

RALGRO IMPLANTED BULLS: PERFORMANCE, CARCASS CHARACTERISTICS,
LONGISSIMUS PALATABILITY AND CARCASS ELECTRICAL STIMULATION

by

JOHN RALPH GREATHOUSE

B. S., Kansas State University, 1980

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree


MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

Approved by:


Major Professor

SPEC
COLL
LD
2668
.T4
1982
G73
C.2

A11202 298163

Acknowledgments

As the author of this thesis, I wish to express sincere gratitude to Dr. Melvin Hunt, major professor, for his guidance, encouragement and friendship throughout my graduate program. Appreciation is also extended to Dr. Larry Corah, Dr. Michael Dikeman and Dr. Curtis Kastner for their support and suggestions as members of my advisory committee.

A special thanks to Dr. Donald Kropf and Dr. David Schafer for their leadership and guidance while helping me to strengthen my educational abilities, and also to Jennifer Kendall and Frank Russo for their technical assistance with my research projects.

To the Animal Science faculty and staff members, and to my fellow graduate students, I wish to express my appreciation for their assistance and friendship during my studies at Kansas State.

I would like to thank my parents, Mr. and Mrs. Ralph Greathouse, and my family for their continued love and support throughout my educational endeavors. Most of all, I express my love and appreciation to my fiancé, Brenda, for her love, patience and encouragement as I strive to reach my educational goals.

Table of Contents

| <u>Chapter</u> | <u>Page</u> |
|---|-------------|
| I. General Introduction | 1 |
| II. Review of Literature | 2 |
| Live Animal Performance of Bulls versus Steers | 2 |
| Effects of DES on Performance | 3 |
| Effects of Zeranol (Ralgro) on Performance | 4 |
| Carcass Characteristics of Bulls versus Steers | 7 |
| Carcass Weights | 7 |
| External/Internal Fat Deposition | 7 |
| Dressing Percentage | 7 |
| Carcass Cutability and Quality Traits | 8 |
| Carcass Composition | 9 |
| Carcass Maturity | 9 |
| Lean Quality | 10 |
| DES Effects on External/Internal Fat Deposition | 10 |
| DES Effects on Dressing Percentage | 11 |
| DES Effects on Cutability Traits | 11 |
| DES Effects on Lean Quality | 12 |
| DES Effects on Carcass Composition | 12 |
| Zeranol (Ralgro) Effects on Carcass Yield and Quality Factors | 13 |
| Zeranol (Ralgro) Effects on Carcass Composition | 14 |
| Zeranol (Ralgro) Effects on Carcass Maturity | 14 |
| Muscle Palatability Characteristics of Bulls versus Steers | 16 |
| Cooking Losses | 16 |
| Juiciness | 16 |
| Flavor | 17 |
| Tenderness | 19 |
| DES Effects on Juiciness | 21 |
| DES Effects on Flavor | 22 |
| DES Effects on Tenderness | 22 |
| Zeranol (Ralgro) Effects on Muscle Cooking Loss and Palatability | 23 |
| Compared Effects of DES and Zeranol (Ralgro) | 24 |
| Mechanisms of DES and Zeranol (Ralgro) Activity | 25 |
| Electrical Stimulation | 28 |
| Literature Cited | 30 |

| <u>Chapter</u> | <u>Page</u> |
|--|-------------|
| III. RALGRO IMPLANTED BULLS: PERFORMANCE, CARCASS CHARACTERISTICS, LONGISSIMUS PALATABILITY AND CARCASS ELECTRICAL STIMULATION | 37 |
| Introduction | 37 |
| Experimental Procedure | 39 |
| Statistical Analysis | 42 |
| Results and Discussion | 43 |
| Performance Data | 43 |
| Carcass Characteristics | 45 |
| Rib Section Chemical Composition | 47 |
| Cooking Losses, Taste Panel Ratings and Warner-Bratzler Shear Forces | 47 |
| Correlations of Quality Indicating Factors and Palatability Traits | 50 |
| Electrical Stimulation Effects on Bull Carcass Quality Characteristics | 51 |
| Electrical Stimulation Effects on Cooking Losses, Taste Panel Ratings and Warner-Bratzler Shear Forces | 51 |
| Conclusions | 55 |
| Literature Cited | 56 |
| IV. Abstract | 59 |

List of Tables

| <u>Table</u> | <u>Page</u> |
|---|-------------|
| 1 FINISHING DIET COMPOSITIONS AND NET ENERGY VALUES | 40 |
| 2 PERFORMANCE DATA FOR NONIMPLANTED AND RALGRO IMPLANTED BULLS | 44 |
| 3 CARCASS CHARACTERISTICS FOR NONIMPLANTED AND RALGRO IMPLANTED BULLS SLAUGHTERED AT LIGHT (454 kg) AND HEAVY (499 kg) WEIGHTS | 46 |
| 4 CHEMICAL COMPOSITION OF THE 9-10-11th RIB SECTIONS FOR NONIMPLANTED AND RALGRO IMPLANTED BULLS SLAUGHTERED AT LIGHT (454 kg) AND HEAVY (499 kg) WEIGHTS | 48 |
| 5 COOKING LOSS PERCENTAGES, TASTE PANEL SCORES AND SHEAR FORCE VALUES FOR LONGISSIMUS STEAKS FROM NONIMPLANTED AND RALGRO IMPLANTED BULLS SLAUGHTERED AT LIGHT (454 kg) AND HEAVY (499 kg) WEIGHTS | 49 |
| 6 CARCASS QUALITY CHARACTERISTICS FOR NON-ELECTRICALLY STIMULATED AND ELECTRICALLY STIMULATED BULL CARCASS SIDES | 52 |
| 7 COOKING LOSS PERCENTAGES, TASTE PANEL SCORES AND SHEAR FORCE VALUES FOR LONGISSIMUS STEAKS FROM NON-ELECTRICALLY STIMULATED AND ELECTRICALLY STIMULATED BULL CARCASS SIDES | 54 |

List of Figures

| <u>Figure</u> | | <u>Page</u> |
|---------------|---|-------------|
| 1 | Structural characteristics of estrogen, diethylstilbestrol and zeranol | 26 |
| 2 | Longissimus muscle temperature and pH decline curves for non-electrically stimulated and electrically stimulated bull carcass sides | 53 |

Chapter I

General Introduction

The economic and diet consciousness of consumers has led to a greater demand for leaner beef. However, total acceptance of leaner beef depends upon consumer confidence that the product they purchase has consistent high quality and nutrition, that results in a pleasing experience when consumed.

Rising beef cattle production costs emphasize the advantages in gain and efficiency of raising bulls for lean beef production. However, consumers resist acceptance of beef from the intact male because they perceive that "bull" meat is of lower quality than meat from steers. Consequently, methods to improve the quality and consumer acceptance of beef from bulls merits consideration.

The objectives of this study were to determine the effects of Ralgro on performance of beef bulls, and its effect on the carcass and palatability characteristics of longissimus steaks. Electrical stimulation effects on bull carcass and palatability traits were also studied.

Chapter II

Review of Literature

Live Animal Performance of Bulls versus Steers

Differences in growth and performance of bulls versus steers have been reported by numerous researchers. However, these differences generally appear more during the postweaning growing and finishing period than during the preweaning phase.

Preweaning growth rates up to 7 months were not significantly different between bulls and steers (Bailey et al., 1966a). Glimp et al. (1971) found no differences in average daily gain from birth to weaning at 200 d of age between bulls, steers and short scrotum bulls. Brown et al. (1962) also indicated there were no differences in preweaning performance of bulls and steers. However, from birth to 120 d of age steers tended to have greater gains. In contrast, Marlowe and Gaines (1958), using performance testing records of 2007 creep-fed and 4166 non-creep-fed calves, reported that bull calves gained 5% faster than steer calves; differences between the creep-fed groups were slightly larger. When adjusted to a 210 d weaning age, non-creep-fed bulls were 7.3 kg heavier than steers.

Glimp et al. (1971) evaluated the effects of sex condition on feedlot performance and found that intact males, short scrotum bulls at weaning and bulls castrated at weaning had significantly faster gains over a 210 d feedlot period than bulls castrated at birth. However, Klosterman et al.

(1954) using bulls castrated both at 1 month of age and at weaning, and Champagne et al. (1969) comparing bulls castrated at birth, 2 months, 7 months and 9 months of age, observed no significant differences in feedlot performance due to age at castration. Reports cited by Turton (1962) found conflicting evidence where castration at different ages resulted in advantages in weight gains.

Two experiments conducted by Hedrick et al. (1969) evaluated growth and performance of bulls, steers and heifers fed high concentrate diets. When animals were slaughtered at either constant weight or time-on-feed endpoints, bulls had significantly faster gains and heavier slaughter weights, respectively. Bulls were more efficient in feed conversion than steers and heifers at either endpoint. Klosterman et al. (1954), Aitken et al. (1963), Nichols et al. (1964), Champagne et al. (1969), Warwick et al. (1970), Wilson et al. (1974) and Arthaud et al. (1977) also reported advantages in feedlot performance for bulls compared with steers.

Effects of DES on Performance

Growth promotants have been widely used to increase rate of gain and efficiency of beef cattle. Diethylstilbestrol (DES), a commonly used growth promotant in feedlot cattle until banned for use in 1979, was successful in improving growth and feed efficiency of steers (Klosterman et al., 1955; Koger et al., 1960; Laflamme and Burgess, 1973). Implanting feedlot bulls with 24 mg of DES, however, had less of an effect on improving performance as similar levels did with steers (Wipf et al., 1964).

Koger et al. (1960) studied the effects of DES and sex condition on performance of bulls and steers fed a 60% concentrate diet and slaughtered at 454 kg. Nonimplanted bulls, bulls implanted with 84 mg of DES and steers

implanted with 36 mg of DES had faster gains and an improved feed efficiency compared with nonimplanted steers. No differences in performance were found between control bulls, implanted bulls and implanted steers.

Laflamme and Burgess (1973) found that nonimplanted bulls, bulls implanted with 72 mg of DES and steers implanted with 72 mg of DES had improved gains and feed efficiency compared with nonimplanted steers, when individually fed for 140 d. However, at the 36 mg implant level, implanted bulls gained faster than implanted steers, whereas no significant differences occurred between implanted and nonimplanted animals within the same sex. In a separate trial, Laflamme and Burgess (1973) reported reimplanting with 36 or 72 mg of DES 98 d after administration of the initial implant had no significant effect on gain or efficiency of bulls and steers fed diets of varying energy levels. However, many of the animals were slaughtered within 60 d after reimplantation occurred, which may have been insufficient time for a second implant to have any effect.

Hunsley et al. (1967) reported that oral feeding of 10 or 20 mg of DES per day to bulls and steers had little effect on feedlot performance. However, bulls implanted with 48 mg of DES tended to have greater gains.

Effects of Zeranol (Ralgro) on Performance

Zeranol (Ralgro), a relatively new growth promotant, has been researched at various dosage levels and implanting frequencies in suckling calves.

Lamm et al. (1980) observed that implanting steer and heifer calves with 12, 24 or 36 mg of zeranol at birth and reimplanting these groups with 36 mg at 100 d of age had no effect on daily gain to weaning compared with the control animals. However, when bulls were implanted with 36 mg of zeranol at birth or 100 d of age, and reimplanted at 100 d intervals, the

nonimplanted bulls weighed more at weaning than did the implanted bulls.

Ralston (1978) evaluated the effects of 24 and 36 mg of zeranol and 12 mg of DES on the growth of castrated and intact male nursing calves. Gains from birth to weaning were similar for calves implanted with either zeranol or DES. In one trial, bulls castrated at birth or 90 d of age and implanted with 36 mg of zeranol had similar gains from birth to weaning compared with implanted and nonimplanted intact males. Data from another trial where animals were implanted with 24 mg of zeranol at birth and 36 mg 90 d later indicated that implanted steers, which had been castrated at birth, had poorer gains to weaning compared with nonimplanted bulls. Data from a third trial indicated that intact male calves implanted with 36 mg of zeranol at birth and again at 90 d of age were slightly heavier at weaning compared with the nonimplanted bulls.

Implanting steers with 24 or 36 mg of zeranol at 85.6 kg average weight and reimplanting with 36 mg 84 d later resulted in faster gains after 132 d compared with control steers (Nichols and Lesperance, 1973). However, they showed no advantages for reimplantation of zeranol over the 205 d trial. Advantages in preweaning growth of steers implanted with 36 mg of zeranol were also reported by Davis et al. (1977) and Ward et al. (1978). Ellington et al. (1978), however, found no significant effects on weaning weights due to implanting steers and heifers with 36 mg of zeranol at 79 d of age or reimplanting 56 d later.

Lamm et al. (1980) indicated that when bull and heifer calves were implanted with 36 mg of zeranol every 100 d from birth to slaughter, implanting had no effect on gain during the postweaning growing and finishing period. However, Kunkle et al. (1980) concluded that reimplanting steers with Ralgro caused an additive effect in postweaning gains, while steers not

reimplanted gained similar to their nonimplanted counterparts after the implant lost its effectiveness. Ward et al. (1978) implanted zeranol at approximately 95 d intervals preweaning and found zeranol had a "carry-over effect" in gains from nursing into the growing and finishing period of steers. Calves reimplanted after weaning with 36 mg of zeranol had similar gains compared with those not reimplanted.

