serum progesterone concentrations and CL weight were greater in corpora lutea having a greater diameter (Table 2). No relationship was detected between CL weight and progesterone concentration at slaughter. Cows with progesterone concentrations greater that 1 ng/ml were classified as having a functional CL. By this criterion, no differences were detected in percentage of cows with functional CL at the first (81.7%) or second (87.7%) injection of $PGF_{2\alpha}$ or at slaughter (79.4%).

TABLE 1. CORRELATION COEFFICIENTS FOR ACTUAL AND ULTRASONIC ESTIMATES OF OVARIAN AND CORPUS LUTEUM DIMENSIONS

Ovarian Length	Ovarian Width	Ovarian Depth	Corpus Luteum Diameter
.69**	.75*	.68**	.62**

*P< .05
**P< .01

TABLE 2. CORRELATION COEFFICIENTS FOR ACTUAL AND ULTRASOUND MEASUREMENTS OF CORPORA LUTEA AND CORPUS LUTEUM WEIGHT AND SERUM PROGESTERONE CONCENTRATION

	Measurement Technique	
	Ultrasound	Calipers
Serum Progesterone Concentration	.39*	.35*
Corpus Luteum Weight	.67**	.86**

*P< .10
**P< .01

Condition scores were not related to luteal function as measured by serum progesterone concentration at the three periods studied. Additionally, of the three cows that did not have a CL, one cow received a CS of 4, while two cows received a CS of 6. Diameter of the CL, as measured by calipers or ultrasound, did not increase with increasing CS although cows of CS 3 did have a smaller (P<.05) diameter CL (Table 3). Weight of the CL did increase with increasing CS (r = .39).

We conclude that real-time linear array ultrasound may provide valuable information concerning luteal and ovarian size in the cow but that operator experience may be a factor. Furthermore, body condition score may not be a reliable indicator of luteal function in the nonlactating beef cow.

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TABLE 3. MEAN CORPUS LUTEUM WEIGHT AND ACTUAL DIAMETER BY CONDITION SCORE

	Condition Score						
CL Characteristics	2	3	4	5	6	7	SEM
CL Weight (g)	2.57[a,b]	2.12[b]	2.92[a]	3.05[a]	3.36[a]	2.92[a]	.39
CL Diameter (mm)	18.05[a,b]	14.90[b]	21.15[a]	20.30[a]	21.72[a]	19.50[a]	.11
n[c]	3	9	21	11	21	4	

[a,b]Numbers in the same row with different letters differ (P< .05).

[c]Three cows did not have a CL.

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Breeding and Genetics

PR-4468

Comparison of Calves Sired by Angus, Gray Brahman, Gir, Indu-Brazil, Nellore, and Red Brahman for Birth, Growth, Feedlot, and Carcass Characteristics

J. C. Paschal and J. 0. Sanders

Summary

Data from 225 birth, 205 weaning, 110 yearling, 52 feedlot, and carcass records of F_1 calves by Angus (A), Gray Brahman (B), Gir (G) Indu-Brazil (I), Nellore (N), and Red Brahman (R) sires mated by artificial insemination (AI) to multiparous Hereford cows were used to evaluate breed of sire for birth, growth, and carcass characteristics. Nellore-sired calves had the longest gestation lengths (292.7 days), and Angus had the shortest (282.5 days). Indu-Brazil crosses were largest and heaviest at birth (86.6 lb), whereas Angus were smallest and lightest (71.7 lb). Red Brahman crosses were heaviest at weaning (468.1 lb), whereas Gir cross were lightest (441.6 lb). Red Brahman crosses were also heaviest 1 yr of age (619.2 lb), and Angus were lightest (555.7 lb). Indu-Brazil crosses were tallest at weaning (44.1 in.) and as yearlings (48.1 in.), and Angus were shortest (40.2 and 43.8 in.).

Red-Brahman-cross steers were heaviest at the beginning and end of the feeding period (689.8 and 1176.2 lb) and gained the most (3.8 lb/day). Angus-cross steers were lightest at the beginning of the feeding period (615.4 lb) but gained similarly to Gray Brahman (3.6 vs. 3.7 lb/day) and were heavier than Gir, which were lightest at the end of the feeding period (1079.2 vs. 1062.8 lb). Gir-cross steers gained the least (3.2 lb/day). Indu-Brazil and Red Brahman steers were tallest at the beginning of the feeding period (48.9 in.), and Red Brahman steers were slightly taller than the other breeds at the end (52.9 in.). Angus steers were shortest at both times (44.6 and 48.6 in.).

The analyses of the carcass data indicated little difference among the sire breeds in warm carcass weight; estimated percentage of kidney, pelvic, and heart fat; ribeye area; fat thickness; and USDA yield grade. Angus steers had a more desirable marbling score (avg. small) and USDA quality grade (low choice) than did the Zebu-cross steers (avg. slight and avg. good, respectively).

These results indicate that among these Zebu breeds, large differences exist for birth and growth measurements, whereas somewhat smaller differences exist in carcass characteristics.

Introduction

Bos indicus (Zebu) cattle have had a tremendous impact on beef cattle production in the southern United States, especially in the Gulf Coast region. Until 1979, the principal *Bos indicus* breeds available to United States cattle producers were the American Gray Brahman, the American Red Brahman, and to a lesser extent, the Indu-Brazil. The Gray Brahman was developed primarily from grading up to the Bos indicus breeds Guzerat and Nellore from a *Bos taurus* base, whereas the Red Brahman were developed from the Gir, and Indu-Brazil Zebu breeds from a predominately Gray Brahman base. The Indu-Brazil was developed in Brazil in the 1920's, primarily from the Gir and Guzerat breeds, influenced somewhat by the Nellore (5).

The usefulness of Zebu breeds in this area of the United States is due to their adaptation to hot tropical or subtropical environments in coat, hide, and skin characterstics (6), and they have higher dressing percentages (1); however, the Zebu breeds have generally been characterized as having lower reproductive rates, later maturity, slower growth rates, and less desirable carcass-quality attributes (but higher dressing percentage) (1) than do *Bos taurus* (British or Continental European) breeds. However, Zebu breeds have been extremely useful in crossbreeding because they transmit their adaptive effects to their progeny, which have high levels of hybrid vigor for growth, reproduction, and maternal ability (6).

Importations of *Bos indicus* cattle of the Gir, Indu-Brazil, and Nellore breeds from Brazil during 1980-82 created a need for information on how these breeds can best be utilized in crossbreeding programs. This study was conducted to compare and quantify the breed differences between the Gray Brahman, Gir, Indu-Brazil, Nellore, and Red Brahman for birth, growth, feedlot, and carcass characteristics; Angus-Hereford crosses were used as an experimental control. This is a preliminary report on the F_1 crossbred data.

Experimental Procedure

Data for this study were collected as part of the TAES project S-6509, "Evaluation of Zebu Breeds for Beef Production." The research was conducted at the USDA Blackland Conservation Research Center at Riesel, Texas. Calves were out of Hereford cows that had previously produced at least one calf and had been mated by artificial insemination (AI) to Angus, Gray Brahman, Gir, Indu-Brazil, Nellore, and Red Brahman sires in 1982, 1983, and 1984. Calves were born in the fall of each year.

The sires included 10 Angus bulls (6 from the R. L. Hruska U.S. Meat Animal Research Center at Clay Center, Nebraska, and 4 from the USDA Brooksville Beef Cattle Research Station in Florida) from two loca-

tions and were selected to represent the type of Angus bulls used in commercial herds. Eleven Gray Brahman and 10 Red Brahman sires, selected from both AI organizations and purebred herds, represented major bloodlines in these breeds. Six Gir, 10 Indu-Brazil, and 10 Nellore sires, chosen from the 1980-82 importations of these breeds from Brazil, represented the type and bloodlines of these importations. The Hereford cows were purchased from 15 different locations in Central Texas and were both horned and polled, purebred, and grade in breeding.

The Hereford cows grazed on warm-season perennial pastures of predominantly Coastal bermudagrass, Common bermudagrass, and Kleingrass. During the winter, cows grazed oat pasture and were fed Coastal bermudagrass and hybrid Sudan hay. Salt was available year around. A high-phosphorus mineral was provided for cattle grazing warm-season perennial grasses, and a high-magnesium supplement was provided while cows were grazing oats. Some grain was fed during the breeding season.

Calves were born from late September through early January. All birth measurements were taken within 72 hr of birth, and bull calves were castrated shortly after birth. All calves were weaned in June at about 7 months of age. Steers were implanted with Ralgro in June, September, and December. After weaning, steers and heifers grazed warm-season perennial pasture until mid-November, when the steers were placed in the feedlot pens at Riesel and the heifers were placed on oats (when available). The feedlot ration contained 70 percent ground milo, 20 percent cottonseed hulls, 10 percent cottonseed meal, and either monensin sodium or lasalocid sodium. The feeding period was approximately 135 days (until early April), after which the steers were taken to the Texas A&M University Animal Science Department Meat Science and Technology Center at College Station for slaughter. Carcass data were collected 48 hr postmortem. The heifers were weighed every 6 months to measure growth.

Results and Discussion

Breed-type means of birth characters are presented in Table 1. The *Bos indicus* crosses had longer gestation periods than did the Angus crosses. The Nellore had the longest gestation period of the *Bos indicus* crosses, and the Gir had the shortest. Indu-Brazil, Gray, and Red Brahman crosses had similar gestation lengths. Indu-Brazil crosses had the heaviest birth weight, whereas Angus were lightest and similar to the Gir. Gray Brahman and Nellore crosses were similar but slightly lighter than Red Brahman. Indu-Brazil crosses were also larger at birth in terms of cannon bone length and heart girth circumference, whereas Angus were smallest. Linear measurements of Nellore crosses were nearly as large as Indu-Brazil, but Red and Gray Brahman crossbred calves were slightly smaller. The shorter gestation length, lighter birth weight, and smaller size of the Gir crosses is an interesting result because birth weight tends to be high in Brahman-sired calves (3); Gir bulls may be useful in breeding heifers for F_1 production.

All breeds were similar in weaning weight but not in weaning height or yearling weight or height (Table 2). Red Brahman crosses were the heaviest at weaning, whereas Gir were lightest. Angus crosses were similar to Gir, whereas Nellore, Gray Brahman, and Indu-Brazil were similar to each other and intermediate to Gir and Red Brahman crosses. Red Brahman crosses were also heavier at 1 yr of age than were the other breed types; Angus were lightest. Gray Brahman crosses weighed less than Red Brahman but were heavier than Gir, Nellore, and Indu-Brazil, which were similar. The Red Brahman crosses had the greatest postweaning gain, while Angus had the least. Gir, Gray Brahman, and Indu-Brazil crosses were similar but lighter than the Red Brahman. Nellore crosses gained the least of the *Bos indicus* crosses.

TABLE 1. AVERAGE GESTATION LENGTH, BIRTH WEIGHT, CANNON BONE LENGTH, AND HEART-GIRTH CIRCUMFERENCE

Sire Breed	No.	Gestation Length(d)	Birth Weight(lb)	Cannon Bone Length(in.)	Heart-Girth Circumference(in.)
Angus	33	282.5	71.7	10.3	28.1
Gray Brahman	37	289.9	81.2	11.1	29.1
Gir	40	287.8	72.8	11.2	28.4
Indu-Brazil	38	289.9	86.6	11.7	29.5
Nellore	38	292.7	81.5	11.6	29.5
Red Brahman	39	290.4	83.0	11.3	29.1

TABLE 2. AVERAGE WEANING AND YEARLING WEIGHT AND HEIGHT AND POSTWEANING WEIGHT GAIN

Sire Breed	Weaning			Yearling			
	No.	Weight(lb)	Height(in.)	No.	Weight(lb)	Height(in.)	Gain (lb)
Angus	31	442.9	40.2	16	555.7	43.8	98.0
Gray Brahman	34	456.2	42.9	20	603.7	46.8	130.4
Gir	36	441.6	42.9	20	594.5	47.0	131.3
Indu-Brazil	34	454.4	44.1	17	592.1	48.1	128.2
Nellore	35	461.4	44.1	19	593.2	48.1	120.9
Red Brahman	35	468.1	43.6	18	619.2	47.6	135.0

Indu-Brazil and Nellore crosses were tallest at weaning and as yearlings, whereas Angus crosses were shortest at both times. Gir and Gray Brahman were nearly the same height, whereas Red Brahman were slightly taller. Although weaning weights were similar, the Zebu breeds exhibited slight differences in their ability to gain on warm-season perennial pasture after weaning.

Feedlot weight, height, and gain of steers are presented in Table 3. All sire breeds were similar for initial feedlot weight. Red Brahman crosses were heaviest and Angus were lightest. Gir were lightest of the Zebu breeds, whereas Nellore, Gray Brahman, and Indu-Brazil were intermediate. Red Brahman had the highest average daily feedlot gain (ADG); Gir had the lowest. Angus ADG was similar to Gray Brahman and Indu-Brazil but higher than Nellore. Red Brahman crosses had the heaviest final feedlot weight and Gir had the lightest. Red Brahman and Indu-Brazil crosses were tallest at initial height, and Red Brahman crosses were tallest at final height. Nellore crosses were similar in initial and final feedlot height to the Red Brahman and Indu-Brazil, whereas Gray Brahman and Gir were shorter but similar to each other. The Gir crosses did not gain as much as the other breeds. Actually, they gained well early in the feeding period but apparently had reached most of their lean growth potential by the middle of the feeding period; consequently, their growth phased into more fat deposition with considerably less weight gain during the last half of the feeding period. This observation was confirmed by the carcass results. The relatively low ADG of the Nellore crosses apparently was due to their nervous disposition, which was especially noticeable during the first half of the feeding period. Their behavior and ADG improved during the last half of the feeding period. The ADG of the *Bos indicus* crosses was similar to that of Brahman- and Sahiwal-sired cross steers from Angus and Hereford cows in Nebraska (2).

The breeds were similar in most of the carcass characters evaluated (Table 4), especially in warm-carcass weight; estimated percentage of kidney, pelvic, and heart fat; ribeye area; fat thickness; and USDA yield grade. The Red Brahman crosses had the heaviest warm-carcass weight, whereas Angus had the lightest. Indu-Brazil crosses had the least amount of kidney, pelvic, and heart fat, and Gray Brahman had the greatest. Indu-Brazil crosses also had the largest ribeye area, and Nellore had the smallest. Gir had the greatest amount of fat thickness, and Gray Brahman had the least.

Indu-Brazil crosses had the most desirable USDA yield grade, whereas Nellore had the least desirable yield grade. Angus crosses had more desirable USDA marbling scores and quality grade scores than did the Zebu crosses. The marbling and quality grades were similar for all *Bos indicus* crosses but were lower than those of Angus. These results indicate small differences among these breeds in most of the carcass characteristics except for the difference between the Angus and the Zebu crosses in the indicators of carcass quality. Results of Brahman crosses (both Gray and Red) were similar to those reported in the literature (4), except that yield grade was more desirable in the Riesel study, which was possibly due to the shorter length of time on feed (135 days).

Weights of crossbred heifers at 12, 18, and 24 months of age (Table 5) were heaviest for the Gray Brahman crosses and lightest for the Angus crosses at all ages. As yearlings and as 2-yr-olds, the Indu-Brazil and Red Brahman crossbred heifers were similar and lighter than Gray Brahman, but Red Brahman heifers were heavier than the Indu-Brazil at 18 months of age. The Nellore crosses were intermediate to the Gray Brahman and the Angus at 12 and 24 months but heavier than the Gir. At 18 months, however, the Gir and Nellore crosses were similar in weight. Indu-Brazil-sired heifers were tallest at all ages, whereas Angus heifers were the shortest. Gray Brahman, Gir, Nellore, and Red Brahman crossbred heifers were similar in height at all ages.

These preliminary results for the *Bos indicus* indicate

TABLE 3. AVERAGE INITIAL AND FINAL FEEDLOT WEIGHT AND HEIGHT AND FEEDLOT GAIN

Sire Breed	No.	Initial		Final		Gain	
		Weight(lb)	Height(in.)	Weight(lb)	Height(in.)	Daily(lb/d)	Total(lb)
Angus	7	615.4	44.6	1079.2	48.6	3.6	464.2
Gray Brahman	8	660.0	47.2	1111.2	51.3	3.7	467.8
Gir	9	647.3	48.2	1062.8	51.4	3.2	415.9
Indu-Brazil	8	669.0	48.9	1149.5	52.6	3.7	481.3
Nellore	10	655.6	48.8	1087.9	52.8	3.4	429.3
Red Brahman	10	689.8	48.9	1176.2	52.9	3.8	486.5

TABLE 4. AVERAGE CARCASS CHARACTERISTICS

Sire Breed	No.	Carcass Weight(lb)	Kidney, Pelvic, Heart Fat (%)	Ribeye Area(in.^{2})	Fat Thickness(in.)	Marbling Score	Quality Grade	Yield Grade
Angus	7	630.0	1.85	11.7	.46	Avg. Small	Low Choice	2.8
Gray Brahman	7	669.8	2.01	12.2	.37	Avg. Slight	Avg. Good	2.7
Gir	9	646.2	1.87	12.0	.54	Avg. Slight	Avg. Good	2.8
Indu-Brazil	8	668.1	1.59	12.3	.46	Avg. Slight	Avg. Good	2.6
Nellore	9	647.2	1.91	11.6	.47	Avg. Slight	Avg. Good	2.9
Red Brahman	10	702.8	1.79	12.2	.41	Avg. Slight	Avg. Good	2.8

TABLE 5. AVERAGE WEIGHT AND HEIGHT OF HEIFERS AT 12, 18, AND 24 MONTHS OF AGE

Sire Breed	12 mo			18 mo		24 mo	
	No.	Wt(lb)	Ht(in.)	No.	Wt(lb)	Ht(in.)	Wt(lb)	Ht(in.)
Angus	14	489.9	42.6	9	756.1	46.8	834.3	47.7
Gray Brahman	18	556.5	46.2	12	852.3	50.0	986.5	51.9
Gir	12	512.6	45.6	10	770.9	49.2	884.7	51.7
Indu-Brazil	14	545.5	47.5	8	793.7	50.7	915.3	53.2
Nellore	18	533.2	47.0	9	770.9	50.0	896.7	51.9
Red Brahman	15	545.9	46.2	7	811.6	50.3	951.1	51.6

that great differences exist among these breeds in birth and growth characters, whereas somewhat smaller differences are found in carcass characteristics. The results of this Zebu breed evaluation should be extremely useful in formulating new crossbreeding programs or in revising existing ones to take advantage of the genetic diversity of these *Bos indicus* breeds.

Acknowledgments

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PR-4469

Gene Mapping in Cattle

James E. Womack

Summary

Somatic cell genetic methods have been employed to map cattle genes. Bovine-hamster hybrid cells selectively segregate cattle chromosomes; 35 cattle genes have been mapped by concordancy of segregation. These genes mark the X-chromosome and 23 of the bovine autosomes. Extensive homology with the human gene map is evident. The identification of conserved chromosomal regions will allow the extrapolation of human gene-mapping data to the bovine genome.

Introduction

Although domestic cattle have long been a target of genetic manipulation, few discrete genes have been identified, and little is known about the organization of these genes on bovine chromosomes. The production of only one offspring per year per mating renders the classical approach to gene mapping prohibitive. Somatic cell and molecular genetic technologies, however, circumvent this obstacle and have been employed in this study to generate a gene map of the cow.

Experimental Procedure

Fresh bovine leucocytes collected over Ficoll-hypaque were fused with HPRT-deficient Chinese hamster E36 cells in the presence of polyethylene glycol (2). Hybrid cells were selected in hypoxanthine = aminopterine thymidine (HAT) media, cloned, and propagated for enzyme, chromosome, and DNA analysis. Thirty-one clones were grown to approximately 10^8 cells and electrophoretically analyzed for 28 enzymes on cellulose acetate gels by modifications of the methods of Harris and Hopkinson (1). Without exception, hamster electromorphs were retained and cattle electromorphs were segregated, apparently at random (Table 1). Concordancy of retention of cattle gene products was regarded as evidence of genetic linkage (synteny).

Results and Discussion

These hybrids uniformly lost cattle chromosomes. The proportion of bovine genes retained in each clone ranged from 10 to 52 percent. All clones maintained in HAT, and thus requiring the presence of the bovine HPRT gene, retained bovine G6PD as well, confirming the previous assignment of that gene to the X-chromosome (3). Discordancy scores of all other genes with each other were calculated, and pairs with less than 10 percent discordancy were assumed syntenic, i.e., located on the same chromosome. The cumulative genetic map com-

TABLE 1. NUMBER OF CLONES TESTED FOR EACH CATTLE GENE PRODUCT AND THE NUMBER AND PERCENTAGE OF CLONES IN WHICH EACH CATTLE GENE PRODUCT WAS OBSERVED

Gene Symbol	Enzyme	No. Clones Tested	No. Bovine Positive Clones	Percentage Retention
G6PD	Glucose-6-phosphate dehydrogenase	31	24	77
PGD	Phosphogluconate dehydrogenase	31	16	52
ENO1	Enolase 1	31	15	48
LDHB	Lactate dehydrogenase B	31	15	48
PEPB	Peptidase B	28	14	50
GAPD	Glyceraldehyde-3-phosphate dehydrogenase	30	15	50
TPI	Triosephosphate isomerase	31	16	52
ITPA	Inosine triphosphatase	26	13	50
ADA	Adenosine deaminase	31	15	48
PGM1	Phosphoglucomutase 1	31	3	10
LDHA	Lactate dehydrogenase A	31	4	13
GPI	Glucose phosphate isomerase	31	4	13
IDH1	Isocitrate dehydrogenase 1, soluble	31	6	19
ACY1	Amioacylase 1	31	8	26
MPI	Mannose phosphate isomerase	31	8	26
PKM2	Pyruvate kinase 2	31	13	42
ME1	Malic enzyme 1, soluble	31	13	42
PGM3	Phosphoglucomutase 3	19	8	42
SOD2	Superoxide dismutase 2, mitochondrial	26	12	46
SOD1	Superoxide dismutase 1, soluble	31	10	32
MDH2	Malate dehydrogenase 2, mitochondrial	31	8	26
ACO1	Aconitase 1, soluble	31	5	16
GSR	Glutathione reductase	31	9	29
GDH	Glucose dehydrogenase	29	13	45
GUK	Guanylate kinase	26	3	12
NP	Nucleoside phosphorylase	31	13	42
CAT	Catalase	31	14	45
GLO1	Glyoxalase 1	31	9	29

piled from these data end previous studies is presented as Table 2. This map provides at least one gene marker for all but six of the bovine autosomes.

Conservation of cattle and human linkage groups is extensive; only three discordancies were observed among the 32 gene loci that have now been mapped in both species. The identification of conserved regions of the bovine chromosomes will be extremely valuable in predicting the location of genes in cattle that have been previously mapped in humans.

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TABLE 2. COMPOSITE GENE MAP OF THE COW. PREVIOUSLY PUBLISHED SYNTENIC GROUP NOMENCLATURE (U = UNASSIGNED) IS USED WHERE POSSIBLE.

Chromosome or Syntenic Group	Gene Locus
X	G6PD HPRT PGK GLA
U1	PGD ENO1
U2	SOD2 ME1 PGM3
U3 (Chr 19)**	GAPD LDHB TPI PEPB
U4	MP1
U5	PKM2
U6	PGM1
U7	LDHA
U8	MDH2
U9	GPI
U10 (Chr 13)**	SOD1 IFREC
U11	ITPA ADA
U12	ACY
U13 (Chr 5)**	PEPC*
U14	GSR
U15	PGM2*
U16	AK1*
U17	IDH1
U18	ACO1
U19	GUK
U20	CAT
U21	GLO1
U22	GDH
U23	NP

*Not included in this study and therefore may not be independent of all other groups.

**Chromosomal assignments are tentative.

Grass Tetany in Different Breeds of Cattle

L. W. Greene, J. F. Baker, and R. E. Knutson

Summary

The cow herd (n = 716) at McGregor Research Center was used to determine the incidence of grass tetany from February 1980 to February 1984. The herd (age = 2-12 yr) was composed of Angus (A), Brahman (B), Hereford (He), Holstein (Ho), Jersey (J), and their crosses, reciprocals pooled. Cattle grazed pastures containing native grasses and Kleingrass during late spring to fall with ad libitum access to a free-choice mineral (4% Mg as MgO) supplement. During late fall to spring, cattle grazed primarily small-grain forage and a 14 percent Mg mineral supplement supplied free-choice. Grass hay and a salt-limiting concentrate were fed when nutrients from pasture forages were inadequate. During the 4-yr period, 32 cows were suspected of having grass tetany, of which 6 recovered and remained in the herd. During this period, 112 cattle were culled if open for 2 consecutive years or if they had health-related problems. Expressed as a percentage of cows culled, 23.2 percent of the culls were due to death from suspected grass tetany. Suspected incidences of grass tetany in cattle of A, B, He, Ho, and J breeding were 7.5, 2.4, 3.9, 3.1, and 4.3 percent, respectively. Cattle with A breeding had 67 percent more ($P < .05$) and B had 47 percent fewer ($P < .10$) suspected incidences of tetany than the herd average of 4.5 percent. Expressed as a percentage of cattle suspected to have gone down from grass tetany, 53.1, 15.6, 40.6, 21.9, and 31.3 percent were of A, B, He, Ho, and J breeding, respectively. Cattle of B breeding were least susceptible and A were most susceptible to grass tetany.

Introduction

In the U.S., hypomagnesemic tetany is most common in beef cows grazing lush spring forages (2). This disease also affects large numbers of high-producing dairy cows consuming predominately grazed forages in other countries (6). The disease is characterized by a mineral imbalance, Mg deficiency, and/or a Ca deficiency that can result from an increase in requirement, a low dietary intake or digestibility of mineral, especially during early lactation (1, 11).

The breed of cattle may contribute greatly to susceptibility to grass tetany. Wiener (14) indicated that blood Cu, Ca, P, and Mg is significantly different between Friesian and Jersey cattle. Field et al. (3) found serum concentrations of Ca, P, and Mg to be different among breeds of sheep in two flocks: Scottish Blackface and Welsh Mountain sheep had higher concentrations of plasma Mg than did Cheviot. Fisher and Wilson (4) indicated that adult lactating Angus cows had a 6 percent lower serum Mg level than do crossbred Angus-Charolais cattle.

The objective of this study was to determine the effect of breed on incidence of grass tetany in five breeds of cattle and their F_1 crosses.

Procedures

This study was conducted at the McGregor Research Center of The Texas Agricultural Experiment Station. Angus (A), Brahman (B), Hereford (He), Holstein (Ho), and Jersey (J) cattle and their F_1 crosses were used to determine the incidence of grass tetany during 4 consecutive years from February 1980 to February 1984. These five major breeds were selected to represent a wide range of biological types. For statistical analysis, breed groups were generated by pooling major breeds with all crossbreds of that respective group. Therefore, crossbred cattle were used in each parent breed group. The herd was established in the 1972-73 calf-crop year (8, 9).

Offspring from the matings of parental types of cattle were included in the data when they became 2 yr of age. The calving season was continuous throughout the year. Cattle that did not calve in 2 consecutive years were culled from the herd. Once per month, cows that were scheduled to calve during the next 30-day period were removed from the herd and maintained in a calving herd. Cows were moved to a nursery herd shortly after parturition. This herd was composed of cow-calf pairs between the ages of 1 day and 1 month. Cows with calves greater than 4 weeks old were removed from this herd and returned monthly to the original herd.

Cattle grazed pastures containing predominately TAM winterharding grass, Kleingrass, and other volunteer noncultivated grasses during late spring to fall. During late fall to spring, cattle grazed predominately small-grain forages (winter oats and wheat). Cattle were routinely supplied, free-choice, a mineral supplement (Table 1) containing 4 percent Mg. During the period of grazing small-grain forages, the Mg content of the mineral supplement was raised to 14 percent. Grass hay and a salt-limiting concentrate were fed when nutrients from pasture forages were inadequate. The supplemental salt-limiting concentrate contained 55 percent ground milo, 34 percent soybean meal or cottonseed meal, 4 percent urea, and 3 percent dicalcium phosphate. When cattle were suspected of having grass tetany, they were treated with 500 ml of a Mg solution IV, which contained 10, 2.76, 6.03, and 75 g of Ca, Mg, P, and dextrose monohydrate, respectively.

Results and Discussion

Numbers of cattle in the herd at the beginning of the 4-yr period is shown in Table 2. Each breed group for A, B, He, Ho, and J contained 228, 210, 335, 227, and 230 cattle, respectively. Ninety-four percent of the suspected grass tetany cases occurred between December

TABLE 1. MINERAL COMPOSITION OF SUPPLEMENTS

Mineral	4% Mg[a]	14% Mg[b]
Calcium	17.6	5.0
Phosphorus	21.2	3.5
Magnesium	4.0	14.0

[a]South Texas Range Mineral No. 5 W/Magnesium. West Flour Mill, Inc., West, TX 76691.

[b]West Grazing Mineral-14 Mag. West Flour Mill, Inc., West, TX 76691.

and April (Table 3). This period corresponds to the grazing period for winter pastures. Grass tetany has been observed most frequently in ruminants grazing lush growing forages, especially small grains (7). Small-grain forages can contain as much as 5.0 percent K on a dry matter basis (10) and are relatively high in many organic acids implicated in the incidence of tetany (13).

Between May 1983 and May, 1984 no incidences of tetany were recorded. This is probably related to a shortage of small-grain forages during the winter and spring grazing periods of 1984. During this time, environmental conditions were not conducive to adequate wheat and oat production at the McGregor Research Center; thus, cattle were maintained on native grasses, hay, and supplemental energy.

