# Symposium: Impact of Implants on Performance and Carcass Value of Beef Cattle

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Oklahoma Agricultural Experiment Station • Division of Agricultural Sciences and Natural Resources
Oklahoma State University

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Prologue:
The Organizing Committee:
Fred Owens, Don Gill,
Glen Dolezal, Brad Morgan,
and Gerald Horn

A wide array of growth stimulating implants is available to cattle producers in the U.S. to enhance rate and efficiency of growth of cattle. Producers must balance the effectiveness of growth stimulants to reduce cost of gain against potentially adverse effects of implants on behavior and, of particular concern, on carcass composition. Papers in this conference represent the reasoned opinions of individual experts. Although these opinions may conflict, free and open discussion is essential for progress and advancement. These papers should represent the "state of the art" with regard to growth enhancing implants. The organizing committee sincerely thanks all the experts for their input and reviews concerning modes of implant action, relative effectiveness, animal behavior, safety, statistics, economics, meat science, and consumer acceptance.

The topic for this conference on "Impact of Implants on Performance and Carcass Value of Beef Cattle" initially was proposed by Robert Botts and Bob Brandt to Don Gill and Fred Owens in July 1993 at the Animal Science Meetings in Spokane, Washington. Employment, locations of individuals, and implant types have changed markedly since that time. Planning the final program and invitations to speakers began in March 1996 using a conference format designed by the organizing committee. With the exception of two panel members, each individual that was invited participated in the conference. We were particularly pleased that Art Raun and Rod Preston consented to provide a detailed historical perspective on implants and that Mike Galyean and Jeff Savell agreed to summarize highlights from the conference. Thanks to financial support from implant manufacturers listed below, joint sponsorship from the Plains Nutrition Council, and to extensive input from speakers, the conference was held at the Sheraton Hotel in Tulsa, OK from November 21-23, 1996. About 320 people attended the conference. Written papers were assembled, albeit gradually, from all the speakers and edited; questions and answers were transcribed, and this proceedings was assembled and published through Oklahoma State University. The organizing committee is particularly indebted to sponsoring companies, all the speakers who took time away from their regular duties to prepare presentations, and to the many feedlot consultants who attended and freely shared their thoughts, opinions, and ideas.

**Sponsors of this Conference:**

Hoechst-Roussel Agri-Vet Company, Somerville, NJ.
*Contact:* Dr. Jerry Rains
Fort Dodge Animal Health, Overland Park, KS.
*Contact:* Dr. Frank Prouty
Mallinckrodt Veterinary, Mundelein, IL.
*Contact:* Dr Richard Sibbel
Vet-Life, Kansas City, MO.
*Contact:* Dr. Robert Botts

**COVER PHOTOS**

Speakers pictured on the front cover from left to right inlcuded: Row 1: Art Raun, Robert Botts, Allen Trenkle, Bob Brandt, Glen Selk. Row 2: Susan Duckett, Terry Mader, Tim Stanton, Ken Eng, Bob Wettemann. Row 3: Alfredo DiCostanzo, Jim Oltjen, Brad Morgan, Glen Dolezal, Don Gill. Row 4: Jim Trapp, Gary Smith, Russell Cross, Rod Preston, Mike Galyean. Speakers who did not supply a picture include: Bill Dayton, Danny Simms, Steve Rust, Robbi Pritchard, Abe Turgeon, Jeff Savell, and Gerry Kuhl.

1996 IMPACT OF IMPLANTS ON PERFORMANCE AND
CARCASS VALUE OF BEEF CATTLE - SYMPOSIUM
OKLAHOMA STATE UNIVERSITY &
PLAINS NUTRITION COUNCIL
Tulsa Sheraton Hotel, Nov. 21 (PM) to Nov. 23 (Noon)

**November 21, 1996**

| | |
|---|---|
| 7:00 PM | History of use of hormonal modifiers - Art Raun and Rod Preston |
| 7:45 PM | Growth Stimulants: Compounds, Concentrations, Combinations, and Regs - Robert Botts |
| | **MECHANISMS OF ACTION OF ESTROGENS AND ANDROGENS** |
| 8:15 PM | Hormonal basis - Allen Trenkle |
| 8:45 PM | Cellular basis - Bill Dayton |
| 9:15 PM | Administration site, carriers, and release profile - Bob Brandt |

**November 22, 1996**

| | |
|---|---|
| | **EFFECTS ON INTAKE, GROWTH RATE AND EFFICIENCY** |
| 8:00 AM | Calves and replacement heifers - Glen Selk |
| 8:30 AM | Stocker Cattle - Gary Kuhl |
| 9:00 AM | Feedlot - Susan Duckett and Fred Owens |
| 9:30 AM | Cows - Danny Simms |
| 10:15 AM | Carryover and Lifetime Effects - Terry Mader |
| 10:45 AM | Cost of Reworking Cattle - Tim Stanton |
| | **INTERACTIONS WITH:** |
| 11:15 AM | Gender, Age, Animal Type - Steve Rust and Robbie Pritchard |
| 11:45 AM | Background and Pen Size - Abe Turgeon |
| 1:30 PM | New considerations: Limit feeding, seasonality, cattle origin- Ken Eng |
| | **IMPACT OF GROWTH STIMULANTS ON:** |
| 2:00 PM | Animal Behavior (bullers & feeding patterns) - Bob Wettemann and Fred Lehman |
| 2:30 PM | Nutrient Requirements - Alfredo DiCostanzo |
| 3:00 PM | Statistical problems: Within vs. across pen comparisons; Endpoint choices - James Oltjen |
| | **EFFECTS ON CARCASS MEASUREMENTS** |
| 3:45 PM | Carcass grade traits and Maturity - Brad Morgan |
| 4:15 PM | Cutout - Glen Dolezal |

**November 23, 1996**

| | |
|---|---|
| 8:15 AM | Economics of beef production with vs without implants - Don Gill and Jim Trapp |
| 8:45 AM | Consumer acceptance - Domestically and internationally - Gary Smith |
| 9:15 AM | USDA/FDA Residue Tracking - Now and in the Future - H. Russell Cross |
| 9:45 AM | Rationale for the Safety of Implants - Rod Preston |
| | **AN EYE TO AND A BIG EAR FOR THE FUTURE** |
| 10:45 AM | Poll of Consultants and Research Needs in Animal Production - Mike Galyean |
| 11:15 AM | Research Needs in Meat Quality - Jeff Savell |

# HISTORY OF HORMONAL MODIFIER USE

A.P. Raun[1] and R. L. Preston[2]
"Historians"

## INTRODUCTION

Hormones naturally produced by man and animals result in morphological, behavioral, physiological and biochemical changes that are well known, i.e., men versus women, bulls versus heifers. When used for meat production in many parts of the world, bulls are castrated (steers) to reduce behavioral problems even though this practice reduces growth rate and efficiency of lean meat production. It is not surprising, then, that animal scientists would be interested in modifying the hormonal status of animals to improve efficiency and product composition. Over the past 42 years, results of this research have found widespread application in the production of beef without any safety problems for either humans or cattle. The history of hormonal modifiers can be characterized as a series of developments that have better optimized the dose and combination of compounds for maximum growth, feed efficiency, and carcass quality and minimized cost of production. This paper focuses on the history of the first hormonal modifier to have widespread application and impact in beef production, diethylstilbestrol (DES).