Yearling steers implanted with 36 mg of zeranol (Embry, 1972) had improved gains and lower feed requirements on finishing diets compared with nonimplanted steers. Advantages in gain and feed efficiency for steers implanted with 36 or 72 mg of zeranol were also found by Thomas and Armitage (1970). Perry et al. (1970) found improved gains for zeranol implanted steers, and indicated that these gain responses were similar to those for steers implanted with DES. Embry (1972) concluded that implanting yearling bulls with 36 mg of zeranol had no effect on gains or feed efficiency during feedlot growth on high concentrate diets.

Carcass Characteristics of Bulls versus Steers

Carcass Weights

Production of bulls as meat animals results in heavier carcass weights compared with steers, when animals are slaughtered at a constant age or a constant time-on-feed endpoint. Bull carcasses were 39 kg heavier than steer carcasses when groups of bulls and steers were slaughtered at an average of 402 d of age (Wilson et al., 1974). Arthaud et al. (1969) found bull carcasses weighed 24.5 kg more than steer carcasses when animals were slaughtered at an average of 445 d and 480 d of age. Feeding animals for the same length of time before slaughter resulted in bulls having significantly heavier carcasses than steers (Hedrick et al., 1969).

External/Internal Fat Deposition

Bulls had less external fat covering and a lower percentage of internal fat compared with steers (Klosterman et al., 1954; Brown et al., 1962; Aitken et al., 1963; Glimp et al., 1971). Wilson et al. (1974) found bulls and short scrotum bulls had less fat cover than steers, but had similar percentages of kidney and pelvic fat. However, Fredeen et al. (1971) reported bulls had higher percentages of kidney and cod fat compared with steers. Champagne et al. (1969) found bull carcasses and carcasses from bulls castrated at 9 months of age had less fat cover over the longissimus muscle than carcasses from bulls castrated at birth, 2 months or 7 months of age.

Dressing Percentage

Klosterman et al. (1954) and Matsushima and Sprague (1963) reported that bulls had lower dressing percentages than steers. Nichols et al. (1964)

attributed this to bulls having heavier hide weights and trimmer carcasses than steers. In contrast, Wilson et al. (1974) found that bulls had significantly higher dressing percentages than steers or short scrotum bulls. Champagne et al. (1969) reported that intact males and bulls castrated at 7 months of age had significantly higher dressing percentages compared with all other castrate groups. Fredeen et al. (1971) recorded a higher percentage of hide for steers, while dressing percentages were approximately 1% greater for bulls. Dressing percentages for bulls and steers increased after extended feeding times (Hedrick et al., 1969) and at increased slaughter weights (Hawrysh and Berg, 1979). From these inconsistencies in dressing percentages between bulls and steers, it is difficult to make any definite conclusions as to the reasons for the differences.

Carcass Cutability and Quality Traits

A study conducted by Jacobs et al. (1977a) found that bulls were rated higher for cutability traits while steers received higher scores for quality traits. Larger loin eye areas and greater carcass yields have been reported for bulls compared with steers (Bailey et al., 1964; Hedrick et al., 1969; Jacobs et al., 1977a). Higher marbling scores and carcass quality grades have been reported for steers compared with bulls (Klosterman et al., 1954; Hedrick et al., 1969; Warwick et al., 1970; Glimp et al., 1971; Jacobs et al., 1977a; Landon et al., 1978). Arthaud et al. (1977) found steers had higher marbling scores and quality grades than bulls when slaughtered at 15, 18 and 24 months of age, but not at 12 months of age. Wilson et al. (1974) found no significant differences in marbling scores between Holstein steers and bulls. Carcass quality grades were similar for bulls and steers slaughtered at 385 d of age, while steers had higher marbling scores and improved quality

grades when slaughtered at 484 d of age (Reagan et al., 1971).

Carcass Composition

Bull carcasses had higher proportions of separable lean (Bailey et al., 1964; Arthaud et al., 1977), less separable fat (Arthaud et al., 1977) and similar percentages of carcass bone (Glimp et al., 1971) in the 9-10-11th rib section than steers. Chemical composition analyses have shown bull carcasses contain higher percentages of moisture (Champagne et al., 1969; Jacobs et al., 1977a), lower percentages of ether extractable material (Bailey et al., 1966b; Arthaud et al., 1969; Champagne et al., 1969; Hedrick et al., 1969; Jacobs et al., 1977a) and higher percentages of crude protein (Arthaud et al., 1969; Glimp et al., 1971; Jacobs et al., 1977a). Champagne et al. (1969) reported no significant differences in protein percentages between bull and steer carcasses.

Carcass Maturity

Negligible differences in carcass maturity were found between bulls and steers when animals were slaughtered at 12 months of age (Arthaud et al., 1977). However, carcasses from bulls slaughtered at 15, 18 and 24 months of age tended to be physiologically more mature (skeleton and lean maturity) than carcasses from steers of the same chronological age. These data agree with Champagne et al. (1969), who observed a darker colored, coarser lean in bull carcasses than in steer carcasses. No significant differences in maturity were apparent between bulls castrated at various ages; but castration at progressively later ages tended to increase carcass maturity scores. According to Reagan et al. (1971), steer carcasses were more youthful than bull carcasses when slaughtered at either 385 or 484 d of age. Bone

ossification was the primary factor affecting the maturity evaluation in steer carcasses, while lean color was the major factor affecting the variation in maturity scores for bull carcasses.

Lean Quality

Steer carcasses had a finer textured lean (Glimp et al., 1971; Arthaud et al., 1969, 1977) which was firmer and lighter in color compared with bull carcasses (Arthaud et al., 1977). Differences in lean color among bulls slaughtered at 377, 565, 624 and 682 kg were not significant (Hawrysh and Berg, 1979).

DES Effects on External/Internal Fat Deposition

Hedrick et al. (1969) found no differences in fat thickness over the 12th rib of bulls, steers and heifers when implanted postweaning, and reimplanted 96 d later, with 24 mg of DES. However, significant differences in fat thickness were reported for bulls, steers and bulls implanted with 12 mg of DES at birth and reimplanted with 24 mg at 3 months and 36 mg at 6, 8 and 10 months of age (Martin et al., 1965). Average fat thickness means were .13, .21 and .15 inches for bulls, steers and implanted bulls, respectively.

Implanting bulls with 45 mg of DES produced carcasses with more fat thickness at the 12th rib compared with nonimplanted bulls (Williams et al., 1975a). Garrigus et al. (1969) reported that bulls implanted with 36 mg or 72 mg of DES tended to have fatter carcasses than nonimplanted bulls. In addition, bulls receiving 36 mg of DES 154 d postweaning had significantly higher percentages of kidney fat compared with nonimplanted bulls and bulls implanted at weaning and reimplanted 84 d later. However, bulls implanted

either once with 72 mg of DES or reimplanted 84 d later had a lower percentage of kidney fat than did the nonimplanted bulls. Cahill et al. (1956) reported more kidney fat weight for bulls implanted with 84 mg of DES compared with nonimplanted bulls, whereas less internal fat was recorded for implanted steers compared with nonimplanted steers.

DES Effects on Dressing Percentage

Hedrick et al. (1969) reported no differences in dressing percentages between bulls, steers and heifers implanted with 24 mg of DES. Andrews et al. (1954) found that dressing percentages were similar for steers implanted with 60 mg, 108 mg or 120 mg of DES. Bulls implanted with 36 mg or 72 mg of DES had similar dressing percentages (Garrigus et al., 1969), which is in agreement with Laflamme and Burgess (1973).

DES Effects on Cutability Traits

No differences in cutability were reported between carcasses from steers implanted with 24 mg of DES and nonimplanted steers (Marchello et al., 1970). Hedrick et al. (1969), however, found steers implanted with 24 mg of DES tended to have a higher yield of retail cuts than nonimplanted steers, while implanted bulls tended to have a lower yield compared with nonimplanted bulls. Klosterman et al. (1955) and Cahill et al. (1956) also found that DES implantation (84 mg) increased the amount of edible meat in steer carcasses, but reduced it in bull carcasses. In contrast, Koger et al. (1960) reported no significant differences in yield of trimmed lean cuts for bulls implanted with 36 mg of DES and nonimplanted bulls.

Pilkingtton et al. (1959) found that bull calves implanted initially with 12 mg and reimplanted with 24 mg of DES had slightly smaller loin eye

areas than nonimplanted calves. Laflamme and Burgess (1973) reported that implanting feedlot bulls and steers with DES resulted in significantly smaller loin eye areas compared with nonimplanted animals. These results were obtained from two trials where bulls and steers were implanted either once or twice with 36 mg or 72 mg of DES. Data from Garrigus et al. (1969) showed significantly larger loin eye areas for bulls implanted once with 72 mg of DES in comparison with loin eye areas from bulls receiving two implants. In contrast, Williams et al. (1975a) showed no differences in longissimus muscle areas between implanted bulls receiving 45 mg of DES at 106 or 205 d of age and nonimplanted bulls. Bailey et al. (1964) reported similar loin eye areas for bulls implanted with 60 mg of DES and nonimplanted bulls.

DES Effects on Lean Quality

Clegg and Cole (1954) found a coarser textured, darker colored lean in carcasses from steers and heifers implanted with 60 mg or 120 mg of DES compared with their nonimplanted counterparts. However, Wilson et al. (1963) reported no differences in lean color for steers implanted and reimplanted with 24 mg of DES, and the nonimplanted steers.

DES Effects on Carcass Composition

Implanting bulls with 72 mg of DES significantly decreased the percentage of muscle and increased the percentage of fat in the 9-10-11th rib section compared with nonimplanted bulls (Garrigus et al., 1969). However, no significant differences in percentage of ether extractable material, protein or moisture were found due to implanting. These data are supported by Williams et al. (1975a) who implanted bulls with 45 mg of

DES and found no significant differences between implanted and nonimplanted animals for percentages of moisture, ether extractable material or protein.

Zeranol (Ralgro) Effects on Carcass Yield and Quality Factors

A limited amount of research has been reported concerning the effects of zeranol on carcass characteristics of bulls, steers and heifers.

Sharp and Dyer (1971) found that implanting steers and heifers with 36 mg of zeranol had no significant effect on carcass marbling score, loin eye area, fat thickness, kidney fat or yield grade. Similar effects were reported by Embry (1972) who used one 36 mg zeranol implant and by Borger et al. (1973a) and Hathaway et al. (1973) who reimplanted animals with 36 mg. In contrast with steers, Sharp and Dyer (1971) reported that implanting improved the carcass quality grades of heifers. Lamm et al. (1980) reported that implanting heifers with 12 mg, 24 mg or 36 mg of zeranol improved yield grade numbers. However, implanting had no effect on the carcass characteristics of bulls, or the other carcass traits measured for heifers.

Steen et al. (1978) found that bulls implanted with 72 mg of Ralgro at an average weight of 312 kg were fatter over the 12th rib and had higher yield grades compared with nonimplanted bulls. Loin eye area and quality grades were not affected by implantation. Embry (1972) reported that feedlot bulls implanted as yearlings with 36 mg of zeranol had more fat cover, while implanted bull calves had less marbling compared with the nonimplanted controls. Thiex and Embry (1972) found bulls implanted at 10 months of age with 36 mg of zeranol, 36 mg of DES or 60 mg of DES tended to have less marbling and a lighter colored lean compared with nonimplanted bulls.

Implanting bulls with 36 mg of Ralgro at 28 d of age and reimplanting

the same bulls three more times at 100 d intervals resulted in improved carcass quality grades compared with nonimplanted bulls, when animals were slaughtered at 430 d of age (Corah et al., 1979). Carcass fat cover and yield grades were not affected by implanting in this trial.

Zeranol (Ralgro) Effects on Carcass Composition

Sharp and Dyer (1971) reported that 36 mg of zeranol significantly increased the percentages of protein and moisture in steer carcasses, while reducing the percentages of fat. Borger et al. (1973b) reported that the longissimus muscle from steers implanted and reimplanted with 36 mg of zeranol contained significantly more moisture, less fat and similar amounts of protein on a fat and moisture free basis when compared with nonimplanted steers. Therefore, it was suggested that zeranol increases water retention and decreases fat deposition in steers (Borger et al., 1973a).

Research concerning carcass composition characteristics of zeranol implanted bulls has not been found.

Zeranol (Ralgro) Effects on Carcass Maturity

Ralston et al. (1975) reported on two trials where the effects of growth promotants on skeletal maturity of steers were evaluated by measuring the degree of ossification in the cartilagenous tip of the spinous process of the first thoracic vertebrae. In one trial, implanting yearling steers with 36 mg of zeranol or 15 mg of DES, at 330 kg initial weight, had no effect on percentage of cartilage ash. In a second trial, implanting and reimplanting steer calves, at 192 kg initial weight, with zeranol or DES resulted in a reduced amount of cartilage ash compared with control steers. In support of this data, Sharp and Dyer (1971) concluded

that zeranol delayed physiological maturity of the growing ruminant.

Muscle Palatability Characteristics of Bulls versus Steers

Cooking Losses

Cooking loss percentages for semimembranosus steaks of bulls and steers were not significantly different when broiled to an internal temperature of 71 C (Jacobs et al., 1977b). Marbling scores (4= small; 6= moderate) were lower for bulls (4.55) than for steers (6.51) in this study. In contrast, Goll et al. (1965) reported total cooking losses and drip losses for longissimus steaks, broiled to an internal temperature of 54 C, were generally greater for steaks from carcasses with a higher degree of marbling.

Hawrysh and Berg (1979) evaluated cooking losses for semitendinosus and longissimus roasts from bulls slaughtered at average weights of 377, 565, 624 and 682 kg. When roasted at 163 C to an internal temperature of 61 C, cooking loss percentages tended to increase as slaughter weight increased, even though no significant differences in marbling scores were found for carcasses between the slaughter weight groups.