Thirty-two cattle were suspected of having grass tetany during the 4-yr period, resulting in a herd mean of 4.5 percent (Table 4). Fontenot (5) indicated that grass tetany occurred in less than 1 percent per year of the adult ruminant female population, the incidence being higher in individual herds. The incidence in the McGregor herd was 1.1 percent per year. Expressed as a percentage of their breed groups, cattle with A breeding had a higher ($P < .05$) incidence of grass tetany than did B, He, Ho, and J cattle (7.5 vs. 2.4, 3.9, 3.1, and 4.3%, respectively) during the experimental period. Cattle of B breeding tended to have a lower ($P < .10$) incidence of grass tetany, and He, Ho, and J were intermediate. Expressed as a percentage of total grass tetany cases, 53.1, 15.6, 40.6, 21.9, and 31.3 percent of the 32 cases were from cattle with A, B, He, Ho, and J breeding, respectively. No reported cases of grass tetany were in straight-bred B cattle, and seven cases were observed in the straight-bred A. When straight-breeds and crosses were pooled to make five major breed groups, there were 17, 5, 13, 7, and 10 cases of grass tetany for A, B, He, Ho, and J groups, respectively.

During the 4-yr period, six of the cattle suspected of having grass tetany and treated for the disease recovered and remained in the herd. Grass tetany did not reoccur in these cattle during the rest of the experimental period. During the experimental period, 112 cattle were removed from the herd because of their failure to rebreed for 2 consecutive years or because of other health-related problems. Of those removed, 23.2 percent were due to death from grass tetany. This loss represents a large monetary and management burden for cattle producers. In this herd, death from grass tetany was the single most important reason for removing animals from the herd.

The incidence of grass tetany between breeds in this herd could be associated with the level of production and the ability of different breeds of cattle to metabolize Mg differently. This difference in Mg metabolism may be associated with a difference in Mg absorption.

In conclusion, it appears that B and B-cross cattle are less susceptible to grass tetany. Furthermore, the lower incidence of grass tetany in B-bred cattle could be associated with an increase in the digestibility of Mg in this breed compared with other breeds of cattle. In a review, Schneider and Flatt (12) indicated that B had a smaller digestive tract volume, which may be related to a shorter ruminal retention time and to more efficient digestion. The change in rate of digesta flow through the stomach in B may be beneficial in increasing the efficiency of Mg absorption, thereby decreasing the incidence of tetany.

TABLE 2. NUMBERS OF CATTLE IN HERD AT BEGINNING OF FOUR-YEAR PERIOD BY BREED GROUP[a]

	Breed of Mate					
Breed Group	Angus (A)	Brahman (B)	Hereford (He)	Holstein (Ho)	Jersey (J)	Total
A	47	48	35	58	40	228
B		28	56	29	49	210
He			86	68	90	335
Ho				31	41	227
J					10	230
Total						716

[a]Reciprocal crosses pooled.

TABLE 3. DATE OF SUSPECTED GRASS TETANY IN A COW HERD OF FIVE BREEDS AND THEIR DIALLELS DURING FOUR CONSECUTIVE YEARS[a]

Angus (A)	Brahman (B)	Hereford (He)	Holstein (Ho)	Jersey (J)	AB	AHe	AHo	AJ	BHe	BHo	BJ	HeHo	HeJ	HoJ
Feb 81		Apr 83	Feb 80	Oct 82	Feb 81	Feb 81	Feb 81	Jan 81	Dec 81	Apr 81		Dec 81	Mar 81	
Dec 81			Feb 80			Jan 82	Feb 83	Mar 81	Jan 82				Dec 81	
Jan 82			Apr 83			Mar 83		Dec 81	Mar 83				Oct 82	
Jan 82								Jan 82					Feb 83	
Mar 83													Apr 83	
Mar 83														
Apr 83														

[a]Reciprocal crosses pooled.

TABLE 4. INCIDENCE OF SUSPECTED GRASS TETANY CASES DURING FOUR-YEAR PERIOD, SUMMARIZED BY BREED GROUP

Breed Group	Incidence	
	% of Breed[b] Groups	% of Total Cases
A	7.5+1.7[c]	53.1
B	2.4+1.1[d]	15.6
He	3.7+1.1[d]	40.6
Ho	3.1+1.1[d]	21.9
J	4.3+1.3[d]	31.3
Herd Mean	4.5	

[a]Reciprocal crosses polled.

[b]Mean + SEM.

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

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PR-4471

Serum Mineral Concentrations in Three Breeds of Cattle Supplemented with Different Levels of Magnesium Oxide

S. K. Matter, L. W. Greene, D. K. Lunt, G. T. Schelling, F. M. Byers

Grass tetany, the major cause of cow deaths in the United States, is characterized by low blood serum magnesium concentrations. This disease occurs most often in beef cows grazing lush growing forages, shortly after calving. A study was conducted from December 1984 to May 1985 on mature cows (bred to calve mid-February to early April) to determine the effect of breed and level of supplemental magnesium on serum mineral values during the peak grass tetany season. Twenty-seven cows of Angus (n = 9), Brahman (n = 9), and Hereford (n = 9) breeding were blocked by breed type, randomized into three treatment groups, and assigned to 3- to 10-acre oat pastures in a 3 x 3 factorial arrangement. One of the following three mineral supplements was assigned to each treatment group: (a) dry 4 percent magnesium (Mg), 17 percent calcium (Ca), and 12 percent phosphorus (P) free-choice supplement, (b) dry 14 percent Mg, 14 percent Ca, and 10 percent P free-choice supplement, and (c) 1:1 mixture of magnesium oxide and liquid molasses with a separate 1:1 dry mixture of dicalcium phosphate and a trace of mineralized salt. Supplements were provided free-choice in covered mineral feeders. Fresh mineral was provided weekly, and refusals were weighed to approximate group supplement intakes. Blood samples were obtained via caudal venapuncture, and serum concentrations of Mg, Ca, and inorganic P were determined. Weekly supplement intake was highly variable over the study period. Average daily intakes (g/hd) for supplements 1, 2, and 3 were 47, 61, and 33 + 71, respectively. Intake of supplement 2 tended to be higher than that of supplement 1, despite the higher concentration of magnesium oxide in the supplement. Average daily Mg intakes (g/hd) from supplements 1, 2 and 3 were 1.87, 8.78, and 8.91 g/hd, respectively. Serum mineral values were

similar across breeds. Serum Ca and P were similar for all treatments; however, serum Mg levels were higher ($P < .05$) for cows on supplement 3 (2.42 mg/dl) than those on supplement 1 or 2 (2.12, 2.15 mg/dl, respectively). Although magnesium intake was suboptimal for all treatments, Mg-containing supplements such as the magnesium/molasses mixture show promise of increasing serum Mg concentrations, which could alleviate some of the losses in production caused by grass tetany.

Carcass and Meats

PR-4472

Effects of Zeranol on Lipid Composition of Beef *Longissimus Dorsi*

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Summary

The effects of zeranol implantation on the lipid composition of beef *longissimus* muscle and related carcass characteristics were investigated. Statistically significant decreases in the relative percentages of saturated fatty acid occurred as a result of zeranol treatment. Lipid content, marbling score, and USDA quality grade were numerically lower, but not statistically different, in treated animals. Collectively, the data suggest that there are small but biologically important effects of zeranol treatment on lipid metabolism in beef muscle.

Introduction

Zeranol, known commercially as Ralgro™, when implanted in steers, results in an increased rate of gain (2). Similarly, trenbolone acetate, an androgen analog, has recently been reported to increase muscle accretion in heifers (5). Several theories have been proposed; however, the mechanism by which an anabolic response is mediated by opposite sex steroids is not known.

There is agreement that the increased rate of gain in zeranol-implanted steers is accompanied by an increased ratio of carcass protein to lipid (2). Therefore, along with an increase in protein, a corresponding decrease in lipid in muscle as well as in the total carcass can be expected. However, before this study, the effects of zeranol on intramuscular lipids had not been systematically studied. Although the lipid composition of cells is not easily altered, steroids inhibit both cholesterol and fatty acid synthesis in various target tissues (1). Such effects could have widespread implications to research directed to altering the fat composition of beef. Thus, the possibility that zeranol, a steroid analog, might alter the lipid composition of *longissimus dorsi* muscle was investigated.

Methods and Materials

Animals

Steaks were provided by the Texas A&M University Meat Science and Technology Center and were from a comprehensive, ongoing research project at the Department of Animal Science at Texas A&M University. Sixteen steers were randomly and equally assigned to treatment and control groups. Treatment groups were implanted with 36 mg zeranol 2-3 months post-weaning and following castration. Additional implants were made at 80-90 days until attainment of mature weight (450-550 kg). Steers were crosses from Charolais or Red Poll bulls and mixed-breed dams. Animals were fed a grain diet consisting of cottonseed hulls (10%), ground milo (74.27%), cottonseed meal (11.03%), molasses (2.0%), calcium carbonate (1.70%), ammonium sulfate (0.25%), TM Salt+ vitamin Premix (0.50%), and Dyna-K (0.25%). Steers were slaughtered and chilled according to normal procedures. Carcass characteristics were evaluated for USDA grade factors and other quality and quantity factors, using standard techniques at the Texas A&M University Meat Science and Technology Center. Portions of the *longissimus* muscle were excised from the 8th to the 12th thoracic rib area 72 hr postmortem, and a 100-g sample was obtained from the center of the sample for biochemical assays.

Quantitation of Lipids

Intramuscular lipid. beef *longissimus dorsi* muscle (100 g) was trimmed of subcutaneous and intermuscular fat and homogenized in a Robot Coupe Commercial Food Processor (Model R6, Robot Coupe). Five grams of the total sample were homogenized thoroughly for 2 min in 100 ml chloroform: methanol (2:1, v/v) in a Waring blender (3). The extraction of the homogenate was repeated once, and the combined chloroform layers were re-extracted by vigorous shaking with water (50 ml). The mixture was allowed to stand at 4 °C until the layers were completely separated. The lower chloroform layer was carefully withdrawn, and the volume was recorded. Total lipid was determined using the average of three gravimetric determinations of 10-ml aliquots separately evaporated to dryness under nitrogen.

Lipid Fractions

Cholesterol. Extracted lipid, containing ≥0.3 mg cholesterol dissolved in chloroform was evaporated to dryness under a stream of nitrogen at 25 °C. Cholesterol was determined using the procedures of Courchaine et al. and Zlatkis et al. as modified by Kates (3). Spectral assays were performed at 550 λ with a Beckman DU-7 Spectrophotometer.

Neutral and polar lipids were separated by silicic acid chromatography and evaporated to dryness with nitrogen. Percentages of neutral and phospholipids were calculated from the gravimetric determinations of single samples (3).

Fatty acids. Intramuscular fatty acids were quantitated as described previously (3,9). Briefly, neutral lipids were esterified, extracted with hexane, and purified on Silica Gel G chromatoplates. Resolved methyl esters were localized by visual inspection under ultraviolet light, scraped, and filtered. Methyl esters were resolved by gas-liquid chromatography using a Varian Model 3700 chromatograph. All chemicals used for the study were

reagent grade or better, available from Sigma Chemical Co. or from Fisher Scientific Co. and were used without further purification. Zeranol[5] was obtained from International Minerals and Chemical Corporation. Solvents were HPLC grade from Burdick and Jackson.

Statistical Analyses

All measurements were performed in duplicate or triplicate. The data were treated statistically using analysis of variance and mean separation techniques.

Results and Discussion

Differences in the lipid composition of beef *longissimus* muscle and related carcass characteristics as a result of zeranol treatment were not pronounced. However, there was a small but statistically significant decrease in the relative percentage of palmitic acid (16:0). Taken together with the numerical decreases in total intramuscular lipid, marbling score, and USDA grade, the data suggest that lipid metabolism may be affected by zeranol implantation. In this regard, others have recently reported decreased adipose cell diameters in *longissimus* muscle of zeranol-treated steers (8). Because the changes are small, additional studies using larger sample sizes than those available to us in the present study are needed to confirm these apparent effects of zeranol treatment on lipid metabolism. We could detect no changes in the distribution of neutral and phospholipids as a result of zeranol treatment. Fatty acid, neutral, and phospholipid distributions in control samples agree with those reported elsewhere (9).

Intramuscular cholesterol in implanted animals was not different from control values. Our results are within the range and variations of reported values for intramuscular cholesterol in raw beef (4,6,7). However, because our assay produces higher values than those typically reported, the data are intended as comparative only.

TABLE 1. EFFECTS OF ZERANOL IMPLANT ON LIPID COMPOSITION AND RELATED CHARACTERISTICS OF BEEF *LONGISSIMUS DORSI* MUSCLE[a]

Trait	Zeranol	Control
Fatty Acid Composition (%)		
16:0	22.3±5.6*	27.6±3.3*
16:1	3.7±2.0	4.4±0.7
17:0	2.5±1.5	1.4±0.4
18:0	16.6±8.4	13.3±1.5
18:1	38.4±5.7	41.6±2.7
18:2	2.9±1.7	3.0±1.3
Neutral lipid	74.9±6.4	77.3±9.3
Phospholipid	25.1±6.4	22.7±9.3
Cholesterol (mg/100g)	95.0±16.0	99.7±10.1
Intramuscular Lipid (g/100g)	3.4±1.7	5.0±1.1
Marbling Score[b]	SL^{40}	Sm^{50}
USDA Quality Grade	Gd^{50}	Gd^{90}

[a]Mean value of data from 8 samples per group.

[b]Marbling score: subjective evaluations SL = slight, SM = small.

*Differences are significant; $P<0.05$.

In summary, the data presented here show that, although zeranol treatment does not markedly affect lipid composition of beef muscle, small changes are observed. More extensive studies are needed to determine whether the changes observed represent generalized effects on lipid metabolism in beef muscle. Such changes could have a significant impact on studies directed to alter the fat composition of beef muscle.

Acknowledgments

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Evaluation of Deuterium Oxide Dilution Systems for Estimating Body Composition of Beef Cattle

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Summary

Fifty cattle including 10 each of young calves, feeder calves, yearlings, fed cattle, and mature cows were infused with D_2O and slaughtered to assess the utility of D_2O dilution and other procedures for estimating body composition in beef cattle. All cattle were infused with D_2O using standard infusion, sample collection, and analysis procedures. All empty body tissues were collected at slaughter, ground, and analyzed to estimate chemical composition. Water pools were derived using standard curve peeling procedures. Additionally, a simpler bi-exponential regression approach was devised for which empty body water (QAE) and total body water (QTL) were estimated from the intercepts of ln D_2O vs. time from 20 to 100 min and from 4 to 48 hr, respectively. All pools were converted from liters to kilograms by adjusting for the difference in density of D_2O vs. H_20. Digestive tract water and fill were estimated as being the difference (QBD) between total (QTL) and empty body (QAE) pools. Models including continuous pool variables with animal class and the interaction indicated no significant pool by class interactions. Therefore, the cattle were evaluated as one population. Water pools from the standard kinetics system (QAW, QBW) or from the simple bi-exponential system (QAE, QBD) predicted empty body (R^2 = .97) and digestive tract water (R^2 = .86) or fill (R^2 = .90) with similar precision, indicating that either system may be used. Minimal intercepts, slopes near 1.0, R^2's of .98, and coefficients of variation of 2.2 percent for empty body weight and 7 percent for water, protein, and lean body mass across animals ranging from 45 to 280 kg in empty body water, indicate that these relationships should be generally useful. Relationships of QAW to empty body water in this study were similar to previously determined equations (3) in the range of animals in that study. Empty body fat was related (R^2 = .88) to fat estimates from the standard (EBWT - LBM) method, but variance was considerable (CV 24.6%). Alternative methods of estimating fat that avoid additive errors by successive or by difference calculations using live weight, water spaces, and ultrasound provided much better estimates of fat, both as percentage (R^2 .78, .82; CV 15.6, 14.0%) and as kg (R^2 .93, .95; CV 19.8, 15.4%). The equations from the previously determined 1979 model (3) did not include small calves, and as a result, did not correctly predict their composition. However, the 1979 equations provided estimates of empty body weight, fill, water, protein, and lean body mass similar to chemical composition for feeder calves, yearlings, fed cattle, and cows. Means for fat were similar for D_2O and chemical estimates for yearlings and for cows and were lower for fed cattle and higher for feeder cattle for D_2O vs. chemical estimates.

The relationships derived in this study indicate that two-pool D_2O methods provide useful estimates of empty body weight, water, protein, and lean body mass with coefficients of variation of 2 percent and 7 percent for estimation of empty body weight and lean body components. Fat is predicted with more variation; inclusion of ultrasound measurements and direct prediction from weight and water pool estimates provide more precise estimates, resulting in group means similar to chemical analyses estimates.

Introduction

Accurate estimation of body composition of live animals has eluded scientists' best efforts for centuries. Technological advances in instrumentation allowed development of radioisotope and, more recently, stable isotope measurement procedures (2). Using a stable isotope of hydrogen as water (D_2O) and standard isotope dilution kinetics approaches, quantities of water in live animals can be estimated. Several investigations have reported successful development of isotope dilution procedures for estimating empty body water and digestive tract fill of cattle, ranging from calves to cows and in cows of various breeds (3, 4, 6, 7).

Other studies indicate variable responses (1) or little relationship to percentage separable carcass fat (5). However, none of these studies included sufficient numbers of cattle in each of the needed weight, cattle type, and stage of development categories to allow unconditional evaluation. A comprehensive study including cattle of desired weight, animal type, and age categories was conducted to allow evaluation of the merit of isotope dilution procedures in conjunction with other procedures across the expected range of cattle for estimating body composition in beef cattle.

Experimental Procedure

Cattle ranging from small to large mature size (10 in each class of young calves, feeder calves, yearlings, fed cattle, and cows) were selected to provide a continuous distribution of body components over a range in weight and a range in composition at similar weight in each class. They were transported from McGregor, Texas, and from other locations to College Station, Texas, and stabilized for a week before infusion.

Deuterium oxide (99.8%, Bio-RAD) was used as the tracer with 9 g of NaCl added per liter to provide a "physiological" infusate. The quantity infused was sufficient to give a 500- to 700-ppm D_2O concentration at time zero (t_o). This required 25 g for small calves (100 kg) and 125 g for finished cattle and cows. In practice, a 30-cm × 1.4-mm I.D. polyethylene catheter (PE200) was passed through a 12-gauge needle into the jugular vein of the animal restrained in a squeeze chute. A one-way stainless steel stopcock was attached to the catheter. All blood samples were placed in heparinized (to avoid clotting of blood to facilitate later transfer), dry polyethylene snap-cap tubes (12 cc). After collection of an initial (t_o) blood sample, preweighed (to .01 g) syringe(s) containing the desired dose of physiological D_2O were infused over a 30-second interval, and beginning and end-

ing times were recorded to the nearest .01 min. The catheter was immediately flushed with 50 ml of normal saline solution and capped. The catheter was flushed by withdrawing and discarding 30 ml of blood immediately before collecting the first sample and 10 ml before later samples were collected through the catheter. Samples were collected at t_0 and 20, 30, 40, 50, and 80 min, at 4-5 hr, following infusion, and on day 1, 2, and 3. Samples were placed in appropriate racks and frozen for subsequent analyses. The 80-min and later samples were collected via venapuncture. All animals were infused in the morning before feeding. Excess feed was removed from the feeder at 4 p.m. on the day preceding infusion to discourage excessive fill, but water was never restricted. After the 80-min sample was taken, the animal was returned to its pen and allowed access to feed and water. The animal was weighed at the start of the infusion and also when the 4- to 6-hr, and day-1, -2, and -3 samples were taken to arrive at an "average" live weight.

All samples were thawed, transferred to 100-ml volumetric flasks, lyophilized, and the collected water analyzed for D_2O via infrared spectrophotometry, using procedures described by Byers (2).

Following infusion and blood sample collection, cattle were transported to the TAMU Meat Sciences and Technology Center and were slaughtered; all tissues were collected and weighed. Ultrasound measures of shoulder, l2th rib, and rump fat were made immediately before slaughter. One half of each carcass was physically separated into bone and soft tissue. The soft tissue was ground through coarse and fine plates and subsampled; the carcass bone and head, feet, and tail were frozen and then ground through an Autio grinder at Colorado State University and then subsampled. A hide sample was collected and ground for analyses. Viscera (less digesta) and organ tissue were coarse ground and then fine ground and subsampled. All collected tissues were summed as empty body weight (EBWT). Samples of all components (blood, hide, head + tail + feet, viscera and organ tissue, carcass soft tissue, and carcass bone) were analyzed for moisture, protein (nitrogen), fat (ether extract), and ash. Empty body and carcass components were determined from percentage of composition and weight of each collected tissue fraction. Fill was measured as live weight at infusion minus slaughter weight plus weight loss on emptying the digestive tract. Moisture of digestive tract contents was determined on samples of contents removed.

Water kinetics were addressed in two ways. The standard curve-peeling process (3) was employed, and pools were adjusted for the difference in D_2O vs. H_2O density by dividing by 1.1044 to yield QAW and QBW. A simplified bi-exponential regression approach was also evaluated where QAE (QA early) and QTL (QT late) were derived as intercepts of the ln D_2O vs. time from 20 to 100 min or 4 hr to 48 hr divided into dose and by 1.1044 to adjust for D_2O vs. H_2O density. The pool reflecting digestive tract water was derived by subtracting empty body (QAE) from total (QTL) and was designated as QBD (QB by difference). The advantage of this system is that no curve peeling is required and that intercepts derived are less vulnerable to analytical sample

TABLE 1. RELATIONSHIPS OF D_2O VARIABLES TO CHEMICAL COMPONENTS IN CATTLE

Variable	Estimate	Intercept	Slope	R^2	SD	Component Mean	CV,%
Total body water	QTL	7.6	.954	.98	12.1	197.8	6.1
GI tract water	QBW	3.2	.667	.88	4.8	31.8	15.1
	QBD	3.9	.734	.86	6.1		19.2
GI tract fill	QBW	4.8	.782	.90	6.2	38.0	19.4
	QBD	5.6	.858	.90	6.4		20.3
Empty body water	QAE	4.83	.998	.98	10.9	166.0	6.6
	QAW	6.01	1.017	.97	12.9		7.8
Carcass water	QAE	.06	.669	.98	7.4	108.1	6.9
	QAW	.77	.682	.97	8.5		7.9
Empty body wt	(LWT-QBW fill est)	.543	.998	.98	6.16	282.4	2.2
Empty body protein	(QAE;Prot/H_20 eq)	−.087	.998	.98	2.83	46.9	6.0
Lean body mass	(QAE;H_2O/LBM eq)	.098	.997	.98	13.6	225.5	6.0
Empty body fat, kg (standard)	(EBWT-LBM)	8.86	.852	.88	14.0	56.9	24.6
, .%	Same/EBWT	.084	.563	.71	.0298	20.13	14.8
, .%	(QAE H_20 est)/EBWT	.621	−.7195	.74	.0281		14.0
, kg	(EBWT-QAE EBH_2O)	−6.87	.548	.92	11.1		19.5
Carcass wt	EBWT (D_20)	−5.56	.684	.993	8.1	187.6	4.3
Carcass LBM	EBLBM (D_20)	−5.19	.679	.982	9.9	148.3	6.7
Carcass protein, kg	EBProt (D_20)	−1.54	.675	.975	2.5	30.2	8.3
Carcass fat, kg	EBFat (D_20)	5.67	.598	.83	11.9	39.3	30.3
, kg	(EBWT-EBH_2O)	−5.39	.385	.87	10.3		26.2
, .%	(EBH_2O/EBWT)	.64	−.740	.65	.0352	21.0	16.8
, .%	EBFat, .%	.086	.586	.62	.0367		17.5

variance. Regression relationships of water pools to compartments initially included animal class and the interaction; class and interactions were not significant for water pools, and these terms were subsequently deleted from model runs.

Results and Discussion

The 50 cattle selected provided a uniform distribution of empty body water from 45 to 280 kg. The statistical analyses indicated no class by pool interactions, and the animals were, therefore, considered to be one population. As evident (Table 1), water pools derived from either the curve-peeling (QAW, QBW) or from the simpler bi-exponential approach (QAE, QTL, and QBD) were well related to respective empty body or digestive tract pools. Of interest is the way in which both QAW or QAE estimate carcass water; intercepts were near zero, and slopes (.68, .67) reflect expected ratios of carcass to empty body water. Empty body weight (EBWT) was estimated with minimal variance (2.2%) with similar (6%) coefficients of variation for empty body protein and lean body mass. The minimal intercepts and slopes of 1.0 for estimating empty body weight, protein, and lean body mass indicate that the derived relationships should be generally useful. Empty body fat, estimated in the standard (3) way as empty body weight minus lean body mass was related to actual fat (R^2 = .88) but was estimated with considerable variation (CV = 24.6%). Percentage relationships of EBWT-LBM and of QAE estimated EBH_2O to EBWT yielded better coefficients of variation (14.0%, 14.8%) with R^2's of .71 and .74.

On the basis of chemical component relationships, the ratio of protein to water increased, and water in lean body mass decreased. Quantity of water reflected age, weight, and maturity.

With QAE and QBW used for water pool estimates, body composition for the cattle in each class was predicted (Table 2). As is evident, mean values for empty body weight, water, protein, and lean body mass were predicted correctly for cattle in all classes. Values for 8, 9, or 10 of 10 cattle in each class were predicted with discrepancies of less than 10 percent between chemical and D_2O estimates. No discrepancies greater than 20 percent were observed for any animal in any class. These observations reflect the low coefficients of variation for these relationships (Table 1). However, fat was more variable with some classes over or under predicted by 8 to 13 percent.

Alternative systems that might provide a better means to predict fat were compared with the standard system of EBWT-LBM (Tables 3 and 4). Inclusion of ultrasound estimates of fat before slaughter was evaluated in models to predict fat. Ultrasound estimates of fat thickness over the shoulder (US1) and over the rump (US2) ranged from 2 to 58 and 1 to 68 mm and averaged 21 and 42 mm, respectively. Equations 2 and 4 (Table 3) estimating percentage fat yielded slightly lower R^2's (.78, .82) than did comparable weight equations 3 and 5, which had R^2's of

TABLE 2. AVERAGE BODY COMPOSITION VS. STANDARD D_2O DILUTION ESTIMATES BY CLASS OF CATTLE

	EBWT[2]		FILL[2]		EBH_2O[1]		LBM[1]		FAT[3]		PROTEIN[1]	
Class	Chem	Est	Chem	Est	Chem	Est	Chem	Est	Chem	Est	Chem	Est
All	282.6	282.6	38.0	38.0	166.0	165.9	225.7	225.7	56.9	56.9	46.9	46.9
Calves	83.2	80.8	14.8	17.2	55.5	55.9	74.1	74.1	9.1	6.7	14.6	14.8
Feeders	198.3	200.4	31.7	29.6	123.1	121.8	164.2	162.8	34.1	37.6	32.6	32.5
Yearlings	252.7	254.3	34.3	32.7	153.4	158.4	208.3	214.5	44.4	39.8	43.5	44.8
Fed cattle	439.2	433.9	40.8	46.1	244.0	246.9	335.5	338.7	103.7	95.2	71.5	72.1
Cows	439.7	443.8	68.3	64.2	253.8	246.6	346.5	338.3	93.2	105.5	72.2	70.5

[1]Estimated empty body water, protein, and lean body mass (LBM) from QAE to EBH_20 regression with ratios of protein/H_20 and H_20/LBM, from chemical relationships to H_20.

[2]Empty body weight estimated as live weight; fill from QBW equation.

[3]Fat estimated as empty body weight - lean body mass.

TABLE 3. ALTERNATIVES FOR ESTIMATING EMPTY BODY FAT

1) Standard system:
Kg fat = 8.86 + .852 (EBWT − LBM);
R^2 = .83, CV = 24.6%

2) As live wt X .% fat, where: .% fat = .4304 − .466 (QAE/LWT) − .682 (QBD/LWT) + .000157 LWT
R^2 = .78, CV = 15.6%

3) Kg fat = −10.29 + .586 (LWT) − .583 (QAE) − .693 (QBD)
R^2 = .93, CV = 19.8%

4) As LWT X .% fat, where: .% fat = .3708 − .361 (QAE/LWT) − .559 (QBD/LWT) + .0024 (US1) + .0012(US2)
R^2 = .82, CV = 14.0%

5) Kg fat = −12.45 + .408 (LWT) − .369 (QAE) − .451 (QBD) + .898 (US1) + .442 (US2)
R^2 = .95, CV = 15.4%

.93 and .95. However, coefficients of variation were lower for percentage equations, and they will probably provide more useful estimates of fat. Predicted quantities of fat are summarized in Table 3 as means for each animal class. As is evident, all alternative equations (2, 3, 4, 5) provided better estimates of fat for cattle in all classes than did equation 1. Choice of the best equation may depend on the class of animals; equations including ultrasound measurements provided better estimates for cows. With equations 2, 3, 4, or 5, over half of the animals across classes were predicted with deviations of less than 10 percent from chemical estimates, most of the remainder fell in the less-than-20-percent category. These equations avoid the additive errors resulting from successive prediction of protein, lean body mass, and empty body weight before predicting fat as in the standard equation form (eq. 1). In these equations, fat is predicted as the fraction of live weight not associated with QAE (i.e., EBH_2O) or QBD (i.e., digestive tract fill), but estimation of fat does not depend on accurate prediction of lean empty body or fill components per se.