### Early Research and Application

Thyroid hormones (e.g., thyroprotein, iodinated casein) were found to increase milk production. Estrogenic activity in several plant foods and feeds was found to be responsible for reproductive problems in livestock. Zondek and Marx (1939), in a single cock, demonstrated that the lipemic response at the onset of egg production could be duplicated by injecting estradiol benzoate. In 1943, Lorenz published a note describing the three-fold increase in the fat content of the breast and leg muscle of cockerels eight weeks after implanting DES subcutaneously, a finding that was applied in the commercial production of broilers from 1947 to 1966.

The first experimental administration of an estrogen, in this case DES, to ruminants for the purpose of growth promotion was done at Purdue University by W.E. Dinusson, a graduate student of F.N. Andrews and W.M. Beeson. They hypothesized that the growth rate in heifers would be affected positively by estrogen, because growth rate of intact heifers is greater than that of spayed heifers. DES was used as the estrogen treatment because DES implants had been formulated for use in poultry by Wick and Fry, Inc., Cumberland, IN. Their first experiment, started on February 9, 1947, utilized twenty-five Hereford heifers that weighed about 225 kg and lasted for 140 days. Five treatments were studied: control, spayed (prior to the start of the study), DES (42 mg implanted in the shoulder region), testosterone (50 mg of testosterone propionate injected initially and 32.5 mg injected at 56 days), and thiouracil (4 gm per animal per day in the feed). The diet consisted mainly of corn and cob meal, soybean meal and mixed clover and timothy hay. The results of this and later studies (Table 1) were first reported November 1948 at the annual meeting of the American Society of Animal Production in Chicago (Dinusson et al., 1948; 1950). A similar second 185 day study was started on December 11, 1947. Three pens of three heifers each, similar to those in the first study, were used on each treatment. The DES implant treatment used was 48 rather than 42 mg, a 50 mg testosterone propionate implant was used rather than oil injections, and a 11 mg per kg body weight oral thyroprotein treatment was used rather than thiouracil. Results of the second trial are shown in Table 2.

The authors drew the following conclusions:

1. DES improved gain and feed conversion
2. DES increased length of leg and back, and width of back
3. DES increased appetite

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[2] P.O. Box 3549, Pagosa Springs, CO 81147-3549.

Table 1. Effect of hormone treatments on the growth and fattening of heifers.

| Item | Control | Spayed | DES | Testosterone | Thiouracil |
|---|---|---|---|---|---|
| No. heifers | 5 | 5 | 5 | 5 | 5 |
| ADG, kg. | .94 | .87[a] | 1.05[a] | .95 | .97 |
| ADF, kg. | | | | | |
| Concentrate | 4.3 | 4.8 | 4.7 | 4.8 | 4.5 |
| Roughage | 2.9 | 2.9 | 3.2 | 3.0 | 3.0 |
| Feed/gain | 7.7 | 8.9 | 7.4 | 8.3 | 7.8 |
| Dressing percent | 58.6 | 59.7 | 59.8 | 59.8 | 58.9 |
| Carcass grade | | | | | |
| Choice, % | 80 | 80 | 40 | 80 | 60 |
| Good, % | 20 | 20 | 40 | 20 | 40 |
| Commercial, % | | | 20 | | |

[a]Difference approached significance (P<0.05) from control.

Table 2. Effect of hormone treatments on the growth and fattening of heifers.

| Item | Control | Spayed | DES | Testosterone | Thyroprotein |
|---|---|---|---|---|---|
| No. heifers | 9 | 9 | 9 | 9 | 9 |
| ADG, kg. | .78 | .70[a] | .91[a] | .78 | .72 |
| ADF, kg. | | | | | |
| Concentrate | 5.4 | 5.1 | 5.7 | 5.3 | 5.4 |
| Roughage | 3.3 | 3.2 | 3.3 | 3.3 | 3.3 |
| Feed/gain | 11.1 | 11.9 | 9.9 | 11.0 | 12.0 |
| Dressing percent | 60.8 | 59.8 | 60.6 | 60.1 | 60.4 |
| Carcass grade | | | | | |
| Choice, % | | | | 11 | |
| Good, % | 78 | 78 | 56 | 56 | 56 |
| Low good, % | 11 | 22 | 44 | 22 | 44 |
| Commercial, % | 11 | | | 11 | |

[a]Difference was significant (P<0.05) from control.

4. DES carcasses were slightly "hooky" (more mature in appearance).
5. DES caused vulva swelling, extended estrus, produced a nymphomaniac stance, elevated tail heads and pronounced mammary and teat development.

Performance of the spayed heifers was inferior to that of either the control or DES treated heifers as had been expected. The authors suggested that "the rate of gain of these three groups was proportional to the amount of estrogen present".

Results from these two small studies utilizing only 14 animals per treatment predicted quite accurately the response to DES (estrogen) treatment by feedlot cattle. DES generally was expected to increase gain by 15%; these studies showed increases of 12 and 17%. The feed conversion improvement was expected to be about 10%; these studies showed improvements of 4 and 11%. These studies also suggested leanness increased and carcass grade decreased, a general finding with DES. Despite the absence of any dose titration studies, the implant dosages selected for use in these studies, 42 and 48 mg, were quite close to the dosage (30 to 36 mg) commonly considered optimal later by the feedlot industry.

The side effects of the DES treatment listed in the final conclusion were considered at that time to be very negative and without any immediate apparent solution. These effects as well as a possible reduction in carcass fatness undoubtedly resulted in a considerable delay in the commercial application of this very valuable technology.

The first study using DES in finishing lambs also was conducted at Purdue University by F.N. Andrews in November 1948 (Andrews et al., 1949). The authors concluded that 12 and 24 mg DES implants improved gain and feed conversion, reduced carcass grade and that DES, because of its carcass effects, appeared to have stimulated "true growth" in these lambs. The only side effect reported was the loss of one lamb in the 12 mg group due to prolapsed rectum. In contrast to the cattle studies, the DES implant doses used in this study were considerably higher than those ultimately used in practice (3 mg).

**Oral Administration of DES**

The research objective that led to the synthesis of DES was to develop an orally effective estrogen for use in human medicine (Dodds et al., 1938). The first report of the effects of oral administration of DES in ruminants was by W. H. Hale at the 1953 American Society of Animal Production meeting in Chicago, IL (Hale et al., 1953). Hale and his graduate student C. D. Story at Iowa State College fed levels of DES that they felt were comparable in terms of estrogenic activity to the levels of estrogens found in certain legumes purported to increase growth rate. They fed DES at levels of 3.3 to 26.5 mcg per kg of diet. They reported that in two studies these lower levels of DES (3.3 to 6.6 mcg/kg) improved both gain and feed conversion; the higher levels had no effect. A third study found no response to the orally administered DES. The responses that they reported in the first two studies are unexplainable, since the effective oral dosages later were found to be in the range of 660 to 1320 mcg per kg of diet (Hale et al., 1955). Even though these initial experiments on the oral administration of DES did not show a consistent response, they did lead to some very significant studies at Iowa State College.