Based on variations in cooking procedures reported in the reviewed literature, the effects of marbling on cooking losses are inconclusive.

Juiciness

Taste panel juiciness ratings were similar for longissimus steaks from bull and steer carcasses, where bull carcasses had lower marbling scores and quality grades than steers (Sumwalt et al., 1964; Hedrick et al., 1969; Warwick et al., 1970; Glimp et al., 1971). Champagne et al. (1969) also found no differences in juiciness ratings between longissimus steaks from bull and steer carcasses. However, steaks from bull carcasses tended

to have slightly higher (nonsignificant) juiciness scores, even though bull carcasses exhibited less marbling than did steer carcasses.

When bull, short scrotum bull and steer carcasses had similar degrees of marbling, longissimus steaks from bull carcasses had more desirable juiciness scores (Wilson et al., 1974). Reagan et al. (1971) found no differences in marbling scores or juiciness ratings between steaks from bull and steer carcasses when animals were slaughtered at an average of 385 d of age. However, steer carcasses had more marbling than bull carcasses when animals were slaughtered at an average age of 484 d, but no differences in juiciness ratings for steaks from either sex were apparent. These data are in agreement with Tuma et al. (1962) and Goll et al. (1965) where degree of marbling had no effect on sensory scores for juiciness.

Contrary to the previous findings, Wellington and Stouffer (1959), comparing longissimus steaks from Top Prime through Top Standard carcasses, found that as the degree of carcass marbling increased there was a significant increase in juiciness ratings. Jennings et al. (1976) reported significantly higher juiciness ratings for steaks from carcasses with marbling scores of "modest" and above, compared with steaks from carcasses containing "slight" or lower degrees of marbling. These findings agree with Romans et al. (1965) where steaks from carcasses with a "moderate" marbling level were rated significantly more juicy than those from carcasses with a "slight" degree of marbling.

Flavor

Barbella et al. (1939) reported that increasing percentages of ether extractable material in the edible portion of beef resulted in increased

sensory scores for flavor desirability. Data from Warwick et al. (1970) supported these findings. Longissimus steaks from steer carcasses were rated significantly higher for flavor desirability and were higher in percentages of ether extractable constituents than steaks from bull carcasses. These data disagree with Champagne et al. (1969) and Hedrick et al. (1969) where flavor desirability scores were similar between steaks from bull and steer carcasses, while percentages of ether extractable material were lower for the longissimus muscle of bulls. In addition, flavor desirability scores were similar for steaks from bull and steer carcasses even when marbling scores were lower for bull carcasses (Glimp et al., 1971; Jacobs et al., 1977b). These findings would further disagree with Barbella et al. (1939) who related percentage of ether extractable material to flavor desirability scores, because marbling score has been found to be directly related to percentage of ether extractable constituents (Goll et al., 1965; Romans et al., 1965).

Cross et al. (1976) reported flavor acceptability scores for longissimus steaks decreased with increasing internal cooking temperature endpoints. However, final internal temperature and carcass maturity had no effect on flavor intensity scores.

Arthaud et al. (1977) observed no differences in flavor intensity between bulls and steers fed high or low energy diets and slaughtered at either 12, 15, 18 or 24 months of age. Within a sex, similar flavor intensity scores were found across all slaughter age groups. These results are contrary to those of Barbella et al. (1939) where flavor intensity was found to increase with animal age. This study concluded that age accounted for 83% of the variability in lean flavor intensity from steers and heifers, and only 3% of the variability was due to sex of the animal.

Tenderness

Slaughtering bulls and steers at similar weight endpoints results in little variation in tenderness between sexes.

Warner-Bratzler shear forces and taste panel tenderness ratings were similar for longissimus roasts from bull and steer carcasses, when animals were slaughtered at 410 kg (Bailey et al., 1966b). However, shear forces and tenderness ratings tended to favor roasts from the steer carcasses compared with roasts from the bull carcasses. Warwick et al. (1970) reported Warner-Bratzler shear forces of lean from the 9-10-11th rib section were similar for bulls and steers when slaughtered between 411.4 kg and 435.0 kg live weight. Again, lean from the steer carcasses tended to have lower shear force values. Warner-Bratzler shear forces were not significantly different for longissimus steaks from bull and steer carcasses when animals were slaughtered at 477 kg live weight (Landon et al., 1978). In contrast, data from Aitken et al. (1963) indicated that meat from steer carcasses was more tender than meat from bull carcasses when slaughtered at a constant weight endpoint. Arthaud et al. (1969) reported Warner-Bratzler shear forces were greater for the longissimus muscle of bulls compared with steers, when carcass weights were adjusted to 235 kg.

Hawrysh and Berg (1979) studied the effects of slaughter weight on tenderness of semitendinosus and longissimus roasts from bull carcasses. Slaughter weights of 377, 565, 624 and 682 kg had no effect on Warner-Bratzler shear forces of either muscle.

Hiner and Hankins (1950) and Tuma et al. (1962) concluded that as animal age increased the tenderness of beef decreased. Coinciding with these findings, Walter et al. (1965) reported that as beef carcass maturity

increased, tenderness decreased.

Albaugh et al. (1975) evaluated the tenderness of semimembranosus and longissimus roasts from bulls, short scrotum bulls and steers slaughtered between 16 and 17 months of age. Taste panel ratings indicated that the semimembranosus muscle of steers was significantly more tender than that from bulls and short scrotum bulls. However, tenderness ratings for the longissimus roasts of steer carcasses were significantly greater than those for the short scrotum bull carcasses. Steer longissimus roasts tended to be more tender than roasts from bulls, while roasts from short scrotum bulls tended to be less tender than roasts from bulls. Warner-Bratzler shear forces were similar for all sex groups and carcass maturity scores for animals in this study were not different.

Reagan et al. (1971) reported that longissimus steaks from steer carcasses were rated more tender than steaks from bull carcasses when animals were slaughtered at an average of 385 d of age. However, no significant differences in taste panel tenderness scores were found when animals were slaughtered at an average age of 484 d. At both slaughter endpoints bull carcasses were significantly more mature than steer carcasses.

Arthaud et al. (1977) conducted a study in which bulls and steers were slaughtered at either 12, 15, 18 or 24 months of age. Bull carcasses were more mature than steer carcasses at the 15, 18 and 24 month slaughter times. Longissimus steaks from steer carcasses were more tender compared with steaks from bull carcasses, as measured by the Warner-Bratzler shear and a trained taste panel. Slaughter age had no effect on tenderness ratings within a sex treatment. In contrast, Hedrick et al. (1969) reported that Warner-Bratzler shear forces and taste panel tenderness ratings were similar for longissimus steaks from bulls, steers and heifers, of comparable ages,

when slaughtered at less than 16 months of age. However, when slaughtered later than 16 months of age, steaks from bulls were less tender than steaks from steers or heifers, when animals had similar chronological ages.

Wilson et al. (1974) found taste panel tenderness ratings were similar for bulls, short scrotum bulls and steers when slaughtered at an average age of 402 d. Field et al. (1966) reported that meat from bulls slaughtered at 300 to 400 d of age was significantly more tender than meat from bulls slaughtered at older ages. No significant differences were observed in the tenderness of bull meat when animal age increased from 400 to 699 d of age.

Field et al. (1966) reported that degree of marbling in bull carcasses had no effect on Warner-Bratzler shear forces of longissimus roasts, when age was held constant. In addition, taste panel sensory scores for tenderness of roasts with "traces", "slight" or "small" degrees of marbling from bull carcasses were not significantly different, but they were lower than roasts with "modest" amounts of marbling.

DES Effects on Juiciness

Pilkington et al. (1959) reported similar juiciness ratings for rib steaks from bulls implanted with 12 mg of DES at 3.5 months of age and reimplanted with 24 mg of DES at 6.5 months of age and nonimplanted bulls. Implanted bulls graded slightly higher than nonimplanted bulls in this study. Williams et al. (1975a) observed similar juiciness ratings for rib steaks from bulls implanted with 45 mg of DES at 106 d of age or bulls implanted with 45 mg of DES at 205 d of age and reimplanted with 45 mg at 306 d, compared with nonimplanted bulls. Marbling scores were slightly higher for the implanted bulls. However, carcass grades were similar for the implanted and nonimplanted bulls.

DES Effects on Flavor

Longissimus roasts from steers implanted with 24 mg of DES tended to have lower taste panel flavor ratings than roasts from the nonimplanted steers (Bailey et al., 1966b). They also found that 24 mg implants decreased the percentage of ether extractable material from the longissimus muscle. However, a slight increase in ether extractable constituents was found when bulls were implanted with 60 mg of DES, but no differences in flavor scores were found between roasts from implanted and nonimplanted animals. Williams et al. (1975b) found slightly higher (nonsignificant) amounts of ether extractable material from carcasses of bulls implanted and reimplanted with 48 mg of DES compared with nonimplanted bulls. However, flavor ratings were slightly lower (nonsignificant) for rib steaks from the implanted bulls.

DES Effects on Tenderness

Bailey et al. (1966b) reported that longissimus roasts from steers implanted with 24 mg of DES tended to have lower taste panel tenderness ratings than nonimplanted steers, when animals were slaughtered at 450 kg. Bulls implanted with 60 mg of DES had similar taste panel tenderness ratings and Warner-Bratzler shear force values compared with nonimplanted bulls. In contrast, Laflamme and Burgess (1973) found that longissimus steaks from nonimplanted bulls and steers were more tender than steaks from bulls and steers implanted with 36 mg of DES, when slaughtered at 500 kg (or had approximately 1.25 cm fat thickness over the 11th rib).

Cahill et al. (1956) reported that longissimus steaks from bulls and steers implanted and reimplanted with 84 mg of DES had lower taste panel tenderness ratings than did the nonimplanted animals when slaughtered at

16 months of age. Longissimus steaks from bulls and steers implanted with 24 mg of DES and slaughtered at 9 and 12 months of age had similar taste panel tenderness ratings and Warner-Bratzler shear force values compared with the nonimplanted controls (Wipf et al., 1964). Williams et al. (1975b) found that tenderness ratings for rib steaks from bulls implanted and reimplanted with 48 mg of DES were similar to tenderness ratings for nonimplanted bulls when slaughtered at 56 weeks of age. However, tenderness scores were slightly lower for the implanted bulls.

Zeranol (Ralgro) Effects on Muscle Cooking Loss and Palatability

Borger et al. (1973a) conducted a study in which 36 steers weighing 269 kg were implanted with 36 mg of zeranol initially and reimplanted 84 d later, and fed for 169 d. Cooking losses were 13.1% greater for rib steaks from the implanted steers compared with the nonimplanted steers. These higher losses appeared to be due to a significantly higher moisture content in the muscle of implanted steers.

Lamm et al. (1980) reported that meat from bulls implanted with 36 mg of zeranol every 100 d from birth to slaughter tended to be more desirable in taste panel evaluations compared with nonimplanted bulls.

The limited amount of information available concerning the effects of zeranol on cooking loss and palatability characteristics of meat from bulls indicates the need for further research in this area.

Compared Effects of DES and Zeranol (Ralgro)

The difficulty in comparing reported effects of DES to the effects of zeranol in beef cattle is due to variations in experimental designs for initial implantation times, dosage levels and implanting frequencies. Therefore, only a generalization can be made concerning a comparative evaluation for the effects of these two substances.

A majority of the research indicates that, for steers and heifers, zeranol improves preweaning performance, while both DES and zeranol are effective in improving postweaning performance. It appears, however, that implanting bulls with either substance has little effect on performance characteristics.

Fat thickness measurements for steers do not appear to be affected by the implantation of either DES or zeranol. However, implanting bulls with either substance has resulted in fatter carcasses. Lower quality grades for steers have been reported when implanting with DES. Zeranol appears to have little effect on bull carcass quality grades, while increased quality grades were noted for bulls implanted with DES.

Based on the limited amount of data available for palatability characteristics of zeranol implanted animals it is not feasible to discuss comparisons with DES implanted animals.

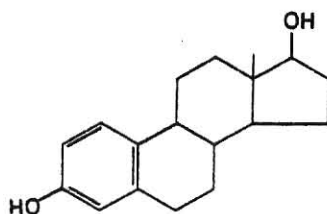
Mechanisms of DES and Zeranol (Ralgro) Activity

The exact modes of action for DES and zeranol as growth promotants in ruminants are not completely understood. However, both compounds appear to work through hormonal mechanisms, resulting in improved animal performance. The mechanisms presented were determined using lambs, steers and heifers, while no research regarding the modes of action in bulls, for either substance, was found.

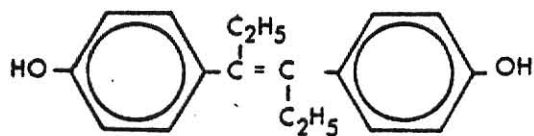
DES, a synthetic hormone with structural similarities of estrogen (figure 1), appears to have estrogenic effects (Trenkle, 1969), which enhances growth by altering the activity of endogenous anabolic hormones (Buttery et al., 1978). A review by Preston (1975) cited several possible modes of action for estrogenic growth promotants. He postulated that estrogens increase the levels of growth hormone released into the blood from an enlarged pituitary gland, and result in increased growth and nitrogen retention. Trenkle (1969) postulated that an increased level of circulating insulin in combination with increased levels of growth hormone in DES treated ruminants may result in protein anabolism. Other proposed modes of action for anabolic responses from estrogenic compounds have been related to increased production of androgens by the adrenal gland (Clegg and Cole, 1954), increased production of thyroid hormone (Burgess and Lamming, 1960) or enhanced tissue utilization of non-protein nitrogen (McLaren et al., 1960).