The relationships of QAW to empty body water were similar in this study to those of Byers (3) over the range of animals included in that study. However, small calves were not included in that study, and because of the derived intercept (-17.92), that relationship has not been used for small animals. As expected, EBH_2O (Table 5) was underpredicted for these small calves. However, the 1979 equations yielded estimates of empty body weight, fill, water, protein, and lean body mass similar to chemical estimates for feeders, yearlings, fed cattle, and cows. Means for fat were similar for chemical and D_2O estimates for yearlings and for cows, and were lower for fed cattle and higher for feeder calves for D_2O vs. chemical estimates. Variance in fat with 1979 equations was similar to that observed with the standard equation form (eq. 1) in this study, as expected, because the calculation sequence is the same. Across all 50 cattle, correlations of D_2O estimates with 1979 equations (and standard water/lean body mass coefficients) to chemical composition were empty body weight (r = .999), GI water (r = .95), GI fill (r = .95), and empty body water (r = .99), protein (r = .99), lean body mass (r = .99), and fat (r = .83). Similar correlations between 1979 equation values and chemical composition pooled by class with 10 animals/class were .97, .84, .86, .73, .80, and .70 for empty body weight, GI water, GI fill, and empty body water, protein, and fat.

The body composition distribution indicated that estimates of EBWT, LBM, and protein in individual animals in the four classes included in the 1979 equation differed less than 10 percent from chemical analyses estimates in most animals; 7, 8, 9, or 10 of the 10 animals in each group predicted had discrepancies of less than 10 percent from the chemical analyses estimates. Minimal average group biases and similar overall means are evident for D_2O vs. chemical estimates for the four groups.

The young calves are obviously outside the range of the 1979 equation; this was a foregone conclusion because of the -17.92 intercept in the 1979 equation. The 1979

TABLE 4. ALTERNATIVE SYSTEMS FOR ESTIMATING EMPTY BODY FAT

		System				
	Chemical Composition	Standard	Alt. D_2O		Alt. D_2O with Ultrasound	
Class	Equations:	1	2	3	4	5
	Empty Body Fat, kg					
Calves	9.0	6.7	9.8	7.0	10.9	6.9
Feeders	34.0	37.6	33.6	36.6	33.3	35.3
Yearlings	44.0	39.8	43.4	46.2	44.3	47.9
Fed cattle	103.6	95.2	98.9	97.6	98.8	99.5
Cows	93.1	105.5	99.6	98.1	91.7	95.6

TABLE 5. BODY COMPOSITION ESTIMATED WITH 1979 EQUATIONS[1]

	EBWT		FILL		EBH_2O		LBM		FAT		PROTEIN	
Class	Chem	Est	Chem	Est	Chem	Est	Chem	Est	Chem	Est	Chem	Est
All	282.6	284	38.0	36.3	166.0	162.5	225.7	222.7	56.9	61.2	46.9	48.8
Calves	83.2	86	14.8	11.6	55.5	39.3	74.1	53.9	9.1	32	14.6	11.9
Feeders	198.3	203.4	31.7	26.3	123.1	112.7	164.2	154.5	34.1	49	32.6	34.0
Yearlings	252.7	256.8	34.3	30.1	153.4	154.5	208.3	211.8	44.4	45	43.5	46.6
Fed cattle	439.2	433.9	40.8	45.9	244.0	253.4	335.5	347.3	103.7	86	71.5	76.4
Cows	439.7	440.2	68.3	67.6	253.8	252.5	346.5	346.1	93.2	94	72.2	76.2
Mean-4 groups	332.5	333.5	43.6	42.5	193.6	193.3	263.6	264.9	68.9	68.5	55.0	58.3

[1]Byers, 1979b (3).

equations correctly predicted the mean values for all components in yearling cattle and cows — the groups for which the method has been commonly used.

The derived equations cover a wide range of cattle types and weights and should provide useful estimates of body composition in studies in which coefficients of variation of 2 percent, 7 percent, and 14 percent are acceptable for measurement of empty body weight, lean body components, and fat, respectively.

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PR-4474

Physical, Sensory, and Microbiological Characteristics of Fresh Vacuum-Packaged Beef Steaks Treated with an Acetylated Monoglyceride

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Summary

An acetylated monoglyceride (Dermatex ® Food Grade, or DFG) was applied to fresh, boneless loin steaks at a rate of 3 percent (W/W), on the basis of the net weight of the steaks. The steaks were vacuum packaged in barrier bags and stored for 7 weeks at 35 °F. Control and treated samples were compared weekly for physical, chemical, sensory, and microbiological characteristics. DFG treatment did not significantly alter vacuum and oxygenated lean color, surface discoloration, or overall appearance of loin steaks, but DFG did maintain a more desirable white fat color through 5 weeks of storage. The natural aroma of DFG caused a slight increase in off-odor scores owing to its acidic-sweet smell, but no apparent souring or putrefaction was noted over the 7-week storage period. A reduction in purge loss was observed after 4 weeks with DFG treatment, but its use did not affect pH of meat and purge, moisture content, or sensory characteristics. DFG use caused a wider distribution of microorganisms to occur on steaks initially and reduced the total number of lactic acid microorganisms on steak surfaces after 5 weeks of storage. At the end of 7 weeks of storage, the species of microflora on both the control and the DFG steaks were similar.

Introduction

Vacuum packaging of fresh-chilled beef primals or retail cuts greatly extends the shelf-life of the product (3, 4). Although increasing shelf-life dramatically, vacuum packaging produces undesirable traits such as increasing the amount of purge in the package and changing the meat color during storage. Trial studies have reported that an edible, acetylated monoglyceride (Dermatex® Food Grade, or DFG) coating applied to various lamb and beef cuts reduced purge, increased shelf-life, reduced discoloration, and served to protect against freezer burn (2, 5, 6, 8). Although not currently approved for use on fresh meat products, substantial benefit to the Texas cattle producer could be derived through the use of DFG by extending the shelf-life characteristics of vacuum-packaged beef cuts. This, in turn, would increase the export potential of fresh boneless beef, reduce product losses caused by shipping delays, and improve product yield, appearance, and value by decreasing purge. This study was initiated to determine the effects of Dermatex® as a protective, edible coating for fresh, vacuum-packaged steaks and to evaluate its potential for commercial application.

Materials and Methods

Vacuum-packaged boneless strip loins (IMPS #180) from USDA Choice carcasses were selected 48 hr after slaughter at a large commercial packing plant by Texas A&M University meat scientists and then shipped by

refrigerated carrier to the Meat Science and Technology Center, College Station. Sanitary precautions were taken when fabricating each loin, such as, the use of disposable gloves, fresh layers of wrapping paper on the tables, and a sterilized knife to avoid cross-contamination. After each loin was removed from the package, steaks were cut serially, 3/4 in. thick, beginning at the anterior end. Steaks were then assigned to either a 3 percent acetylated monoglyceride treatment or to a control group. Dermatex® was added to half the Cryovac® B- 620 vacuum packages at a rate of 3 percent (W/W) on the basis of the net weight of the steaks. All packages were then vacuumed and heat sealed, placed in corrugated cardboard boxes, and stored in a 35 °F cooler until evaluated. Three replications each of the control and treated loin steaks were randomly assigned to be evaluated after 0, 1, 2, 3, 4, 5, 6, and 7 weeks of storage. For evaluation, steak samples were removed from their cardboard boxes and placed in a retail display case. Each package was evaluated for vacuum-packaged lean color (8 = bright purple-red; 1 = extremely dark brown), 30-min oxygenated lean color (8 = bright cherry-red; 1 = extremely dark brown), surface discoloration (8 = no surface discoloration; 1 = total surface discoloration), fat color (8 = white; 1 = extremely dark brown or green), off-odor (5 = no off-odor; 1 = unacceptable off-odor), and overall appearance (8 = extremely desirable; 1 = extremely undesirable) by a trained, four-member panel. Purge loss from each cut was measured volumetrically, and pH was determined on both steaks and purge. Moisture content of each sample was determined by the air-dry oven technique (1).

Sensory tests were performed on steaks on the same day as the visual evaluations. Steaks were broiled on Farberware Open-Hearth broilers to an internal temperature of 158 °F and served warm to a trained 10-member taste panel. Each member independently evaluated each sample for juiciness (8 = extremely juicy; 1 = extremely dry), muscle fiber and overall tenderness (8 = extremely tender; 1 = extremely tough), connective tissue amount (8 = none; 1 = abundant), and overall flavor (8 = extremely flavorful; 1 = extremely unflavorful). Cooking times and percentage of cooking losses were recorded for all samples.

Microbial sampling was conducted on three control and three DFG-treated samples at each storage period by removing a 10-cm^2 (area 2 mm thick) from the surface of each steak with a sterile scalpel. Aerobic plate counts (APC) and APT counts were determined by plating 1.0- and 0.1-ml volumes of appropriate dilutions on prepoured plates of tryptic soy agar (TSA, Difco) and APT agar (Difco). A few of each of the colony types appearing on each countable plate were picked, placed on TSA slants, and incubated for 48 hr at 25 °C. Identity of these isolates was determined by biochemical tests and identification schemes previously described by Vanderzant and Nickelson (9). Diagnostic tests and classification schemes presented by Sharpe (7) were used to further describe the *Lactobacillus* isolates. The number of coliforms was determined by a pour-plate method containing violet red bile agar (VRB, Difco).

Data were analyzed by analysis of variance and using the general linear model program the statistical analysis system of the SAS Institute. Mean separation was accomplished with Duncan's multiple range test.

Results and Discussion

Steaks used in this study were representative of those considered to be microbiologically "clean" (counts of approximately 1000 bacteria/cm^2 or less) and of very high quality (bright purple red, absence of purge, white or light cream-colored fat, no off-odors).

Visual/Olfactory Evaluations

No significant differences in vacuum-packaged or oxygenated lean color were observed between treated and control loin steaks except at 4 weeks of storage (Table 1). Vacuum-packaged lean color of the control and treated steaks darkened progressively with storage time ($P < 0.05$ and were perceived as being slightly purple-red to purple-red after 7 weeks of storage. Oxygenated lean color was more variable but also tended to darken as storage progressed. No significant differences in surface discoloration were found between control and treated top loin steaks; likewise, no surface discoloration appeared over the 7-week storage period. Steaks treated with DFG possessed significantly lighter or whiter fat than did the controls, except after storage weeks 3, 6,

TABLE 1. MEAN VALUES OF SUBJECTIVE EVALUATIONS OF COLOR AND ODOR CHARACTERISTICS OF BONELESS, VACUUM-PACKAGED LOIN STEAKS TREATED WITH 3% DERMATEX® FOOD GRADE AND STORED AT 35°F

Storage Time	Lean Color (Vacuum)		Lean Color (Oxygenated)		Surface Discoloration		Fat Color		Overall Appearance		Off-Odor (Immediate)		Off-Odor (30 min)	
Week	C[e]	DFG[e]	C	DFG	C	DFG	C	DFG	C	DFG	C	DFG	C	DFG
0	7.00^{a}	7.00^{a}	5.50^{c}	5.50^{d}	7.00^{a}	7.00^{a}	5.25^{b*}	7.25^{a*}	6.75^{bc}	7.50^{a}	5.00^{a}	5.00^{a}	5.00^{a}	5.00^{a}
1	6.50^{a}	6.17^{abc}	6.50^{b}	7.17^{a}	7.00^{a}	7.00^{a}	4.17^{c*}	6.17^{bcd*}	6.00^{cd}	6.00^{cd}	5.00^{a*}	4.33^{b*}	5.00^{a*}	4.33^{abc}
2	6.67^{a}	6.38^{abc}	7.44^{a}	7.00^{ab}	6.67^{a}	6.75^{a}	5.78^{ab*}	6.63^{ab*}	6.22^{bcd}	7.00^{ab}	4.00^{b}	3.88^{bc}	4.56^{a*}	3.88^{bcd*}
3	6.43^{ab}	6.50^{ab}	6.50^{b}	6.56^{abc}	6.86^{a}	6.75^{a}	6.36^{a}	6.75^{ab}	6.93^{ab}	6.81^{abc}	4.64^{a}	4.31^{b}	4.57^{a}	4.56^{ab}
4	6.67^{a*}	5.20^{d*}	5.33^{c*}	6.80^{ab*}	7.00^{a}	7.00^{a}	5.00^{b*}	6.80^{ab*}	7.67^{a}	7.40^{a}	5.00^{a*}	4.40^{ab*}	5.00^{a*}	4.40^{ab*}
5	5.42^{c}	5.85^{bcd}	6.50^{b}	6.23^{bcd}	7.00^{a}	7.00^{a}	5.50^{b*}	6.46^{abc*}	5.92^{d}	6.31^{bcd}	4.50^{a*}	3.92^{bc*}	4.75^{a*}	4.00^{bcd*}
6	5.75^{bc}	5.50^{cd}	5.50^{c}	5.83^{cd}	6.75^{a}	6.67^{a}	5.50^{b}	5.50^{d}	5.58^{d}	5.67^{d}	3.42^{cd}	3.42^{cd}	3.83^{b}	3.58^{cd}
7	5.17^{d}	5.67^{bcd}	5.33^{c}	5.75^{cd}	7.00^{a}	7.00^{a}	5.17^{b}	5.75^{cd}	5.50^{d*}	6.25^{bcd*}	3.58^{bc*}	2.92^{d*}	3.67^{b}	3.25^{c}

[a,b,c,d]Means within the same column followed by a common superscript are not different (P>0.05).

*Means within the same row with an asterisk are different (P<0.05).

[e]Control; DFG = 3% Dermatex® Food Grade.

and 7, when they were equivalent in fat color. By the sixth week of storage, however, sufficient time had elapsed for partial enzymatic degradation of the DFG and subsequent release of purge to cause an equivalent amount of fat darkening. Overall appearance was not different between the control and the DFG-treated steaks except after 7 weeks of storage; overall appearance declined slightly for all steaks toward the end of the storage period. DFG treatment was perceived as having more immediate off-odor than the control after 1, 4, 5, and 7 weeks, and 30-min off-odor was greater on weeks 2, 4, and 5. Evaluators indicated, however, that the off-odor was not putrefactive in nature but rather the acidic-sweet aroma of the DFG material.

Physical/Chemical Determinations

DFG treatment, as shown in Table 2, significantly reduced purge loss in the vacuum package on storage weeks 4 and 6 and showed a definite trend toward purge reduction over the entire storage period. Determinations of meat pH were not different, except on weeks 1 and 5, and varied no more than 0.22 and 0.21 units, respectively, for the control and DFG treatment during storage. Purge pH and percentage of moisture were variable during storage and did not show a consistent trend.

Taste Panel Evaluation

No significant differences were observed between the control and DFG-treated steaks for juiciness, amount of connective tissue, and overall tenderness (Table 3). After 2 and 4 weeks storage, DFG steaks were rated as having greater muscle fiber tenderness, but the control was scored as being more flavorful. Overall, DFG did not affect sensory characteristics, and all steaks were acceptable after 7 weeks as determined by a trained, descriptive panel.

Microbiological Evaluation

During the first 4 weeks of storage, log aerobic plate counts (APC) and log APT counts (APT) of all steaks did not differ ($P > 0.05$) and were comparable to one another (Table 4). On weeks 5 and 7, APT counts on DFG steaks were significantly lower than the control and tended to be lower for week 6. None of the steaks were spoiled microbiologically after 7 weeks of storage, and the DFG treatment apparently tended to suppress microbial growth

TABLE 2. MEAN VALUES OF PURGE LOSS, PH DETERMINATIONS, AND PERCENTAGE MOISTURE OF BONELESS VACUUM-PACKAGED LOIN STEAKS TREATED WITH 3% DERMATEX® FOOD GRADE AND STORED AT 35°F

Storage Time	Ratio of Purge[d]		pH of Meat		pH of Purge		Percentage Moisture	
Week	C[e]	DFG	C	DFG	C	DFG	C	DFG
0	0^{c}	0^{c}	5.33^{a}	5.37^{ab}	—	—	67.21^{a}	67.21^{ab}
1	10.16^{b}	4.12^{abc}	5.37^{a*}	5.30^{bc*}	5.55^{ab*}	5.39^{ab*}	66.21^{a}	64.59^{b}
2	12.35^{b}	10.90^{a}	5.15^{a}	5.17^{d}	5.25^{c}	5.36^{b}	66.75^{a*}	69.78^{a*}
3	11.36^{b}	6.95^{abc}	5.32^{b}	5.29^{c}	5.46^{ab}	5.41^{ab}	66.07^{a}	66.48^{ab}
4	13.60^{b*}	1.16^{bc*}	5.40^{a}	5.35^{abc}	5.44^{b}	5.61^{a}	66.07^{a}	64.99^{b}
5	10.12^{b}	4.87^{abc}	5.36^{a*}	5.29^{c*}	5.53^{ab}	5.42^{ab}	65.39^{a}	67.37^{ab}
6	16.01^{ab*}	7.63^{ab*}	5.33^{a}	5.38^{a}	5.53^{ab}	5.31^{b}	66.81^{a}	63.93^{b}
7	25.01^{a}	11.19^{a}	5.41^{a}	5.35^{abc}	5.58^{a}	5.55^{ab}	68.96^{a}	66.66^{ab}

[a,b,c]Means within the same column followed by a common superscript are not different (P>0.05).

*Means within the same row with an asterisk are different (P<0.05).

[d]ml of purge/kg of steak.

[e]C = control; DFG = 3% Dermatex® Food Grade.

TABLE 3. MEAN VALUES OF SENSORY CHARACTERISTICS OF BONELESS, VACUUM-PACKAGED LOIN STEAKS TREATED WITH 3% DERMATEX® FOOD GRADE AND STORED AT 35°F

	Sensory Characteristics									
Storage	Juiciness		Muscle Fiber Tenderness		Connective Tissue Amount		Overall Tenderness		Overall Flavor	
Week	C[d]	DFG[d]	C	DFG	C	DFG	C	DFG	C	DFG
0	6.23^{abc}	6.47^{a}	6.17^{b}	6.37^{c}	6.70^{a}	6.43^{a}	5.90^{b}	6.13^{b}	6.23^{ab}	6.17^{a}
1	6.67^{ab}	6.43^{a}	6.77^{ab}	6.53^{bc}	6.70^{a}	6.97^{a}	6.60^{ab}	6.57^{ab}	6.13^{ab}	6.27^{a}
2	6.20^{abc}	6.30^{a}	7.07^{a*}	6.83^{abc*}	6.93^{a}	7.00^{a}	7.00^{a}	6.77^{ab}	6.40^{ab}	6.50^{a}
3	5.80^{bc}	6.00^{a}	7.03^{a}	7.27^{ab}	6.53^{a}	7.10^{a}	6.67^{ab}	7.07^{ab}	6.13^{ab}	6.37^{a}
4	6.13^{abc}	6.93^{a}	7.00^{a*}	7.43^{a*}	7.07^{a}	6.83^{a}	6.83^{a}	7.20^{a}	6.33^{ab*}	6.10^{a*}
5	7.03^{a}	6.77^{a}	7.27^{a}	7.17^{ab}	6.77^{a}	6.73^{a}	7.00^{a}	6.90^{ab}	6.73^{a}	6.43^{a}
6	5.97^{abc}	6.67^{a}	6.67^{ab}	7.33^{ab}	6.63^{a}	6.73^{a}	6.50^{ab}	6.93^{ab}	6.13^{ab}	6.23^{a}
7	5.33^{c}	6.10^{a}	6.30^{b}	6.97^{abc}	6.97^{a}	6.37^{a}	6.33^{ab}	6.77^{ab}	5.70^{b}	5.60^{b}

[a,b,c]Means within the same column followed by a common superscript are not different (P>0.05).

*Means within the same row with an asterisk are different (P<0.05).

[d]C = control; DFG = 3% Dermatex® Food Grade.

during the last 3 weeks of the storage period. On week 3, more coliforms were found on the control than on the DFG-treated steaks; however, at week 4 the opposite was true.

The low percentage of lactic acid bacteria (TSA and APT agar) initially present on the vacuum-packaged steaks (Table 5) indicates that the wholesale cuts were not aged (in vacuum) but were received in fresh condition. However, after 1 week of storage at 35 °F, the lactic acid bacteria were the predominant microflora and remained so over the entire storage period.

At 0 week (Table 6), the initial microflora of control steaks on TSA consisted of *Flavobacterium* (75%) and *Moraxella* (25%), and those on APT were *Staphylococcus* (83.3%) and *Acinetobacter* (16.7%). The initial microflora on DFG-treated steaks at 0 week were *Acinetobacter* (35.3%), *Flavobacterium* (17.6%), coryneform bacteria (17.6%), *Moraxella* (11.8%), *Pseudomonas* (5.9%), *Bacillus* (5.9%), and *Micrococcus* (5.9%). Microorganisms isolated from APT plates were *Moraxella* (50.0%), coryneform bacteria (33.3%), and *Flavobacterium* (16.7%). Although the counts on APC and APT agar were initially similar, the species of microorganism making up these counts were more diverse for the 3 percent DFG treatment. As shown in Table 4, the counts on APC and APT agar tended to be lower for the steaks treated with DFG and stored 7 weeks, but the species of microflora on all steaks after 7 weeks were similar and consisted primarily of *Lactobacillus cellobiosus*.

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TABLE 4. MEANS OF LOG PLATE COUNTS ON VACUUM-PACKAGED LOIN STEAKS TREATED WITH 3% DERMATEX® FOOD GRADE AND STORED AT 35°F

	Enumeration of Microorganisms (Log Counts/cm² Tissue)					
	TSA[f] (Aerobic Plate Count)		APT (Heterofermentative Lactic Acid Bacteria)		VRB (Coliforms)	
Storage Week	C[g]	DFG[g]	C	DFG	C	DFG
0	1.17[d]	1.27[b]	1.07[e]	1.06[b]	<1.00[b]	<1.00[b]
1	1.94[d]	2.37[b]	2.17[d]	2.35[b]	<1.00[b]	<1.00[b]
2	4.35[c]	4.40[a]	4.44[c]	4.53[a]	<1.00[b]	<1.00[b]
3	5.11[bc]	4.03[a]	5.37[b]	4.19[a]	1.75[b*]	<1.00[b*]
4	4.29[c]	5.01[a]	4.25[c]	5.05[a]	1.99[b*]	3.61[a*]
5	5.94[ab*]	5.41[a*]	5.92[ab*]	5.42[a*]	4.83[a]	3.32[a]
6	6.20[a]	5.01[a]	6.21[ab]	4.93[a]	4.21[a]	3.31[a]
7	6.62[a]	4.65[a]	6.55[a*]	4.68[a*]	3.82[a]	1.38[b]

[a,b,c,d,e]Means within the same column followed by a common superscript are not different (P>0.05).
Means within the same row with an asterisk are different (P<0.05).
[f] TSA = tryptic soy agar; APT = APT agar; VRB = violet red bile agar.
[g]C = control; DFG = Dermatex® Food Grade.

TABLE 5. PERCENTAGE OF LACTIC ACID BACTERIA AND OXIDASE POSITIVE BACTERIA ON VACUUM-PACKAGED LOIN STEAKS TREATED WITH 3% DERMATEX® FOOD GRADE AND STORED AT 35°F

	% Lactic Acid Bacteria				% Oxidase + Bacteria			
Storage	TSA[a]		APT[a]		TSA		APT	
Week	C[b]	DFG[b]	C	DFG	C	DFG	C	DFG
0	<1%	<1%	<1%	<1%	50.00[c]	11.77	0	22.23
1	92.87	67.13	100.00	94.83	0	0.63	0	1.87
2	99.73	97.53	99.17	99.67	0.17	0	0	0
3	99.17	98.10	99.83	98.37	0	0	0	0
4	82.40	86.13	88.80	78.93	0	0	0	0
5	83.93	83.33	76.67	82.40	0	0	0	0
6	88.97	67.60	88.63	68.37	0	0	0.77	0
7	88.13	99.87	88.73	97.87	0	0	0	0

[a]TSA = tryptic soy agar; APT = APT agar.
[b]C = control; DFG = Dermatex® Food Grade.
[c]Average of two replications due to laboratory accident.

TABLE 6. DISTRIBUTION OF MICROBIAL FLORA ON VACUUM-PACKAGED LOIN STEAKS TREATED WITH 3% DERMATEX® FOOD GRADE AND STORED AT 35°F

Storage Time Week	Media	Percentage Distribution of Microflora[a]										
		L.cel	L.plant	H.alvei	Mic.	Cor.	Bac.	Staph-	Mor.	Aci.	Flav.	Ps.
						Control						
0	TSA[b]	—	—	—	—	—	—	—	25.0	—	75.0	—
	APT	—	—	—	—	—	—	83.3	—	16.7	—	—
7	TSA	88.1	—	11.9	—	—	—	—	—	—	—	—
	APT	88.7	—	11.3	—	—	—	—	—	—	—	—
						3% DFG						
0	TSA[c]	—	—	—	5.9	17.6	5.9	—	11.8	35.3	17.6	5.9
	APT[c]	—	—	—	—	33.3	—	—	50.0	—	16.7	—
7	TSA	99.9	—	0.1	—	—	—	—	—	—	—	—
	APT	89.8	8.0	2.1	—	—	—	—	—	—	—	—

[a]L. cel = *Lactobacillus cellobiosus*, L. plant = *Lactobacillus plantarum*, H. alvei = *Hafnia alvei*, Mic = *Micrococcus*, Cor = Coryneform bacteria, Bac = *Bacillus*, Staph- = *Staphylococcus* coagulase neg., Mor = *Moraxella*, Aci = *Acinetobacter*, Flav = *Flavobacterium*, Ps = *Pseudomonas*.

[b]Based on average of two replications due to laboratory accident.

[c]Based on one replication due to microbial count below level of detection.

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Evaluation of "Bone" in Different Types of Cattle

D.K. Lunt, G.C. Smith, and C.E. Richmond

Visual appraisal of beef cattle often includes an estimation of "bone." Studies have indicated that a positive correlation exists between weight of bone and weight of lean tissue in a carcass, but these correlations are generally low. Cattle that have "heavy bone" are purported by some to gain faster and to have "more desirable" carcasses. The cannon bone has long been used by livestock judges as an indicator of the bone structure of the entire animal. Research findings have been varied regarding the usefulness of visual assisments of the cannon bone in such estimates. Research results have also varied on the usefulness of objective measurements of the size of the cannon bone for estimating the weight of carcass bone.

The present study was undertaken to determine which physical measurements of the cannon bone would be most useful for estimating total weight of the skeleton in carcasses from beef steers of different biological types. Cannon bones from 75 Angus, Brahman, and Brahman x Angus crossbred steers were measured for length, width, circumference, and weight. Carcasses from these same animals were physically separated into fat, lean, and bone. Steers of the three breed types had similar USDA quality and yield grades. When carcass weight and weight of separable fat in the carcass were held constant, cannon bones from Brahman cattle were longer than those of Angus and crossbreds; the crossbreds also had longer cannon bones than did Angus steers. Brahman steers also had heavier cannon bones than did Angus steers; whereas Angus steers had wider cannon bones than did the other two breed types. When width, circumference, and length of cannon bone were used in prediction equations to estimate total weight of bone in the carcass, these three measurements differed in relative importance among the three breed types. Width was most important in Angus steers; length was most important in Brahman steers, and circumference was most important in crossbreds. These data suggest that evaluation of the size of cannon bones might be useful as an indicator of weight of carcass bone but that among cattle such as Brahman, which have longer legs in relation to their body, size of cannon bone should be appraised differently than for other breeds. Length of leg (or height) seems to be a better indication of weight of carcass bone in Brahman cattle than does the traditional focal point, circumference of the shaft of the cannon bone.

Feeding and Nutrition

PR-4476

The Texas Cattle-Feeding Industry–Operations, Management, and Costs

R. A. Dietrich, P. J. Thomas, and D. E. Farris

Summary

The Texas cattle-feeding industry is composed primarily of large-scale, highly efficient feeding operations located predominantly in the Panhandle-Plains area, where more than 85 percent of the Texas cattle are fed annually. Feedlots with 16,000 head or more capacity, which accounted for almost 80 percent of the cattle marketed from Texas feedlots in 1981, generally enjoyed a cost advantage over smaller size feedlot operations. Fixed investment per head of capacity in 1980-81 varied from $133 for lots with less than 2,000 head capacity to $63 for lots with 50,000 head or more capacity. Most of the advantage of larger feedlots was in lower fixed costs, as there was no clear relation in size and variable costs. The Texas cattle-feeding industry, currently the largest in the United States, is a high-risk industry, dependent upon skilled management for dealing with rapidly changing economic conditions and the competitive nature of cattle feeding.

Introduction

The Texas cattle-feeding industry is characterized by large-scale, highly specialized and mechanized commercial feedlot operations that feed cattle primarily on a custom basis. Various sizes and types of feedlots are, however, dispersed throughout the state. The growth and development of the Texas feeding industry occurred primarily in the 1960's and 1970's (3, 6). The rapid growth of the Texas feeding industry, however, has not been without problems. The changing economic environment resulted in prolonged periods of unpredictable and often negative profit margins for cattle feeders during much of the 1970's and early 1980's (1). The net results were that some feedlot firms closed operations, some declared bankruptcy, and some either merged with existing feedlot firms or were acquired by allied agricultural interests.

Procedure

The purpose of this study (5) was to analyze the rapidly changing Texas cattle-feeding industry relative to (a) the structure of the industry, (b) the feeding and management practices employed, (c) the marketing practices, and (d) the costs and economies of size of feedlot operations. A secondary purpose was to update two earlier studies concerning the structure and operational characteristics of Texas feedlots (3) and costs and economies of size in Texas feedlot operations (4).

Data for this study were obtained through personal interviews of Texas feedlot firms concerning feedlot operations during June 1980 to July 1981. Respondents in this study were selected on a stratified random sample basis by feedlot size and feeding area. Details concerning the sampling procedure are in Dietrich et al. (5). Feedlots sampled accounted for more than 45 percent of the cattle fed in their respective feeding area and for almost 55 percent of the total cattle fed in Texas during 1980-81.