Hale and Wise Burroughs, a co-author on the Hale papers, discussed the idea of feeding DES to cattle. It was known that DES was not very effective orally in chickens but Hale had seen a research note in a British pharmaceutical journal (source unknown) indicating that DES was rapidly detoxified in chickens but not in cattle (Hale, 1996). Hale and Burroughs conducted a small experiment at the Beech Avenue cattle facility at Iowa State using individually fed cattle that indicated there may be a response to a "high level" of DES (unpublished results).

In the spring and summer of 1953 at the Iowa Southwestern Experimental Farm, Burroughs conducted an experiment that indicated "cattle gains could be increased substantially and that feed costs could be reduced materially by placing 5 mg or more of DES in the daily supplemental feed fed to each steer" (Burroughs et al, 1954a). Subsequent cattle feeding studies were carried out in which he fed levels of DES ranging from 2.75 to 20 mg per head per day to yearling steers fed corn-corn silage or corn-corn cob fattening diets for periods of 46 to 120 d (Burroughs et al., 1954b; Culbertson et al, 1954; Burroughs et al., 1955). Results of three of these studies are shown in Table 3. Burroughs concluded that DES increased gains up to 35% and reduced feed cost up to 20%. He also reported that in these studies no reduction in fatness or meat quality was observed and none of the undesirable side effects previously reported with DES implants were observed. He noted that cattle feeders would not find DES implantation to be practical which he attributed to the following:

1. Potential human health hazard if substantial pellet residues remain in tissues at slaughter.
2. DES implantation appears to adversely influence carcass quality.
3. Implanted animals may exhibit undue restlessness or abnormal sexual behavior.
4. Some animals may exhibit toxicity symptoms (such as uterine and rectal prolapse and difficulty in urination) from DES implantation.

In contrast he suggested that feeding DES was practical because of ease of administration, no undesirable side effects, withdrawal of treatment is possible and feeding allows the accurate administration of a constant dosage of DES. The biological effects of DES in cattle and lambs have been reviewed (Preston, 1975).

Table 3. Effects of DES in the diets of fattening steers[a].

| Item | Control | 2.5 mg | 5.0 mg | 10.0 mg |
|---|---|---|---|---|
| | DES/head/d | | | |
| Experiment 1; 46 days: | | | | |
| ADG, kg. | .96 | | 1.29[b] | 1.13 |
| Feed/gain | 11.4 | | 9.3 | 10.6 |
| Experiment 2; 84 days: | | | | |
| ADG, kg. | 1.13 | 1.23 | 1.43[b] | 1.55b |
| Feed/gain | 11.6 | 10.8 | 10.0 | 9.1 |
| Experiment 3; 84 days | | | | |
| ADG, kg. | 1.14 | | 1.43[b] | |
| Feed/gain | 9.1 | | 8.3 | |

[a]Eight steers per treatment.
[B]Significantly different (P<0.05) from control.

**Special Iowa State Feeders Day**

On February 18, 1954, a special Cattle Feeders Day was held at Iowa State University to announce the discovery of the growth promotion by oral DES in cattle. Previous publicity about a new discovery resulted in a huge and unexpected crowd (over 1000). To accommodate the crowd, the morning and afternoon programs were presented simultaneously. There were insufficient copies of the research report; one of us (RLP) overheard some cattle feeders saying that without a report, they would not be able to show their wives where they had been that day.

**Iowa State Patents Oral DES**

Purdue University made no attempt to obtain patent protection for the use of DES implants in cattle and sheep (Andrews, 1995). The Purdue administration at that time felt that commercialization of new technology was beyond the academic role of the university (Perry, 1996). However, Iowa State College and Wise Burroughs filed for a U.S. patent on the oral administration of DES to cattle on June 3, 1953 which was granted May 1956. Eighty five percent of the royalties from the patent accrued to the Iowa State College Research Foundation. The patent was based on many of the advantages of feeding DES over implanting suggested in Burroughs' Science publication (Burroughs et al, 1954). At that time, Dr. Jean F. Downing had the responsibility for finding and developing new animal products for the recently formed Agricultural Products Division of Eli Lilly and Co., Inc. The President of Specified Inc. (an agriculture/pharmaceutical company) in Indianapolis, IN, Downing's previous employer, was returning to Indianapolis after attending a Cattle Feeders Day program at the University of Minnesota. Seated in front of him on the plane were two persons discussing the results of the DES studies at Iowa State. As soon as the plane landed, he called Downing and passed on what he had heard. Downing immediately contacted Lilly patent counsel, called Wise Burroughs and arranged a meeting at Iowa State the following day. Iowa State had made contact earlier with a potential DES manufacturer for development of the product but had received a noncommittal response. Lilly, also a manufacturer of DES, came to the meeting ready to make a commitment to this development project. Lilly also possessed some manufacturing technology that was critical to the safe handling of the drug. As a result of this meeting, and after the President of Iowa State University, James H. Hilton, met confidentially with interested parties in agriculture and approved, Iowa State College granted the exclusive five year license under the patent to Lilly on July 29, 1954 (R.L. Willham, 1996).

Lilly worked with Iowa State College in developing the data needed for the approval of DES by the FDA. The tissue residue data submitted was determined using an immature mouse uterine weight, parallel line bioassay with a sensitivity of 2-3 ppb (Preston et al, 1956). The registration package was submitted to the FDA and DES was approved to be fed to beef cattle at a level of 10 mg per head per day on November 5, 1954. Clearance came only one year after the report of the results from the first DES cattle feeding studies. Within four weeks after FDA approval, the DES premix STILBOSOL was available to feed manufacturers. STILBOSOL was the product that provided the foundation for the development of the animal product business of ELANCO Animal Health.

A quote from A. Marcus (1994, p25) characterizes the university-industry partnership that was at work at that time:

> "Indeed, the case of DES seemed to be a model of the application of the partnership idea. A college scientist uncovered a new technique, pharmaceutical scientists produced the drug, feed-manufacturing scientists compounded the material as a premix, federal scientists approved its use, agricultural college scientists publicized it by demonstrating its utility, and farmers made use of it. That type of expert-based interaction had been the model for 'progress' since the 1920s. With respect to stilbestrol, little in the mid-1950s seemed to undercut faith in that model."

Today, this partnership still exists except that pharmaceutical scientists have taken the lead in developing new drugs and combinations.