Zeranol has been classified pharmacologically as a protein anabolic agent (Brown, 1970). However, its structural similarities of estrogen (figure 1) suggest that its modes of action may be somewhat similar to those of DES. Increased circulating growth hormone (Borger et al., 1973a,b;

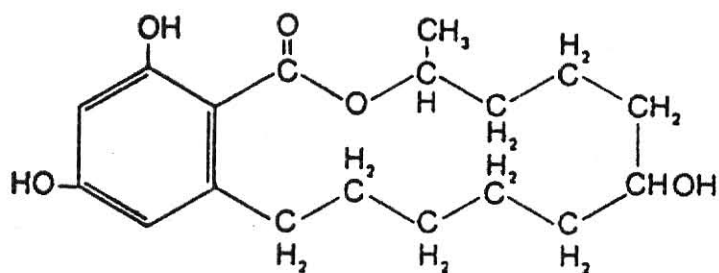
Figure 1. Structural characteristics of estrogen, diethylstilbestrol and zeranol.



Estradiol 17- β (the major estrogen)



α - α' diethyl, 4-4' dihydroxystilbene
(Diethylstilbestrol)



6-(6,10-dihydroxyundecyl)- β -resorcylic acid- μ -lactone
(Zeranol)

Wiggins et al., 1976) and insulin (Sharp and Dyer, 1970; Olsen et al., 1977) in zeranol treated animals support this theory. However, a differential response in blood metabolite levels between zeranol and DES treated animals has been found (Wiggins et al., 1976). Zeranol implanted lambs had lower levels of circulating insulin and blood urea nitrogen levels and increased growth hormone and cortisol levels compared with DES implanted animals. Apparently, the exact relationships between the mechanisms of DES and zeranol as anabolic agents are yet to be elucidated.

Electrical Stimulation

Electrical stimulation (ES) of beef carcasses improved lean color (Savell et al., 1978b,c; McKeith et al., 1981b; Salm et al., 1981), lean maturity (Savell et al., 1978b; McKeith et al., 1981a,b), lean texture (McKeith et al., 1981b; Salm et al., 1981), lean firmness (Savell et al., 1978b), 24 h marbling score (Savell et al., 1978b; McKeith et al., 1981a,b), 24 h quality grade (Savell et al., 1978b; McKeith et al., 1981b), flavor desirability (Savell et al., 1976, 1979; McKeith et al., 1981a) and overall palatability (Savell et al., 1978c, 1979; McKeith et al., 1981a) of steer and heifer carcasses. Savell et al. (1978b) and Cross et al. (1979) reported cooking losses for ES beef were greater compared with cooking losses from non-electrically stimulated carcasses.

Electrical stimulation of beef carcasses improved tenderness (Grusby et al., 1976; Smith et al., 1977; Savell et al., 1976, 1978c, 1979; Salm et al., 1981). Proposed mechanisms for the improvement in tenderness of stimulated beef carcasses have been reported by Bendall et al. (1976), Chrystall and Hagyard (1976), Davey et al. (1976), Savell et al. (1978a), Dutson et al. (1980) and Judge et al. (1980), and are outlined below:

- (1) The prevention of toughening associated with cold shortening due to the rapid depletion of ATP during ES, and thus, a quicker onset of rigor mortis.
- (2) Structural damage to muscle fibers during ES.
- (3) Enhanced lysosomal enzyme activity, while carcass temperatures are high and muscle pH is low, due to ES, resulting in a faster rate of muscle protein degradation.
- (4) Reduction in thermal stability of intramuscular collagen by ES, resulting in a lowered shrinkage temperature for collagen.

A limited amount of research has been reported concerning the effects

of ES on carcasses from the intact male. Ray et al. (1980) studied ES using 40 Mor-Less (short scrotum bull) carcasses from animals fed high concentrate diets for 147 d. Warner-Bratzler shear forces and cooking yield percentages for semimembranosus and semitendinosus roasts were not significantly affected by ES. Eikelenboom et al. (1981) conducted a study in which 24 bull carcasses, from animals approximately 1.5 years of age, were subjected to either high or low voltage ES parameters. Longissimus muscle samples from ES carcasses had a greater drip loss, higher percentages of cooking losses and lower Warner-Bratzler shear force values compared with control carcasses. Taste panel tenderness ratings were superior for longissimus muscle samples from the ES carcasses.

Literature Cited

- Aitken, J.N., T.R. Preston, A. Macdearmid and E.B. Phillip. 1963. Intensive beef production: bulls versus steers. *Anim. Prod.* 5:215 (Abstr.).
- Albaugh, A., F.D. Carroll, K.W. Ellis and R. Albaugh. 1975. Comparison of carcasses and meat from steers, short scrotum bulls and intact bulls. *J. Anim. Sci.* 41:1627.
- Andrews, F.N., W.M. Beeson and F.D. Johnson. 1954. The effects of stilbestrol, dienestrol, testosterone and progesterone on the growth and fattening of beef steers. *J. Anim. Sci.* 13:99.
- Arthaud, V.H., C.H. Adams, D.R. Jacobs and R.M. Koch. 1969. Comparison of carcass traits of bulls and steers. *J. Anim. Sci.* 28:742.
- Arthaud, V.H., R.W. Mandigo, R.M. Koch and A.W. Kotula. 1977. Carcass composition, quality and palatability attributes of bulls and steers fed different energy levels and killed at four ages. *J. Anim. Sci.* 44:53.
- Bailey, C.M., C.L. Probert, J. Chancerelle, V.R. Bohman and J.E. Hunter. 1964. Characteristics of young bulls and steers. *J. Anim. Sci.* 23:858 (Abstr.).
- Bailey, C.M., C.L. Probert and V.R. Bohman. 1966a. Growth rate, feed utilization and body composition of young bulls and steers. *J. Anim. Sci.* 25:132.
- Bailey, C.M., C.L. Probert, P. Richardson, V.R. Bohman and J. Chancerelle. 1966b. Quality factors of the longissimus dorsi of young bulls and steers. *J. Anim. Sci.* 25:504.
- Barbella, N.G., B. Tannor and T.G. Johnson. 1939. Relationships of flavor and juiciness of beef to fatness and other factors. *Proc. 32nd Annu. Meeting Amer. Soc. Anim. Prod.* p 320.
- Bendall, J.R., C.C. Ketteridge and A.R. George. 1976. The electrical stimulation of beef carcasses. *J. Sci. Food Agr.* 27:1123.
- Borger, M.L., L.L. Wilson, J.D. Sink, J.H. Ziegler and S.L. Davis. 1973a. Zeranol and dietary protein level effects on live performance, carcass merit, certain endocrine factors and blood metabolite levels of steers. *J. Anim. Sci.* 36:706.
- Borger, M.L., J.D. Sink, L.L. Wilson, J.H. Ziegler and S.L. Davis. 1973b. Zeranol and dietary protein level effects on DNA, RNA and protein composition of three muscles and the relationship to serum insulin and GH levels of steers. *J. Anim. Sci.* 36:712.
- Brown, C.J., J.D. Bartee and P.K. Lewis, Jr. 1962. Relationships among performance records, carcass cut-out data, and eating quality of bulls and steers. *Ark. Agr. Exp. Sta. Bull.* 655.

- Brown, R.G. 1970. An anabolic agent for ruminants. J. Amer. Vet. Med. Assoc. 157:1537.
- Burgess, T.D. and G.E. Lamming. 1960. The effect of diethylstilbestrol, hexestrol and testosterone on the growth rate and carcass quality of fattening beef steers. Anim. Prod. 2:93.
- Buttery, P.J., B.G. Vernon and J.T. Pearson. 1978. Anabolic agents - some thoughts on their mode of action. Proc. Nutr. Soc. 37:311.
- Cahill, V.R., L.E. Kunkle, E.W. Klosterman, F.E. Deatherage and E. Wierbicki. 1956. Effect of diethylstilbestrol implantation on carcass composition and the weight of certain endocrine glands of steers and bulls. J. Anim. Sci. 15:701.
- Champagne, J.R., J.W. Carpenter, J.F. Hentges, Jr., A.Z. Palmer and M. Koger. 1969. Feedlot performance and carcass characteristics of young bulls and steers castrated at four ages. J. Anim. Sci. 29:887.
- Chrystall, B.B. and C.J. Hagyard. 1976. Electrical stimulation and lamb tenderness. N. Z. J. Agr. Res. 19:7.
- Clegg, M.T. and H.H. Cole. 1954. The action of stilbestrol on the growth response in ruminants. J. Anim. Sci. 13:108.
- Corah, L.R., L. Fink, G.H. Kiracofe, and M. McKee. 1979. Sexual development and carcass traits of bulls after sequential implanting with Zeranol. J. Anim. Sci. 49(Suppl. 1):287.
- Cross, H.R., M.S. Stanfield and E.J. Koch. 1976. Beef palatability as affected by cooking rate and final internal temperature. J. Anim. Sci. 43:114.
- Cross, H.R., G.C. Smith, A.W. Kotula and D.A. Muse. 1979. Effects of electrical stimulation and shrouding method on quality and palatability of beef carcasses. J. Food Sci. 44:1560.
- Davey, C.L., K.V. Gilbert, and W.A. Carse. 1976. Carcass electrical stimulation to prevent cold shortening toughness in beef. N. Z. J. Agr. Res. 19:13.
- Davis, D.I., J.E. Huston, C.S. Menzies, S. Lindsey, J.D. DeBord, and D.B. Herd. 1977. Response of nursing calves to zeranol implants. J. Anim. Sci. 45(Suppl. 1):382.
- Dutson, T.R., G.C. Smith and Z.L. Carpenter. 1980. Lysosomal enzyme distribution in electrically stimulated ovine muscle. J. Food Sci. 45:1097.
- Eikelenboom, G., F.J.M. Smulders and H. Rudérus. 1981. The effect of high and low voltage electrical stimulation on beef quality. Proc. 27th European Meeting of Meat Res. Workers. V1:148.

- Ellington, E.F., K.R. Helm and M.K. Nielsen. 1978. Effect of zeralanol on body weight gains and pelvic size in calves. *J. Anim. Sci.* 47(Suppl. 1): 40.
- Embry, L.B. 1972. Effect of sex, castration and hormonal compounds on feedlot performance and carcass merit of cattle. Sixteenth Annu. South Dakota Cattle Feeders Day Rep. pp 10-53.
- Field, R.A., G.E. Nelms and C.O. Schoonover. 1966. Effects of age, marbling and sex on palatability of beef. *J. Anim. Sci.* 25:360.
- Fredeen, H.T., A.H. Martin and G.M. Weiss. 1971. Characteristics of youthful beef carcasses in relation to weight, age and sex. I. Organ weights, slaughter loss and cooler shrink in production of the dressed carcass. *Can. J. Anim. Sci.* 51:279.
- Garrigus, R.R., T.G. Martin, M. Stob and D.R. Perks. 1969. Influence of creep feeding and post-weaning diethylstilbestrol implantation on post-weaning weight gain and carcass composition of beef bulls. *J. Anim. Sci.* 29:75.
- Glimp, H.A., M.E. Dikeman, H.J. Tuma, K.E. Gregory and L.V. Cundiff. 1971. Effect of sex condition on growth and carcass traits of male Hereford and Angus cattle. *J. Anim. Sci.* 33:1242.
- Goll, D.E., A.F. Carlin, L.P. Anderson, E.A. Kline and M.J. Walter. 1965. Effect of marbling and maturity on beef muscle characteristics. II. Physical, chemical, and sensory evaluation of steaks. *Food Technol.* 19:845.
- Grusby, A.H., R.L. West, J.W. Carpenter and A.Z. Palmer. 1976. Effects of electrical stimulation on tenderness. *J. Anim. Sci.* 42:253 (Abstr.).
- Hathaway, R.L., A.L. Lesperance, T.P. Ringkob and J.A. McCormick. 1973. Influence of zeranol and stilbestrol on carcass characteristics. *J. Anim. Sci.* 36:1206 (Abstr.).
- Hawrysh, Z.J. and R.T. Berg. 1979. Eating quality of beef from young Hereford bulls as influenced by slaughter weight. *Can. J. Anim. Sci.* 59:237.
- Hedrick, H.B., G.B. Thompson and G.F. Krause. 1969. Comparison of feedlot performance and carcass characteristics of half-sib bulls, steers and heifers. *J. Anim. Sci.* 29:687.
- Hiner, R.L. and O.G. Hankins. 1950. The tenderness of beef in relation to different muscles and age in the animal. *J. Anim. Sci.* 9:347.
- Hunsley, R.E., R.L. Vetter, E.A. Kline and W. Burroughs. 1967. Effects of age, sex and diethylstilbestrol on feedlot performance, carcass characteristics and muscle tenderness of male beef cattle. *J. Anim. Sci.* 26:1469 (Abstr.).