Results

Feedlots with less than 16,000-head capacity were generally at a disadvantage when competing with larger feedlots with respect to annual fixed costs per pound of gain. The largest decrease in annual fixed costs per pound of gain occurred as feedlot size increased from less than 1,000-head capacity to 4,000-head capacity. Results revealed generally more variability in costs among smaller feedlots compared with larger lots, and a few smaller feedlots exhibited cost structures similar to larger feedlots.

Total capital investment in equipment and facilities averaged about $75 per head of capacity. Total capital investments decreased from $133 per head of capacity for the smallest size feedlots to $63 for the largest size group. The major items of capital investments were milling equipment, pens, and associated equipment. Other major items of capital investment were land, feed, storage, facilities, and feed-distribution equipment.

Variable costs composed more that 95 percent of the total feeding costs, and annual fixed costs accounted for the rest. Feed accounted for 78 percent of the variable costs, followed by interest costs of 15 percent. Interest and depreciation accounted for more than three-fourths of the total annual fixed costs. There was no clear trend in variable costs among size groups. The Gulf Coast–Rio Grande Plains had the lowest variable costs per pound of gain because they fed lighter weight cattle (primarily heifers) to grade mostly U.S. Good compared with Panhandle-Plains feedlots, which finished cattle at heavier weights to grade primarily U.S. Choice.

Panhandle-Plains feedlots accounted for 85 percent of the 4.3 million head of cattle placed on feed in Texas feedlots from July 1980 through June 1981 (Figure 1). Almost all the remaining 15 percent were fed in Gulf Coast–Rio Grande Plains and Plateau-Pecos feedlots. Steers composed 57 percent of the Texas placements, and heifers accounted for nearly all the remaining 43 percent. Steers composed approximately two-thirds of the Panhandle-Plains placements, whereas heifers ac-

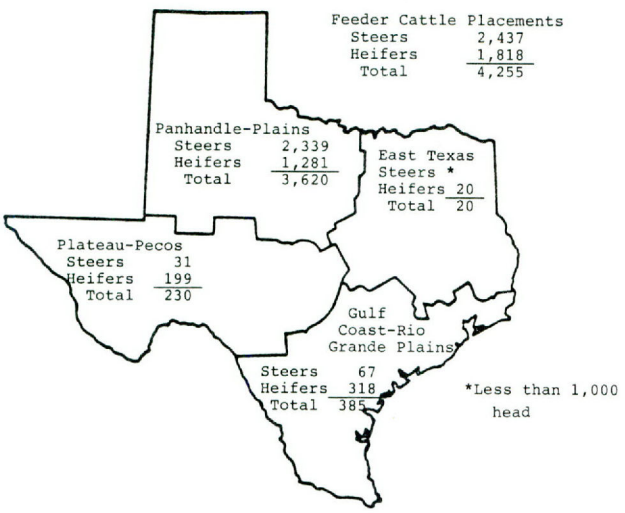

Figure 1. Cattle placed on feed (1,000 head), by sex and feeding area, Texas, June 1980-July 1981.

counted for 82 percent or more of the placements in all other feeding areas of Texas. Even though heifers represented only one-third of the Panhandle-Plains placements, they composed more than 70 percent of the heifer placements in Texas (Figure 1). Steer placements in Panhandle-Plains feedlots accounted for 96 percent of the steers fed in Texas during 1980-81.

Almost three-fourths of the cattle were fed on a custom basis during 1980-81. Custom clients not affiliated with feedlots owned two-thirds of the custom-fed cattle, and members of the feedlot company or corporation owned the remaining custom cattle. Ranchers owned over 55 percent of the custom-fed cattle.

More than 60 percent of the cattle placed on feed in Texas feedlots originated from sources within Texas. Feedlots tended to reach out further for feeder-cattle supplies as well as rely on a larger number of geographic sources as feedlot size increased. Weights of cattle placed on feed were influenced largely by geographic location and sex of cattle. Steer placement weights by Panhandle-Plains feedlots ranged mostly from 400 to 699 lb. Placement weights in the Gulf Coast–Rio Grande Plains and Plateau-Pecos areas, which fed predominantly heifers, ranged mostly from 300 to 599 lb.

Days on feed tended to vary more by feeding area than by size of feedlots. This is partly related to the relative lower cost of feed in the Plains. Steers were fed an average of 149 days and heifers 142 days during 1980-81. Feedlots in the Gulf Coast–Rio Grande Plains area generally fed cattle (predominantly heifers) an average of 10 to 15 fewer days than did Panhandle-Plains feedlots.

English breeds and English crosses represented more than 50 percent of the cattle placed on feed. Brahman and Brahman crosses accounted for another one-third of the placements, followed by exotic European crosses representing about 7 percent. As the Texas cattle-feeding industry has matured, it has become more like the cattle-feeding areas north of the Panhandle-Plains in terms of market weights and days on feed. In 1966-67, more than 40 percent of the cattle fed in Texas feedlots were marketed at less than 800 lb compared with 14 percent in 1980-81. During 1980-81, market weights of steers averaged almost 1,050 lb, and heifers averaged about 865 lb.

Almost 70 percent of the fed steers marketed from Texas feedlots graded U.S. Choice or higher compared with 50 percent for fed heifers. Fed cattle marketed from Panhandle-Plains feedlots were predominantly U.S. Choice or higher, in contrast to Gulf Coast–Rio Grande Plains feedlots, where more than two-thirds of the fed cattle were estimated to grade U.S. Good.

More than 90 percent of the fed cattle were sold to packers within Texas during 1980-81, in contrast to 1966-67, when about one-half of the fed cattle were sold to out-of-state slaughter plants.

Because of competitive and locational advantages, the Texas cattle-feeding industry is concentrated predominantly in the Panhandle-Plains area and will likely become more concentrated in that area in the future. Major contributing factors to the increased concentration of cattle feeding in the Panhandle-Plains area compared with other areas in Texas include economies of size in feedlot operations, proximity to feed-grain supplies and large beef-slaughter plants, favorable climate, and locational advantage with respect to shipping beef to southern and western markets (2).

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Feeding Frequency and Variation in Supplement and Forage Intake in Cows Grazing Dormant Native Rangeland

J. E. Huston, F. M. Byers, D. Cooper, and L. M. Schake

Summary

Adult Hereford cows grazing on dormant winter rangeland were either unfed or fed a concentrate at the same average daily equivalent but at three frequencies (daily, three times per week, or weekly). Response measurements included weight change, supplement intake, and forage intake. Feeding a supplement that provided an average of 300 g crude protein and 2.7 Mcal digestible energy daily equivalent increased weight gain between fall and midwinter (precalving), but gain was not affected by feeding frequency. The weight advantage in the fed groups did not continue after calving, and at the end of the feeding period (spring), differences between the groups were not detectable. Cows fed weekly (seven times the daily feed rate per feeding) were less variable in supplement intake compared with cows fed either daily or three times per week. However, the effect of supplement on forage intake was more variable for the cows fed weekly compared with the cows fed daily. Variations within the three-times-weekly group were generally intermediate. Average forage intake was not significantly affected by either feeding or frequency of feeding. Supplement fed either daily or weekly increased the total digestible dry matter intake compared with the control group. Regression relationships between supplement intake and forage intake indicated that level of supplement intake affected forage intake differently at different feeding frequencies.

Introduction

Cow herds grazing West Texas ranges usually require supplemental nutrients during late fall and winter (1). Studies have reported little if any average effect on production whether cows are fed daily or two or three times per week (5). This study was designed to determine the effects of supplemental feed and of feeding frequency on the feeding behavior of individual cows grazing dormant range vegetation.

Experimental Procedure

Sixty-eight Hereford cows (ages 5 to 10 yr) bred to Brangus bulls were divided into four treatment groups to equalize average age, weight, and body condition among the groups. The cattle grazed on native pastures of approximately equal size from December 11 to April 24 (134 days). Forage dry matter in each pasture was in surplus, but average quality was below the animals' requirements. The cows were weighed at the beginning of the treatment period, at midwinter (January 30), and at the end of the study. Calving occurred between January 24 and April 21. Supplemental feed was bulk-fed to groups 2, 3, and 4 at the same average daily-feeding level, but feeding frequencies were daily, three times per week, and one time per week, respectively (Table 1). Group 1 had access to a high-phosphorus mineral concentrate but received no additional supplemental feed.

Estimation of Forage and Supplement Intake

Intake was estimated from total fecal output determined by the pulse-dose method (2) during a 5-day period (January 30 to February 3). Supplement intake was estimated by use of a second indigestible marker (chromic oxide) incorporated into the supplemental feed. A marked supplemental feed was prepared by mixing chromic oxide with the premixed concentrate at 2 percent. Feeding of the marked feed began on January 21 for the daily and the three-times groups and continued throughout the predosing and collection periods. The one-time group was first fed the marked feed on January 23. Chromic oxide concentration was determined in all fecal samples from the cows in the fed groups (4). Chromic oxide concentration in the feces was multiplied by total fecal output determined by the pulse-dose of ytterbium to determine total chromic oxide excretion for each individual. Supplement intake was estimated by determining the fraction of the total fed marker that was excreted by the individual and by multiplying this factor to the allocated feed. Actual concentration for the different groups and sampling times was irrelevant to the study because of differences in feeding frequency. Therefore, only one sampling time (January 31 sample) was selected for determination of supplement intake as all groups received the marked feed on January 30. Forage fecal output was calculated by subtracting the contribution of undigested supplemental feed to the feces. Forage intake was estimated by assuming that fecal output arising from forage

TABLE 1. SUPPLEMENTAL FEED AND FEEDING LEVELS IN A STUDY OF FEEDING FREQUENCY IN RANGE COWS

Supplemental feed	
Ingredients:	% air dry
Sorghum grain	23
Cottonseed meal	72
Cane molasses	2.5
Salt	1.5
Mono-dicalcium phosphate	1
Vitamin A acetate[a]	

	Groups			
	1	2	3	4
Feeding frequencies and levels[b]:				
Feeding frequency	0	daily	3/wk	1/wk
Feed/cow/feeding, lb	0	2	4.7	14
Nutrients supplied per feeding[b]:				
Crude protein, lb	0	.67	1.5	4.63
Digestible energy, Mcal	0	2.7	6.3	18.9
Phosphorus, g	0	9	21	63
Vitamin A, 1000 IU	0	24	56	170

[a]Added 26,500 IU/kg.

[b]Group 1 had free access to a high-phosphorus, high-vitamin-A concentrate for the duration of the study.

consumption represented 60 percent by weight of consumed forage (forage digestibility = 40%).

Statistical Analysis

The data were analyzed by analysis of variance for treatment effects. Data found to be significantly different were subjected to the Studentized Range Test for mean separation. Linear regression equations were calculated for the effect of supplement intake on forage intake (7).

Results and Discussion

Weight changes were detectably different only during the first half of the experimental period (Table 2). Cows receiving supplemental feed gained more weight before calving than did control cows ($P < .10$), but no effect of feeding frequency was observed. The relatively small weight loss (12.1% of fall weight) of the control group for the entire period was less than would be expected in unfed cows, indicating mild winter conditions. Weight changes for the entire period were not different among treatment groups ($P < .10$).

Intake estimates indicate that cows fed once per week varied less in supplement intake than did those fed more often, but this reduced variability does not carry through to forage, total dry matter, and digestible dry matter intake (Table 3). Both the daily fed and three-feedings-per-week groups showed the "boss cow - timid cow" pattern, as indicated by the range and CV in supplement intake. The variation was greatly reduced in the weekly fed group. Supplementation, regardless of frequency, had no detectable effect on forage intake. The daily fed group had the greater dry matter intake and both the daily fed and the weekly fed groups had greater digestible dry matter intake than did the control cows. Whereas, cows fed supplement daily had a high variation in supplement intake, they displayed the lowest variation in forage intake, which led to less variable total dry matter and digestible dry matter intakes. Supplemental feeding of beef cows has reportedly stimulated forage intake under some circumstances (3) and substituted for forage under others (6). The strong relationship between supplement intake and forage consumption in the daily fed cows in this study (Table 4) indicates that protein was limiting and that cows were stimulated to consume more forage with increased supplement. In this case, the y intercept was very near the intake of the control cows (106.4 and 107.4 g/kg MW, Tables 4 and 3, respectively). Surprisingly, the regression equation for the infrequently fed cows suggested that at low levels of supplement intake, forage consumption would be reduced, but with increasing supplement intake, forage intake would be strongly increased. These relationships were much more variable, as would be expected with the more tightly grouped levels of supplement intake compared with the daily fed cows. Supplement feeding may have increased fecal output by decreasing digestibility of forage in addition to or instead of increasing intake. If this occurred, one could conclude from the increased regression coefficient that the effect was greater and more variable in infrequently fed cows. However, the average weight changes were reasonably consistent with the estimated average increases in total digestible dry matter intake. Increased variability may be associated with variable effects of momentary, high intakes of supplement on both intake and digestibility in the infrequently fed groups.

TABLE 2. EFFECTS OF FEEDING FREQUENCY ON WEIGHT CHANGES IN MATURE COWS GRAZING DORMANT RANGE VEGETATION

	Feeding Frequency			
Item	Control	Daily	3-times weekly	1-time weekly
Number of cows	9	5	11	6
Cow wt, lb[a]				
Fall	1042	985	1057	1093
Winter	1055	1029	1101	1148
Spring	916	870	965	989
Cow wt change, lb				
Fall to winter	13[b]	44[c]	44[c]	55[c]
Winter to spring	−139	−159	−136	−159
Fall to spring	−126	−115	−92	−104

[a]Weights were taken on Dec. 11, Jan. 30, and Apr. 24. Calving occurred between winter and spring weighing dates.

[bc]Values in the same row that do not share a common superscript differ ($P < .10$).

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TABLE 3. EFFECTS OF FEEDING FREQUENCY ON INTAKE (DMI) IN COWS GRAZING DORMANT RANGE VEGETATION

	Feeding Frequency			
Parameter	Control	Daily	3-times	Weekly
Supplement intake, g/kg$^{.75}$				
Ave		8.4	7.8	7.8
Range				
Low		4.8	2.5	5.7
High		14.5	15.5	9.3
Forage DMI, g/kg$^{.75}$	107.4	122.7	111.1	117
Total DMI, g/kg$^{.75}$	107.4[a]	131.1[b]	119[ab]	124.8[ab]
Digestible DMI, g/kg$^{.75}$	43[a]	54.8[b]	49.9[ab]	52.2[b]
Variation in intake, CV[c]				
Supplement		44	41	19
Forage	18	9	19	23
Dry matter	18	12	22	24
Digestible dry matter	17	11	19	19

[ab]Values in the same row that do not share a common superscript differ ($P < .10$).

[c]Coefficient of variation.

TABLE 4. REGRESSION OF SUPPLEMENT INTAKE (X) ON FORAGE INTAKE (Y) IN COWS FED SUPPLEMENT EITHER DAILY, THREE TIMES PER WEEK, OR ONE TIME PER WEEK

Group	Equation	R^2
2—daily	y = 106.4 + 1.96x	.62
3—three times	y = 76.9 + 4.31x	.50
4—weekly	y = 56 + 7.79x	.24

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Grass Tetany in Beef Cattle: A Review

L. W. Greene

Hypomagnesemic tetany (grass tetany) is characterized by low serum magnesium concentrations in mature cows. Normal serum magnesium concentrations range from 1.7 to 3.2 mg/dl, but cattle showing clinical signs of grass tetany generally have concentrations of serum magnesium ranging from .5 to 1.5 mg/dl. Additionally, cattle with clinical symptoms of grass tetany are often hypocalcemic. Low calcium levels are also thought to contribute to the onset of tetanigenic symptoms. Grass tetany generally occurs during the spring-grazing period shortly after calving. High dietary concentrations of potassium decrease the availability of magnesium in spring forages, thereby increasing cattle's susceptibility to grass tetany. Research in our laboratory indicates that magnesium absorption is increased when an ionophore is fed. Additionally, increasing magnesium intake during calving can help guard against this malady. This disease is the major cause of cow deaths in the U.S. and affects approximately 1 percent of the cow population annually. The prevention of grass tetany will require a combination of management practices that will alter nutrient-magnesium interactions in the digestive tract as well as increase the level of magnesium intake and absorption.

Literature Review

Grass tetany is most often reported in beef cows grazing lush spring forages, especially small-grain and cool-season perennials. The disease is most commonly observed shortly after parturition and often affects the highest producing cows in a herd. Several factors may contribute to the increased incidence of tetany in cows during this season. For example, the magnesium requirement of cows approximately doubles from late gestation to early lactation (15, 16). This rapid change in the magnesium requirement at the onset of lactation can rapidly reduce available magnesium stores, thereby causing a metabolic deficiency of this mineral. Additionally, lush growing spring forages contain components that lower the availability of magnesium. It has been reported that the increased organic acid concentrations in lush growing forages contribute to the onset of tetany through a decrease in magnesium availability. Heavy applications of nitrogen and potassium fertilizers to maximize forage yield also have an unfavorable influence on the availability of forage magnesium. High-potassium fertilization lowers the magnesium and sodium content and increases the potassium content of the forage (8). High levels of dietary potassium will decrease the absorption of magnesium from the digestive tract (6, 14). Actively growing winter and spring forages are commonly high in potassium; they may contain as much as 5.0 percent of the dry matter as potassium. Greene et al. (6) indicated that a linear decrease in preintestinal magnesium absorption occurred in lambs with increasing dietary concentrations of potassium.

Grass tetany is generally considered to be the leading cause of cow deaths in the United States. Our laboratory (3) reported that during a 4-yr period (February 1980 to February 1984) at the McGregor Center of the Texas Agricultural Experiment Station (80 miles southwest of Dallas), 1.1 percent of the cows were diagnosed as having grass tetany annually. Approximately 94 percent of the reported cases of grass tetany occurred from December to March, which corresponds to the period that cattle are generally grazing small-grain forages. The annual incidence of grass tetany in cows of Angus, Brahman, Hereford, Holstein, and Jersey breeding in this herd was 1.7, .6, 1.1, .7, and 1.0 percent, respectively. The incidence of tetany in Angus was significantly higher and in Brahman was significantly lower than the herd mean. Additionally, the apparent magnesium digestibility in Angus-Hereford and Hereford cattle was lower than that of cattle with Brahman breeding (18). It appears that the relatively low incidence of grass tetany in Brahman and Brahman-cross cattle may be the result of their capability to maintain a higher availability of magnesium compared with other beef and dairy breeds.

Cattle with clinical symptoms of grass tetany are often hypocalcemic (1, 10). Low serum calcium concentrations are believed to contribute to the onset of tetanigenic symptoms. Clinical observations of cows at the McGregor Research Center during the 1986 winter grazing period indicate that grass tetany can occur if serum magnesium and/or calcium is low. Calcium was below normal in all cows sampled, and magnesium was extremely low in three of the five cows sampled. Average serum magnesium and calcium concentrations in cows of this herd during February and March of 1984, while grazing oat pastures, were 1.7 and 7.8 mg/dl. Both serum magnesium and calcium concentrations were below normal in these cattle during this period.

Several management practices have been used to control the incidence of grass tetany in cattle grazing spring forages, but with limited success. Grass tetany can be

controlled in cattle grazing winter pastures if the negative effects of nutrient interactions can be overcome and/or if additional magnesium is supplied to the digestive tract. Feeding 20 to 30 grams of magnesium per day will generally protect animals from a magnesium deficiency. The incorporation of magnesium oxide into free-choice mineral supplements during the tetany-prone season is commonly recommended to increase magnesium intake. However, magnesium sources are not very palatable and thus pose a potential intake problem when offered ad libitum. Greene et al. (6) reported that absorption of magnesium increased when dietary intake of magnesium increased 60 percent. Generally, magnesium levels in free-choice mineral supplements will be increased from 2-4 percent to 13-15 percent during the winter and spring grazing seasons. The incorporation of 14 percent magnesium into a mineral supplement requires the addition of 23 percent magnesium oxide, which dilutes other minerals that may be supplied by the supplement. Since magnesium oxide is not very palatable, the free-choice intake of the supplement is reduced, which could potentiate other mineral-related problems. This may be especially critical for calcium since this mineral is often reported to be low in the serum of cows diagnosed with grass tetany.

The addition of energy or protein supplements to high-magnesium mineral supplements may be advantageous in overcoming the palatability problems. However, cows grazing tetany-prone forages require no additional energy or protein supplementation, and the cost associated with the additional supplement is usually greater than is economically feasible if the intent is largely or solely to increase supply of magnesium. Horvath (7) reported that magnesium-molasses mixtures were readily consumed by cattle but that problems existed in maintaining a uniform mixture. McLaren et al. (13) reported that a liquid magnesium, urea, and molasses supplement increased serum magnesium levels in cattle during the winter feeding period. However, magnesium oxide will not remain equally dispersed in liquid feed without the aid of suspending agents. The use of suspending agents such as xanthan gum, marketed as Kelflo®, is effective in suspending 6 percent magnesium oxide in a liquid supplement. Additionally, the use of colloidal attapulgite clay effectively maintains a suspension of minerals in liquid supplements. The use of these mixtures presents a problem similar to that of addition of supplemental energy or protein to free-choice mineral mixes in that cows would have to consume at least 1.25 lb of supplement daily to acquire the needed quantity of supplemental magnesium. The additional energy from the molasses is not needed for production when cattle are grazing actively growing forages. In fact, the urea-containing supplements could pose additional problems because winter and spring pastures have an excess of nonprotein nitrogen; this is especially true for small-grain forages.

Research conducted in our laboratory (2) shows that from 40 to 70 percent magnesium oxide mixed in liquid molasses may be useful in overcoming the negative palatability of magnesium oxide. Ad libitum feed intake increased when heifers were fed supplements having increasing quantities of molasses. An additional 30.7 and 35.8 grams of magnesium were consumed per day when 30 and 60 percent molasses were mixed with magnesium oxide, respectively. Heifers fed the 70 percent magnesium oxide/30 percent molasses supplement consumed approximately 21.9 grams of molasses compared with 89.5 grams when heifers were offered the 40 percent magnesium oxide/60 percent molasses supplement. An additional study (12) was conducted with cows grazing oat pastures and supplemented with 50 percent magnesium oxide/50 percent molasses in a mineral feeder. Cows consumed an average of 33 grams per head daily of the supplement. These data indicate that magnesium-molasses mixtures may be advantageous in supplementing magnesium to cattle during the winter and spring grazing seasons.

Other practices to control grass tetany include the addition of a soluble magnesium salt to drinking water. This appears to be effective in controlling grass tetany, but optimal production may be depressed owing to a lowered consumption of water. Additionally, producers have indicated that limited grazing, by turning cows in on small-grain forages for a few hours per day and then removing them to a dry-lot with ad libitum hay or dry native grass pasture, is effective in controlling grass tetany. Although effective in controlling tetany, this practice is labor intensive and would not fit some management systems. Currently, our laboratory is investigating the susceptibility to grass tetany of cows grazing small grains continuously with or without ad libitum access to sorghum-sudan hay.

Research from our laboratory (9) indicated that sheep fed 20 ppm monensin-sodium had a 52.4 percent improvement in magnesium retention, which was brought about by an increased absorption coupled with less magnesium excreted in the urine. Starnes et al. (19) also reported an increase in apparent magnesium absorption in steers fed ionophores. The ability of the ionophore to drive the sodium-potassium pump (17) may be responsible for the increased absorption of magnesium through the sodium-potassium-ATPase-dependent magnesium absorption mechanism proposed by Martens et al. (11). Because the primary role of monensin is to transfer potassium ions across cellular membranes and monensin has been shown to increase magnesium availability, our laboratory conducted an experiment to determine the effectiveness of monensin in neutralizing the negative effects of potassium on magnesium absorption (5). Twelve ruminally cannulated lambs were used in three balance trials in a 2 x 3 factorial arrangement of treatments. Lambs were fed a cottonseed-hull-corn grain-based diet, which contained .44% potassium, and were infused ruminally with 0, 7.6, or 31.6 grams of potassium per day. Addition of monensin to the diet decreased excretion of fecal and urinary magnesium 15.9 percent and 15.5 percent, respectively. Apparent absorption and retention of magnesium were increased with the addition of monensin. Increasing the potassium level increased fecal magnesium excretion. Apparent absorption of magnesium decreased from .93 to 80 grams per day when either level of potassium was infused into the rumen. There was no interaction between level of monensin and level of infused potassium, but when magnesium absorption

data were summarized by monensin x potassium level, lambs fed 20 ppm monensin and infused with 31.6 grams of potassium per day absorbed a quantity of magnesium similar to that of lambs fed no monensin and no supplemental potassium. Additional research (4) indicated that monensin increased the pre-intestinal absorption of magnesium. Apparently, monensin has the capability of altering the negative effects of high dietary potassium by its action on the Na-K-ATPase system located in the rumen.

Currently, monensin is marketed as Rumensin® and is cleared for stocker and replacement heifers in grazing production systems. The clearance of this ionophore for breeding cattle may provide a useful tool to aid in the control of grass tetany in winter and spring grazing programs.

Cattle showing clinical signs of grass tetany can be treated at a relatively high success rate if in the early stages of tetany. Cows with symptoms of this disease will typically respond to intravenous administration of a calcium, magnesium, phosphorus, and dextrose monohydrate solution. Emergency treatments using magnesium chloride enemas have been successful in treating cows with clinical symptoms of grass tetany. Cattle with a severe magnesium deficiency will develop nonreversible structural tissue damage.

Conclusions

The prevention and control of grass tetany in cattle is difficult but possible. Prevention requires use of management practices that alter other nutrient-magnesium interactions in the digestive tract combined with procedures that increase the level of magnesium intake, especially when cattle are lactating and grazing winter and spring forages.

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PR-4479

Digestibility of Magnesium in Mature Cows of Five Breeds and Their Crosses

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Summary

Sixty dry, open, mature cows of five breeds (Angus, A; Brahman, B; Hereford, He; Holstein, Ho; and Jersey, J) and their F_1 crosses (AB, AHe, AHo, AJ, BHe, BHo, BJ, HeHo, HeJ, and HoJ, reciprocal crosses pooled) were used in a 51-day experiment (four cows/breed group) to determine apparent and true digestibility of magnesium (Mg). True digestibility of Mg was predicted from the regression of apparent Mg absorption on Mg intake. Apparent digestibility of Mg increased ($P < 0.05$) from 13.2 to 43.4 percent as intake level increased from 50 to 150 percent. The apparent digestibility of Mg in AHe, J, and HoJ was lower ($P < 0.05$) than that of B, AB, BHe, BHo, HeJ, and BJ. The predicted true digestibility of Mg across all breed groups was 61.1 percent. Predicted true digestibility of Mg was higher ($P < 0.05$) for B, BHo, A, and HeHo than for He, HeJ, BHe, J, and Ho. The estimated endogenous excretion of Mg ranged from 1.8 to 10.5 g/day. Holstein-Jersey and HeHo had a larger ($P < 0.05$) quantity of estimated endogenous Mg excreted than did AB, He, Ho, HeJ, and BHe. Differences observed between breeds of cattle in the frequency of grass tetany may be partly related to these changes in Mg digestibility.

Introduction

Hypomagnesemia, one of the maladies associated with grass tetany, is caused by a metabolic deficiency of magnesium (Mg) that can result from a low dietary intake or availability of Mg and occurs most frequently during early lactation (2, 10). Breed of cattle may play an important role in the susceptibility to grass tetany. Recently, genetic involvement has been suggested as a cause of variation in the mineral status of livestock (4, 12). Blood Cu, Ca, P, and Mg concentrations have been shown to be significantly different between Friesian and Jersey (J) cattle (12), and Ca, P, and Mg were different among breeds of sheep in two flocks (3). Fisher and Wilson (5) indicated that adult lactating Angus (A) cows had a 6 percent lower serum Mg level than did crossbred Angus-Charolais cattle. Cattle of Brahman (B) breeding have been shown to have a lower incidence and cattle of A breeding a higher incidence of grass tetany than cattle of Holstein (Ho), J, or Hereford (He) breeding (8). The objective of this study was to determine Mg availability in dry, open, mature cows of different breeds and their crosses.

Materials and Methods

A 51-day experiment was conducted with 60 dry nonpregnant cows of five breeds (A, B, He, Ho, and J) and their F_1 crosses (AB, AHe, AHo, AJ, BHe, BHo, BJ, HeHo, HeJ, and HoJ, reciprocal crosses pooled) at the McGregor location of the Texas Agricultural Experiment Station. Cows were greater than 10 yr old and averaged 535 kg (1,179 lb). Cows were penned at 8 a.m. daily in groups of four into 15 concrete-floored pens with waterers and 4 electronic gate feeders, which allowed each cow to eat out of only one feeder. Cows were allowed to consume their daily allotment of feed and then were removed to dry lots for the remaining part of the day.

During four trials, cows were fed a cottonseed-hull-based diet (Table 1) at four levels of intake in a 4 x 4 Latin square design (replicated by breed group). Intake levels were 50, 83, 117, and 150 percent of each animal's estimated daily maintenance energy requirement, according to animal weight. During period 1, the four intake levels were randomly assigned to cows within each breed group. Intake levels rotated in each subsequent trial as 50→ 117→ 83→ 150→ 50 percent. Fecal samples were collected daily for five consecutive days at randomly assigned 2-hr intervals between 8 a.m. and 4 p.m.