**DES Implant Development**

The formulation work on DES implants for use in poultry was done by Bill Wick and Henry Fry who were formulation chemists for Eli Lilly and Co., Inc. This development work was a "moonlight" project carried out in their personal laboratory, a converted garage in Cumberland, IN. They approached George Varnes who was the President of the newly formed Lilly Industrial and Agriculture Products Division to determine if Lilly had an interest in developing DES implants for cattle. Varnes indicated that he was not optimistic about the commercial possibilities for use of growth promoting implants in beef cattle and declined the offer (Means, 1996). Wick and Fry then cooperated with Chas. Pfizer, Inc., Terre Haute, IN in the development of DES implants for use in cattle. Pfizer obtained FDA approval for DES implants for cattle in 1957.

**Oral and Implanted DES Used Together**

With two commercial product forms available and no specific regulation preventing their simultaneous use, it was inevitable that innovators would try simultaneous use of implant and oral DES in an attempt to produce greater gain and efficiency. Experiments showed a larger total response to DES, particularly in heavier cattle. The results of one of these experiments is shown in the Table 4. This Iowa State study utilized yearling steers that averaged about 345 kg, fed a typical corn, hay and supplement diet for 126 days (Burroughs et al., 1963). Greater responses were observed with the dual oral and implant DES treatment. Gain was increased 9% by the 10 mg oral treatment and 17% by the dual treatment. There was some suggestion that carcass grade was reduced by the combination treatment. The dual usage of oral and implanted DES was widely used in feedlots even though FDA ruled that dual usage violated regulations but could enforce this only by finding residues in slaughtered cattle by the approved method, the mouse uterine weight assay.

**Oral 5 to 20 mg of DES Approved for Cattle**

At the time of the original DES clearance for cattle, there were data suggesting that levels of DES higher than 10 mg would produce greater responses. However, it was the opinion of Burroughs and his coworkers (Culbertson et al., 1954) that the 10 mg dosage was close to the optimum and the best compromise at that time. It would seem likely that there was some concern about potential side effects with widespread use in the field. However, the dual usage clearly showed that 10 mg was not the optimal dose and that higher dosages were manageable. Data were developed to support the clearance of feeding a variable dosage of DES (5 to 20 mg per day) and this was approved in 1970. One of the comparisons of the efficacy of 10 and 20 mg is shown in Table 5 (Raun and McAskill, 1965). This study utilized yearling steers averaging about 385 kg fed a complete mixed finishing diet for 127 days. The higher dosage of DES increased rate of gain about 6% and reduced feed required per unit of gain about 4% over the lower dose. Carcass grade appeared to be reduced.

**Low Bioassay DES Found to be Less Effective**

It was common practice to assay feed and premixes for DES using a chemical assay. It was observed that some feeds and premixes were at or near theoretical DES levels by chemical assay but when assayed biologically, using the mouse uterine weight assay, assay results were in some cases only about 50% of theory (Raun et al, 1970; Hutcheson and Preston, 1971). It was found that these low bioassay DES premixes contained up to 24 percent of the cis- isomer. Purified or enriched preparations of cis- and trans- isomers of DES were prepared, and the efficacy of these two forms of DES were compared in a number of different studies (Raun et al., 1970; Preston et al., 1971). The results of one of the cattle efficacy studies is shown in Table 6. Little if any response was noted with the cis- DES treatment while the expected response was observed with the purified trans- DES.

Table 4. Effect of oral and implanted DES on feedlot performance of yearling steers.

| Item | Control | DES 10 mg oral/d | DES 10 mg oral/d + 15 mg implant |
|---|---|---|---|
| No. steers | 35 | 34 | 36 |
| ADG, kg. | 1.21 | 1.32 | 1.42 |
| ADF, kg. | 12.1 | 12.2 | 12.2 |
| Feed/gain | 10.1 | 9.2 | 8.7 |
| Dressing percent | 59.2 | 59.2 | 59.2 |
| Carcass grade[a] | 6.9 | 7.1 | 6.8 |

[a] 6 = low choice, 7 = avg. choice.

Table 5. Effect of two levels of DES on feedlot performance of steers.

| Item | DES 10 mg oral/d | DES 20 mg oral/d |
|---|---|---|
| No. steers | 63 | 62 |
| ADG, kg. | 1.01 | 1.07 |
| ADF, kg. | 10.4 | 10.5 |
| Feed/gain | 10.25 | 9.86 |
| Dressing percent | 59.0 | 59.2 |
| Carcass grade[a] | 5.50 | 5.25 |

[a] 6 = low choice, 7 = avg. choice.

Table 6. Effect of cis- and trans- isomers of DES on performance of feedlot steers.

| Item | Control | Cis- (89%) DES 10 mg. oral/d | Trans- (100%) DES 10 mg. oral/d |
|---|---|---|---|
| No. steers | 20 | 20 | 19 |
| ADG, kg. | 1.10 | 1.11 | 1.30[a] |
| ADF, kg. | 7.7 | 7.6 | 8.1 |
| Feed/gain | 7.04 | 6.85 | 6.29 |

[a]Greater than cis- DES ($P<0.05$).

Early in 1970, a stabilized trans- DES premix was introduced into the market. By this time, there were multiple suppliers of DES operating under a sub-license to the Iowa State/Lilly patent agreement. This premix was promoted by ELANCO as "High Trans Stilbosol" and it had an immediate and dramatic effect on market share. This product designation had to be removed because FDA ruled that an efficacy claim was being made without submission of data; however, the stabilized premix continued to be used as STILBOSOL.

**The Rise and Fall Of DES in Cattle Feeding**

By the end of 1955, one year after approval of oral DES, it was estimated that six million cattle (~50%) were being fed DES. Eventually, it was estimated that 80 to 95% of the fed cattle received DES in some form. Early on, however, there were industry concerns and misconceptions about the effects of DES. Physiological (high tail heads and teat development) and behavioral (estrus-like) "observations" were mentioned, mostly because of early experimental observations. Carcass grade and dressing percent reduction were constantly used by packer buyers to reduce the price paid for cattle, something that still plagues the use of implants today (Preston, 1993). Carcasses from cattle given DES were said to be soft and cut "dark". It was even said that water retention was responsible for the growth response to DES, something later proven false using radioactive water (Preston, 1969). These concerns culminated in a special "packer" meeting at Iowa State on a Saturday (4/16/55) where data on the carcass effects were presented, which diminished the rumors somewhat at that time. Corn belt feeders used to feeding small to medium frame cattle on high corn silage diets to a certain final body weight did not realize that higher energy diets and heavier final weights were required to achieve the same carcass grade, since DES increased mature body weight (Preston, 1978).