- Jacobs, J.A., C.E. Hurst, J.C. Miller, A.D. Howes, T.L. Gregory and T.P. Ringkob. 1977a. Bulls versus steers. I. Carcass composition, wholesale yields and retail values. *J. Anim. Sci.* 46:695.
- Jacobs, J.A., J.C. Miller, E.A. Sauter, A.D. Howes, A.A. Araj, T.L. Gregory and C.E. Hurst. 1977b. Bulls versus steers. II. Palatability and retail acceptance. *J. Anim. Sci.* 45:699.
- Jennings, T.G., B.W. Berry and A. Buchanan. 1976. Fat thickness, marbling and aging. I. Effects on beef palatability. *J. Anim. Sci.* 43:240 (Abstr.).
- Judge, M.D., E.S. Reeves and E.D. Aberle. 1980. Effect of electrical stimulation on thermal shrinkage temperature of bovine muscle collagen. Proc. 26th European Meeting of Meat Res. Workers. V2:74.
- Klosterman, E.W., L.E. Kunkle, P. Gerlaugh, and V.R. Cahill. 1954. The effect of age of castration upon rate and economy of gain and carcass quality of beef calves. *J. Anim. Sci.* 13:817.
- Klosterman, E.W., V.R. Cahill, L.E. Kunkle and A.L. Moxon. 1955. The subcutaneous implantation of stilbestrol in fattening bulls and steers. *J. Anim. Sci.* 14:1050.
- Koger, T., H. Elliott, F.G. Harbaugh and R.M. Durham. 1960. Sex effects on carcass and productive traits in fattening beef calves. *J. Anim. Sci.* 19:1238 (Abstr.).
- Kunkle, W.E., E.C. Leffel, R.C. Hammond and L.W. Douglass. 1980. The performance of steers reimplanted with Ralgro. *J. Anim. Sci.* 51(Suppl. 1):164.
- Laflamme, L.F. and T.D. Burgess. 1973. Effect of castration, ration and hormone implants on the performance of finishing cattle. *J. Anim. Sci.* 36:762.
- Lamm, W.D., R.F. Kelly, W.H. McClure and J.P. Fontenot. 1980. Effect of zeranol implants on performance of suckling calves and growing-finishing bulls and heifers. *J. Anim. Sci.* 51(Suppl. 1):377.
- Landon, M.E., H.B. Hedrick and G.B. Thompson. 1978. Live animal performance and carcass characteristics of beef bullocks and steers. *J. Anim. Sci.* 47:151.
- Marchello, J.A., D.E. Ray and W.H. Hale. 1970. Carcass characteristics of beef cattle as influenced by season, sex and hormonal growth stimulants. *J. Anim. Sci.* 31:690.
- Marlowe, T.J. and J.A. Gaines. 1958. The influence of age, sex, and season of birth of calf, and age of dam on preweaning growth rate and type score of beef calves. *J. Anim. Sci.* 17:706.

- Martin, T.G., J.L. Albright, and M. Stob. 1965. Comparison of growth rate and carcass traits of bulls, stilbestrol treated bulls, and steers of the Holstein-Friesian breed. *J. Dairy Sci.* 48:813 (Abstr.).
- Matsushima, J.K. and J.I. Sprague. 1963. Bulls produce leaner, lower grading carcasses in CSU feeding study. *Colo. Agr. Exp. Sta. Bull. Gen. Series* 785.
- McKeith, F.K., G.C. Smith, J.W. Savell, T.R. Dutson, Z.L. Carpenter and D.R. Hammons. 1981a. Effects of certain electrical stimulation parameters on quality and palatability of beef. *J. Food Sci.* 46:13.
- McKeith, F.K., J.W. Savell and G.C. Smith. 1981b. Tenderness improvement of the major muscles of the beef carcass by electrical stimulation. *J. Food Sci.* 46:1774.
- McLaren, G.A., G.C. Anderson, J.A. Welch, C.D. Campbell and G.S. Smith. 1960. Diethylstilbestrol and length of preliminary period in the utilization of crude biuret and urea by lambs. II. Various aspects of nitrogen metabolism. *J. Anim. Sci.* 19:44.
- Nichols, J.R., J.H. Ziegler, J.M. White, E.M. Kesler, and J.L. Watkins. 1964. Production and carcass characteristics of Holstein-Friesian bulls and steers slaughtered at 800 or 1,000 pounds. *J. Dairy Sci.* 47:179.
- Nichols, N.E. and A.L. Lesperance. 1973. Type, level and frequency of implant on suckling calves. *J. Anim. Sci.* 36:1206 (Abstr.).
- Olsen, R.F., P.J. Wangsness, R.J. Martin, and J.H. Gahagen. 1977. Effects of zeranol on blood metabolites and hormones in wether lambs. *J. Anim. Sci.* 45:1392.
- Perry, T.W., M. Stob, D.A. Huber and R.C. Peterson. 1970. Effect of subcutaneous implantation of resorcylic acid lactone on performance of growing and finishing beef cattle. *J. Anim. Sci.* 31:789.
- Pilkington, D.H., L.E. Walters, L.S. Pope, G.V. Odell and D.F. Stephens. 1959. Carcass studies with steers, bulls, and stilbestrol implanted bulls sold as slaughter calves. *Okla. Agr. Exp. Sta. Misc. Pub.* 55:62.
- Preston, R.L. 1975. Biological responses to estrogen additives in meat producing cattle and lambs. *J. Anim. Sci.* 41:1414.
- Ralston, A.T., W.H. Kennick and T.P. Davidson. 1975. Effect of currently-used growth promotants upon skeletal maturation of beef steers. *J. Anim. Sci.* 40:1211.
- Ralston, A.T. 1978. Effect of zearalanol on weaning weight of male calves. *J. Anim. Sci.* 47:1203.
- Ray, E.E., D.M. Stiffler and B.W. Berry. 1980. Effects of electrical stimulation and hot boning upon physical changes, cooking time and losses, and tenderness of beef roasts. *Proc. 26th European Meeting of Meat Res. Workers.* V2:26.

- Reagan, J.O., Z.L. Carpenter, G.C. Smith and G.T. King. 1971. Comparison of palatability traits of beef produced by young bulls and steers. *J. Anim. Sci.* 32:641.
- Romans, J.R., H.J. Tuma and W.L. Tucker. 1965. Influence of carcass maturity and marbling on the physical and chemical characteristics of beef. I. Palatability, fiber diameter and proximate analysis. *J. Anim. Sci.* 24:681.
- Salm, C.P., E.W. Mills, E.S. Reeves, M.D. Judge and E.D. Aberle. 1981. Effect of electrical stimulation on muscle characteristics of beef cattle fed a high energy diet for varying lengths of time. *J. Food Sci.* 46:1284.
- Savell, J.W., G.C. Smith, T.R. Dutson, Z.L. Carpenter and D.A. Suter. 1976. Effect of electrical stimulation on beef palatability. *J. Anim. Sci.* 43:246 (Abstr.).
- Savell, J.W., T.R. Dutson, G.C. Smith and Z.L. Carpenter. 1978a. Structural changes in electrically stimulated beef muscle. *J. Food Sci.* 43:1606.
- Savell, J.W., G.C. Smith and Z.L. Carpenter. 1978b. Beef quality and palatability as affected by electrical stimulation and cooler aging. *J. Food Sci.* 43:1666.
- Savell, J.W., G.C. Smith and Z.L. Carpenter. 1978c. Effect of electrical stimulation on quality and palatability of light-weight beef carcasses. *J. Anim. Sci.* 46:1221.
- Savell, J.W., G.C. Smith, Z.L. Carpenter and F.C. Parrish, Jr. 1979. Influence of electrical stimulation on certain characteristics of heavy-weight beef carcasses. *J. Food Sci.* 44:911.
- Sharp, G.D. and I.A. Dyer. 1970. Metabolic responses to zearalanol implants. *J. Anim. Sci.* 30:1040 (Abstr.).
- Sharp, G.D. and I.A. Dyer. 1971. Effect of zearalanol on the performance and carcass composition of growing-finishing ruminants. *J. Anim. Sci.* 33:865.
- Smith, G.C., T.R. Dutson, Z.L. Carpenter and R.L. Hostetler. 1977. Using electrical stimulation to tenderize meat. *Proc. Meat Ind. Res. Conf.* p 147.
- Steen, W.W., S.D. Farlin and V.H. Arthaud. 1978. The effect of fat and Ralgro on growth and carcass characteristics of young bulls. *J. Anim. Sci.* 47(Suppl. 1):42.
- Sumwalt, K.L., V.J. Rhodes, W. Stringer, and H.D. Naumann. 1964. Consumer acceptance of loin steaks from young bulls. *Mo. Agr. Exp. Sta. Bull.* 867.
- Thiex, P.J. and L.B. Embry. 1972. Feedlot performance of bulls and the response to diethylstilbestrol or zeranol. Sixteenth Annu. South Dakota Cattle Feeders Day Rep. pp 68-70.

- Thomas, O.O. and J. Armitage. 1970. Zearalanol for growing-fattening steers. *J. Anim. Sci.* 30:1039 (Abstr.).
- Trenkle, A.H. 1969. The mechanisms of action of estrogens in feeds on mammalian and avian growth. In: *The Use of Drugs in Animal Feeds*. Natl. Acad. Sci. Pub. 1679. pp 150-164.
- Tuma, H.J., R.L. Henrickson, D.F. Stephens and R. Moore. 1962. Influence of marbling and animal age on factors associated with beef quality. *J. Anim. Sci.* 21:848.
- Turton, J.D. 1962. The effect of castration on meat production and quality in cattle, sheep and pigs. *Anim. Breed. Abstr.* 30:447.
- Walter, M.J., D.E. Goll, E.A. Kline, L.P. Anderson, and A.F. Carlin. 1965. Effect of marbling and maturity on beef muscle characteristics. I. Objective measurements of tenderness and chemical properties. *Food Technol.* 19:841.
- Ward, J.K., T.J. Klopfenstein, S.D. Farlin, L. Peterson and G.E. Schindler. 1978. Ralgro implants from birth through finishing. *J. Anim. Sci.* 47(Suppl. 1):43.
- Warwick, E.J., P.A. Putnam, R.L. Hiner and R.E. Davis. 1970. Effects of castration on performance and carcass characters of monozygotic bovine twins. *J. Anim. Sci.* 31:296.
- Wellington, G.H. and J.R. Stouffer. 1959. Beef marbling - its estimation and influence on tenderness and juiciness. *Cornell Agr. Exp. Sta. Bull.* 941.
- Wiggins, J.P., L.L. Wilson, H. Rothenbacher and S.L. Davis. 1976. Effects of diethylstilbestrol, zeranol and sex on live, blood metabolite, carcass and endocrine characteristics of lambs. *J. Anim. Sci.* 43:518.
- Williams, D.B., R.L. Vetter, W. Burroughs and D.G. Topel. 1975a. Effects of ration protein level and diethylstilbestrol implants on early-weaned beef bulls. *J. Anim. Sci.* 41:1525.
- Williams, D.B., R.L. Vetter, W. Burroughs and D.G. Topel. 1975b. Dairy beef production as influenced by sex, protein level and diethylstilbestrol. *J. Anim. Sci.* 41:1532.
- Wilson, L.L., C.A. Dinkel, D.E. Ray and J.A. Minyard. 1963. Beef carcass composition as influenced by diethylstilbestrol. *J. Anim. Sci.* 22:699.
- Wilson, L.L., M.C. Rugh, J.H. Ziegler and T.J. McAllister. 1974. Live and carcass characteristics of Holstein castrated, short scrotum and intact males. *J. Anim. Sci.* 39:488.
- Wipf, V.K., J.W. Carpenter, H.L. Chapman, Jr., A.Z. Palmer and T.J. Cunha. 1964. Effects of slaughter age and diethylstilbestrol implants on feed lot performance and carcass characteristics of bulls and steers. *J. Anim. Sci.* 23:865 (Abstr.).

Chapter III

RALGRO IMPLANTED BULLS: PERFORMANCE, CARCASS CHARACTERISTICS, LONGISSIMUS PALATABILITY AND CARCASS ELECTRICAL STIMULATION

Introduction

Bulls gain more rapidly with less feed than steers (Klosterman et al., 1954; Hedrick et al., 1969; Field, 1971; Arthaud et al., 1977). Carcasses from bulls generally are leaner (Hunsley et al., 1967; Hedrick, 1968; Arthaud et al., 1977), but they may have less marbling, lower quality grades (Glimp et al., 1971; Jacobs et al., 1977; Landon et al., 1978) and display a darker colored lean (Turton, 1962; Champagne et al., 1969; Carroll et al., 1975) when compared with steer carcasses. Some researchers also have observed that meat from bulls is less tender than meat from steers (Klosterman et al., 1954; Turton, 1962; Reagan et al., 1971), although others (Field et al., 1966; Hedrick et al., 1969) have found that meat from young bulls is comparable in palatability to that of steers.

Implanting steers with Ralgro improved performance compared with nonimplanted steers (Thomas and Armitage, 1970; Nichols and Lesperance, 1973; Nicholson et al., 1973). Ralston (1978) found that weaning weights were slightly heavier for bulls implanted with Ralgro compared with nonimplanted bulls. A limited amount of research has been done relating Ralgro implantation to the feedlot performance and carcass merit of intact males. Lamm et al. (1980) and L. R. Corah (personal communication) indicated that meat from Ralgro implanted bulls tended to be more desirable than

meat from nonimplanted bulls.

The objectives of this study were to determine the effects of Ralgro on performance of bulls, and its effect on the carcass and palatability characteristics of longissimus steaks. Electrical stimulation effects on bull carcass and palatability traits were also studied.

Experimental Procedure

Twenty of 40 fall-born Angus bulls from first calf heifers were implanted (I) with 36 mg of Ralgro within 3 d after birth and reimplanted with 36 mg of Ralgro at 123, 198, 324 and 425 d of age. The remaining 20 bulls served as nonimplanted (NI) controls. All bulls remained with their dams on native bluestem pasture for about 320 d and then were randomized by weight to six drylot pens of five to eight animals each (feedlot beginning). Three pens served as replicates for each treatment. After a 31 d adjustment period, animals were fed ad libitum high concentrate diets (table 1) until slaughter. Pen feed consumption and individual animal weights were monitored for feed efficiency and average daily gain calculations.