Indigestible neutral detergent fiber was used as a digestive tract marker to determine total fecal output. Digested feed and fecal samples were analyzed for Mg by atomic absorption spectrophotometry. Magnesium intake, fecal excretion, and absorption were analyzed as a replicated Latin square with breed group as replicate. True digestibility of Mg was predicted for each breed by using a linear regression analysis for apparent Mg absorbed on Mg intake. In the regression analysis, apparent Mg absorbed and Mg intake were corrected for differences in metabolic body size. Endogenous excretion of Mg was predicted by extrapolation of the regression analysis to zero Mg intake and by multiplying the intercept by metabolic body size.

Results and Discussion

Average dry matter intakes for cows fed the four levels of feed were 4.1, 6.5, 9.0, and 11.2 kg/day. Magnesium intake increased ($P < 0.05$) from 12.4 to 33.5 g/day as level of feeding increased from 50 to 150 percent of maintenance (Table 2). Fecal Mg excretion increased (P

TABLE 1. INGREDIENT AND CHEMICAL COMPOSITION OF DIET[a]

Item	
Ingredient composition, %	
Cottonseed hulls (IFN 1-01-599)	70.0
Cottonseed meal (IFN 5-01-617)	15.0
Ground milo (IFN 4-04-444)	9.8
Liquid molasses (IFN 4-06-696)	4.0
Limestone (IFN 6-02-632)	0.3
Dicalcium phosphate (IFN 6-01-080)	0.2
Trace mineral salt[b]	0.5
Vitamin mix[c]	0.2
Chemical composition	
Dry matter, %	92.9
Gross energy, Mcal/kg	4.1
Magnesium, %	0.30
Calcium, %	0.60
Phosphorus, %	0.44

[a]As fed basis.

[b]Composition of trace mineral salt is NaCl, 91%; Mn, 0.3%; Zn, 0.25%; Fe, 0.15%; Cu, 0.015%; I, 0.009%; Co, 0.005%.

[c]Composition of vitamin A, D, and E mix is 2.2×10^6, 1.1×10^6, and 2.2×10^3 IU/kg, respectively.

< 0.05) 36.4, 60.6, and 87.8 percent as Mg intake increased from 12.4 to 19.4, 27.0, and 33.5 g/day, respectively. Apparent absorption of Mg increased ($P < 0.05$) from 2.5 to 14.9 g/day when Mg intake increased from 12.4 to 33.5 g/day. Increases in apparent digestibility of Mg of 130, 200, and 229 percent ($P < 0.05$) were observed when larger quantities of feed were fed compared with those fed at the low level. As Mg intake increased, the percentage of Mg absorbed did not change at the same rate as grams of Mg absorbed. Previous research (9) reported that lambs fed 0.2 vs. 0.1 percent Mg in 800 g of feed daily had a greater quantity of Mg absorbed but a similar digestibility. In the present study, the increase in Mg digestibility may be associated with the increase in organic matter intake. Grace et al. (6) indicated that Mg digestibility increased from 18 to 24 percent, and larger quantities of Mg flowed to the duodenum, ileum, and feces in sheep fed 800 g of organic matter daily when compared with those fed 500 g. They further reported that larger quantities of Mg were absorbed in the stomach when animals were fed the larger quantity of feed.

Intake, fecal excretion, and apparent absorption of Mg and cow weight for each breed group are presented in Table 3. Cow weights ranged from 427 kg for J to 604 kg for BHo, with an overall mean weight of 535 kg. Because cows were fed according to metabolic body size, quantity of Mg intake increased at each level of feeding as cow weight increased. Overall intake of Mg averaged 22.7 g/day. Intake of Mg ranged from 18.3 g/day for J to 25.0 g/day for BHo.

Fecal Mg excretion (Table 3) averaged 14.3 g/day and ranged from 12.0 g/day for BHo to 17.5 g/day for Ho. Fecal Mg excretion was lower for A, B, AB, HeJ, BJ, and BHo than for HeHo, HoJ, and Ho. Although BHo consumed more ($P < 0.05$) Mg than did HeJ, AB, BJ, A, AJ, and B, fecal Mg excretion was similar ($P > 0.05$) for these breed groups.

The mean apparent digestibility of Mg was 31.2 percent; the mean for straightbred cows was 29.2 percent and for crossbred cows was 32.2 percent. These data indicate an improvement in apparent digestibility of Mg of 10.7 percent attributable to heterosis. Within the straightbred group, J had the lowest and B the highest ($P < 0.05$) apparent digestibility of Mg; A, Ho, and He were intermediate. Apparent digestibility in He and Ho cows were lower ($P < 0.05$) than in B cows. Of the crossbred groups, B crosses had the highest apparent digestibility of Mg. Jersey, AHe, and HoJ cows had a lower ($P < 0.05$) apparent digestibility of Mg than did any cows with B breeding. Digestibility of Mg in A and He-crossed cows was intermediate. Greene et al. (9) indicated that during a 4-yr period, the incidence of grass tetany in cattle of A, B, He, Ho, and J breeding was 6.9, 2.2, 4.2, 2.8, and 4.0 percent, respectively. The incidence of tetany in B was lower than the herd mean of 4.1 percent. Although numerous production parameters can increase the incidence of tetany, the higher digestibility observed in B cows could be a significant factor in reducing the susceptibility to tetany in cows with B breeding. Greene et al. (9) reported that 53.1 percent of the cattle with grass tetany were A or A-crossbred cattle, whereas only 15.6 percent of the cattle with this malady were of the B breeding.

TABLE 2. LEAST-SQUARE MEANS OF INTAKE, FECAL EXCRETION, AND APPARENT ABSORPTION OF MAGNESIUM IN COWS FED AT FOUR LEVELS OF INTAKE

	Feeding level, % of maintenance				
Item	50	83	117	150	SE[a]
Intake, g/d	12.4[b]	19.4[c]	27.0[d]	33.5[e]	0.59
Fecal excretion, g/d	9.9[b]	13.5[c]	15.9[d]	18.6[e]	0.47
Apparent absorption, g/d	2.5[b]	5.9[c]	11.1[d]	14.9[e]	0.63
% of intake	13.2[b]	30.3[c]	39.6[d]	43.4[d]	2.28

[a]Standard error of mean.

[b,c,d]Means with different superscripts within the same row differ ($P < .05$).

TABLE 3. LEAST-SQUARE MEANS OF COW WEIGHTS AND INTAKE, FECAL EXCRETION, AND APPARENT ABSORPTION OF MAGNESIUM IN COWS OF FIVE BREEDS AND THEIR CROSSES[a]

Breed	Cow weight, kg	Intake, g/d	Fecal excretion, g/d	Apparent absorption, % of intake
Angus	528[bcd]	22.7[bcd]	13.1[ef]	36.46[bcdfg]
Brahman	533[bcd]	22.7[cd]	12.3[e]	40.6[dg]
Hereford	502[bf]	21.8[bcf]	15.0[bcdf]	25.5[bcef]
Holstein	600[hi]	23.9[dgh]	17.5[d]	25.8[bcef]
Jersey	427[e]	18.3[e]	15.3[bcdf]	17.3[e]
Mean of straightbred		21.9	14.6	29.2
Angus X Brahman	512[bcf]	22.8[bcf]	12.6[ef]	38.4[cdg]
Angus X Hereford	542[cd]	22.9[cd]	15.4[bcd]	23.0[ef]
Angus X Holstein	579[ghi]	23.8[dgh]	15.1[bcdf]	26.9[bcef]
Angus X Jersey	486[f]	21.4[bf]	13.6[bcef]	30.8[bcdef]
Brahman X Hereford	594[hi]	24.4[gh]	14.8[bcdef]	37.4[bcdg]
Brahman X Holstein	604[i]	25.0[h]	12.0[e]	46.4[g]
Brahman X Jersey	536[bcd]	23.0[cdg]	12.9[bef]	37.4[bcdg]
Hereford X Holstein	562[dgh]	23.7[dgh]	15.7[cd]	24.1[bef]
Hereford X Jersey	480[f]	21.3[f]	12.9[ef]	36.5[bcdg]
Holstein X Jersey	541[cdg]	23.0[cdg]	16.4[d]	21.1[e]
Mean of crossbred		23.1	14.1	32.2
Overall mean		22.7	14.3	31.2
Avg. heterosis, units		1.2	−.5	3.1
%		5.5	−3.4	10.7
SE[i]	12.7	.4	1.23	4.6

[a]Reciprocal crosses pooled.

[bcdefghi]Means within the same column without a common letter in their superscripts differ ($P<0.05$).

[i]Standard error of mean.

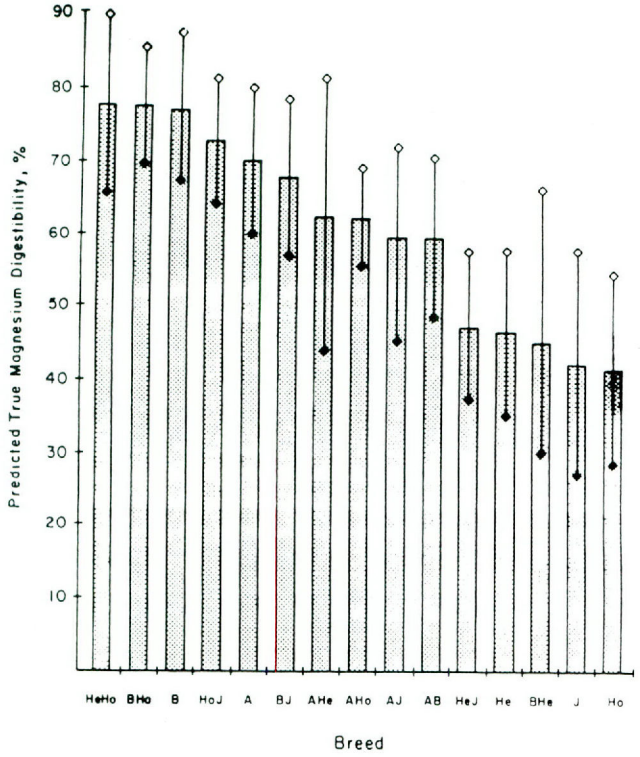

Figure 1. Predicted true absorption of Mg in cattle of five breeds and their crosses, reciprocal crosses pooled (Angus, A; Brahman, B; Hereford, He; Holstein, Ho; Jersey, J).

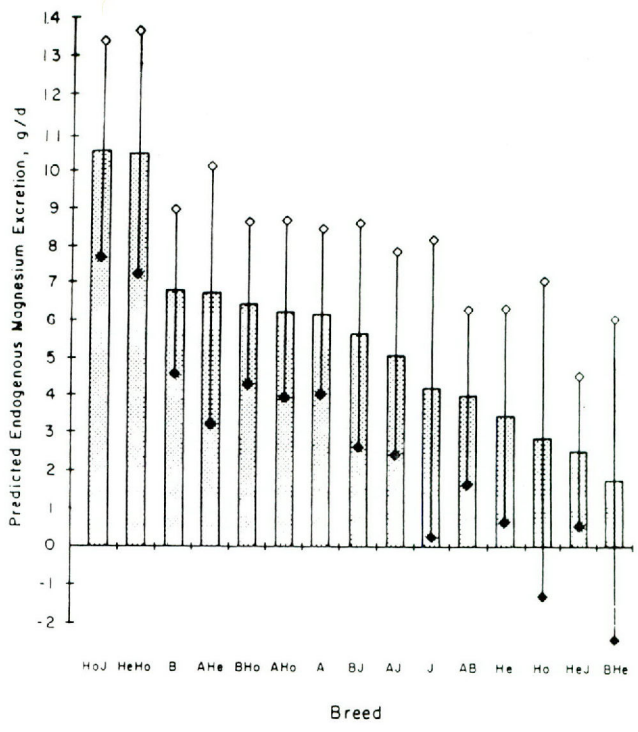

Figure 2. Predicted endogenous excretion of Mg in cattle of five breeds and their crosses, reciprocal crosses pooled (Angus, A; Brahman, B; Hereford, He; Holstein, Ho; Jersey, J).

Prediction of true Mg digestibility was 62.7 percent when summarized over all breed groups. This represents a 101 percent increase over the apparent Mg digestibility. Predicted true digestibility of Mg (Figure 1) was 70.7, 59.4, 62.6, 62.0, 59.6, 77.0, 45.0, 77.5, 67.5, 46.5, 77.5, 47.0, 41.4, 72.6, and 42.2 percent for A, AB, AHe, AHo, AJ, B, BHe, BHo, BJ, He, HeHo, HeJ, Ho, HoJ, and J cows, respectively. Predicted true digestibility was 93, 63, 172, 130, 122, 90, 20, 67, 80, 82, 204, 29, 60, 244, and 144 percent higher than apparent digestibility for A, AB, AHe, AHo, AJ, B, BHe, BHo, BJ, He, HeHo, HeJ, Ho, HoJ, and J cows, respectively. Predicted true digestibility of Mg was greater ($P < .05$) for B, BHo, HeHo, and HoJ than HeJ, He, BHe, J, and Ho.

With the exception of BHo cows, the apparent digestibility for Ho or Ho-crossed cows was relatively low, but the predicted true digestibility of Ho-crossed cows was relatively high compared with other breeds. Although the incidence of grass tetany was higher in A-bred cattle compared with B and was intermediate for He (9), the predicted true digestibility of Mg in A was not different ($P < .05$) from B but was higher than He. Genetic differences associated with production level are also contributing factors in the onset of tetany.

The estimated mean endogenous Mg excretion for each breed group is shown in Figure 2. The extrapolation of the data points to zero Mg intake resulted in greater variation than recorded for the slope of the regression. These estimates may be high (1) and may range from 3 to 19.5 mg/kg body weight. However, the estimated endogenous excretion of Mg was greater for HeJ and HeHo than for AB, He, Ho, HeJ, and BHe. Crossbred Ho cows tended to have larger quantities of Mg secreted into the digestive tract when compared with straightbred breeds except B.

In conclusion, it appears that B and B-cross cattle are less susceptible to grass tetany partly because of an increased ability to maintain a higher Mg digestibility compared with other beef and dairy breeds. Furthermore, the lower incidence of grass tetany in B-bred cattle (9) could be associated with an increase in the digestibility of Mg in this breed compared with other breeds of cattle. Brahman cattle have a smaller digestive tract volume (11), which may be related to a shorter ruminal retention time and more efficient digestion. Grace and MacRae (7) concluded that the efficiency of Mg absorption in the stomach of sheep is more efficient when animals were fed from continuous belt feeders compared with once-daily feeding. The change in rate of digesta flow through the stomach in B may be beneficial in increasing the efficiency of Mg absorption observed in this study.

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PR-4480

The Effect of Magnesium Oxide - Molasses Emulsions on Serum Mineral Concentrations and Rumen Volatile Fatty Acid Profile of Bred Heifers

N. Chirase, L. W. Greene,
G. T. Schelling, and F. M. Byers

Lactating beef cows grazing small-grain forages during the spring require supplemental magnesium. The presence of high-potassium concentrations in spring forages decreases magnesium absorption, but this can be alleviated by increasing magnesium intake. Although magnesium oxide (MgO) is normally the most accessible source of magnesium, it is not palatable to cattle. Addition of MgO to free-choice mineral supplements during the spring generally lowers mineral supplement consumption. Addition of magnesium to more palatable feed-stuffs improves magnesium intake.

An experiment was conducted to determine the feasibility of diluting MgO with liquid molasses and determine its acceptability by feeding, free-choice, to bred heifers. Six bred heifers (avg. wt 420 kg) of Angus (n = 3) and Hereford (n = 3) breeds were fed a cottonseed-hull-based diet and were randomly allotted to one of the following free-choice supplements: (a) 100 percent magnesium oxide, (b) 70 percent magnesium oxide and 30 percent liquid molasses, and (c) 40 percent magnesium oxide and 60 percent liquid molasses. Heifers consuming 40:60 magnesium:molasses consumed more magnesium than those consuming 100 percent MgO ($P < 0.001$). The 70:30 magnesium:molasses supplement was consumed at an intermediate level. Magnesium intake was 21.4, 49.7, and 55.8 g/day for heifers supplemented with 100 percent MgO, 70 percent MgO:30 percent molasses, and 40 percent MgO: 60 percent molasses, respectively. Feed intake tended to increase as heifers consumed greater quantities of magnesium (10.93, 11.87, and 12.50 kg/hd/day, respectively) but was not statistically significant. Serum magnesium concentrations did not differ with supplement (2.45, 2.80, and 2.90 mg/dl, respectively). However, heifers offered 40 percent MgO:60 percent molasses had higher ($P < 0.05$) serum calcium concentrations than those offered 70 percent MgO:30 percent molasses (7.56, 7.63, and 8.19 mg/dl, respectively). Serum inorganic phosphorus concentrations did not differ ($P > 0.05$) with supplement. When data were analyzed by breed, Angus heifers consumed significantly ($P < 0.001$) more magnesium than did Hereford heifers (50.65 vs. 33.91 g/hd/day, respectively). However, serum magnesium concentrations did not differ between breeds ($P > 0.05$). Angus heifers had higher ($P < 0.01$) serum calcium than did Hereford heifers (8.12 vs. 7.46 mg/dl, respectively). Serum inorganic phosphorus concentrations were higher ($P < 0.01$) in Hereford than in Angus (8.38 vs. 7.04 mg/dl, respectively). Volatile fatty acid (VFA) concentrations and ratios did not differ ($P > 0.05$) with supplementary treatments, although total VFA concentrations tended to increase with an increase in magnesium consumption (39.53, 59.34, and 71.29 mM/l, respectively). Angus cattle tended to have higher total VFA concentration than did Hereford (61.50 vs. 51.94 mM/l, respectively). These data indicate that MgO oxide-molasses emulsions may be of potential use in supplementing magnesium to cattle, especially during the winter and early spring, when magnesium deficiencies are known to occur.

PR-4481

The Effect of Lasalocid and Calcium on Serum Mineral Concentrations of Pregnant Beef Cows Grazing Small-Grain Forages

N. Chirase, L. W. Greene, D. K. Lunt, G. T. Schelling, R. E. Knutson, and F. M. Byers

Lasalocid (Bovatec®) has been used in beef cattle diets to increase feed efficiency and to improve rate of gain. These performance improvements are partly in response to a shift in the ruminal microbial population, which results in a more favorable rumen fermentation. Lasalocid's primary role is to facilitate the passage of ions across cell membranes. One potential use of this ionophore is for influencing mineral absorption in cattle. The use of lasalocid in field conditions may be advantageous in controlling grass tetany and increasing efficiency of microbial fermentation in cattle grazing small-grain forages. The objective of this experiment was to determine the mineral status of mature (average age, 7 yr), pregnant beef cows grazing small-grain forages during the winter and early spring when supplemented with lasalocid and two levels of calcium (Ca).

The cows were fed .25 kg of ground corn with or without 200 mg of lasalocid daily. Two levels of calcium (6% and 18%) were fed in free-choice mineral supplements. The magnesium and phosphorus concentrations of the mineral supplement were 4 percent and 12 percent, respectively. Treatments were imposed in a two by two factorial arrangement and assigned to eight oat pastures (10 acres per pasture). Four cows were randomly assigned to each pasture, and all cows were bled by jugular puncture every 28 days. Forage samples were collected weekly. Serum and forage Ca and magnesium (Mg) were determined by atomic absorption spectrophotometry. Serum inorganic phosphorus (P) and forage P were determined colorimetrically. Forage Ca, Mg, and P averaged 0.53; 0.13, and 0.27 percent, respectively. Serum Mg of cows consuming low- and high-Ca supplements were 1.72 and 1.76 mg/dl, respectively. These concentrations are low; however, they are typical for cows grazing small-grain forages. Serum Mg did not differ for lasalocid levels. Serum Ca tended to increase in cows receiving the low-Ca supplement (9.46 vs. 8.87 mg/dl) compared with the cows consuming the high-Ca supplements. Serum Ca concentrations decreased during the first month of grazing and increased during the subsequent month. The mineral supplement intake for the low- and high-Ca supplements were 19.2 and 9.9 g/d, respectively. As a result, cows supplemented with the high-Ca mineral consumed 54 percent more Ca than did those supplemented with the low-Ca mineral. Cows supplemented with lasalocid tended to consume more mineral supplement than did cows not receiving lasalocid (16.5 vs. 12.6 g/d), resulting in a higher ($P < 0.01$) serum inorganic P concentration (5.6 vs. 6.6 mg/dl) and consequently lower ($P < .01$) serum Ca:P ratio.

These data indicate that supplementation with higher levels of Ca decreased total mineral consumption. Lasalocid supplementation did not effect serum concentrations of Mg or Ca, but it did increase serum P.

PR-4482

Microbial Fermentation in a Continuous Culture Fermentation System Treated with Potassium, Magnesium, and Monensin

N. Chirase, L. W. Greene, G. T. Schelling, and F. M. Byers

Low magnesium (Mg) absorption in the gastrointestinal tract of ruminants has been attributed to the interaction of Mg with other nutrient components of the diet. One identified interaction is that of Mg and potassium (K). Higher concentrations of K in sheep and cattle diets have been reported to decrease Mg absorption, thereby increasing dietary Mg requirements. Previous research in our laboratory showed that an ionophore, monensin, increased Mg absorption and retention in sheep and cattle. Additionally, monensin alleviated the depressed absorption of Mg when higher concentrations of K were fed. Very little research has been conducted to define the role of rumen microorganisms in the interaction of K, Mg, and monensin and its impact on mineral metabolism in cattle.

This study was conducted to determine if K, Mg, and monensin affects microbial fermentation. A combination of mature Coastal Bermudagrass hay (80%) and cellulose (20%) were used as substrate during five trials with two levels of Mg (0.07% and 0.14%), K (0.6% and 2.5%), and monensin (0 and 20 ppm) in a two by two by two factorial arrangement. The fermentors were inoculated with rumen fluid obtained from a steer fed Coastal Bermudagrass hay and infused constantly (.42 ml/min) with a modified McDougall's artificial saliva to produce a turnover rate of 1.4 times/day. Substrate was added to the fermentors every 8 hr (5 g/fermentor) for 5 days, and digesta was collected every 2 hr (20 hr total) for volatile fatty acid (VFA) analysis. Acetate production was not affected by either level of Mg (10.3 vs. 9.7 mM) or K (9.5 vs. 10.4 mM). Although low K (0.6%) tended to favor propionate production (4.2 vs. 3.8 mM), the difference was not significant ($P > 0.1$). Monensin depressed ($P < 0.001$) acetate production (10.5 vs. 9.4 mM) and increased ($P < 0.01$) propionate production (4.4 vs. 3.7 mM), giving rise to a higher ($P < 0.001$) acetate:propionate (A:P) ratio (3.0 vs. 2.2). There was a significant interaction between monensin and Mg on acetate and propionate production. When monensin was fed with low Mg, the A:P ratio was depressed (2.9 vs. 2.4), and this ratio was further depressed when high Mg was fed (3.1 vs. 2.0), resulting in

an apparent synergism between high-Mg concentrations and monensin activity. A three-way interaction among Mg, K, and monensin was also observed. Low K and high Mg with monensin tended to favor propionate production more than did high K and high Mg with monensin (5.2 vs. 4.3 mM). The high-Mg-monensin synergism was relatively unaffected by high-K concentrations in terms of A:P ratio (1.9 vs. 2.1). Total VFA production was not affected by either Mg or K levels. Monensin sustained an increase in propionate production 20 hr postfeeding. These data indicate that a synergistic relationship exists between Mg and monensin, as this affects microbial fermentation in a continuous culture system. Mineral (Mg) interactions with monensin and its affect on microbial fermentation probably causes some of the variability in VFA production observed cattle fed monensin.

Management

PR-4483

Computerized Decision Aids in Nutrition Management of Range Beef Cows

J.E. Huston

Summary

A software program written for the Apple II computer predicts requirements for supplemental feed for beef cows on rangeland. Summarized research data form the basis for estimating nutrients in forages; forage consumption; animal requirements; periods of deficiency; and recommended feed type, feeding level, and feeding period. The user is asked to give information regarding rangeland type and plant composition, animal size, and breeding data and a listing of acceptable feed formulations and prices that are used for formulating recommendations.

Introduction

This report describes a software package developed at the Texas A&M University Research and Extension Center at San Angelo for aiding in decisions regarding supplemental feed needs for range beef cows in the Edwards Plateau region of Texas.

Components of the Program

The program, named "FEEDSTUFF, Version l-C," runs on an Apple II computer with at least 64 kilobytes (K) of random access memory (RAM) and a single 5¼-in. floppy disk drive (Apple II+, IIe, or IIc). An attached printer will allow for a printed copy of recommendations but is not essential for the program to run. Additionally, various data files stored on the disk supply the programs with essential information. The six components (programs) of FEEDSTUFF will be discussed separately.

Introduction

The user is introduced to FEEDSTUFF and given training on how to respond to questions, select alternatives, and proceed to the next step.

User Input

The user is asked to supply the following:

1. Average cow weight (actual or estimated).
2. Estimated average breeding date.
3. Description of range vegetation based on variety of plant types.
4. Preferred feed concentrate from a list of nine common feeds (or user can allow FEEDSTUFF to recommend a feed concentrate).
5. Feed prices ($/ton).

Diet and Requirements

Computations are made on how much cows consume throughout the year and the amounts of energy, protein, and phosphorus contained in these diets. These computations were based on data of forage composition (1), diet selection (4), and response to supplemental feeds (2). Nutrient requirements were adapted from tabular recommendations of the National Research Council (3).

Plots

Forage quality, cow requirements, dietary intake, periods of excess and periods of deficiency are graphically illustrated for each of the three nutrients (energy, protein, phosphorus). A January through December plot of forage composition depicts the highs and lows in forage quality associated with season and typical rainfall pattern. The 12-month production cycle, beginning with the breeding date, shows how nutrient requirements relate to dietary intake of nutrients. These plots give the user a hint of depth and duration of deficiency periods and how breeding date can be an important determinant of supplemental feed needs.

Deficiencies

Computations are made to determine when the cows go into negative balance, how long they are able to use stored nutrients without adverse effect, and the beginning and ending dates of a deficiency period. Only energy can be consumed in excess and stored efficiently for later use. The cow's ability to store nutrients for later use is lower for phosphorus and much lower for protein. Cows can endure rather extended periods of marginal- to low-energy nutrition provided these periods are preceded and followed by periods of excess. These beginning and ending dates, the amounts of stored nutrients, the nutrient depletion rates, and the extent of nutrient deficiencies are computed.

Feed Recommendations

A feeding rate and feeding period are recommended for the designated feed or the feed selected by FEEDSTUFF for least-cost to supply energy and protein requirements. In neither case is phosphorus considered. However, FEEDSTUFF computes whether phosphorus requirements are satisfied by the recommended feed concentrate and feeding level. If not, a phosphorus-containing mineral formula is recommended for free-choice feeding. Following the initial feed-concentrate recommendation, the user is given the option of trying another feed concentrate. In the final step, the user is given the option to either start over with a new set of conditions or to end the session.

This software package is the first of a family of decision aids based on animal and plant data collected at the Texas A&M University Agricultural Research and Extension Center at San Angelo. Concurrently, Version 1-S and Version 1-G are being completed to apply to sheep and goats, respectively. Immediate plans include a Version 2 of FEEDSTUFF, which will add considerations of forage quantity, moisture conditions, animal species combinations, feed distribution costs, and marginal return to increased feeding rates below requirements.

Literature Cited

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PR-4484

Factors Affecting Feeder-Cattle Prices

M. G. Phillips, D. E. Farris, and H. W. Franke

Summary

To estimate what the market pays for different animal characteristics, four Central Texas livestock auction markets were studied in the fall of 1984. A 420-head sample of feeders was described, and the sale price was recorded. Statistical analyses were used to estimate the premiums and discounts associated with the USDA feeder-cattle grades as well as other attributes. Breed type, sex, weight, age, condition, fill, frame score, and muscle score all had a statistically significant relation to price. Small-framed calves had a 15 percent discount from medium-frame calves, whereas large-frame calves had only a 2 percent premium. Thin-muscled calves had a 25 percent discount compared with average muscling, whereas thick-muscled cattle had a 3 percent premium. The 1 percent premium of crossbreds over "okies" was not statistically significant, but the 5 percent discount of crossbreds for feeders with more than one-half Brahman cross was statistically significant. Discounts for heifers was 15 percent compared with steers. The discount for bulls was 10 percent. The price declined 5 percent with each increase in 100 lb of weight.

Interactions create some problems of isolating a premium or discount for individual attributes; however, the results indicate small price differences among medium and large frames, average and thick muscling, and "okies" and crossbreds. A mail questionaire to 47 order buyers, dealers, and traders provides additional evaluation. They ranked as essential information to have in the following order: finish, conformation, frame, weight, and muscling.

Introduction

Production of feeder cattle requires long-range planning in selecting and developing an efficient herd. Critical to the planning process are good estimates of the market value of different characteristics of the product of the herd. A wide variety of factors affect the price of feeder cattle. Supply and demand set the general price level at a given time, but on a particular market day, the difference in animal characteristics primarily influence price. James and Farris sampled order buyer invoices and found a difference of about 5 percent among each of the order buyer's grades of "okie" #1, #2, and #3 in 1966-68 (1). Market news data showed a 10 percent difference in USDA feeder-cattle grades from Choice to Good and from Good to Standard in 1964-68 (USDA feeder-cattle grades have since been changed to focus on frame size and muscle score).