The popular and scientific press also misrepresented the safety of beef produced using this new technology. The Police Gazette ran a cover headline "Beef Will Make You Sterile". Nicholas Wade published a "science news" article in Science (1972) where he described DES as "a chemical of bizarre and far-reaching properties, chief of which is that it is a spectacularly dangerous carcinogen" and accused the FDA of political manipulation in an election year. The infinitesimal risk of cancer from eating beef produced using DES was repeatedly made by Dr. Tom Jukes (1976) and others. FDA was under considerable congressional pressure to enforce the Delaney amendment prohibiting the use of any carcinogen if there was a residue in food, the so-called "zero residue" amendment. One person advocated that "Congress needed to enact legislation outlawing all substances that caused cancer in any species, even if no evidence existed that these materials could produce cancer in man" (Marcus, 1994, p40). FDA maintained the position that residues were not found in beef based on the mouse uterine weight assay that was sensitive to 2-3 ppb. During the 1960's, it was found that about 0.5% of the livers, the primary organ of DES excretion, but not the meat of commercial cattle at post-mortem inspection had detectable residues. In the early 1970's, however, this incidence rose to 2-2.5% probably because of dual usage, higher oral doses and, most important, lack of adherence to the required withdrawal periods. FDA prosecuted cattle feeders who did not use DES correctly. USDA studies using $^{14}$C-labled DES (Aschbacher, 1972) detected presumed residues (<2-3ppb) based on total radioactivity. Since the carcinogenic level of DES in cancer prone laboratory animals was equivocal (Cole et al., 1975), FDA maintained that the carcinogenicity of DES in humans had not been demonstrated. However, after the report (Herbst et al., 1971) of adenocarcinoma in daughters of mothers that had taken massive doses of DES (up to 125 mg daily during the first trimester of pregnancy) that was prescribed (mistakenly as it turned out) for the prevention of threatened miscarriage, FDA had no option except to ban the use of DES in cattle production, even though Herbst later pointed out that this disease was extremely rare even among the DES exposed group which was confirmed by a National Cancer Institute study.

Thus the time-line for the rise and fall of DES use in cattle was as follows:

- 1954 FDA approves oral DES feeding
- 1957 FDA approves DES implants
- 1959-75 USDA isotope studies show DES residues <2-3ppb
- 1972 FDA bans oral DES; 120 day withdrawal on DES implants
- 1973 FDA bans DES implants
- 1973 FDA prosecutes cattle feeders with "DES contaminated" cattle
- 1974 U.S. Court of Appeals overturns ban; FDA failed to hold proper hearings
- 1977 FDA holds DES hearings
- 1979 FDA bans all use of DES in cattle production

**Epilogue**

The use of DES in cattle and sheep became the victim of zealous attempts to protect the public from all risk. Needless to say, the use of DES in cattle and sheep was not treated objectively by politicians and the press who put unbelievable pressure on the FDA. As Marcus said (1994, p6), "no one could prove that DES beef had harmed a single member of the populace. Conversely, no one could prove that it had not". It is our opinion that if DES had not been banned, it would still rank as one of the most effective cattle growth promotants and that human safety would have never been compromised with proper use. Feeding DES offered dosage and withdrawal control not available in implant products. However, the removal of DES from the marketplace allowed for the development and use of a number of alternative products, listed in the following chronology, that came to the market only after significant expenditures of research time and money, and regulatory agency effort, all of which could have been directed toward the discovery, development and approval of new technology for the cattle industry. It is ironic that we still do not have a clear explanation for the mode of action of estrogen growth promotants in cattle and sheep.

Chronology of Cattle Anabolic Agents in the U.S.

- 1954 Oral DES approved for cattle
- 1956 Estradiol benzoate/progesterone implants approved for steers
- 1957 DES implants approved for cattle
- 1958 Estradiol benzoate/testosterone propionate implants approved for heifers
- 1968 Oral MGA approved for heifers

- 1969 Zeranol implants (36 mg) approved for cattle
- 1982 Silastic estradiol implant approved for cattle
- 1984 Estradiol benzoate/progesterone implants approved for calves
- 1987 Trenbolone acetate (TBA) implants approved for cattle
- 1991 Estradiol/TBA implants approved for steers
- 1993 BST approved for lactating dairy cows
- 1994 Estradiol/TBA implants approved for heifers
- 1995 72 mg Zeranol implants approved for cattle
- 1996 Estradiol/TBA implants approved for stocker cattle

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# GROWTH STIMULANTS: COMPOUNDS, CONCENTRATIONS, COMBINATIONS AND REGULATIONS

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## ABSTRACT

Over the past fifteen years, the number and type of growth promotant implants available for improvement of beef productivity has increased dramatically. Currently, ten New Animal Drug Approvals (NADA's) cover products marketed under nineteen different tradenames. All growth promotant implants are regulated by the Food and Drug Administration (FDA). The implants can be classified as either single ingredient or combination ingredient products that contain estrogens, androgens or progestins. The best source of information on products can be found on the product label or insert or from Freedom of Information documents available through Freedom of Information Services, Washington, DC.

## INTRODUCTION

Growth promotant implants have been available since the mid-1950's for improving average daily gain and feed conversion in beef cattle. Implants are approved and regulated by the Food and Drug Administration. Information on products is best obtained from the product label or insert; however, for more complete information on a product, Freedom of Information documents can be obtained from:

Food and Drug Administration
Freedom of Information Staff
HFI-35
5600 Fisher Lane
Rockville, MD 20857

All implants currently on the market contain active ingredients which can be classified as estrogens, androgens or progestins. Table 1 identifies the different active compounds found in implants; melengestrol acetate is available only as a feed additive.

Utilizing these active ingredients either alone or in different combinations and at various concentrations has resulted in thirteen different products marketed under nineteen tradenames. These different products can be divided into single ingredient or combination ingredient products. Single ingredient products contain either estradiol 17 B, zeranol or trenbolone acetate at various concentrations (Table 2).

**Table 1. Hormonal Growth Promotant Compounds**

Estrogens
- Estradiol 17B (E2)
- Estradiol benzoate (EB ⇒ 71% E2)
- Zeranol (Z)

Androgens
- Testosterone propionate (TP)
- Trenbolone acetate (TBA)

Progesterones
- Progesterone (P)
- Melengestrol acetate (MGA)

The combination products (Table 3 and 4) contain estradiol benzoate/ progesterone, estradiol benzoate/ testosterone, estradiol benzoate/ trenbolone acetate or estradiol/trenbolone acetate with various concentrations of each of these active ingredients. These concentrations and combinations have been utilized for the approval of the products in steers and heifers during different stages of production, i.e., calf, stocker and feedlot.

Implants are manufactured as compressed pellets; pellets per dose ranges from three to ten based on the product. Exceptions are the estradiol products Compudose and Encore which utilize a single silastic rubber implant as the support matrix for the active ingredient. This carrier, being non-absorbable, remains with the animal indefinitely.

When comparing products for estrogen content, it is important to convert the compound its active ingredient, estradiol 17 B. For example, in the case of Synovex Plus, the 28 mg of estradiol benzoate equals 20 mg of estradiol 17 B because estradiol benzoate contains only 71.4% estradiol 17B.

The "Indication of Use" reflects where a product is approved for use and the sex for which it is approved. As indicated earlier, the segment of use can be feedlot, pasture and(or) suckling calf.