An equal number of bulls from the replicate pens of each treatment were slaughtered at either a light (454 kg) or heavy (499 kg) target weight. Actual slaughter weights and ages for animals in each treatment combination were: NI-light, 454 kg, 581 d; NI-heavy, 515 kg, 552 d; I-light, 453 kg, 538 d; and I-heavy, 501 kg, 522 d.

At slaughter either the left or right side of each carcass was electrically stimulated for 2 min at 45 min postmortem with 420 V, 60 Hz AC current. Sides were pulse stimulated with .68 sec on and .32 sec off, with approximately 1 amp going through the carcass.

Longissimus muscle cores (1.27 cm diameter) from each carcass side were excised at 40 min, 2, 4, 6, 8 and 24 h postmortem and blended with 5 mM iodoacetate for pH determinations. Temperature declines in the center of the longissimus muscle were recorded at 2, 4, 6, 8 and 24 h postmortem.

After chilling for 48 h, visual fat scores were assigned to each carcass on a 6-point scale, according to procedures of the Meat and Livestock Commission (1975). Carcass sides were ribbed and USDA carcass quality and

TABLE 1. FINISHING DIET COMPOSITIONS AND NET ENERGY VALUES¹

| Item | Finishing diets | | |
|-------------------------------|-----------------|------|------|
| | 1 | 2 | 3 |
| Days fed | 104 | 38 | 94 |
| Diet composition, % | | | |
| Grain sorghum (IFN 4-04-444) | 75.0 | 79.0 | 51.0 |
| Corn (IFN 4-02-931) | 0 | 0 | 25.0 |
| Corn silage (IFN 3-08-153) | 20.0 | 0 | 0 |
| Sorghum silage (IFN 3-04-468) | 0 | 16.0 | 19.0 |
| Supplement ² | 5.0 | 5.0 | 5.0 |
| Mcal NE _m per kg | 1.7 | 1.7 | 1.8 |
| Mcal NE _g per kg | 1.1 | 1.1 | 1.1 |

¹Dry matter basis.²Composition: 73.5% soybean meal; 17.8% limestone; 6% salt; .5% trace mineral mix; .5% KCl; .2% 30,000 IU vitamin A; 1.5% fat.

yield grades were determined. The 9-10-11th rib section from either the left or right side of each carcass was removed for composition analyses.

A longissimus steak 2.54 cm in thickness was removed from each shortloin for taste panel analysis, and an adjacent 2.54 cm thick steak was removed for Warner-Bratzler shear force determination. Steaks were vacuum packaged in oxygen impermeable film, aged for 6 d at 2 C, frozen and stored at -20 C for not more than 7 mo.

Steaks for taste panel evaluation were thawed overnight at 2 C. Eight steaks (non-stimulated and stimulated pairs from each slaughter group) were modified oven broiled at 166 C in a rotary oven to an internal temperature of 70 C (monitored by thermocouples). Cores, 1.27 cm in diameter, were removed with a mechanical coring device perpendicular to the steak's surface and served warm to a 6-member trained taste panel (AMSA, 1978). Evaluations for flavor intensity, juiciness, myofibrillar tenderness, overall tenderness and connective tissue amount were made on the samples using 8-point scoring scales (8= extremely intense flavor, extremely juicy, extremely tender or no connective tissue; 1= extremely bland flavor, extremely dry, extremely tough or abundant connective tissue).

Steaks used for Warner-Bratzler shear determinations were trimmed of subcutaneous fat, lightly blotted, weighed, cooked according to the procedures outlined for the taste panel steaks, blotted again and reweighed to determine total cooking loss. After weighing, steaks were cooled at room temperature for 2 h before coring. Eight 1.27 cm diameter cores were removed perpendicular to the surface of each steak and sheared once through the center with a Warner-Bratzler shear device, and the average shear force calculated.

Statistical Analysis. Data were analyzed by analysis of variance using the Statistical Analysis System (SAS) General Linear Model procedures (Barr et al., 1979). Least squares analysis of variance was used to separate means (Steel and Torrie, 1960). Tests for interaction between implantation, slaughter weight and electrical stimulation were performed (Snedecor and Cochran, 1978). Duncan's New Multiple Range testing procedure (Barr et al., 1979) was used to separate interaction means. Correlation coefficients between quality indicating traits and palatability characteristics were pooled over slaughter groups according to the Chi-square procedure of Snedecor and Cochran (1978).

Results and Discussion

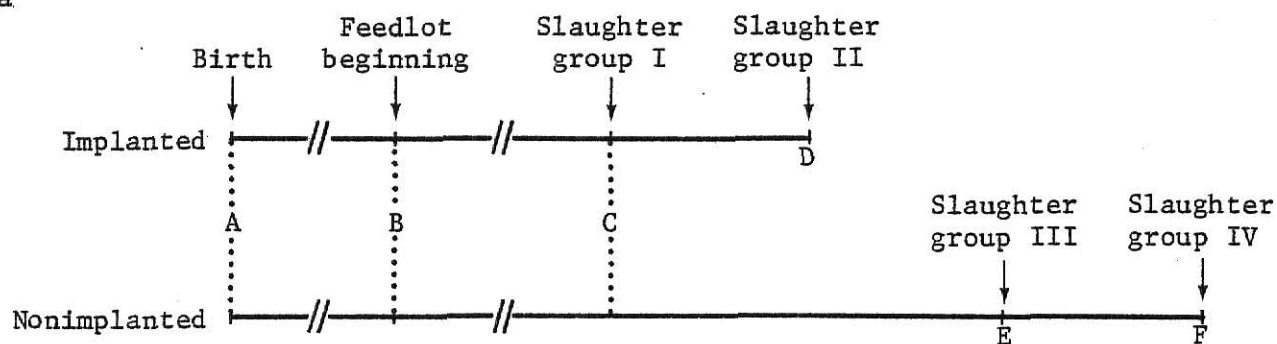
Performance Data. Average daily gain (ADG) and feed efficiency (F/G) data are presented in table 2. Implanting with Ralgro improved ($P<.05$) ADG 6.5% from birth (time A, footnote table 2) to the time the bulls were placed on feed (time B, average age of 320 d). From the beginning of the feedlot period until the first group of bulls was slaughtered (time C, 196 d), I bulls gained 9.3% faster ($P<.05$) and tended to have an advantage (7.9%, $P<.06$) in feed efficiency compared with the NI bulls. Implanted bulls gained 10.4% faster ($P<.05$) and tended to consume less feed/kg of gain (8.1%, $P<.07$) when comparisons were made from the feedlot beginning until the first group of I (time C) and NI (time E) bulls were slaughtered. In this comparison, NI bulls were fed 35 d longer to reach their first slaughter weight endpoint. When gain comparisons were made between slaughter groups from the feedlot beginning to the respective slaughter endpoints (times C, D, E or F), implanting increased ($P<.05$) daily gain 8.6%, and the I bulls reached their slaughter weights an average of 42 d sooner than the NI bulls.

Advantages in performance for steers implanted with 36 mg of Ralgro from birth through finishing have been found by Ward et al. (1978). However, Corah et al. (1979) and Lamm et al. (1980) reported no differences in gain for bulls implanted (subcutaneously in the middle of the ear; L. R. Corah and W. D. Lamm, personal communication) with 36 mg of Ralgro at either 28 d of age or at birth, and reimplanted every 100 d until slaughter. Because we implanted our bulls in the muscle at the base of the ear, these contrasting results may be related to implantation site, as Plegge and Corah (1979) reported that implanting steers with Ralgro in the muscle at the base of the ear resulted in improved gains compared with steers implanted subcutaneously

TABLE 2. PERFORMANCE DATA FOR NONIMPLANTED AND RALGRO IMPLANTED BULLS

| Trait | Time comparisons ^a | | | Implant group | | Probability ^b |
|---|-------------------------------|----|-----------|---------------|-----------|--------------------------|
| | Nonimplanted | | Implanted | Nonimplanted | Implanted | |
| Average daily gain, kg birth to feedlot beginning | AB | vs | AB | .62 | .66 | .03 |
| Average daily gain, kg feedlot beginning to slaughter group 1 | BC | vs | BC | 1.07 | 1.17 | .01 |
| Feed efficiency, F/G feedlot beginning to slaughter group 1 | BC | vs | BC | 7.69 | 7.13 | .06 |
| Average daily gain, kg feedlot beginning to first treatment slaughter | BE | vs | BC | 1.06 | 1.17 | .01 |
| Feed efficiency, F/G feedlot beginning to first treatment slaughter | BE | vs | BC | 7.71 | 7.13 | .07 |
| Average daily gain, kg feedlot beginning to actual slaughter endpoints | BE&BF | vs | BC&BD | 1.05 | 1.14 | .01 |

a



^bProbability level for differences between nonimplanted and Ralgro implanted bulls.

in the middle of the ear.

Thiex and Embry (1972) reported little improvement in feedlot performance of bulls implanted at 10 mo of age and reimplanted 4 mo later with 36 mg of Ralgro. Embry (1972), using data from two trials, reported no appreciable effect on performance of yearling bulls implanted with a single 36 mg Ralgro implant. Consequently, the time of initial implantation or the frequency of reimplanting also may affect the response of bulls to Ralgro.

Carcass Characteristics. Hot carcass weights were similar ($P>.05$) for NI and I bulls, and, as expected, the hot carcass weights were heavier ($P<.05$) for the heavy weight groups (table 3). Dressing percentages were not affected ($P>.05$) by implanting or slaughter weight.

Lean maturity, firmness and color scores were similar ($P>.05$) for NI and I bulls, and for animals slaughtered at light and heavy weights. However, higher scores ($P<.05$) for both skeletal maturity and final maturity indicated that I bull carcasses were more mature physiologically than NI bull carcasses, even though the I animals were slaughtered at earlier chronological ages. Our results contrast the findings of Sharp and Dyer (1971) who suggested that Ralgro delayed physiological maturity of growing steers, heifers and wether lambs. Light weight bulls tended ($P<.10$) to have greater skeletal maturity values than the heavy weight bulls, but no differences ($P>.05$) in final maturity values were found for bulls in either slaughter weight group.

Yield grade numbers were larger ($P<.05$) for carcasses in the heavy weight slaughter groups compared with carcasses in the light weight groups, and yield grade numbers tended ($P<.10$) to be higher for carcasses from the I bulls than those from the NI bulls. Carcasses in both the I and heavy weight groups had greater ($P<.05$) adjusted fat thicknesses than carcasses in the NI and light

TABLE 3. CARCASS CHARACTERISTICS FOR NONIMPLANTED AND RALGRO IMPLANTED BULLS SLAUGHTERED AT LIGHT (454 kg) AND HEAVY (499 kg) WEIGHTS

| Trait | Implant group | | Slaughter group | |
|---------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | Nonimplanted | Implanted | Light | Heavy |
| Hot carcass weight, kg | 301 ^b | 299 ^b | 282 ^c | 318 ^b |
| Dressing percentage | 62.2 ^b | 62.9 ^b | 62.5 ^b | 62.7 ^b |
| Quality grade, 48 h | Good ^{75b} | Good ^{76b} | Good ^{73b} | Good ^{78b} |
| Skeletal maturity | A 75 ^c | B 03 ^b | A 94 ^b | A 84 ^b |
| Lean maturity | A 57 ^b | A 49 ^b | A 52 ^b | A 55 ^b |
| Final maturity | A 69 ^c | A 80 ^b | A 77 ^b | A 73 ^b |
| Lean firmness ^a | 2.2 ^b | 2.5 ^b | 2.4 ^b | 2.2 ^b |
| Lean texture ^a | 3.0 ^c | 3.3 ^b | 3.2 ^b | 3.2 ^b |
| Lean color ^a | 2.1 ^b | 2.2 ^b | 2.2 ^b | 2.0 ^b |
| Marbling | Slight ^{84b} | Slight ^{90b} | Slight ^{87b} | Slight ^{88b} |
| Yield grade | 2.8 ^b | 3.1 ^b | 2.7 ^c | 3.2 ^b |
| Adjusted fat thickness, cm | 1.1 ^c | 1.4 ^b | 1.1 ^c | 1.4 ^b |
| Rib eye area, cm ² | 75.5 ^b | 75.7 ^b | 73.8 ^b | 77.4 ^b |
| Kidney, pelvic and heart fat, % | 2.0 ^b | 2.2 ^b | 2.1 ^b | 2.2 ^b |

^aScores: 4= slightly soft, slightly fine or moderately dark red; 3= moderately firm, moderately fine or slightly dark red; 2= firm, fine or cherry red.

^{b,c}Means in the same row within an implant or slaughter group bearing a different superscript letter are different (P<.05).

weight groups, respectively. Carcasses from I bulls also tended ($P < .07$) to have higher percentages of kidney, pelvic and heart fat than carcasses from the NI bulls. Rib eye areas were not different ($P > .05$) for carcasses in either the implant or slaughter groups. Although carcasses in the I and heavy weight groups were fatter than carcasses in the NI and light weight groups, respectively, no differences ($P > .05$) between those groups were found for either marbling or quality grade.

Rib Section Chemical Composition. Chemical composition of the 9-10-11th rib section are summarized in table 4. Carcasses in the NI group tended ($P < .06$) to have higher percentages of moisture and lower percentages of ether extractable material than carcasses in the I group. Percentages of protein in the rib sections were not different ($P > .05$) between NI and I groups. Rib sections from bulls in the heavy weight slaughter groups had lower ($P < .05$) percentages of moisture and protein and higher ($P < .05$) percentages of ether extractable material than did ribs from the light weight animals. Rib composition data for both implant and slaughter weight groups are in accord with the carcass composition data.