Procedure

This study attempts to measure the market value of differences in feeder attributes by describing a systematic

TABLE 1. SUBCLASS VARIABLES USED IN THE REGRESSION MODEL

Date and market	D1—October 5, 1984
	D2—October 10, 1984
	D3—October 12, 1984
	*D4—October 13, 1984
	D5—November 24, 1984
Age	A1—Calves
	A2—Yearlings
Frame score	F1—Large frame
	*F2—Medium frame
	F3—Small frame
Muscle score	M1—Number one (thick)
	M2—Number two (average)
	*M3—Number three (thin)
Fill	L1—Empty
	*L2—Average
	L3—Full
Condition	C2—0.05-0.15 in. fat
	*C3—0.15-0.25 in. fat
	C4—0.26 in. of fat or more
Sex	*S1—Steer
	S2—Heifer
	S3—Bull
Breed	B1—Okies
	*B2—Crossbreds
	B3—Brahman crosses
	B4—Dairy crosses

*Denotes trait used as basis for comparison among classes.

sample of feeder cattle at four different markets in Central Texas during October and November of 1984. The sale price was recorded and used as the dependent variable in regression analyses. A dummy variable was used to adjust for the different days and market locations. The attributes used in the analyses are listed in Table 1, and the general statistical model is in Table 2.

The edited data base consisted of 420 individually priced animals. To avoid some of the problems of interaction, a more uniform data base was created by selecting only steers with large and medium-frame size and thick and average muscling. Animals with more than one-half dairy breeding were also dropped from the new data base.

Results and Discussion

All the factors shown in Table 1 had a statistically significant effect on price per hundredweight. In addition, the interaction of weight with many of the other factors plus the sex X frame score interaction was statistically significant. When the sample was modified to include steers only and the dairy animals were excluded, the weight effect increased as did the value of most all of the premium attributes in each class except for thick muscling (Table 3).

By converting data in Table 3 to a percentage difference and by keying on a 600-lb medium-frame, average-muscling steer, a price index was developed to give the results a more general application (Table 4). With this animal as the base at 100 percent, a thick-muscled steer was valued at 3 percent more. A large-frame steer was valued 2 percent more than a medium frame, whereas an "okie" steer was discounted only 1 percent from the crossbred. A cross of more than one-half Brahman was discounted 5 percent, whereas a cross of more than one-half dairy steer was discounted 13 percent. A lower weight gave a 5 percent premium for each 100 lb. This priced the 300-lb calves an estimated 15 percent more per pound above the 600-lb feeder (Table 4).

TABLE 2. GENERAL STATISTICAL MODEL

$$P = b_0 + b_1D + b_2S + b_3F + b_4M + b_5C + b_6L + b_7A + b_8W + E + G + H + I + J + R$$

where:
- P = price
- b = regression coefficients
- D = date
- S = sex
- F = frame score
- M = muscle score
- C = condition
- L = fill
- A = age
- W = weight
- E = interaction between sex and weight
- G = interaction between fill and weight
- H = interaction between age and weight
- I = interaction between sex and frame
- J = interaction between fill and condition
- R = error term

TABLE 3. COMPARISON OF ESTIMATES OF PRICE DIFFERENCES FROM THREE SAMPLES OF FEEDER CALVES, FALL 1985

Item	Total Sample	Steers Only	Steers Only (excl. dairy)
Variation Explained (R^2)	65%	55%	55%
Sample size	420	228	205
Variable[a]		(dollars per cwt.)	
Intercept	76.94	79.34	80.17
Weight x 100#[b]	− 2.87	− 3.18	− 3.44
Steers	.00	—	—
Bulls	− 6.85	—	—
Heifers	−10.00	—	—
Large frame	.86n.s.	.21n.s.	1.14n.s.
Medium frame	.00	.00	.00
Small frame	− 8.93	− 7.97	—
Thick muscle	3.04n.s.	1.85n.s.	1.96
Average muscle	0.00	.00	.00
Thin muscle	−16.56	−23.08	—
Thin condition	.48n.s.	1.42n.s.	1.75
Average condition	.00	.00	.00
Heavy condition	.22n.s.	− 1.67n.s.	− 4.48
Empty	− .55n.s.	− 1.78n.s.	—
Average fill	.00	.00	—
Full	− 4.02	− 3.40	—
Okies	− .42n.s.	− .10n.s.	− .44n.s.
Crossbreeds	.00	.00	.00
½ Brahman or more	− 2.18n.s.	− 2.73	− 3.20
½ Dairy or more	− 7.81	−13.49	—

[a]Five market dates used as dummy variable not shown.

[b]Refers to the price decline for every 100# increase in weight.

N.S.: not statistically different from the base subclass (.00) at the 90 percent confidence level.

Source: Calculated from sample obtained at four Central Texas auctions.

Heifers were discounted 15 percent and bulls 10 percent from steers. Feeders in thin condition received a 3 percent premium, and fleshy ones were discounted 7 percent compared with average condition. For full cattle, subtract 6 percent from the value of average filled cattle.

Analysis of variance showed that each of the factors of age, sex, weight, frame score, muscle score, condition, fill, breed type, and market date had a statistically significant effect on price. Owing to variability of cattle prices and the likelihood of error in description, some of the adjacent degrees within a class such as frame score or breed type were not statistically different. Furthermore, some of the interactions were significant, creating some problems of interpreting the effect of a single factor. This related mostly to the significant interaction of weight with some of the other factors. These estimates appear to be useful estimates for planning decisions and for "rules of thumb" for estimating the value of feeder cattle based on a cash market quote or on the feeder-cattle futures market. They would not substitute for experienced buyer or seller knowledge on any given trade because price differences are subject to change with changes in the level of the market for cattle or grain, but when converted to percentage of price differences, this problem is reduced. Some of the percentage of price differences found in this study correspond rather well to the James and Farris study (1) made in the late 1960's, despite price levels having almost doubled since then.

Resultes of the statistical analysis are reinforced by a survey of buyers, dealers, and traders. Two factors not considered in current cattle-feeder grades (finish and conformation) were listed "essential"by the highest percentage of the respondants (Table 5).

Literature Cited

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TABLE 4. INDEX OF PRICE DIFFERENCE AMONG FEEDER STEERS FROM A MEDIUM FRAME CROSSBRED[a], 600 POUNDS, AVERAGE MUSCLING, AND AVERAGE CONDITION, = 100 PERCENT[b,c,d,e,f,g]

	Frame Size							
	Large (L)				Medium (M)			
	(weight)				(weight)			
Muscle Score	300	400	500	600	300	400	500	600
Thick (1)	120	115	110	105	118	113	108	103
Average (2)	117	112	107	102	115	110	105	100

Source: Survey data from four Central Texas livestock auctions, 1984; 420 animals. The average price of all feeder cattle in the sample was $59.79, and average weight was 442 pounds. Average steer price was $64.64.

[a]Crossbreds with ⅛ to less than ½ brahman influence.

[b]For feeders in "thin" condition (.06-.15 in. fat) add 3 percentage points for those in "fleshy" condition (.26 in. or more fat), subtract 7 percentage points from the numbers above.

[c]For "okie" breed type (British, British cross, or British X exotic), subtract 1 percentage point; for more than ½ brahman cross, subtract 5 percentage points; and for more than ½ dairy cross, subtract 13 percentage points from the numbers above.

[d]For heifers subtract 15 percentage points and for bulls subtract 10 percentage points from the number above.

[e]For "full"-filled cattle, subtract 6 percentage points from the numbers above.

[f]For small frame cattle, subtract 15 percentage points, and for thin-muscled cattle, subtract 25 percentage points from the numbers above.

[g]Weight premiums included in figures above are a 5 percent increase in price for each 100-pound decline compared to the base price quote for the 600 weight.

TABLE 5. SURVEY RESPONSE FROM ORDER BUYERS, LIVESTOCK DEALERS, AND TRADERS*

Identification of:	Essential (%)	Convenient (%)	Not Necessary (%)
Sex	64	15	21
Weight	72	26	2
Frame	74	24	2
Muscling	68	28	4
Finish	83	17	0
Conformation	79	15	6
Breed	43	40	17
Origin	43	40	17

*Out of 100, 47 responses were received.

PR-4485

Influence of Pasture Implant Status on Feedlot Performance of Senepol-Cross Steers and Heifers

D. P. Hutcheson and F. M. Rouquette, Jr.

Summary

Senepol-cross steers and heifers that had received either a double implanting of Ralgro® or no implant during the winter pasture, stocker phase were fed either 4 percent or 8 percent cottonseed hulls (CSH) in a feedlot ration. Feedlot average daily gain (ADG), feed intake, and feed conversion were not affected by previous pasture implant. Steers that were implanted during the pasture phase and fed a 4 percent CSH ration exhibited the highest carcass quality grades. Steers that had not been implanted during the pasture phase had the lowest carcass quality grades regardless of level of roughage in the feedlot ration. Steers had higher ADG and more desirable feed conversions than did heifers. Feed intake expressed as a percentage of body weight was higher for heifers than for steers.

Introduction

The effects of implanting pasture cattle and the subsequent effects upon feedlot performance have not been well documented. Growth-promoting implants have been shown to increase ADG of cattle during either the stocker and/or the feedlot phase. However, the additive effect of live weight gain from both pasture and feedlot has not been established. This study describes data from one trial in which half of the calves were implanted on pasture and all cattle were implanted during the feedlot phase.

Procedure

Spring-born, one-half Senepol × one-quarter Brahman × one-quarter Hereford steers (n = 30) and heifers (n = 30) were weaned in October and stratified into each of six groups according to age, weight, and body condition at the Texas A&M University Agricultural Research and Extension Center at Overton. Three groups of heifers and three groups of steers were implanted with Ralgro on November 27, 1984, and reimplanted on February 27, 1985. The remaining three groups of each sex were not implanted. All calves grazed "Elbon" rye and "Marshall" ryegrass from November 27, 1984, to May 29, 1985. Additional details of the pasture trial are included in a paper in *Forage Research in Texas 1986* (1).

At termination of the grazing trial, calves were transported 500 miles to the Texas A&M University Agricultural Research and Extension Center at Amarillo. All calves were implanted with Ralgro and reallotted to groups that received either 4 percent or 8 percent cottonseed hulls (CSH) in the feedlot ration. Feedlot rations are presented in Table 1. Rations contained Rumensin at 30 g/ton and Tylan at 10 g/ton. Cattle were fed increasing energy levels during the first 21 days, after which the 4 percent and 8 percent CSH levels were maintained.

All calves were housed in pens with individual daily-feed-intake-monitoring devices (Pinpointer) during the feedlot period. Cattle were weighed at 28-day intervals, and individual daily feed intakes were recorded.

Calves were slaughtered in two kill groups (at visual estimates of 0.5 in. back fat, which resulted in 126-day and 168-day feeding periods). Carcass data recorded included hot carcass weight; rib eye area; percentage of kidney, heart, and pelvic fat; USDA quality grade; USDA yield grade; and fat thickness. The experimental design was a three-factor arrangement of treatments: sex (steers or heifers), previous implant (none or implanted twice), and two levels of CSH (4% or 8%). Data were analyzed using least-squares analysis of variance techniques.

Results and Discussion

Detailed animal performance from pasture x Ralgro implant treatments are presented in a companion paper titled, "Influence of Ralgro Implant and Nitrogen Fertilizer Rate on Animal Performance from Rye-Ryegrass Pastures" (1). Table 2 illustrates the on-pasture, off-pasture, and total winter pasture gain of Senepol steers and heifers that were either implanted or nonimplanted. The gain advantage shown for implanted calves was significant ($P < .16$) and represented an advantage of 0.2 lb/hd/day.

Weights for steers and heifers fed either 4 percent or 8 percent CSH rations are presented in Table 3. The

TABLE 1. FEEDLOT RATION COMPOSITION

Ingredients	8% CSH[1]	4% CSH
Corn Rolled	77.43	81.93
Cottonseed Meal	6.50	6.00
Cottonseed Hulls	8.00	4.00
Molasses Cane	5.00	5.00
Calcium Carbonate	1.50	1.50
Dicalcium Phosphate	0.50	0.50
Ammonium Sulfate	0.30	0.30
Salt	0.25	0.25
Potassium Chloride	0.50	0.50
Vitamin A, 20 m/lb	0.01	0.01
Trace Mineral	0.01	0.01

[1]CSH = cottonseed hulls

TABLE 2. BEGINNING AND FINAL CALF WEIGHTS DURING THE PASTURE PHASE

	Implant	Non-Implant
	----------Pounds----------	
On Pasture		
Steers	354	350
Heifers	310	312
Average	332	331
Off Pasture		
Steers	710	655
Heifers	610	590
Average	660	623
Gain		
Steers	356	305
Heifers	300	278
Average	328	292

TABLE 3. BEGINNING AND FINAL CALF WEIGHTS DURING THE FEEDLOT PHASE IN WHICH TWO LEVELS OF COTTONSEED HULLS (CSH) WERE FED

	Pasture Implant				Pasture Non-Implant			
	4% CSH		8% CSH		4% CSH		8% CSH	
	lbs							
Feedlot Arrival								
Steers	(9)[a]	649	(9)[a]	611	(8)[a]	575	(9)[a]	603
Heifers	(6)	549	(8)	534	(7)	510	(6)	519
Average	(15)	609	(17)	574	(15)	544	(15)	569
Slaughter								
Steers		1058		1032		970		1029
Heifers		945		895		934		884
Average		1013		968		953		971
Gain								
Steers		409		421		395		426
Heifers		396		361		424		365
Average		404		394		409		402

[a]Number of cattle in each group.

TABLE 4. AVERAGE DAILY GAIN (LB/DAY) OF CALVES RECEIVING TWO LEVELS OF COTTONSEED HULLS (CSH) IN FEEDLOT RATION

	Pasture Implant		Pasture Non-Implant	
	4% CSH	8% CSH	4% CSH	8% CSH
	lb/day			
Feedlot Arrival Weight[1]				
Steers	2.94	3.00	2.55	3.11
Heifers	2.61	2.52	2.74	2.31
Average	2.81	2.77	2.64	2.79
Off-Pasture Weight[2]				
Steers	2.40	2.41	2.22	2.50
Heifers	2.24	1.98	2.26	1.82
Average	2.34	2.21	2.24	2.23

[1]Feedlot arrival weights used for calculations.
[2]Pasture departure weights used for calculations.

TABLE 5. CONVERSION OF FEED:GAIN FOR SENEPOL STEERS AND HEIFERS RECEIVING TWO LEVELS OF COTTONSEED HULLS (CSH) IN FEEDLOT RATIONS

	Pasture Implant		Pasture Non-Implant	
	4% CSH	8% CSH	4% CSH	8% CSH
Feedlot Arrival Weight[1]				
Steers	7.29[a,b]	7.27[a,b]	7.42[a,b]	6.88[b]
Heifers	8.10[a]	8.44[a]	7.54[a,b]	8.76[a]
Average	7.61	7.82	7.48	7.63
Off-Pasture Weight[2]				
Steers	8.94	9.23	8.67	8.58
Heifers	9.56	10.93	9.19	11.22
Average	9.18	10.03	8.92	9.64

[1]Feedlot arrival weights include transit shrink.
[2]Pasture departure weights used for calculations.
[a,b]Means followed by a different superscript are different ($P < .05$).

off-pasture weight (Table 1) less the feedlot arrival weight was the shrink encountered during the 500-mile transit. Cattle shrink during transit was 10-11 percent, which is the typical shrink encountered by long-haul cattle. Both the off-pasture weight (Overton departure weight) and the feedlot arrival weights were used to calculate ADG (Table 4). Primary emphasis should be directed to the feedlot-arrival weights and the subsequent ADG. There were no differences in ADG for either the previous pasture implant treatment or the CSH level in the feedlot ration. Cattle gained 2.79 and 2.72 lb/day, respectively, for previously implanted and not implanted; thus, previous implanting had no effect on feedlot gains. Across all treatments, steers gained more than did heifers (2.91 vs. 2.55 lb/day, $P < .05$) during the feedlot phase.

Feed conversions are presented in Table 5. Across all groups, steers had more desirable feed conversions (7.2 lb feed/lb gain) than did heifers (8.2 lb feed/lb gain). There was a significant ($P < .05$) interaction among steers and heifers, CSH level, and previous implant treatment. Steers that were not implanted on pasture and that received the 8 percent CSH ration had better feed conversion than did heifers that received 8 percent CSH, regardless ot pasture treatment; however, these steers were not different from heifers that received 4 percent CSH and were implanted on pasture ($P < .05$).

Individual daily feed intake was measured via Pinpointer 5000 and reported as a percentage of body weight (BW) (Table 6). Intake, calculated as a percentage of BW, was not influenced by either previous pasture implant treatment or level of CSH in the feedlot ration. Heifers consumed 0.3 percent more than did steers (2.82% vs. 2.52%, $P < .05$). The feedlot data from this single trial indicate that heifers consumed more feed when measured

TABLE 6. FEED INTAKE AS A PERCENTAGE OF BODY WEIGHT (BW) OF CALVES RECEIVING TWO LEVELS OF COTTONSEED HULLS (CSH)

	Pasture Implant		Pasture Non-Implant	
	4% CSH	8% CSH	4% CSH	8% CSH
	%			
Feedlot Arrival Weight[1]				
Steers	2.48[b]	2.59[b]	2.43[b]	2.57[b]
Heifers	2.80[a]	2.86[a]	2.85[a]	2.76[a]
Average	2.61	2.72	2.62	2.64
Off Pasture Weight[2]				
Steers	2.38[b]	2.46[b]	2.35[b]	2.44[b]
Heifers	2.70[a]	2.71[a]	2.71[a]	2.62[a]
Average	2.50	2.58	2.52	2.51

[1]Feedlot arrival weights used for calculations.

[2]Pasture weight used for calculations.

[a,b]Means followed by a different superscript are different ($P < .05$).

TABLE 7. CARCASS TRAITS OF CALVES RECEIVING TWO LEVELS OF COTTONSEED HULLS (CSH) IN FEEDLOT RATION

	Pasture Implant		Pasture Non-Implant	
	4% CSH	8% CSH	4% CSH	8% CSH
Hot Carcass Wt. (lb)				
Steers	661.7	653.4	603.0	642.9
Heifers	600.0	571.9	601.0	582.5
Ribeye Area (in.^{2})				
Steers	11.4	11.2	10.8	10.9
Heifers	11.3	10.9	11.7	10.9
KHP (%)				
Steers	2.17	2.33	2.19	2.06
Heifers	2.25	2.12	2.29	2.42
USDA Quality Grade[1]				
Steers	3.67[a,b]	2.78[b,c]	2.25[c]	2.33[c]
Heifers	4.83[a]	4.25[a]	4.43[a]	3.83[a,b]
USDA Yield Grade[2]				
Steers	3.0	2.7	2.6	2.7
Heifers	2.7	2.6	2.6	2.7
Fat Thickness (in.)				
Steers	.42	.36	.31	.33
Heifers	.40	.39	.41	.37

[1]USDA quality grades scored as follows: 1 = Standard; 2 = Good −; 3 = Good; 4 = Good +; 5 = Choice −; 6 = Choice; 7 = Choice +.

as a percentage of BW, but the feed conversion of heifers was not as good as that of steers.

Heifer carcasses exhibited higher USDA quality grades than did steer carcasses (Table 7). The average quality grade of heifers was 4.33 (intermediate between Good+ and Choice-), whereas that for the steers was 2.77 (intermediate between Good- and Good) ($P < .05$). Steers that had not been implanted during the pasture-stocker phase had lower quality grades than steers that had been pasture-implanted and had received the 4 percent CSH feedlot ration ($P < .05$). Because there were no differences in any of the other carcass traits evaluated, the quality differences between steers and heifers were primarily due to intramuscular fat or to marbling. The age at slaughter of these Senepol-cross calves was approximately 18-20 months. Data from this trial certainly indicate that calves implanted twice on winter pasture during the stocker phase should not be discounted when entering the feedlot. The data also indicate that cattle previously implanted, particularly steers, might reach quality grades quickerwhen fed a high-energy ration (4% CSH).

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PR-4486

Update on Horn Fly Control in Beef Cattle

C.E. Richmond, D.K. Lunt, and J. Cocke

Horn fly infestation in cattle has been shown to decrease gains and lower milk production. Insecticide-impregnated ear tags have been used to control horn flies with varying degrees of success. Increased use of ear tags treated with pyrethroid insecticide, however, has led to a larger incidence of flies resistant to this insecticide. Some areas of Central Texas (Bell, Coryell, and McLennan counties) have been shown to be infested with horn flies at resistance levels as high as 10 times that of the Kerrville pyrethroid-susceptible lab strain. A test of four experimental insecticide-impregnated ear tags was conducted during the summer of 1985 at the Texas A&M University Agricultural Research Center in McGregor. Two compounds were identified that gave excellent control of horn flies in marginally resistant areas. One pasture tested, using a USDA resistance kit, had a resident horn fly population that had an LC90 (amount of insecticide required to kill 90% of the flies) of 1.17 compared with an LC90 of 0.63 for the Kerrville susceptible lab strain. These data indicate that the horn fly population in this pasture had a resistant/susceptible ratio of 1.85:1. This means that more insecticide would be required to obtain the same level of control. Another pasture tested showed an LC90 of 0.65 (not resistant). This difference in resistance may be accounted for by the fact that the pasture with the highly resistant population is adjacent to a commercial cattle operation, which has a program of continuous use of pyrethroid-treated ear tags for fly control, whereas the pasture that showed a low incidence of resistant flies is in the interior of the station. The cattle on this station are managed under a program of multiple-treatment insect control (ear tags in combination with spraying and pour-ons with nonpyrethroid insecticides). Two of the four compounds tested showed a 90.6 percent and 99.9 percent horn fly control rate on crossbred and Hereford cattle, respectively. Unfortunately, these compounds are not now approved for commercial use. The manufacturer is seeking approval, and they should be of great benefit when they are released. Research has shown that resistance to insecticides in flies is heritable. Once resistance to an insecticide is developed in part of the fly population, the proportion of resistant flies increases with the continued use of the product as the resistant flies survive and produce eggs. Because the gene for resistance to pyrethroid insecticide in horn flies is recessive, a management program of alternate-year ear tag control and spraying or dipping with nonpyrethroid compounds may be the most effective method to reestablish pyethroid-susceptible genes and control horn flies with these compounds without a continuous increase in resistance. The Texas Agricultural Experiment Station, the Texas Agricultural Extension Service, and industry concerns are continuing research in efforts to identify cost-effective solutions to this problem.

Growth and Development

PR-4487

Fat Synthesis in Adipose Tissue from Heifers Implanted with a Synthetic Steroid

L.C. St. John, P.A. Ekeren, J.D. Crouse, B.D. Schanbacher, and S.B. Smith

Summary

Forty-two heifers were allotted randomly to six treatment groups: (a) intact controls; (b) intact heifers implanted with trenbolone acetate; (c) ovariectomized heifers; (d) ovariectomized heifers implanted with trenbolone acetate; (e) intact heifers immunized against estradiol; and (f) intact heifers immunized against estradiol and implanted with trenbolone acetate. Lipogenic enzyme activities and acetate incorporation into fatty acids were increased in subcutaneous adipose tissue obtained at slaughter from heifers receiving immunization or the combination of immunization and trenbolone acetate. The increased lipogenic capacity was not reflected in either cell diameter or cells per gram tissue. Ovariectomy in combination with trenbolone acetate caused the lowest activities of all enzymes measured in conjunction with a decrease in acetate incorporation into fatty acids. This treatment also caused the greatest decrease in cell diameter, which resulted in the largest number of cells per gram of tissue. Conclusions are that (a) immunization and ovariectomy increased lipogenic enzyme activities; (b) trenbolone acetate alone had no detectable effect on lipogenesis in the intact heifer; (c) the combination of ovariectomy and trenbolone acetate caused substantial decreases in enzyme activities, which indicates that trenbolone acetate can overcome the effects of ovariectomy on adipose tissue metabolism.

Introduction

The growth and distribution of fat have been of considerable importance to both the producer and the consumer of animal products. The beef industry has been interested in the subject as it relates to the heifer because the heifer typically is fatter and thus valued lower than the steer. The differences in fat partitioning and live weight gains of heifers usually have resulted in a price differential of up to $4/cwt compared with the steer. However, the use of anabolic agents may be able to reduce this difference. Heitzman (2) suggested that the combination of androgen and estrogens are necessary for maximum growth potential. It has been suggested that androgens act directly at the muscle cell and are known to increase protein accretion, while possibly reducing protein turnover rates. Most of these studies emphasize the effects of anabolic hormones on the muscle cell. Little research has been reported dealing with the effect of androgens on adipose tissue. In this investigation, specific aspects of fatty acid synthesis and adipose tissue growth were investigated to clarify the mechanisms that are affected when an anabolic agent is used and/or taken away.

Materials and Methods

Ninety crossbred heifers were allotted randomly to one of six treatment groups at 5 months of age. These categories consisted of (a) intact heifers injected with 1 ml of .9 percent saline solution; (b) intact heifers implanted in the ear with 200 mg of trenbolone acetate at four 56-day intervals, with a 60-day withdrawal period; (c) ovariectomized heifers injected with .9 percent saline; (d) heifers receiving a combination of ovariectomy and trenbolone acetate; (e) intact heifers immunized against estradiol by injection along the udder; and (f) heifers receiving a combination of immunization and trenbolone acetate treatments.

Five to seven heifers from each treatment group were used in the preceding measurements. Samples of subcutaneous adipose tissue along the 12th and 13th thoracic vertebrae were removed after slaughter. Samples of adipose tissue were homogenized, and the activities of key lipogenic enzymes assayed as described previously (4). Other adipose tissue samples (100-150 mg) were fixed with osmium tetroxide by the method of Etherton et al. (1), modified as described by Smith and Crouse (4), to determine cell size. Particle number was determined with the Coulter Electronics coulter counter. Individual adipocytes were magnified, then manually measured with the aid of a Timbrell/Coulter Shearicon (100-200 cells per animal) and sorted into appropriate diameter channels for analysis.

Adipose tissue lipogenesis *in vitro* was determined by incubating 100-150 mg of fresh subcutaneous adipose tissue in flasks containing 5 mM D-glucose, 5 mM L-lactate, and 5 mM acetate and 1 uCi of [$U^{14}C$] acetate, in 3 ml of Krebs-Henseleit Ca^{2+}-free buffer. The reactions were terminated by the addition of .5 ml 2N H_2SO_4. Glyceride fatty acids were extracted by the method described by Smith and Prior (5).

Results

Carcass characteristics were determined on all cattle and will be reported elsewhere. Marbling scores did not change significantly among treatments in our subsamples, and the adjusted fat thicknesses for treatments 1 through 6 were .38, .42, .44, .30, .56, and .42 in., respectively. The adjusted fat thickness of the immunized group was significantly greater than that of the control group and the ovariectomy/trenbolone acetate group; tren-

bolone acetate implants in the immunized group eliminated these differences.

Ovariectomy tended to increase acetate incorporation into fatty acids relative to intact heifers, as seen in Table 1. However, ovariectomy in conjunction with trenbolone acetate caused a decrease in lipogenesis relative to ovariectomized heifers. Trenbolone acetate reduced acetate incorporation into fatty acids in adipose tissue of ovariectomized heifers to rates similar to control rates. Trenbolone acetate in the intact heifer had no observable effect on lipogenesis. Immunization against estradiol significantly increased the incorporation of acetate into fatty acids relative to the control, the trenbolone acetate, and the ovariectomy/trenbolone acetate groups, as seen in Table 1.

Fatty acid synthetase activity in adipose tissue from most treatment groups was similar to the control rates as seen in Table 1. However, the combination of estradiol immunization and trenbolone acetate caused elevated fatty acid synthetase activity. The activity of NADP-malate dehydrogenase tended to be increased by the ovariectomy treatment and was reduced significantly by the implantation of trenbolone acetate. The immunized treatment group demonstrated a significantly higher activity of NADP-malate dehydrogenase relative to the ovariectomy/trenbolone acetate group.

Immunization against estradiol, in the absence or presence of trenbolone acetate, significantly increased the activity of glucose-6-phosphate dehydrogenase compared with either the control or the ovariectomy/trenbolone acetate group. Similar results were observed in 6-P-gluconate dehydrogenase activity.

Peak adipose cell diameter and the number of adipose cells per gram tissue were inversely related in most of the groups, as seen in Table 2. Ovariectomy in conjunction with trenbolone acetate caused the smallest cell diameter. This diameter was significantly smaller than the diameters of adipose cells from the control, trenbolone-acetate-implanted, or ovariectomized heifers. As expected, cells per gram tissue were increased by the ovariectomized/trenbolone acetate treatment and were significantly different from the ovariectomized treatment.

Discussion

Intact heifers treated with trenbolone acetate exhibited results similar to those observed in the control heifers for all experimental parameters measured. Heitzman and Chan (3) documented no differences in plasma insulin, glucose, or nonesterified fatty acids when comparing the effects of trenbolone-acetate-implanted heifers to the intact heifers. This suggests that the reduction in carcass adipose tissue elicited by trenbolone acetate in ovariectomized heifers was not due to lipolysis but could, in fact, have been the result of depressed lipogenesis.

The ovariectomized and immunized heifers demonstrated similar results; lipogenesis tended to increase as a result of these treatments. In most situations, trenbolone acetate was able to reverse the effects of ovariectomy, but not of immunization.

Immunization and immunization combined with trenbolone acetate resulted in significantly greater rates of lipogenesis from acetate and generally increased all enzyme activities investigated, which should have resulted

TABLE 1. TREATMENT EFFECTS ON SPECIFIC LIPOGENIC ENZYME ACTIVITIES

	Treatment					
Enzyme	CTL[a]	TA	OVX	OVX/TA	IMM	IMM/TA
	nmol/min per 10^6 cells					
Fatty acid synthetase	221^{b}	150^{b}	213^{b}	150^{b}	239^{bc}	382^{c}
NADP-malate dehydrogenase	876^{bc}	649^{c}	1432^{b}	554^{c}	1355^{b}	1211^{bc}
6-P-gluconate dehydrogenase	355^{bc}	308^{bc}	427^{bc}	245^{c}	608^{b}	562^{bc}
Glucose-6-P dehydrogenase	794^{d}	1071^{cd}	1122^{cd}	776^{d}	1521^{bc}	1725^{b}
Acetate incorporation	3565^{c}	3731^{c}	5759^{bc}	2644^{c}	8357^{b}	8670^{b}

[a]Abbreviations: CTL, control; TA, trenbolone acetate; OVX, ovariectomy, OVX/TA, ovarietomy/trenbolone acetate; IMM, immunization; IMM/TA, immunization/trenbolone acetate.