**Table 2. Concentrations and Trade Names of Single Ingredient Implants**

| Ingredient | Concentration (mg) | Trade Name |
|---|---|---|
| Estradiol | 25.7 | Compudose® |
| | 43.9 | Encore® |
| Zeranol | 36.0 | Ralgro® |
| | 72.0 | Ralgro Magnum® |
| Trenbolone Acetate | 140 | finaplix® - S |
| | 200 | finaplix® - H |

**Table 3. Concentrations and Trade Names of Combination Ingredient Implants**

| Ingredient | Concentration (mg) | Trade Name |
|---|---|---|
| Estradiol benzoate | 20 (14 E2) | Synovex® S |
| Progesterone | 200 | Implus® S |
| | | Component® E-S |
| Estradiol benzoate | 10 (7 E2) | Synovex® C |
| Progesterone | 100 | Implus® C |
| | | Component® E-C |
| Estradiol benzoate | 20 (14 E2) | Synovex® H |
| Testosterone propionate | 200 | Implus® H |
| | | Component® E-H |
| Estradiol | 24 | revalor® S |
| Trenbolone acetate | 120 | |
| Estradiol | 14 | revalor® H |
| Trenbolone acetate | 140 | |
| Estradiol | 8 | revalor® G |
| Trenbolone acetate | 40 | |
| Estradiol benzoate | 28 (20 E2) | Synovex® Plus |
| Trenbolone acetate | 200 | |

**Table 4. Indication of Use for Feedlot Cattle**

| | | Improved ADG | | Improved FE | |
|---|---|---|---|---|---|
| | | Steer | Heifer | Steer | Heifer |
| Estradiol | 25.7+ | X | X | X | X |
| | 43.9++ | X | X | X | X |
| Zeranol | 36 | X | X | X | X |
| | 72 | X | | | |
| TBA | 140* | | | X | |
| | 200** | | X | | X |

* Reimplant once after 63 days for continued effectiveness.
** Use only the last 63 days prior to slaughter.
\+ Effective daily dose for at least 200 days.
\++ Effective daily dose for at least 400 days.

**Table 5. Indication of Use of Combination Implants for Feedlot Cattle**

| | | Improved ADG | | Improved FE | |
|---|---|---|---|---|---|
| | | Steer | Heifer | Steer | Heifer |
| EB/P | (20/200)* | X | | X | |
| EB/T | (20/200) | | X | | X |
| E2/TBA | (24/120) | X | | X | |
| | (14/140) | | X | | X |
| EB/TBA | (28/200) | | | X | |

* Synovex S - Reimplant after 70 days for additional improvement in ADG.

For the feedlot phase of cattle production, six single ingredient products are approved (Table 4) and five combination products are approved (Table 5). The claims for these products reflect whether they received approval to improve average daily gain and feed conversion in steers or heifers. The single ingredient estradiol products also carry a time claim for an effective life span of 200 and 400 days for the 25.7 and 43.9 mg products, respectively.

Some of the products, such as the zeranol 72 mg product (Ralgro Magnum) and the TBA 140 mg product (finaplix S) carry claims for only gain or feed conversion. This does not necessarily mean that the product is not effective for the other claim, only that an additional claim was not supported by the data that was submitted to the FDA. In general, additional information is provided to the public by the marketer after approval by the FDA for better assessment of the product under different feeding conditions. Currently all combination products have been approved on a gender specific basis. The Synovex S and finaplix S implants also carry specific reimplantation claims for additional or continued improvement in gain or feed conversion, respectively.

In the pasture phase of production, there currently are three single ingredient products approved and three combination products approved (Table 6). All products in this phase of production have approval for average daily gain.

The 25.7 and 43.9 mg estradiol products only have approval in steers. The latest approval on pasture was received in 1995 for a reduced dosage of E2/TBA (8/40).

In the calf phase of production there are three single ingredient and one combination ingredient products approved (Table 7). The estradiol products again only have steer approval while the zeranol and E2/progesterone products have both steer and heifer approval. In addition to improved average daily gain, Ralgro and Synovex C have approval for use in heifers that may later be used for replacement purposes. Heifers that are to be kept for replacements should be implanted no sooner than 30 or 45 days of age for Ralgro and Synovex C respectively.

The final area for consideration is warnings and cautions associated with the use of the implants. These areas concern possible side effects, implantation site and situations where implants should not be used. Implantation site for all implants is in the ear. Any other implant site is in violation of Federal law. Growth promotant implants should not be utilized for dairy cattle and bull calves intended for reproductive purposes. Other considerations for use of implants are shown in Table 8. Labels should be read completely for information on these areas.

**Table 6. Pasture Implants**

| | | Improved ADG | |
|---|---|---|---|
| | | Steer | Heifer |
| Estradiol | 25.7 | X | |
| | 43.9 | X | |
| Zeranol | 36 | X | X |
| EB/P | (20/200) | X | |
| EB/T | (20/200) | | X |
| E2/TBA | (8/40) | X | X |

**Table 7. Implants for Suckling Calves**

| | | Improved ADG | | |
|---|---|---|---|---|
| | | Steers | Heifers | Replacement Heifers |
| Estradiol | 25.7 | X | | |
| | 43.9 | X | | |
| Zeranol | 36 | X | X | 30 day |
| EB/P | (10/100) | X | X | Synovex C 45 days |

**Table 8. Major Considerations**

| Item | |
|---|---|
| Implant Location (All) | Implant in the ear only. Any other location is a violation of Federal law. |
| Implant Withdrawal (All) | No withdrawal prior to slaughter. |
| Possibly decreased marbling scores | revalor S, revalor H, Synovex Plus Synovex S reimplant |
| Bulling, vaginal and rectal prolapse, udder development, signs of estrus | E2, EB/P E2, EB/T, Z |
| Use in breeding herd replacements and dairy animals | Do not use (except Synovex C and Ralgro in beef replacement calves). |
| Storage (room temperature) | E2, Z, EB/P, EB/T, EB/TBA |
| Storage (refrigerated) | E2/TBA, TBA |

Holders of the implant NADA and marketers of the implants have changed dramatically over the past 12 months due to consolidation of companies. Current holders, manufacturers and marketers of growth promotant implants are listed in Table 9. As trends for consolidation may continue, this area should be updated routinely.

Growth promotant implants are approved in a number of countries including: Australia, New Zealand, Canada, Mexico, South Africa, Columbia, Chile, Japan and Argentina. Readers should check with the NADA holder to determine the international approval status of specific products of interest.

**Table 9. Holders of NADA, Manufacturers and Marketers**

| Product | NADA Holder | Manufacturer | Marketer |
|---|---|---|---|
| Synovex | Ft. Dodge Animal Health | Syntex, Inc.<br>Palo Alto, CA | Ft. Dodge<br>Animal Health |
| Ralgro | Mallinckrodt | Mallinckrodt<br>Terre Haute, IN | Mallinckrodt |
| Compudose | Elanco Animal Health | Elanco Animal Health,<br>Mexico | VetLife, Inc. |
| Finaplix<br>Revalor | Roussel UCLAF | Roussel UCLAF<br>Hoechst | Hoechst |
| Implus<br>Component | Ivy Laboratories | Ivy Laboratories<br>Overland Park, KS | Upjohn<br>VetLife, Inc. |

## QUESTIONS & ANSWERS

Q: Why does Synovex not have a claim for improving feed efficiency in cattle?