Cooking Losses, Taste Panel Ratings and Warner-Bratzler Shear Forces. Cooking loss percentages were similar ($P > .05$) for longissimus steaks from NI and I bulls (table 5). However, steaks from bulls in the heavy weight slaughter groups had greater ($P < .05$) cooking losses than steaks from bulls in the light weight groups. These data agree with Hawrysh and Berg (1979) who reported that cooking loss percentages for longissimus and semitendinosus roasts from bulls tended to increase as slaughter weight increased.

Taste panel juiciness ratings for longissimus steaks were not affected ($P > .05$) by implanting or slaughter weight. Implanting with Ralgro increased

TABLE 4. CHEMICAL COMPOSITION OF THE 9-10-11th RIB SECTIONS FOR NONIMPLANTED AND RALGRO IMPLANTED BULLS SLAUGHTERED AT LIGHT (454 kg) AND HEAVY (499 kg) WEIGHTS

| Chemical composition | Implant group | | Slaughter group | |
|-------------------------------|-------------------|-------------------|-------------------|-------------------|
| | Nonimplanted | Implanted | Light | Heavy |
| Moisture, % | 49.4 ^a | 46.5 ^a | 50.1 ^a | 45.9 ^b |
| Ether extractable material, % | 36.1 ^a | 39.7 ^a | 35.4 ^b | 40.4 ^a |
| Protein, % | 14.2 ^a | 13.2 ^a | 14.3 ^a | 13.1 ^b |

^{a,b}Means in the same row within an implant or slaughter group bearing a different superscript letter are different ($P < .05$).

TABLE 5. COOKING LOSS PERCENTAGES, TASTE PANEL SCORES AND SHEAR FORCE VALUES FOR LONGISSIMUS STEAKS FROM NONIMPLANTED AND RALGRO IMPLANTED BULLS SLAUGHTERED AT LIGHT (454 kg) AND HEAVY (499 kg) WEIGHTS

| Trait | Implant group | | Slaughter group | | Treatment combination | | | |
|---|--------------------|--------------------|--------------------|--------------------|-----------------------|--------------------|------------------|-------------------|
| | Nonimplanted | Implanted | Light | Heavy | Nonimplanted light | Nonimplanted heavy | Implanted light | Implanted heavy |
| Cooking loss, % | 23.38 ^b | 22.98 ^b | 22.56 ^c | 23.80 ^b | 22.95 | 23.82 | 22.18 | 23.78 |
| Taste panel juiciness ^a | 6.2 ^b | 6.1 ^b | 6.2 ^b | 6.1 ^b | 6.2 | 6.2 | 6.2 | 5.9 |
| Taste panel flavor ^a | 6.1 ^c | 6.2 ^b | 6.2 ^b | 6.1 ^b | 6.1 | 6.0 | 6.3 | 6.2 |
| Taste panel connective tissue amount ^a | 6.5 ^c | 6.8 ^b | 6.5 ^b | 6.7 ^b | 6.3 | 6.6 | 6.7 | 6.8 |
| Taste panel myofibrillar tenderness ^a | 5.9 | 6.5 | 6.1 | 6.3 | 5.6 ^s | 6.1 ^r | 6.6 ^p | 6.4 ^{pr} |
| Taste panel overall tenderness ^a | 6.0 | 6.6 | 6.2 | 6.4 | 5.8 ^s | 6.2 ^r | 6.6 ^p | 6.5 ^{pr} |
| Warner-Bratzler shear forces, kg | 3.1 | 2.5 | 2.9 | 2.7 | 3.4 ^p | 2.8 ^r | 2.3 ^s | 2.6 ^{rs} |

^aScores: 7= very juicy, very intense, practically none or very tender; 6= moderately juicy, moderately intense, traces or moderately tender; 5= slightly juicy, slightly intense, slight or slightly tender.

^{b,c,p,r,s}Means in the same row within an implant or slaughter group and treatment combination bearing a different superscript letter are different (P<.05).

taste panel flavor intensity ($P < .05$) and decreased taste panel detectable connective tissue ($P < .05$). No differences ($P > .05$) between slaughter weight groups were found for either of those traits.

Interaction means (implant group x slaughter weight group) for taste panel myofibrillar tenderness, overall tenderness and Warner-Bratzler shear forces are presented in table 5. For all three traits, steaks from NI-light weight bulls were less tender ($P < .05$) than steaks from bulls in the other treatment combinations. Steaks from the I-light weight bulls were more tender ($P < .05$) than steaks from NI-heavy weight bulls. No differences ($P > .05$) in tenderness were found for steaks from bulls in the NI-heavy weight or I-heavy weight slaughter groups, and for I animals in the light and heavy slaughter weight groups. Although differences in tenderness were not significant for all comparisons in the four treatment combinations, it appears that implanting resulted in improved tenderness values for longissimus steaks, even though NI bulls were less mature physiologically than I bulls.

Correlations of Quality Indicating Factors and Palatability Traits.

Visual fat scores were correlated ($P < .05$) with 48 h marbling score (.42) and taste panel myofibrillar tenderness ratings (.37) when the slaughter group data were pooled. Adjusted fat thickness was correlated ($P < .05$) with 48 h marbling score (.43) and Warner-Bratzler shear forces (-.32), and tended to be related ($P < .10$) with taste panel myofibrillar tenderness (.27), connective tissue amount (.28) and overall tenderness scores (.29). Correlations between 48 h marbling score and taste panel flavor intensity (.16), juiciness scores (-.01) and shear forces (-.03) were nonsignificant ($P > .05$). Skeletal maturity was correlated ($P < .05$) with shear force values (-.44), taste panel myofibrillar tenderness (.32) and overall tenderness

ratings (.29). Therefore, adjusted fat thickness, visual fat score and skeletal maturity appear to be better predictors of palatability than marbling in bull carcasses. Carcass fat and skeletal maturity each accounted for 8% to 20% of the variability in palatability of longissimus steaks, while 48 h marbling accounted for less than 3% of the variability.

Electrical Stimulation Effects on Bull Carcass Quality Characteristics.

Savell et al. (1978b) and McKeith et al. (1981) reported that electrical stimulation (ES) improved lean color and maturity scores in either steer or heifer carcasses. We found, however, no differences ($P > .05$) in lean color, lean maturity, final maturity, 48 h quality grades and marbling scores between non-stimulated and stimulated bull carcass sides (table 6).

Stimulated sides had a softer, coarser textured lean ($P < .05$) compared with non-stimulated sides. Apparently, ES may have induced a condition similar to that reported by Hunt and Hedrick (1977), where the lean is soft and exudative, but with normal color. Bendall and Rhodes (1976) hypothesized that if pH values fell below 6.0 within 1.5 h postmortem while the deep muscle temperatures were above 35 C, a pale, soft and exudative condition could occur. Temperature and pH decline data (figure 2) indicate that the pH for ES sides fell below 6.0 between 1.5 and 2.0 h postmortem, and that the carcass temperatures would have been at least 35 C at that time.

Electrical Stimulation Effects on Cooking Losses, Taste Panel Ratings and Warner-Bratzler Shear Forces.

Eikelenboom et al. (1981) found greater cooking losses for longissimus samples from ES bull carcasses than for non-stimulated carcasses. Our cooking loss percentages for steaks from the ES sides were higher, but nonsignificant, than cooking loss percentages for steaks from the non-stimulated sides (table 7). Warner-Bratzler shear values

TABLE 6. CARCASS QUALITY CHARACTERISTICS FOR NON-ELECTRICALLY STIMULATED AND ELECTRICALLY STIMULATED BULL CARCASS SIDES

| Trait | Side treatment | | Probability ^a |
|----------------------------|-----------------------------|-------------------------|--------------------------|
| | Non-electrically stimulated | Electrically stimulated | |
| Quality grade, 48 h | Good ⁷⁶ | Good ⁷⁵ | .84 |
| Lean maturity | A 55 | A 52 | .32 |
| Final maturity | A 75 | A 74 | .65 |
| Lean firmness ^b | 2.1 | 2.6 | .02 |
| Lean texture ^b | 3.0 | 3.4 | .02 |
| Lean color ^b | 2.2 | 2.1 | .38 |
| Marbling | Slight ⁸⁹ | Slight ⁸⁵ | .70 |

^aProbability level for differences between non-stimulated and electrically stimulated groups.

^bScores: 4= slightly soft, slightly fine or moderately dark red; 3= moderately firm, moderately fine or slightly dark red; 2= firm, fine or cherry red.

Figure 2. Longissimus muscle temperature and pH decline curves for non-electrically stimulated and electrically stimulated bull carcass sides.

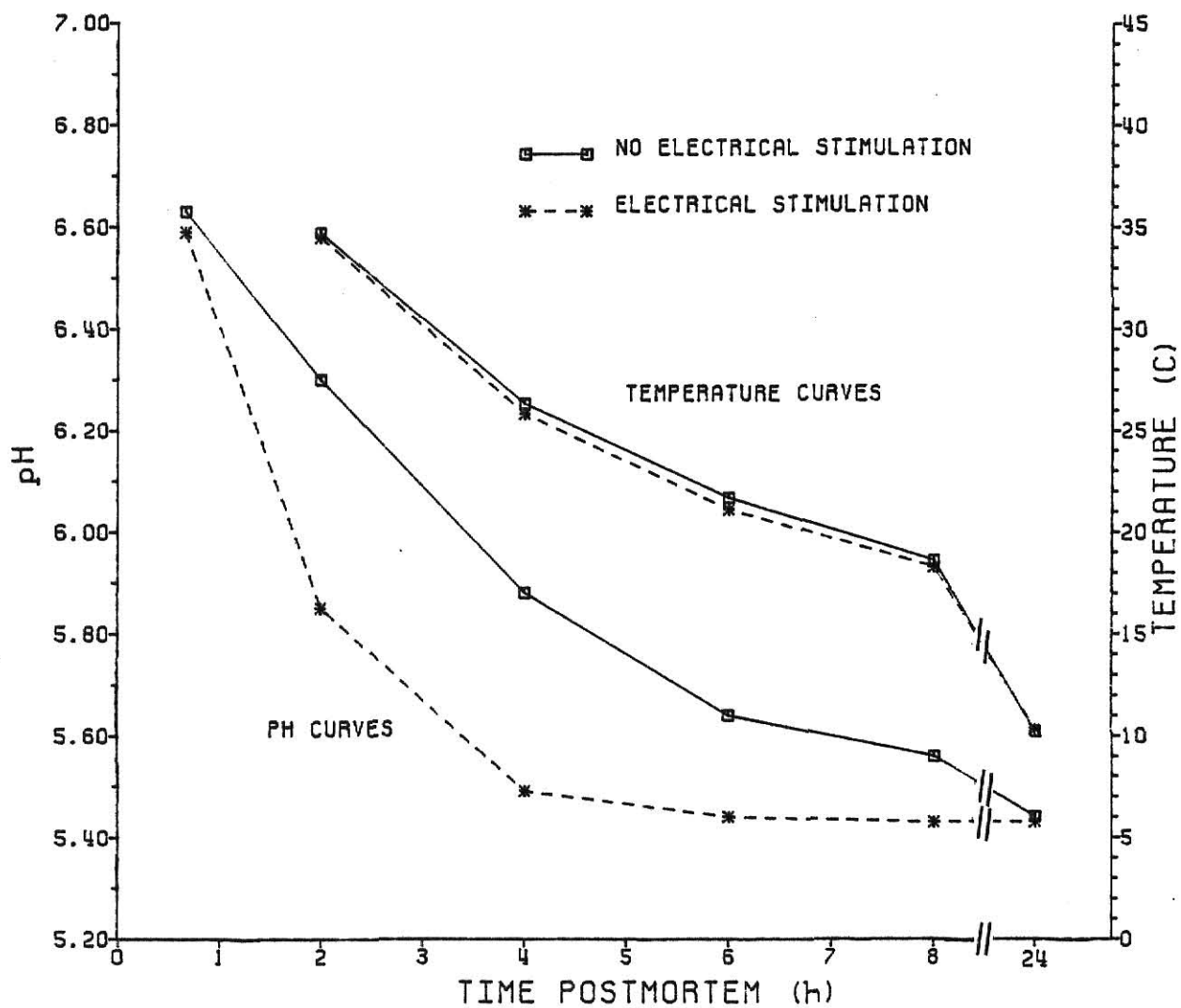


TABLE 7. COOKING LOSS PERCENTAGES, TASTE PANEL SCORES AND SHEAR FORCE VALUES FOR LONGISSIMUS STEAKS FROM NON-ELECTRICALLY STIMULATED AND ELECTRICALLY STIMULATED BULL CARCASS SIDES

| Trait | Side treatment | | Probability ^a |
|---|-----------------------------|-------------------------|--------------------------|
| | Non-electrically stimulated | Electrically stimulated | |
| Cooking loss, % | 22.64 | 23.72 | .17 |
| Taste panel juiciness ^b | 6.1 | 6.1 | .86 |
| Taste panel flavor ^b | 6.2 | 6.1 | .06 |
| Taste panel connective tissue amount ^b | 6.6 | 6.6 | .74 |
| Taste panel myofibrillar tenderness ^b | 6.1 | 6.3 | .09 |
| Taste panel overall tenderness ^b | 6.2 | 6.4 | .15 |
| Warner-Bratzler shear forces, kg | 2.8 | 2.8 | .77 |

^aProbability level for differences between non-stimulated and electrically stimulated groups.