[bcd]Means with same superscript in each row are not different (P>.05).

TABLE 2. TREATMENT EFFECT ON ADIPOSE TISSUE CELL SIZE AND QUANTITY PER GRAM TISSUE

	Treatment					
Parameter	CTL[a]	TA	OVX	OVX/TA	IMM	IMM/TA
Cell diameter (uM)	176^{b}	166^{bc}	175^{b}	145^{d}	154^{cd}	159^{bcd}
Cells/gram ($x10^{-6}$)	$.36^{bc}$	$.37^{bc}$	$.29^{c}$	$.47^{b}$	$.27^{c}$	$.31^{c}$

[a]Abbreviations as in Table 1.

[bcd]Means with the same superscript in each row are not different (P>.05).

in an increase in adipose tissue accretion. This was supported by the increase in adjusted fat thickness in the immunized group. However, the addition of trenbolone acetate to the immunized group decreased the adjusted subcutaneous fat thickness.

In summary, ovariectomy in conjunction with trenbolone acetate elicited the least acetate incorporation into fatty acids and NADP-malate dehydrogenase, 6-phosphogluconate dehydrogenase, glucose-6-phosphate dehydrogenase, and fatty acid synthetase activities. Cell size of this treatment was significantly smaller than the control. A decrease in subcutaneous adipose tissue thickness was observed in the ovariectomy/trenbolone acetate group without any significant change in marbling scores, indicating that lipogenesis may be regulated differently in subcutaneous fat and intramuscular adipose tissue. Thus, for producers, the ovariectomized/trenbolone acetate treatment was the most promising test treatment in its results. Using this specific treatment would produce a heifer that would yield more lean tissue and would eliminate the problem of pregnancy, which also greatly affects dressing percentage.

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PR-4488

Recent Findings on Efficiency in Beef Cattle

D. K. Lunt, F. M. Byers, and G. C. Smith

Cow maintenance is the largest expense in beef production. Cows that maintain themselves on less feed are more cost effective and can use more of their feed energy in the production of milk. In feedlots, efficiency of gain impacts profitability more than the common measure of cattle performance, average daily gain. Scientists have recently placed increased emphasis on understanding metabolic functions as they relate to growth in an effort to make beef production profitable. Past research has relied on the concept that animals of equal size have the same maintenance requirements. Recent reports, however, indicate that cattle of the same size and weight vary in their ability to maintain themselves. Energy used by certain vital organs (heart and liver) has been found to constitute a major proportion of total energy use in animals. To gain understanding of this phenomenon, a study was undertaken to determine if these organ masses of cattle of different breed types and on different feeding programs differed. In the first part of the study, 75 Angus, Brahman, and Brahman x Angus crossbred steers were full-fed a finishing diet. At the same carcass weight and rate of gain, Angus steers had heavier hearts and livers than did Brahman steers. Because protein turnover is faster in these organ tissues than in skeletal muscle, this represents a potential loss in efficiency of energy use. Growth of vital organ mass was also shown to increase as rate of gain increased. In the second part of the study, Braford steers were fed a grain-based finishing diet or were grown on forage alone. Forage-fed steers had larger hearts and livers than did their counterparts that were fed grain. This helps to explain why forage-fed cattle do not perform as well as calculations from standard values published by the National Research Council predict they should. These data indicate that we should adjust calculations of maintenance requirements that reflect differences in breed type, rate of gain, and nutrient density of the diet that cattle consume.

PR-4489

Fatty Acid Content of Tissues from Cattle and Pigs Fed Whole Rapeseed or Rapeseed Oil

L.C. St. John, C.R. Young, G.T. Schelling, D.A. Knabe, and S.B. Smith

Abstract

Twelve Angus x Hereford steers were assigned to either a control, high-energy diet or to a test diet consisting of 20 percent rapeseed at the expense of 20 percent corn. The loin eye and the top round muscles and kidney fat and external fat overlaying the loin eye and top round were collected immediately after slaughter for fatty acid profile determinations. Palmitic acid decreased significantly in fat, but all other fatty acids, either in fat or lean, remained unchanged by the rapeseed diet. In a second experiment,

12 pigs (4 sets of litter mates) were allotted to 1 of 3 diets consisting of a control soybean/cornmeal meal diet and 2 test diets containing either 10 percent or 20 percent canola oil (CO). Lean and fat were collected as described for steers. In porcine fat, the change in the ratio of monounsaturated to saturated fatty acids (M/S) increased from 1.19 in fat from control pigs to 3.63 with the addition of 20 percent CO to the diet. In pork lean, the M/S ratio increased from 1.21 in control pigs to 2.46 in the 20 percent CO treatment. Carcass characteristics were not affected by diet either in steers or in pigs, except that significant increases in "oiliness" and decreases in fat firmness were observed when increasing levels of canola oil were fed to pigs. Beef and pork palatability were not changed significantly in either species as a result of treatment. In conclusion, oleic acid content can be elevated substantially in pork without adversely influencing the quality of the meat, thus producing what is perceived by some to be a more healthful product. Rapeseed digestibility will have to be increased before similar effects can be elicited in cattle.

Introduction

The consumption of saturated fatty acids increases the concentrations of plasma low-density lipoprotein (LDL)-cholesterol in humans (3). In addition, elevated levels of LDL-cholesterol are correlated with increased risk of coronary heart disease (CHD). Conversely, when polyunsaturated fatty acids are substituted for saturates, plasma LDL-cholesterol falls (3). However, polyunsaturates also reduce plasma high-density lipoprotein (HDL)-cholesterol (3). This depression of HDL-cholesterol is of concern because of the inverse correlation between HDL-cholesterol levels and the risk of CHD. On the other hand, increasing monounsaturated fatty acids (oleic acid) in the diet decreases plasma LDL-cholesterol without reducing the plasma HDL-cholesterol (3). Reiser et al. (4) observed that feeding beef fat containing 49 percent monounsaturated fat significantly lowered total cholesterol and LDL-cholesterol in human subjects compared with diets containing coconut oil as the saturated fat.

With the U.S. population becoming more diet/health conscious, it is of considerable importance to the meat industry to produce a red-meat product that is perceived as being conducive to good health. One objective of this investigation therefore was to significantly reduce the amount of saturated fatty acids deposited in the adipose (fat) and muscle (lean) tissues of cattle and swine and also to replace this amount of saturated fatty acids with monounsaturated fatty acids. Therefore, elevated amounts of oleic acid were incorporated into the diets of steers and pigs in an attempt to increase the amount of monounsaturated fats in muscle and adipose tissues.

Materials and Methods

Twelve Angus x Hereford steers were assigned randomly to either a control high-energy diet or to a test diet similar to the control diet (Table 1). The test diet consisted of 20 percent canola rapeseed at the expense of 20 percent corn. Rapeseed was used because, being in the form of a seed, it could thereby potentially escape hydrogenation in the rumen. The oil from this rapeseed contained approximately 60 percent oleic acid (Table 2). The animals began treatment at an approximate weight of 550 lb and were slaughtered at the Texas A&M abattoir after being on feed for 100 days.

Twelve pigs (four sets of litter mates) were allotted randomly to one of three treatments consisting of a control corn/soybean meal diet and two similar test diets containing either 10 percent or 20 percent canola oil (CO) from United Oil Seed Co., Alberta, Canada (Table 3). All test diets contained the same amount of lysine. Canola oil was chosen because of its high percentage of oleic acid (Table 4). The swine began treatment at about 35 days of age and were slaughtered at approximately 100 kg live weight.

Immediately after slaughter, samples for fatty acid profile analysis were taken from the *longissumus dorsi* (loin eye) and semimembranous muscles (top round or ham), subcutaneous (external) fat over the 13th rib, subcutaneous fat overlaying the semimembranous muscle, and perirenal (kidney) fat.

Carcass Evaluation

Carcass characteristics were taken 24 hr postmortem to determine USDA yield and quality grades. An additional characteristic was evaluated to assess the "oiliness" of the carcass to study the effects of the diet high in oleic

TABLE 1. COMPOSITION OF DIETS (WITH AND WITHOUT RAPESEED) FED TO STEERS

Ingredient	Without Rapeseed	With Rapeseed
Rapeseed	0	200
Cracked corn	700	500
Cottonseed hulls	100	100
Cottonseed meal	122	122
Molasses	50	50
Limestone	15	15
Vitamin pre-mix	5	5
Potassium chloride	5	5
Trace mineral salt	3	3

TABLE 2. FATTY ACID COMPOSITION OF CANOLA RAPESEED

Fatty Acid Type[a]	Percentage
14:0	1.0
16:0	4.0
18:0	3.0
18:1	60.0
18:2	12.0
18:3	5.0
20:0	3.0
20:1	1.0
22:0	3.0
22:1	5.0
Total	100.0

[a]14:0 means a 14-carbon chain with no double bonds (completely saturated); 18:3 means an 18-carbon chain with 3 double bonds between carbons (polyunsaturated); 18:1 means an 18-carbon chain with 1 double bond between carbons (monounsaturated).

acid and the differences in melting points of the saturated versus unsaturated fatty acids on the softness of the external carcass fat.

Sensory Evaluation

Samples were removed from the loin eye 48 hr postmortem for sensory-panel evaluation. Each steak was broiled at 275 °C to an internal temperature of 70 °C. Upon reaching the desired temperature, the steaks were removed and sectioned into uniform pieces (1.3 cm × 1.3 cm × 1.9 cm) and distributed randomly to the panelists. A nine-member, trained descriptive-attribute panel was used to evaluate the cooked samples by use of nine-point structured scales (2) for the following traits: juiciness, tenderness, flavor, and amount of connective tissue, with values of 8 = extremely juicy, tender, flavorful, or no connective tissue; and 1 = extremely dry, tough, unflavorful, or abundant, respectively.

Warner-Bratzler shear force was determined using cooked loin eye steaks prepared in exactly the same manner as were the steaks for sensory-panel evaluation. Upon cooling to ambient temperature, six 1.3-cm cores were removed parallel to the longitudinal orientation of the muscle fibers. Each core was then sheared using the Warner-Bratzler machine.

Fatty Acid Profile Analysis

Duplicate samples of all muscle and adipose tissues were weighed and homogenized in a modified Dole's reagent (5), using the Polytron model s63c. The neutral lipids were extracted according to the procedure of Smith and Prior (5). The extracted lipids were weighed to determine percentage of lipid and then converted to methyl esters according to Christopherson and Glass (1). The methyl esters were analyzed for individual fatty acids with the Varian 1200 gas chromatograph packed with 10 percent DEGS on Chromasorb G.

Statistical Analysis

Data were analyzed with the General Linear Model program using a five by five factorial for the pigs and a five by two (location X treatment) factorial design for the cattle in a split plot arrangement. Tissue site and treatment were the main effects. Mean separation was achieved by Duncan's multiple range test.

Results and Discussion

Kidney fat in steers contained more saturated fatty acids than did external fat depots overlaying the top round or loin eye (Table 5). Both areas of external fat exhibited similar fatty acid percentages. When increased levels of oleic acid were fed to the cattle, only palmitic acid decreased significantly in fat; small, nonsignificant increases in oleic and linoleic acid also were observed. All other

TABLE 3. DIET COMPOSITION FOR SWINE FED 0%, 10%, OR 20% CANOLA OIL

	% Canola Oil		
Ingredient	0	10	20
Sorghum	44.71	33.75	22.75
Oats	25.00	25.00	25.00
Soybean meal 44%	26.81	27.29	28.77
Ground limestone	.16	.16	.16
Defluorinated phosphate	2.17	2.17	2.17
Salt	.25	.25	.25
Trace mineral premix	.25	.25	.25
Vitamin premix	.25	.25	.25
Aureo-SP-250[a]	.25	.25	.25
TOTAL	100	100	100
Calculated analysis, %			
Protein	18.80	18.30	17.70
Lysine	.95	.95	.95
Calcium	.85	.85	.85
Phosphorus	.75	.72	.70

[a]Medication was removed from the diet 21 days before slaughter.

TABLE 4. FATTY ACID COMPOSITION OF CANOLA OIL

Fatty Acid Type	Percentage
16:0	3.8
16:1	.1
18:0	1.8
18:1	64.0
18:2	18.6
18:3	9.1
20:0	.5
21:1	1.0
22:0	.1
Total	100.0

TABLE 5. FATTY ACID PROFILES OF FAT FROM STEERS FED DIETS WITH AND WITHOUT RAPESEED

	Fatty Acid					
Treatment	14:0	16:0	16:1	18:0	18:1	18:2
Diet						
Corn	3.9[a]	26.7[a]	2.0[a]	20.2[a]	41.2[a]	4.8[a]
Corn/rapeseed	3.6[a]	24.3[b]	2.0[a]	20.5[a]	43.0[a]	5.5[a]
Fat depot						
Kidney	2.9[b]	24.3[a]	1.1[a]	28.4[a]	38.3[b]	4.4[a]
Top round	4.3[a]	25.8[a]	2.2[a]	17.2[b]	43.4[a]	5.3[a]
Loin eye	4.1[a]	26.7[a]	2.8[a]	14.9[b]	44.7[a]	5.6[a]

[ab]Means within a column and for the same comparison (e.g., Diet) with a different superscript letter are different ($P < .05$).

TABLE 6. FATTY ACID PROFILES IN LEAN FROM STEERS FED DIETS WITH AND WITHOUT RAPESEED

	Fatty Acid					
Treatment	14:0	16:0	16:1	18:0	18:1	18:2
Diet						
Corn	3.5[a]	30.4[a]	1.6[a]	11.8[a]	47.5[a]	4.0[a]
Corn/rapeseed	3.1[a]	27.5[a]	2.4[a]	13.1[a]	47.3[a]	3.9[a]
Muscle						
Top round	3.4[a]	29.1[a]	2.5[b]	12.4[a]	47.3[a]	4.8[b]
Loin eye	3.3[a]	29.4[a]	1.4[a]	12.2[a]	48.9[a]	3.2[a]

[ab]Means within a column and for the same comparisons (e.g., Diet) with a different superscript letter are different ($P < .05$).

fatty acids, in either fat or lean, remained unchanged (Tables 5 and 6). Investigations of the digestibility of rapeseed indicate that the limited effects observed in this study with steers were due to the relative indigestibility of the rapeseed. Because the canola rapeseed diet elicited minimal effect on the fatty acid profiles, carcass characteristics and sensory traits in the control and treated steers were not different (data not shown).

As in steers, the kidney fat of pigs had significantly higher percentages of saturated fatty acids than other fat depots (data not shown in tabular form). No significant differences were observed between the external fat overlaying the top round or the fat overlaying the loin eye. Interactions among individual tissue site and treatment groups were nonsignificant for swine tissues; therefore, the data were pooled across tissue site for subsequent analysis and discussion.

Fatty acid profiles of pigs that were fed elevated levels of CO exhibited significant effects in both saturated and unsaturated fatty acids (Table 7). In fat tissues, the percentage of total saturated fatty acids (14:0, 16:0, and 18:0) decreased from 40 percent in the control pigs to 15 percent in animals fed 20 percent CO. The ratio of monounsaturated fat (16:1 plus 18:1) to saturated fat (M/S) in the control animals was 1.19 and increased to 3.63 in the 20 percent CO treatment. The M/S ratio increased from 1.21 in lean in the control to 2.46 in lean in the 20 percent CO treatment.

Adjusted fat thickness, loin eye area, and marbling scores in pigs fed elevated levels of CO did not differ significantly from the control animals (Table 8). Fat firmness and oiliness of the carcass did increase significantly with increasing amounts of unsaturated fatty acids in the diet. This was expected because of the lower melting point of unsaturated fat relative to saturated fat.

Sensory-panel evaluations revealed no significant differences in juiciness, flavor, tenderness, and amount of connective tissue in pork when increased levels of canola oil were fed to pigs, even though there was a significant increase in unsaturated fat in both the lean and the fat of the pork chops. Percentage of cooking loss and shear force also demonstrated no effects of treatment.

It is evident that the diet of the pigs was able to change substantially the fatty acid composition in both fat and lean, unlike results observed in cattle fed rapeseed. Recent research has indicated that the consumption of saturated fats in the diet can lead to elevated levels of plasma LDL-cholesterol (3). The inclusion of monounsaturates in the diet in humans reduces LDL-cholesterol without decreasing the HDL-cholesterol, which polyunsaturates have been shown to decrease. Therefore, this investigation provides evidence that a red-meat product can be made that may be considered more healthful by consumers.

TABLE 7. FATTY ACID PROFILES OF FAT FROM PIGS FED CANOLA OIL BY TREATMENT AND LOCATION

	Fatty Acid						
Treatment	14:0	16:0	16:1	18:0	18:1	18:2	18:3
Fat							
0% CO	1.3[a]	25.6[a]	.9[a]	12.9[a]	46.9[a]	11.5[c]	.9[a]
10% CO	.9[b]	16.7[b]	.7[ab]	7.3[b]	52.7[b]	17.2[b]	4.6[b]
20% CO	.5[c]	10.8[c]	.4[b]	4.3[c]	56.1[c]	21.5[a]	6.5[c]
Lean							
0% CO	1.9[a]	31.8[a]	2.9[a]	8.6[a]	48.6[a]	6.2[c]	—
10% CO	1.7[ab]	24.0[b]	1.4[b]	5.5[b]	52.3[ab]	13.5[b]	—
20% CO	1.2[b]	18.8[b]	1.2[b]	3.5[c]	56.6[b]	18.3[a]	—

[abc]Means within a column and for the same comparisons (e.g., Fat) with a different superscript letter are different ($P < .05$).

TABLE 8. CARCASS CHARACTERISTICS OF PIGS FED DIETS CONTAINING 0%, 10%, OR 20% CANOLA OIL.

	Trait					
			Loineye			
Treatment Group	Backfat Thickness (in.)	Backfat Firmness	Area ($in.^2$)	Firmness	Marbling	Oiliness
Control	1.0[a]	7.25[a]	7.1[a]	3.00[a]	2.23[a]	5.00[a]
10% CO	1.1[a]	4.75[b]	7.3[a]	3.75[ab]	1.50[a]	3.00[b]
20% CO	.9[a]	3.75[c]	7.5[a]	4.25[b]	1.13[a]	1.50[c]

[abc]Means within a column with a different superscript letter are different ($P < .05$).

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PR-4490

Muscle and Adipose Tissue Development in Heifers Fed the Beta-Agonist Clenbuterol

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Summary

Muscle and adipose tissue growth was evaluated in heifers fed finishing rations with or without 10 mg/hd/d clenbuterol. Charolais x Hereford and Charolais x Hereford x Jersey heifers (eight animals per treatment group) were fed for 50 days either a sucrose-based clenbuterol supplement or a placebo in which the clenbuterol had been omitted. Beginning and final weights of the heifers were 392 and 432 kg. Ribeye surface areas were greater (93.5 vs. 78.1 cm^2) in the clenbuterol-fed heifers ($P < .05$). Adjusted fat thickness was reduced by 42 percent by feeding clenbuterol ($P < .05$), and a significant reduction in marbling scores resulted in reduced USDA quality grades ($P < .05$) in the clenbuterol-fed heifers. Subcutaneous, intramuscular, and kidney-pelvic fat cell sizes were not significantly different between groups, but tended to be smaller in the clenbuterol-fed heifers. The activities of lipogenic enzymes were approximately 60 percent lower ($P < .05$) in subcutaneous adipose tissue from clenbuterol-fed heifers than from control heifers. Fiber typing of *longissimus* samples indicated that those fibers that stained positively for alkali-stable ATPase had 63 percent greater surface area in the clenbuterol-fed heifers, whereas negatively staining fibers tended to be smaller, relative to muscle fibers from control heifers. The results indicate that clenbuterol increased muscle hypertrophy in heifers, primarily by increasing the diameter of white fibers, and reduced lipogenic capacity in subcutaneous adipose tissue.

Introduction

Previous studies have indicated that the repartitioning agent clenbuterol increases muscle growth and decreases fat accretion when fed to sheep (1,2,4) and steers (5) as a top dressing to a high-concentrate diet. The effects of clenbuterol were more pronounced in sheep than in steers. This could be because sheep have relatively less muscle mass than do steers, so the effects of clenbuterol were more easily elicited. Heifers also deposit less muscle and more fat relative to steers. This propensity to accumulate body fat at the expense of muscle in heifers results in heifer carcasses being less desirable economically and nutritionally.

No research has yet been reported on the effects that feeding a repartitioning agent would elicit on carcass composition in the finishing heifer. Therefore, one objective of this study was to investigate for the first time the effects of feeding the repartitioning agent clenbuterol to finishing heifers on growth and carcass traits. An additional objective was to provide evidence of the cellular mechanism by which repartitioning agents affect muscle and fat accretion in cattle.

Materials and Methods

Animals and Procedures

Sixteen heifers of Charolais x Hereford and Charolais x Hereford x Jersey breeding, approximately 12 months of age, were used as experimental animals. Heifers were separated into two groups according to weight and breed type. Heifers were fed a measured amount of a high-energy diet (Table 1) twice daily, and uneaten feed was recovered and weighed. Heifers were fed according to this regime for 85 days before the start of the trial. One group of heifers received 10 mg/hd/d clenbuterol for 50 days. The compound was administered in 63.94 ml/dose of a sucrose-based top dressing. The control heifers received the same amount of a placebo in which the clenbuterol and other compounds with no nutritive value had been omitted. Heifers were weighed at 14-day intervals after a 12-hr fast.

Heifers were slaughtered at the Meat Science and Technology Center, Texas A&M University, College Station, Texas. Samples to be used for assays of enzyme activities and *in vitro* incubations were collected immediately after slaughter and placed in 37 °C Krebs-Henseleit buffer plus 5 mM glucose (pH 7.4) for transport to the laboratory. Carcasses were chilled at 2 °C.

Adipose Tissue Lipogenesis in Vitro

Subcutaneous adipose tissue overlaying the fourth-sixth rib region of the *triceps brachii* muscle was obtained at slaughter as described previously. Incubations with [U-^{14}C]acetate were carried out using the method of Smith and Crouse (6) except that incubation time was 2 hr. Neutral lipids were extracted as described by Smith and Prior (7).

Assay of Enzyme Activities

Fresh portions of subcutaneous adipose tissue (3 g) were homogenized on ice in 3 volumes (w/v) .154 M KCl:.01 M phosphate buffer (pH 7.4) with a Potter-Elvehjem homogenizer at medium speed. The homogenate was centrifuged at 3,000 xg for 15 min, decanted, and the supernate centrifuged at 15,000 xg for 30 min. All procedures were performed at 4 °C. Adipose tissue centrifugal fractions were assayed immediately for the activities of fatty acid synthetase, NADF-malate dehydrogenase (EC 1.1.1.40), and glucose-6-phosphate dehydrogenase (EC

TABLE 1. COMPOSITION OF DIET

Ingredient	As Fed (%)
Cottonseed hulls	10.00
Cottonseed meal	11.03
Ground milo	72.12
Molasses	4.00
Calcium carbonate	1.70
Ammonium sulfate	.25
T.M. salt	.25
Vit. A, D, and E	.40
Dyna-K	.25
Nutrient content	
NEm, Mcal/kg	1.68
NEp, Mcal/kg	1.10

1.1.1.49) and 6-phosphogluconate dehydrogenase (EC 1.1.1.44) (6).

Samples of adipose tissue from the intramuscular, perirenal, and subcutaneous depots (100-150 mg) were stored at –25 °C in screw-cap vials. Adipose tissue samples were sliced into 1-mm thicknesses while still frozen and fixed with osmium tetroxide as described previously (6). Intramuscular adipose tissue samples were collected only for three clenbuterol-treated and four control heifers. Cell size was determined by measuring 100 cells/sample using a Timbrell/Coulter Shearicon. The number of adipose cells per gram tissue was measured with a Coulter Counter.

Carcass Characteristics

Quality grade and yield grade factors were evaluated 24 hr postmortem by personnel of the Meats and Muscle Biology Section, Department of Animal Science, Texas A&M University.

Muscle Fiber Type and Area

Muscle samples were obtained 24 hr postmortem from the *longissimus dorsi* muscle and frozen in liquid nitrogen. Cross sections, 10 micrometer thick, were cut on a cryostat at –20 °C and mounted on glass slides. These cross sections were incubated for myofibrillar ATPase at pH 9.4 and 37 °C for 30 min after preincubation at pH 10.4 and at 21 °C for 10 min. Fibers were classified as type I (alkali-ATPase negative) or type II (alkali-ATPase positive).

Means were separated using the student's T-test. Expressing the lipogenic data either as per gram tissue or as per 10^5 cells did not influence the statistical conclusions.

Results and Discussion

Growth Rate and Carcass Traits

Feeding clenbuterol to heifers did not improve growth rate or feed efficiency (Table 2). One animal from the clenbuterol-fed group and one control heifer were eliminated from the study because of refusal to consume the diets. Carcass evaluation of the remaining animals (Table 3) indicated that carcasses from clenbuterol-fed heifers had significantly larger ribeye areas and less subcutaneous, intramuscular (marbling) and kidney, pelvic, and heart fat and a concomitant reduction in USDA yield grade.

Lipogenesis and Adiposity

Lipogenesis, as measured *in vitro* by lipogenic enzyme activities and [U-^{14}C]acetate incorporation into fatty acids, was depressed ($P < .05$) in subcutaneous adipose tissue samples from the clenbuterol-fed heifers (Table 4). However, part of this substantial decrease in lipogenesis *in vitro* could have been caused by lower energy intake. Previous work in this and other laboratories has shown a strong relationship between energy intake and lipogenesis, as measured *in vitro* (6).

Adipose cell number data indicated smaller adipocytes (i.e., more cells/g tissue) in the subcutaneous adipose tissue depot of the clenbuterol-fed animals compared with the control animals (4.22×10^5 vs. 2.98×10^5 cells/g adipose tissue, respectively) (data not presented in tabular form). This difference in numbers of cells per gram tissue was not observed in the intramuscular or perirenal adipose tissue depots, despite the observed differences in marbling scores and kidney-pelvic fat (Table 3). It is likely that the decrease in fat cell size was due to the decrease in lipogenesis *in vitro* observed in the clenbuterol-fed animals relative to the control animals.

Muscle Fiber Type and Size

Fiber typing of *longissimus* muscle samples (data not presented in tabular form) for alkali-stable ATPase indicated that those fibers that stained positively for ATPase had approximately 63 percent greater surface area in the clenbuterol-fed animals relative to the control animals. Conversely, cross-sectional areas of negatively staining

TABLE 2. GROWTH RATE AND FEED EFFICIENCY OF HEIFERS FED DIETS WITH AND WITHOUT CLENBUTEROL

Observation*	Control	10 mg Clenbuterol
Number of animals	7	7
Beginning weight (kg)	399	385
Final weight (kg)	440	423
Rate of gain (kg/hd/d)	.78	.76
Feed/gain	11.24	9.47

*No significant differences ($P > .10$) between means (SD) within rows.

TABLE 3. CARCASS CHARACTERISTICS OF HEIFERS FED DIETS WITH AND WITHOUT CLENBUTEROL

Observation	Control	10 mg Clenbuterol
Number of animals	7	7
Carcass weight (kg)	273	270
Adj. fat thickness (cm^2)	.99*	.58
KPH (%)	2.1*	1.3
Ribeye area (cm^2)	78.1*	93.5
Marbling score	S1 ^{96}*	Tr ^{76}
Maturity score	A ^{51}	A ^{25}
Yield grade	2.3*	1.0
Quality grade	Gd ^{90}*	St ^{89}

*Denotes significant difference ($P < .05$) between means within rows.

TABLE 4. LIPOGENESIS *IN VITRO* IN HEIFERS FED DIETS WITH AND WITHOUT CLENBUTEROL

Observation	Control	10 mg Clenbuterol
Number of animals	4	3
Enzyme activities		
	(nmol/min/g)	
Fatty acid synthetase	54* (22)	13 (10)
NADP-malic dehydrogenase	192* (70)	78 (35)
6-phosphogluconate dehydrogenase	1077* (318)	460 (156)
Glucose-6-phosphate dehydrogenase	1631* (304)	680 (263)
	(nmol/2 h/100 mg)	
Acetate to fatty acids	31.5* (12.6)	4.5 (6.6)

*Denotes significant difference ($P < .05$) between means (SD) within rows.

fibers were not different between clenbuterol-fed and control animals.

Summary

Differences reported for ribeye surface area are similar to those reported by Ricks et al. (5) for steers. However, the reduction in the USDA quality grade of clenbuterol-fed animals, as seen in this study, was not reported by Ricks et al.(5).

Data on muscle fiber type suggest that the increased muscle hypertrophy elicited by clenbuterol was due to an increase in the diameter of type II myofibers, but Beermann et al. (2) reported an increase in the cross-sectional area of both type I and type II myofibers from the semitendinosus muscle of sheep fed the repartitioning agent cimaterol. This discrepancy could have been due to species or anatomical differences.