A: Information submitted for clearance probably was inadequate for this claim. Others from the audience might address this question further.

Q: Why do the labels not specifically state "zero withdrawal required"?

A: You would think that the FDA would want to include that information on the label. But that hasn't been the case so they haven't been put on there. Also, in the early years, some products had withdrawal times. For example, I think Ralgro had a withdrawal period of days following implanting whereas other implants had zero withdrawals and maybe the FDA thought that such a statement might affect the concept of relative safety of two different products.

# MECHANISMS OF ACTION OF ESTROGENS AND ANDROGENS ON PERFORMANCE OF CATTLE - HORMONAL BASIS

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## ABSTRACT

Numerous modifications of the endocrine system have been observed in cattle given exogenous anabolic steroids or steroid-like compounds. Changes in concentrations of thyroid hormones, insulin or adrenal corticosteroids probably are not involved directly in the anabolic responses observed with steroid implants. However, extensive evidence indicates that implanted cattle have higher concentrations of plasma growth hormone (GH) resulting from increased secretion (not decreased clearance) of GH from the vascular system. Pituitary glands from implanted steers have a greater number of GH secreting cells. Implanted steers also have a greater number of high-affinity GH receptors in the liver, a greater concentration of mRNA for insulin-like growth factor-1 (IGF-1) in the liver, and increased plasma concentrations of IGF-1 and IGF-1 binding protein-3. All of these changes could result from an increased secretion of GH. However, observations that the growth response and changes in carcass composition of cattle resulting from administration of exogenous GH and steroid implants are additive suggests that the growth responses to these two compounds may be independent; steroids may not act solely through increased secretion of GH. Steroid hormone receptors have been detected in skeletal muscle of cattle and estradiol enhances the concentration of IGF-1 mRNA in bovine muscle. Thereby, steroids and GH may have independent actions on muscle growth.

## INTRODUCTION

Somatic growth is the result of interactions between genetics, the environment and supply of nutrients to the body. The endocrine system is the mechanism by which these interactions are coordinated to control growth. Pituitary growth hormone (GH) is essential for somatic growth. The succession starting with regulation of GH secretion in the hypothalamus to release of insulin-like growth factors and their binding proteins by tissues constitutes an elaborate system that is predominant in regulation of growth. This complex is referred to as the somatotrophic axis. Compared with GH, other hormones, such as those from the thyroid, pancreas and adrenal cortex are more permissive than regulatory.

Physiological changes associated with use of anabolic steroids have been studied in numerous cattle experiments to gain some understanding of the growth promoting properties of these compounds. Weights of endocrine glands were measured in the early experiments. Administration of diethylstilbestrol (DES) to steers resulted in increased weights of the anterior pituitary (1,5,24), heavier adrenal glands when DES was implanted (1), but no consistent increase in thyroid weight (5). Following the development of assays to measure hormone concentrations in blood, emphasis was placed on plasma hormones rather than gland weights. Since the initial studies, most of the research dealing with endocrine changes has focused on the somatotrophic axis. Nevertheless, a mode of action of estrogens on growth of cattle has not been definitively established.

### Plasma Concentrations of Hormones from the Thyroid, Adrenal and Pancreas

Implanting estrogenic anabolic compounds increases thyroid gland activity, as reflected by increased plasma concentrations of thyroxin (9,14,18). However, estrogen anabolics do not affect plasma concentrations of triiodothyronine. Implanting cattle with trenbolone acetate (TBA) alone or in combination with estradiol decreased thyroxin with no effect on triiodothyronine (9,14,18). In another study with steers, implanting estradiol had no effect on either thyroxin or triiodothyronine (10).

Plasma concentrations of adrenal glucocorticoids of cattle implanted with anabolic steroids have been measured in several experiments. Implanting steers with estradiol tended to decrease corticoids in one study (10) but not another (13). Implanting TBA alone or in combination with estradiol, however, decreased plasma cortisol (13). This decrease in plasma cortisol following implanting with TBA is consistent with the observation of decreased responsiveness of the adrenal cortex to ACTH in TBA-treated sheep (26).

In most studies, plasma insulin is not significantly increased by anabolic implants in cattle (10,19). In situations where there is a trend for plasma insulin to be increased (2,27), the pancreas may be responding to increased feed intake of cattle given anabolic hormones.

Taken together, these experiments do not present convincing evidence that an increase in thyroid hormones and insulin or a decrease in cortisol constitute a primary site of action to explain the effects of anabolic steroids on growth of ruminants. The decrease in cortisol with TBA and the increase in thyroxin with estrogens along with an increase in insulin, however, would contribute to an overall anabolic response.

**The Somatotrophic Axis**

Heavier pituitary glands which contained more GH relative to body weight (Table 1) was the initial evidence that the somatotrophic axis might be involved in the action of estrogen on growth of ruminants (24). Later, implanting steers with DES was observed to increase DNA content of the pituitary, suggesting that cell number was increased (15). More recently (Table 2), implanting steers with TBA and estradiol was found to increase the number of GH secreting cells in the pituitary (25). These findings indicate that estrogens have some effect either directly on the pituitary or indirectly on the hypothalamus and release of growth hormone releasing hormone (GHRH); this results in pituitaries with an increased capability for secreting GH. One experiment showed that incubation of bovine pituitary cells with estradiol did not significantly increase GHRH-induced GH release, but preincubating the cells with testosterone increased the GH response to a GHRH challenge (12). These results suggest that anabolic steroids may directly affect the anterior pituitary.

Administration of estrogens to cattle by feeding DES or implanting estradiol or zeranol elevates concentrations of GH in plasma (2,4,7,10,11,27). Representative data from one study of steers implanted with estradiol are shown in Table 3. The greater plasma GH concentrations brought about by estrogen implants is not a result of a decrease in clearance of GH from the circulatory system (Table 4), but is due to greater secretion of the hormone (8). Administration of TBA alone to steers does not increase concentrations of GH in plasma (7,13), but steers implanted with TBA plus estradiol (13,19) or TBA plus hexoestrol (7) have greater plasma concentrations of GH than steers without implants.

Table 1. Growth hormone in pituitary glands of steers fed diethylstilbestrol as determined by bioassay[1].

| | DES fed, mg/d | | |
|---|---|---|---|
| | 0 | 5 | 10 |
| Anterior pituitary, g | 1.18 | 1.43 | 1.50 |
| Growth hormone assay | | | |
| Width of tibia, μ | 269 | 254 | 268 |
| Growth hormone index | 316 | 369 | 405 |
| GH index/100 kg body wt | 71.6 | 78.6 | 84.6 |

[1]Struempler and Burroughs (24).

Table 2. Effects of an estradiol implant with trenbolone acetate in steers on growth hormone secreting cells in the pituitary gland[1].

| | Cell type | | | |
|---|---|---|---|---|
| | Growth hormone | Prolactin | Mammosomatotropin | All growth hormone |
| Control | 10.0 | 42.0 | 20.8 | 30.8 |
| Implant | 27.8 | 40.5 | 10.7 | 38.5 |

[1]Thomson (25).