^bScores: 7= very juicy, very intense, practically none or very tender; 6= moderately juicy, moderately intense, traces or moderately tender.

were similar ($P>.05$) for steaks from ES and non-stimulated sides. These data agree with ES effects on Mor-Lean (short scrotum bull) carcasses (Ray et al., 1980). Taste panel scores for juiciness and connective tissue amount were not affected ($P>.05$) by ES.

Taste panel scores for steaks from ES sides tended to have lower ($P<.06$) flavor intensity and higher ($P<.09$) myofibrillar tenderness scores than steaks from non-stimulated sides. The tendency for improved tenderness may be the result of either structural damage (Savell et al., 1978a) or enhanced autolytic enzyme activity (Dutson et al., 1980) due to the rupturing of lysosomal membranes at low pH's while carcass temperatures are high (figure 2). Prevention of cold toughening by ES was not likely because conditions (muscles at either 10 C in less than 10 h postmortem, Bendall, 1972, or 10 C before a pH of 6.0 has been reached, Chrystall et al., 1980) for muscle shortening did not occur.

Conclusions

Under the conditions of this study, the consecutive implantation of bulls with 36 mg of Ralgro from birth to slaughter will: 1) improve gain and efficiency; 2) increase the rate of carcass physiological maturation; 3) increase carcass fatness; and 4) improve tenderness attributes of longissimus steaks, when compared with nonimplanted bulls. Electrical stimulation of bull carcasses has little effect on the improvement of longissimus muscle characteristics. Visual fat score, adjusted fat thickness and skeletal maturity appear to be better predictors of palatability than marbling for longissimus steaks from bulls.

Literature Cited

- AMSA. 1978. Guidelines for cookery and sensory evaluation of meat. Amer. Meat Sci. Assoc. and Natl. Livestock and Meat Board, Chicago, IL.
- Arthaud, V.H., R.W. Mandigo, R.M. Koch and A.W. Kotula. 1977. Carcass composition, quality and palatability attributes of bulls and steers fed different energy levels and killed at four ages. J. Anim. Sci. 44:53.
- Barr, A.J., J.H. Goodnight, J.P. Sall, W.H. Blair and D.M. Chilko. 1979. SAS User's Guide. SAS Institute, Inc., Raleigh, NC.
- Bendall, J.R. 1972. Meat Chilling - Why and How? ARC Meat Research Institute Symposium No. 3. (April). Cited by: A. Cuthbertson. 1980. Hot processing of meat: a review of the rationale and economic implications. In: Ralston Lawrie (Ed.) Developments in Meat Science - 1. pp 61-88. Applied Science Publishers, London.
- Bendall, J.R. and D.N. Rhodes. 1976. Electrical stimulation of the beef carcass and its practical application. Proc. 22nd European Meeting of Meat Res. Workers. Vol. 1. B2:3.
- Carroll, F.D., W.C. Rollins, K.A. Wagnon and R.G. Loy. 1975. Comparison of beef from bulls and DES implanted steers. J. Anim. Sci. 41:1008.
- Champagne, J.R., J.W. Carpenter, J.F. Hentges, Jr., A.Z. Palmer and M. Koger. 1969. Feedlot performance and carcass characteristics of young bulls and steers castrated at four ages. J. Anim. Sci. 29:887.
- Chrystall, B.B., C.E. Devine and C.L. Davey. 1980. Studies in electrical stimulation: postmortem decline in nervous response in lambs. Meat Sci. 4:69.
- Corah, L.R., L. Fink, G.H. Kiracofe, and M. McKee. 1979. Sexual development and carcass traits of bulls after sequential implanting with Zeranol. J. Anim. Sci. 49(Suppl. 1):287.
- Dutson, T.R., G.C. Smith, and Z.L. Carpenter. 1980. Lysosomal enzyme distribution in electrically stimulated ovine muscle. J. Food Sci. 45:1097.
- Eikelenboom, G., F.J.M. Smulders and H. Rudéus. 1981. The effect of high and low voltage electrical stimulation on beef quality. Proc. 27th European Meeting of Meat Res. Workers. V1:148.
- Embry, L.B. 1972. Effect of sex, castration and hormonal compounds on feedlot performance and carcass merit of cattle. Sixteenth Annu. South Dakota Cattle Feeders Day Rep. pp 10-53.
- Field, R.A., G.E. Nelms and C.O. Schoonover. 1966. Effects of age, marbling and sex on palatability of beef. J. Anim. Sci. 25:360.

- Field, R.A. 1971. Effect of castration on meat quality and quantity. *J. Anim. Sci.* 32:849.
- Glimp, H.A., M.E. Dikeman, H.J. Tuma, K.E. Gregory and L.V. Cundiff. 1971. Effect of sex condition on growth and carcass traits of male Hereford and Angus cattle. *J. Anim. Sci.* 33:1242.
- Hawrysh, Z.J. and R.T. Berg. 1979. Eating quality of beef from young Hereford bulls as influenced by slaughter weight. *Can. J. Anim. Sci.* 59:237.
- Hedrick, H.B. 1968. Bovine growth and composition. *Univ. Mo. Agr. Exp. Sta. Bull.* 928.
- Hedrick, H.B., G.B. Thompson and G.F. Krause. 1969. Comparison of feedlot performance and carcass characteristics of half-sib bulls, steers and heifers. *J. Anim. Sci.* 29:687.
- Hunsley, R.E., R.L. Vetter, E.A. Kline and W. Burroughs. 1967. Effects of age, sex and diethylstilbestrol on feedlot performance, carcass characteristics and muscle tenderness of male beef cattle. *J. Anim. Sci.* 26:1469 (Abstr.).
- Hunt, M.C. and H.B. Hedrick. 1977. Chemical, physical and sensory characteristics of bovine muscle from four quality groups. *J. Food Sci.* 42:716.
- Jacobs, J.A., J.C. Miller, E.A. Sauter, A.D. Howes, A.A. Araj, T.L. Gregory and C.E. Hurst. 1977. Bulls versus steers. II. Palatability and retail acceptance. *J. Anim. Sci.* 45:699.
- Klosterman, E.W., L.E. Kunkle, P. Gerlaugh, and V.R. Cahill. 1954. The effect of age of castration upon rate and economy of gain and carcass quality of beef calves. *J. Anim. Sci.* 13:817.
- Lamm, W.D., R.F. Kelly, W.H. McClure and J.P. Fontenot. 1980. Effect of zeranol implants on performance of suckling calves and growing-finishing bulls and heifers. *J. Anim. Sci.* 51(Suppl. 1):377.
- Landon, M.E., H.B. Hedrick and G.B. Thompson. 1978. Live animal performance and carcass characteristics of beef bullocks and steers. *J. Anim. Sci.* 47:151.
- McKeith, F.K., J.W. Savell and G.C. Smith. 1981. Tenderness improvement of the major muscles of the beef carcass by electrical stimulation. *J. Food Sci.* 46:1774.
- Meat and Livestock Commission. 1975. Guidelines for beef carcass improvement. Marketing and Meat Trade Tech. Bull. 18. Bletchley, Milton Keynes, UK.
- Nichols, N.E. and A.L. Lesperance. 1973. Type, level and frequency of implant on suckling calves. *J. Anim. Sci.* 36:1206 (Abstr.).

- Nicholson, L.E., A.L. Lesperance and J.W. McCormick. 1973. Influence of interval between implants of zeranol on weight gain. *J. Anim. Sci.* 36:1206 (Abstr.).
- Plegge, S.D. and L.R. Corah. 1979. Effect of location and crushing of Zeranol implants on cattle performance. *J. Anim. Sci.* 49(Suppl. 1):199.
- Ralston, A.T. 1978. Effect of zearalanol on weaning weight of male calves. *J. Anim. Sci.* 47:1203.
- Ray, E.E., D.M. Stiffler and B.W. Berry. 1980. Effects of electrical stimulation and hot boning upon physical changes, cooking time and losses, and tenderness of beef roasts. *Proc. 26th European Meeting of Meat Res. Workers.* V2:26.
- Reagan, J.O., Z.L. Carpenter, G.C. Smith and G.T. King. 1971. Comparison of palatability traits of beef produced by young bulls and steers. *J. Anim. Sci.* 32:641.
- Savell, J.W., T.R. Dutson, G.C. Smith and Z.L. Carpenter. 1978a. Structural changes in electrically stimulated beef muscle. *J. Food Sci.* 43:1606.
- Savell, J.W., G.C. Smith and Z.L. Carpenter. 1978b. Beef quality and palatability as affected by electrical stimulation and cooler aging. *J. Food Sci.* 43:1666.
- Sharp, G.D. and I.A. Dyer. 1971. Effect of zearalanol on the performance and carcass composition of growing-finishing ruminants. *J. Anim. Sci.* 33:865.
- Snedecor, G.W. and W.G. Cochran. 1978. *Statistical Methods.* (6th Ed.). Iowa State Univ. Press, Ames.
- Steel, R.G.D. and J.H. Torrie. 1960. *Principles and Procedures of Statistics.* McGraw-Hill Book Co., New York.
- Thiex, P.J. and L.B. Embry. 1972. Feedlot performance of bulls and the response to diethylstilbestrol or zeranol. *Sixteenth Annu. South Dakota Cattle Feeders Day Rep.* pp 68-70.
- Thomas, O.O. and J. Armitage. 1970. Zearalanol for growing-fattening steers. *J. Anim. Sci.* 30:1039 (Abstr.).
- Turton, J.D. 1962. The effect of castration on meat production and quality in cattle, sheep and pigs. *Anim. Breed. Abstr.* 30:447.
- Ward, J.K., T.J. Klopfenstein, S.D. Farlin, L. Peterson and G.E. Schindler. 1978. Ralgro implants from birth through finishing. *J. Anim. Sci.* 47(Suppl. 1):43.

RALGRO IMPLANTED BULLS: PERFORMANCE, CARCASS CHARACTERISTICS,
LONGISSIMUS PALATABILITY AND CARCASS ELECTRICAL STIMULATION

by

JOHN RALPH GREATHOUSE

B. S., Kansas State University, 1980

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

Twenty fall-born Angus bulls were implanted (I) with 36 mg of Ralgro beginning near birth and were reimplanted four more times at about 106 d intervals. Twenty other nonimplanted (NI) bulls served as controls. The bulls remained with their dams on native bluestem pasture until they were 320 d old, and then were fed a high concentrate diet until slaughter at either 454 kg (light weight) or 499 kg (heavy weight). Individual weights and pen feed consumption were monitored at regular intervals. At slaughter, one side of each carcass was electrically stimulated for 2 min at 45 min postmortem with 420 V, 60 Hz and 1 amp of alternating current (.68 sec on and .32 sec off). Carcass quality and yield grades and visual fat scores were obtained at 48 h postmortem. Chemical composition was determined for the 9-10-11th rib section. Longissimus steaks, aged 6 d at 2 C, frozen, thawed and modified oven broiled at 166 C to an internal temperature of 70 C, were evaluated by a trained taste panel. Cooking losses and Warner-Bratzler shear forces also were determined.

Implanting improved ($P < .05$) average daily gain 6.5% from birth until the bulls were placed on feed. From the feedlot beginning until the first group of bulls was slaughtered (196 d on feed), I bulls gained 9.3% faster ($P < .05$) and tended to have an advantage (7.9%, $P < .06$) in feed efficiency.

Implanted bulls reached their slaughter weights an average of 42 d sooner than NI bulls, but carcasses of I bulls had higher ($P < .05$) skeletal maturity and final maturity scores. Marbling scores and quality grades were similar ($P > .05$) for carcasses of NI and I animals. Implanted and heavy weight bulls had greater ($P < .05$) fat thicknesses than did NI and light weight bulls, respectively. Carcasses from I bulls tended ($P < .10$) to have higher yield grade numbers than carcasses of NI bulls. Yield grade numbers were higher ($P < .05$) for carcasses in the heavy weight slaughter groups than for those in

the light weight groups.

Carcasses in the NI group tended ($P < .06$) to have higher percentages of moisture and lower percentages of ether extractable material in the 9-10-11th rib soft tissue. No differences ($P > .05$) in percentages of protein in the rib soft tissue were found between NI and I groups. Rib sections from the heavy weight slaughter groups had lower ($P < .05$) percentages of moisture and protein and higher ($P < .05$) percentages of ether extractable material than those from the light weight groups.

Cooking losses were not affected ($P > .05$) by implanting; however, steaks from the heavy weight bulls had greater ($P < .05$) losses compared with those from bulls in the light weight groups. Juiciness ratings were similar ($P > .05$) for steaks from bulls in either implant group or slaughter weight category. Flavor intensity and detectable connective tissue scores were higher ($P < .05$) for steaks from I bulls compared with steaks from NI bulls, but were similar for bulls in either slaughter weight group. Steaks from NI-light weight bulls were the least tender ($P < .05$) and had the highest Warner-Bratzler shear forces. Steaks from I-light weight bulls were more tender ($P < .05$) than steaks from the NI-heavy weight bulls. Steaks from the I-heavy weight bulls were intermediate in tenderness.

Adjusted fat thickness, visual fat score and skeletal maturity were more highly correlated ($r = -.44$ to $.37$) with palatability traits than was marbling ($r = -.03$ to $.16$).

Electrical stimulation produced a softer, coarser textured ($P < .05$) lean, but did not affect lean color, marbling or quality grades. Steaks from electrically stimulated sides tended to have higher taste panel myofibrillar tenderness ($P < .09$) and lower flavor intensity ($P < .06$) scores than steaks from the non-stimulated sides.