The possibility that animals in the clenbuterol-fed group were more genetically predisposed to deposit fat was unlikely because ultrasound measurements taken at weighing periods (data not presented) indicated that animals in both groups were similar in fatness after 85 days on the finishing diet at the start of the trial. Duquette and Muir (3) found that clenbuterol depressed lipogenesis in rats and reported that the anti-lipogenic activity of some beta-agonists may cause the decrease in fat accretion associated with feeding these compounds. However, this laboratory has not been able to demonstrate an effect of beta-agonists *in vitro* on lipogenesis from acetate.

In summary, the results in this study indicate that clenbuterol increased muscle hypertrophy in heifers, primarily by increasing the diameter of type II fibers, and reduced lipogenic capacity in subcutaneous adipose tissue.

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Health

PR-4491

Economic and Epidemiologic Analysis of U. S. Bovine Brucellosis Programs

R. A. Dietrich, S. H. Amosson, and R. P. Crawford

A base program and eight alternative bovine brucellosis programs were simulated for the contiguous 48 states from 1976 to 2005 to analyze the economic and epidemiologic impact of these alternative bovine brucellosis programs. Four programs—the theoretical eradication program, the realistic eradication program, the base program with a 25 percent increase in efficiency in Class C regions, and the current program—were highly effective in reducing brucellosis infection and physical losses. Brucellosis infection and physical losses increased in all other programs simulated, especially the no-state-federal-programs scenarios. Calfhood vaccination was highly effective in reducing infection and physical losses under the no-program scenarios, but such programs were inferior to other programs simulated. The realistic eradication program ranked above other alternative programs analyzed, except the theoretical eradication program, in total benefits, net benefits, and benefit-cost ratios. Equity analysis revealed that consumers were the major beneficiaries of investments in publicly funded bovine brucellosis programs, which decreased physical losses and increased supplies of meat and milk.

Introduction

Bovine brucellosis, an infectious reproductive disease, which can cause calf deaths, abortions, light calves, reduced milk production, and undulant fever in humans, is a major economic problem affecting beef and dairy industries, consumers, and related agricultural industries. U. S. Cattle producers incurred production losses exceeding $32 million from brucellosis in 1983 (2). Although such production losses are substantial, in some instances catastrophic, producers incur additional costs associated with testing and prevention practices. Consumers are impacted adversely through higher prices and smaller supplies of meat and milk, while related agricultural industries may incur losses from reductions in sale of products and services.

Bovine brucellosis reactors as identified by the Market Cattle Identification (MCI) program decreased from .97 percent of the total cattle tested in 1966 to .31 percent in 1984 (3). Further, initial follow-up tests of Brucellosis Ring Test (BRT) suspicious herds that were found to be infected declined from 1,653 in 1967 to 197 in 1984 (3). Although these data represent program progress, U.S. Department of Agriculture data indicate that bovine brucellosis infection was still present in 31 of the 50 states as of April 1985. Given the wide variation in reactor rates among the non-Class-Free states and the concentration of infection in nine states where 90 percent or more of the infection in the U. S. still exists (3), this research was designed to analyze current and alternative bovine brucellosis programs to aid program officials in implementing economical and epidemiologically efficient bovine brucellosis programs.

Procedures

An epidemiologic-simulation model and an econometric model were employed to analyze alternative U.S. bovine brucellosis programs (1, 3). The epidemiologic model, BRUSIM, was designed to measure the impact of various program components upon selected epidemiologic parameters and to determine associated costs and physical losses of brucellosis control/eradication programs given epidemiologic coefficients and economic criteria from 1976 through 2005 (1, 3). The U. S. was delineated into 16 regions according to such factors as prevalence, producer characteristics, and cattle population (Table 1).

The econometric model, TECHSIM, was designed to measure the economic impact of the change in physical losses associated with various program alternatives that accrue to consumers, producers, and related industries (1, 3). The econometric model facilitated the estimation of total change in benefits, net change in benefits, change in program costs, and benefit/cost ratios for determining economic acceptability of the programs analyzed.

A base program and eight alternative bovine brucellosis programs were simulated for the contiguous 48 states (3). The base program was designed to simulate the U.S. bovine brucellosis program on a regional basis from FY 1976 to FY 1984 along with changes in program procedures that maintained the disease at a relatively steady state from 1985 to 2005. The base program served as a bench mark from which changes in program efficiency could be measured for alternative bovine brucellosis programs simulated in BRUSIM. Alternative programs simulated included (a) current program, (b) theoretical eradication program, (c) realistic eradication program, (d) base program with a 25 percent increase in program efficiency in Class C regions, (e) base program with a 25 percent decrease in program efficiency in Class C regions, (f) no state-federal program with a milk-ordinance-enforced brucellosis program, (g) no state-federal program with a 45 percent vaccination level of female calves

TABLE 1. NUMBER OF CATTLE OPERATIONS, NUMBER OF INFECTED HERDS, AND INFECTED HERD RATE PER 1,000 OPERATIONS, BY REGION, CONTIGUOUS 48 STATES, MARCH 31, 1985

Region	Operations[a] With Cattle	Number of[b] Infected Herds	Infected Herd Rate Per 1,000
(1) NE-Lake[c]	398,120	18	.045
(2) Atlantic[d]	115,000	4	.035
(3) Alabama	42,000	108	2.571
(4) Georgia	37,000	43	1.162
(5) Kentucky	65,000	119	1.831
(6) Mississippi	36,000	340	9.444
(7) Tennessee	77,000	47	.610
(8) Florida	21,000	742	35.333
(9) Arkansas	40,000	545	13.625
(10) Louisiana	25,000	665	26.600
(11) Oklahoma	66,000	352	5.333
(12) West Texas[e]	57,255	135	2.358
(13) East Texas[e]	94,650	1,492	15.763
(14) N-Plains[f]	298,500	261	.874
(15) West[g]	138,600	43	.310
(16) California	35,000	26	.743
Total	1,546,125	4,940	3.195

[a]Any place having one or more head on hand at any time during the year for 1984. Source: U.S. Department of Agriculture. 1985. Cattle. Washington, D.C.

[b]Infected herds as of March 31, 1985. Source: U.S. Department of Agriculture. 1985. Washington, D.C.

[c]Includes Connecticut, Delaware, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, and Wisconsin.

[d]Includes North Carolina, South Carolina, Virginia, and West Virginia.

[e]West Texas and East Texas correspond to Class B and Class C counties, respectively, as of March 31, 1985.

[f]Includes Iowa, Kansas, Missouri, Nebraska, North Dakota, and South Dakota.

[g]Includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

entering the herd, and (h) no state-federal program with a 75 percent vaccination level of female calves entering the herd. Details concerning program design and assumptions, base program projections, and model validation are available in Dietrich et al. (3). Data sources, methodology, development of epidemiologic coefficients, and input matrices are available in Amosson et al. (1).

Results

Major findings resulting from the alternative bovine brucellosis programs analyzed are as follows with respect to:

1. *Control and/or eradication of brucellosis infection.* Four programs—the theoretical eradication program, the realistic eradication program, the base program with a 25 percent increase in efficiency in Class C regions, and the current program—were highly effective in reducing brucellosis infection from 1984 to 2005 (Table 2). The theoretical eradication program demonstrated that the current state of technology was sufficient to achieve eradication within 3 to 5 yr when known infected herds are depopulated and when program constraints relative to financial and manpower commitment, producer cooperation, and program inefficiencies with respect to adherence to the Uniform Methods and Rules (UM&R) are eliminated (3).

The realistic eradication program, which assumed 1982-84 funding levels, the strict adherence to the UM&R by program personnel, and a modified depopulation scheme (3) reduced total infected cows by more than 92 percent from 1984 to 2005 (Table 2). The results revealed that the realistic program would be a powerful tool leading to eradication, given increased producer cooperation via incentives or education programs plus producer incentives for depopulating known infected herds.

The base program with a 25 percent increase in program efficiency in Class C regions, although revealing infection levels ranging from 5 to 7 percent higher in all infection parameters than did the realistic eradication program by 2005 (3), was more effective in reducing infection than was the current program. These results suggest that a 25 percent increase in program efficiency in high incidence or Class C regions through stricter adherence to the UM&R or other incentives would be highly effective in reducing infection levels.

The base program with a 25 percent decrease in program efficiency in Class C regions demonstrated that reductions in program efficiency in high-incidence regions would result in substantial increases in infection (Table 2). However, the most dramatic increases in bovine brucellosis infection were generated by the three no-state-federal-program scenarios. Total infected cows increased 69-fold under the no-state-federal program without calfhood vaccination from 1984 to 2005, compared with a 4-fold increase in infected cows for the no-program scenario with a 75 percent calfhood vaccination level (Table 2). These results demonstrate that calfhood vaccination would be highly beneficial under a no-state-federal-program scenario or when bovine brucellosis infection exists at relatively high levels. However, the results also revealed that a program of calfhood vaccination, even at a high level of vaccination, under a no-state-federal-program scenario was inferior with respect to reducing bovine brucellosis infection compared with other alternative programs simulated.

2. *Economic benefits.* The highest positive change in benefits to society, net change in benefits to society, and benefit/cost ratios accrued from the theoretical eradication program, followed closely by the realistic eradication program (Table 2). The three no-state-federal-program scenarios and the base program with a 25 percent decrease in program efficiency in Class C regions all produced negative changes in benefits to society as well as generated economically unacceptable benefit/cost ratios. Further, equity analysis revealed that consumers and related agricultural industries would accrue substantial, positive benefits from programs that decrease infection as do the eradication programs, the base program with a 25 percent increase in efficiency in Class C regions, and the current program. Consumers, however, would incur large negative benefits or losses from programs that increase infection as do the no-state-federal-program scenarios.

TABLE 2. ECONOMIC AND EPIDEMIOLOGIC IMPLICATIONS OF VARIOUS BRUCELLOSIS PROGRAM ALTERNATIVES ON INFECTION, PROGRAM BENEFITS, AND COSTS, RELATIVE TO THE BASE PROGRAM, UNITED STATES, 1984-2005

Program Alternative	Infected Cattle*	Base Program Costs**	Net Change In Program Costs**	Net Change In Benefits	Benefit/ Cost Ratios
	% change		million dollars		ratio
Current program	−82.9	2157.0	−67.7	541.0	1.26
Realistic eradication	−99.5	2157.0	−424.4	1157.5	1.68
Theoretical eradication	−100.0	2157.0	−428.3	1266.0	1.73
Base program—25% increase in efficiency in Class C regions	−92.6	2157.0	−124.4	760.5	1.37
Base program—25% decrease in efficiency in Class C regions	78.0	2157.0	46.6	−252.7	.89
No state-federal program	6926.2	2157.0	−1709.8	−16,628.3	−36.19
No state-federal program—45% calfhood vaccination	2049.2	2157.0	−1284.3	−4145.5	−3.75
No state-federal program—75% calfhood vaccination	432.3	2157.0	−889.7	−498.3	.61

*Total number of infected cattle for the 1984 base program was 146,480.

**Dollars are in 1982 real dollars along with a 4 percent discount rate.

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Acknowledgments

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PR-4492

A Cause of Primary Photosensitization of Cattle and Deer in South Central Texas

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Photosensitization in cattle has been reported infrequently since 1913 in south central Texas. The disease was extensively investigated during the 1950's, but no solution was found. Photosensitization is most frequent and widespread in DeWitt and surrounding counties. Many cases occurred in 1982-83 and 1984-85 in DeWitt County; an estimated 15,000 head of cattle were affected in February 1983 and 6,000 in February 1985. During 1984 and 1985, numerous cases of photosensitization in white-tailed deer were reported in DeWitt County.

Plant material collected during plant surveys of areas where photosensitization was or had been occurring was tested for the presence of phototoxins, using a *Candida* assay. From extensive plant surveys, animal diet analyses, animal necropsies, and attempts to isolate and identify photodynamic chemicals in plant and animal parts, this resulted in the identification of rain lily (*Cooperia pedunculata* in the Amaryllis family) as a culprit species. The necropsies confirmed primary photosensitization (no liver involvement). Using the *Candida* assay to screen for

phototoxic activity in plant material, an extraction scheme was developed that was highly reliable and reproducible. With this technique, a photodynamic substance was found in dead materials of rain lily plants taken from the rumen or feces of photosensitized animals. The phototoxic substance is being isolated and studied for chemical characterization. Its presence in only dead leaf materials suggests a precursor chemical or mycotoxin(s) as being the possible causative agent.

All mice fed four levels (7.5% to 30%) of rain lily plant material in their ration exhibited signs of primary photosensitization after 2 hr of exposure to light. A calf fed 1.75 percent of his body weight of dried rain lily material exhibited signs by the sixth day, and a subsequent necropsy confirmed primary photosensitization. All evidence indicates that rain lily is definitely associated with the photosensitization disease in south central Texas, but the toxic principle has not been completely purified or chemically characterized.

Rain lily is a native of south central Texas; its distribution has been verified in 32 counties of the region. Moreover, it is present in parts of the Coastal Prairies, southern Blackland Prairies, southern Edwards Plateau, and northern Rio Grande Plains. Additional studies are planned to complete the verification of rain lily as a major culprit species and to isolate and identify the chemical or mycotoxin involved in the disease.

PR-4493

Cellular Mechanisms for Lead Encephalopathy: Alterations of Intracellular Trace Metal Concentrations in Cultured Astroglia

E. Tiffany-Castiglioni, J. Zmudzki, J. Wu, and G. R. Bratton

Lead (Pb) is one of the two most common toxicological problems of cattle in Texas. After exposure to moderate doses of Pb, calves develop encephalopathy characterized by cerebral dysfunction, seizures, and numerous pathological changes. Brains from animals with encephalopathy are swollen, congested, and in many cases exhibit gross lesions in both white and gray matter. However, mechanisms of cellular damage are unknown. Astroglia are implicated in the pathogenesis of Pb neurotoxicity in two capacities: (a) as a lead sink that sequesters lead and (b) as a target for direct cellular damage. A proposed cellular mechanism of Pb neurotoxicity is the alteration of metal concentrations, particularly the intracellular accumulation of Cu^{++}.

Lead uptake and the effects of Pb acetate on intracellular trace metal concentrations were measured by atomic absorption spectrophotometry in astroglial cultures prepared from 0- to 4-day-old rat cerebral hemispheres. Mature Sprague Dawley and immature Wistar rat astroglia in culture took up Pb from the medium. This result demonstrates *in vitro* the finding reported by others *in vivo* that astroglia in the brain take up Pb.

Immediately after a 1-day exposure to 100 μm Pb, the Pb content of cultures of mature glia was increased above the control level by 360-fold (μg/2 × 10^{-6} cells) or 680-fold (μg/flask). When exposure was increased to 3 days, the Pb level immediately following treatment was approximately double that level. Moreover, when cultures were exposed to Pb for 3 days and then incubated in Pb-free medium for 5 days, the Pb level per flask was the same as that immediately after treatment, indicating that the cells did not release Pb during this time. The intracellular copper (Cu) concentration was increased from 2- to 4-fold at each of these times. Iron (Fe) levels were unchanged. The simultaneous administration of thiamin (1 mM) with 100 μm Pb produced similar results except that Pb uptake was slightly reduced 1 day after treatment. Furthermore, the intracellular Cu concentration was not significantly greater than the control level until 5 days after a 3-day treatment with Pb and thiamin. Cultures of immature glia also showed high Pb uptake. When cultures were exposed to 100 μM Pb for 3 days, followed by an 11-day incubation without Pb, Pb content was 1,300 times that of controls. Copper concentration was four times that of controls. Iron concentration was seven times that of controls, unlike findings with mature glia. Both mature and immature glia treated with a low Pb level, 1 μM, showed significant Pb uptake but no alterations of Cu or Fe concentrations. The significance of the finding that Pb treatment induced an increase in intracellular Cu concentration is that Cu is a potent inhibitor of Na^+, K^+–ATPase, an enzyme by which astroglia are thought to remove K^+ from the extracellular fluid in the brain. Thus, this finding supports the hypothesis that elevated Cu, and perhaps Fe, is a subcellular mechanism of neurotoxicity.

PR-4494

Lead Encephalopathy in Calves: *In Vitro* Model for Cellular Targets of Neurotoxicity

E. Tiffany-Castiglioni, J. Zmudzki, and G. R. Bratton

Lead (Pb) is the environmental pollutant most often incriminated as a cause of accidental poisoning in cattle. The pathological effects of Pb on the central nervous

system are numerous: cortical necrosis, gliosis, neuronal degeneration, demyelination, vascular damage, hemorrhage, and edema. However, the primary cellular targets of Pb in the brain are not known. This question was addressed using isolated cell types in culture. Four types of cells in culture were exposed to lead (Pb) acetate (0.1 to 1000 μM): (a) astroglia-enriched, (b) oligodendroglia-enriched, (c) meningeal fibroblast cultures prepared from neonatal rat brains, and (d) and human neuroblastoma cultures prepared from the SK-N-SH-SY5Y cell line. The viability (trypan blue dye exclusion and proliferation) of these cell types after Pb exposure was compared to identify cellular targets in the central nervous system that were directly susceptible to cytotoxicity. Of the four cell types tested, only oligodendroglia showed marked sensitivity to Pb treatment. However, proliferation of the SY5Y cells was temporarily inhibited if the cells were treated 1 day (but not 3 days) after seeding. The potential for thiamin, which is used to treat Pb intoxication in cattle, to prevent this effect was tested. Rather than preventing this toxic effect, thiamin (1 mM) exacerbated the inhibition of proliferation. Astroglia and meningeal fibroblasts, which were resistant to Pb toxicity, were shown by atomic absorption analysis to take up Pb from the culture medium and to concentrate it intracellularly to at least 55 times the extracellular concentration, thus supporting hypotheses that these cells act as Pb sinks in the brain. Finally, astroglia in culture exhibited only minimal gliotic or morphological reactions to Pb as determined immunocytochemically by staining for glial fibrillary acidic protein, whereas gliosis usually accompanies Pb encephalopathy *in vivo*. This finding suggests that the gliosis is not directly stimulated by an action of Pb on the astroglia. Techniques are currently being developed for obtaining bovine neural cell cultures in which to study Pb toxicity.

PR-4495

Effects of Fescue Seed Extract on Hypophysial Prolactin in the Rat: An Immunocytochemical and Ultrastructural Study

W. S. Manning, G. R. Bratton, and M. S. Amoss

Cattle grazing fescue pastures have decreased plasma prolactin (PRL) levels and depressed lactation. These observations have been confirmed experimentally by exposing cattle to extracts of fescue grass. What remains unclear is whether fescue inhibits release of prolactin or inhibits synthesis of this hormone at the cellular level. Our laboratory has recently established that fescue extracts decrease plasma PRL in time-bred rats, and the decrease is followed by an absence of lactation after littering. The laboratory rat offers an excellent model to study whether fescue inhibits PRL synthesis or release. Pituitary glands were removed from rats exposed to fescue extracts and from nonfescue-exposed control rats. The concentration of prolactin in the mammotrophic cells was observed and quantitated by immunocytochemical staining of PRL in prepared microscopic sections. Prolactin concentration was significantly decreased in the mammotrophic cells of fescue-treated rats ($P < 0.05$). Treated animals contained fewer mammotrophic cells within the pituitary and fewer PRL granules within the identifiable mammotrophic cells. Intracellular organelles directly relevant to secretion and packaging of hormone were observed to be markedly disrupted at the ultrastructural level.

Coupled with decreased plasma PRL levels, these findings indicate that PRL synthesis rather than release is inhibited. The conclusion that synthesis rather than release is inhibited is based on the following logic. When plasma PRL levels decrease for any reason in normal animals, mammotrophic cells would normally be triggered to increase production. As production increases, the mammotrophic cells would significantly increase the number of intracellular PRL granules, and plasma PRL would rise. If the decreased plasma PRL in fescue-treated rats were due only to inhibited PRL release from pituitary mammotrophic cells, the morphological evaluation would have disclosed mammotrophic cells filled with secretory granules. However, the decreased plasma PRL, along with the significant absence of PRL granules in the mammotrophic cells, indicates an inhibition of PRL synthesis. The exact mechanism of synthesis inhibition is currently being investigated. Successful completion of these studies will help define the reasons for poor lactation performance in cattle grazing fescue pasture.

PR-4496

Effects of an Alcoholic Extract of Fescue Grass on Plasma Prolactin Levels in Cattle

L.V. Sheeler, M.S. Amoss, and G.R. Bratton

There are over 50 million acres of fescue pasture in the United States; although the potential of this hardy grass is outstanding, cattle grazing such pastures show less than outstanding performance. A 30 percent drop in calving rate, poor lactation, and losses because of decreased rate of gain and general unthriftiness in feeder calves commonly occur. The biological reasons for these fescue-related problems are unknown; the loss to agriculture exceeds $2 million per yr. Our preliminary work suggests that toxins interfere with the normal interaction

between the central nervous system and the endocrine system by a common mechanism of action. This series of experiments was performed to compare the effects of cationic, anionic, and alkaloid fractions of an alcohol extract of endophyte-infected fescue (KY-31) grass on plasma prolactin (PRL) levels, rectal temperatures, and respiration rates of cattle.

Jersey bull calves were cannulated via the external jugular vein, and blood samples were drawn at 10-min intervals for 2 hr to establish baseline PRL levels. Intravenous injections (IV) of 0, 3.64, 36.4, and 364 g eq of each fraction were given, and blood sampling continued at 10-min intervals for an additional hour. At this time, each calf received an IV injection of thyrotropin-releasing hormone (TRH) to determine the responsiveness of the pituitary gland to PRL release following administration of the various fractions. Four repetitions of this experiment were performed for each fraction tested. Each experiment followed a crossed factorial design. Thirty minutes postinjection of both 36.4 and 364 g eq of the cationic fraction, plasma PRL levels, rectal temperature, and respiration rates were elevated ($P < 0.01$). However, injections of the anionic or alkaloid fractions did not produce any significant changes in plasma PRL levels, rectal temperatures, or respiration rates, regardless of dose. All animals responded uniformly to TRH stimulation following treatment with any of the three fractions.

These results indicate that upon acute intravenous administration, only the cationic extract fraction contains a material that alters plasma PRL levels, respiration rates, and rectal temperatures. These results represent a key step in helping to narrow the focus toward identification of the toxins associated with fescue pasture. The ultimate benefit to the cattle producer will be a fescue variety free of associated toxins.

PR-4497

A Model for Studying Comparative Disposition of Selected Antibacterial Agents in Bronchopneumonic Calves

L.G. Friedlander, J.A. Allert, W.L. Jenkins, and R.B. Simpson

The impact of respiratory disease on livestock production today is well known. What remains unclear is the reason for the frequent failure of rational antibacterial therapy in combating feedlot pneumonias. To better understand the effect of respiratory disease on antimicrobial therapy, studies were initiated to develop a model that would provide a reproducible clinical *Pasteurella haemolytica* bronchopneumonia in calves for use in assessing the effect of this disease on the disposition of selected antibacterial agents. This project had four objectives: (a) collection of standard distribution and elimination pharmakinetic data from clinically healthy calves to establish baseline values; (b) surgical implantation of intrapulmonary dialysis sachets to provide multiple sample collections of lung parenchyma ultrafiltrate; (c) induction of a localized right cranial lobar bronchopneumonia that was reproducible and comparable to field cases; (d) assessment of disposition pharmacokinetics in the diseased animals, utilizing both plasma drug concentrations and information from the intrapulmonary system, and comparison of these data with those collected from the clinically healthy calves.

Initial progress in the study has been highly rewarding. Samples were collected from the clinically healthy animals for all the antibacterial agents under investigation. Preliminary analyses indicate that the disposition pharmacokinetics of these drugs correspond well to values cited in the literature. Implantation of intrapulmonary devices is now routine, and the postsurgical induction of a localized bronchopneumonia is reproducible. Very preliminary evidence indicates that the disposition of some of the antibacterial agents is altered in the diseased animals and that drug concentration during acute respiratory disease may not always be adequate at the site of infection. Substantially more data will be needed before the significance of these findings can be fully evaluated. The ultimate benefits to the cattle industry will be improved antimicrobial therapy with ensured effective concentration of antibacterial drug at the site of infection.

PR-4498

Internal Parasite Control in Stocker Cattle in West Texas

J.E. Huston and Jerry Cowley

Summary

A study was conducted during the fall and winter of 1983-84 to determine the effects of two anthelmintics on fecal concentration of gastrointestinal parasite eggs and on growth rate in stocker calves fed on rangeland. Observations made on a control group of calves (untreated) were compared with those made on a group treated with Tramisol and a group treated with Nematel. Both anthelmintics decreased the number of parasite eggs observed in the feces ($P < .05$); however, differences in live animal gain were small and probably attributable to chance. Internal parasites do not appear to depress weight gain in stocker cattle under the conditions of this study. Tramisol and Nematel were equally effective in controlling internal parasites.

Introduction

Internal parasitism is a major deterrent to high-level production in sheep and goats in Texas. Routine treatment for these gastrointestinal parasites typically involves "drenching" from two to six times per year. Treatment for internal parasites in cattle is uncommon and is generally considered unnecessary in low- to moderate-rainfall areas. However, in higher rainfall areas, parasite control in cattle is common and beneficial, and under certain circumstances, parasite control could prove beneficial in the range area of Texas. Because of the short grass conditions during the fall of 1983, it was suspected that stocker cattle grazing close to the ground during warm, moist conditions might respond favorably to treatment with an anthelmintic. Nematel, a relatively new product by Pfizer, Inc., was used as a treatment agent, and its effectiveness compared with that of a more common injectable drug, Tramisol.

Experimental Procedure

Treatments imposed on 73 stocker calves between December 1, 1983, and April 12, 1984, included (a) control (no anthelmintics), (b) Tramisol (injected per directions), and (c) Nematel (per balling gun). Calves weighing between 345 and 605 lb (mostly 450-550 lb) were trucked to the Texas A&M University Agricultural Research and Extension Center at San Angelo, Texas, from research ranches near Sonora and Brady, Texas. The calves were from Hereford x Brangus cows sired by either Charolais or Beefmaster bulls. The cattle were assigned to treatment groups to equalize average body weight and breeding between groups. Ten calves were selected at random from each group at initial weigh-in (December 1, 1983) for fecal sampling. Follow-up samples at the intermediate and terminate dates were taken from the same calves. Fecal samples were sent at the request of Pfizer, Inc., to AEF Research, Inc., Waunakee, Wisconsin. Samples were identified with number codes to assure objectivity. Counts were made on eggs from *Haemonchus* sp., *Ostertagia* sp., *Trichostrongylus* sp., *Cooperia* sp., *Oesophagostomum* sp., *Moniezia* sp., and *Coccidia* sp. Reported totals do not include *Moniezia* sp. and *Coccidia* sp. Weights were recorded at the beginning of the study period (December 1), at the first appearance of springlike conditions (March 7), and at termination (April 14).

During the 135-day study period, the calves were grazed together on native rangeland and were fed intermittently the supplemental feed described in Table 1. For the entire study period, average supplemental feeding rate was 1.53 lb/head/day.

TABLE 1. SUPPLEMENTAL FEED RATION FED TO STOCKER CALVES DURING A 135-DAY TRIAL[a,b]

Ingredients	%
Sorghum grain	64
Dehydrated alfalfa	5
Cottonseed meal	26
Molasses	5
Total	100

[a]Computed crude protein content, 18.5 percent.
[b]Average feeding level for 135 days, 1.53 lb/head/day.

Results and Discussion

Fecal egg numbers were similar between treatment groups at the beginning of the study period (Table 2). These levels of infestation were considered marginal; that is, animal performance may not be adversely affected by these levels of parasitism. However, both Tramisol and Nematel significantly reduced total parasite egg counts and appeared to be equally effective at the observed levels of infestation. Moniezia and coccidia egg numbers are much below a damaging threshold and were not included in the computed total.

Although the levels of parasitism were apparently reduced by both anthelmintic treatments, neither treatment affected body weight gain (Table 3). Contrary to what was expected at the beginning of this study period, conditions that favor large parasite infestation never occurred. The rangeland became dry, and the humidity remained relatively low throughout the study period. Although this study did not test the proposed hypothesis, the results confirm the generally accepted idea that under dry range conditions, internal parasite infestation is too low to substantially reduce performance of cattle on rangeland.

TABLE 2. SUMMARY OF INTERNAL PARASITE EGGS IN FECES OF STOCKER CALVES EITHER UNTREATED OR TREATED WITH ONE OF TWO ANTHELMINTICS

Sampling Date	Pretreatment (12/1)			Intermediate (3/7)			Final (4/12)		
Treatment Group[a]	1	2	3	1	2	3	1	2	3
	Eggs/g Feces								
Parasite species:									
Haemonchus	26	43	34	52	18	25	44	18	14
Ostertagia	32	33	22	20	7	7	21	5	5
Trichostrongylus	1	1	1	0	0	0	0	0	0
Cooperia	9	21	25	i 12	3	1	8	3	0
Oesophagostomum	17	25	23	23	9	9	4	4	0
Moniezia	0	12	1	0	1	11	0	0	6
Coccidia	104	237	114	4	113	3	1	2	6
Total[b]	85	123	105	107	37	42	77	30	19

[a]Groups 1, 2 and, 3 received treatments Control, Tramisol, and Nematel, respectively.
[b]*Moniezia* and *Coccidia* not included.

TABLE 3. SUMMARY OF WEIGHT AND WEIGHT CHANGES IN STOCKER CALVES EITHER UNTREATED OR TREATED WITH ONE OF TWO ANTHELMINTICS

	Treatment Groups		
Item	1 Control	2 Tramisol	3 Nematel
Number of calves	25	24	24
Average weights, lb			
Initial, 12/1/83	512	492	503
Intermediate, 3/7/84	519	498	512
Final, 4/12/84	563	538	550
Average weight gains, lb			
Period 1	7	6	9
Period 2	44	40	38
Total	51	46	47

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