Growth hormone is secreted during discreet intervals throughout the day. Each period of active secretion is followed by a period of quiescence. Plasma GH profiles of cattle have not been consistently changed by implants (Table 3). Implanting estradiol has been reported to change neither the amplitude nor the frequency of GH peaks (10) and to not increase GH peak height (4). Although implanting steers with TBA and estradiol increased GH peak height in one study (19), implanting had no significant effect (a tendency to decrease) in another study (13). The number of secretory peaks has not been increased by anabolic implants in any of the studies. Bulls which are subjected to increasing concentrations of testosterone during development have greater amplitude of GH peaks during the secretory period (20) as compared with steers or heifers without implants. Administration of estradiol and TBA to steers makes their GH secretion pattern more similar to that of bulls.

The secretion of GH is regulated by a dual system of hypothalamic hormones; GHRH stimulates GH release while somatostatin inhibits GH release. The release of these hypothalamic hormones is influenced by a network of neurotransmitters and extrahypothalamic influences. Steers implanted with estradiol (22) or estradiol and TBA (16) responded with greater secretion of GH in response to venous injection of a combination of GHRH and thyrotropin-releasing hormone or GHRH, respectively. Results of the study with steers implanted with estradiol and TBA are shown in Table 5. These findings are consistent with the concept that administration of estrogens to cattle results in anterior pituitary glands which are more sensitive to release of GH, i.e., their response to GHRH.

Table 3. Effects of an estradiol implant on growth hormone secretory patterns in steers[1].

| | GH mean | GH baseline | Peak amplitude | No. peaks |
|---|---|---|---|---|
| | ng/ml | | | |
| Control | 3.3 | 2.6 | 11.9 | 3.1 |
| Implant | 4.6[2] | 3.7 | 9.6 | 5.2 |

[1]Grigsby and Trenkle (10)
[2]$P < .05$

Table 4. Effects of estrogen implants in steers on growth hormone secretion and clearance from plasma[1].

| | Plasma clearance | Secretion |
|---|---|---|
| | ------ ml/kg/hr ------ | ------ µg/kg/hr ------ |
| Control | 72.6 | .53 |
| DES | 63.9 | 1.04[2] |
| Zeranol | 83.3 | 1.10[2] |
| Synovex S | 78.0 | .96[2] |

[1]Gopinath and Kitts (8).
[2]$P < .05$.

Table 5. Effects of an estradiol implant with trenbolone acetate in steers on plasma growth hormone and response to growth hormone releasing hormone[1].

| | Growth hormone | GH response to GHRH |
|---|---|---|
| | -------- ng/ml -------- | ---- Area under curve ---- |
| Control | 5.7 | 1894 |
| Implant | 8.3 | 3461 |

[1]Hongerholt et al. ( 16).

The conventional tenet is that GH reacts with membrane receptors on liver cells to activate a cascade of intracellular signals to produce insulin-like growth factor-1 (IGF-1), a growth factor for muscle and the skeleton. Estradiol implants markedly increase the number of high capacity GH receptors in bovine liver and marginally increase the number of low capacity GH receptors (4) but have no effect on the dissociation constants of either class of receptors (Table 6). Further down the somatotrophic axis, plasma IGF-1 concentrations in steers (Table 7) implanted with estradiol are elevated (3,11). Adding TBA with estradiol results in even greater plasma IGF-1 in implanted steers (Tables 8 and 9) compared with control steers (17,19). Another indication that anabolic steroids might be acting via the somatotrophic axis is the increase in liver concentration of IGF-1 mRNA (Table 8) in steers either implanted with estradiol, administered exogenous GH, or implanted with estradiol and TBA (11,19). Presumably an increased liver production of IGF-1 might be the anabolic stimulus for greater somatic growth.

Specific proteins present in serum have been found which selectively bind IGF-1 (IGFBP); these play a role in regulation of the biological activity of IGF-1 in tissues. A number of different proteins that bind IGF-1 have been isolated from different tissues and cells. Steers implanted with estradiol and TBA (Table 9) have increased concentrations of IGFBP-3 (17). This binding protein is GH dependent and carries the majority of IGF-1 in plasma. IGF-1 bound to IGFBP-3 presumably is a storage pool of the growth factor in blood. The binding proteins also may play a role in delivery of IGF-1 to cells or control its availability to cells.

Table 6. Effects of an estradiol implant in steers on binding of growth hormone to liver membranes[1].

| | Capacity | | Dissociation constant | |
|---|---|---|---|---|
| | --- pmol/100 mg liver --- | | -------- pmol/l -------- | |
| | High | Low | High | Low |
| Control | 1.87 | 20.1 | 11.6 | 106.4 |
| Implant | 6.56[2] | 30.1[2] | 10.8 | 110.6 |

[1]Breier et al. (4).
[2]$P < .05$.

Table 7. Effects of an estradiol implant in steers on plasma concentrations of growth hormone and insulin-like growth factor-1[1].

| | GH | IGF-1 | IGF-1[2] |
|---|---|---|---|
| | | ------------------ ng/ml ------------------ | |
| Control | 3.1 | 60.6 | 97.5 |
| Implant | 4.7[3] | 85.2[3] | 133.0[3] |

[1]Breier et al. (3).
[2]Eight hours after administration of exogenous GH.
[3]$P < .05$.

Table 8. Effects of an estradiol implant with trenbolone acetate in steers on plasma concentrations of growth hormone and insulin-like growth factor-1 and liver concentrations of insulin-like growth factor-1 mRNA[1].

| | GH | IGF-1 | IGF-1 mRNA |
|---|---|---|---|
| | ------------ ng/ml | ------------ | --- pg/mg --- |
| Control | 1.6 | 190 | 10.9 |
| Implant | 3.0[2] | 264[2] | 20.1[2] |

[1]Miller (19).
[2]$P < .05$.

Anabolic steroids, especially estradiol, enhance many aspects of the somatotrophic axis in cattle. These steroids may modify either the pituitary or the hypothalamus making the pituitary more responsive to GHRH and thereby causing greater secretion of GH. Subsequent effects on the somatotrophic axis may be the consequence of greater secretion of GH. It is tempting to conclude that this represents the mode of action of estrogen on growth of cattle.

Three experiments have been conducted with cattle to compare the growth responses to anabolic steroids and exogenous GH (6,21,28). All of these experiments show conclusively that the growth responses of cattle to GH and the steroids are additive and probably independent. The results of one study designed to study the independent actions of exogenous GH and estradiol in steers are shown in Figure 1. Based on these results the anabolic response to exogenous steroid hormones by cattle clearly are not due solely to an increase in GH secretion.

Table 9. Effects of an estradiol implant with trenbolone acetate in steers on plasma concentrations of insulin-like growth factor-1 and its binding protein[1].

| | IGF-1 | IGFBP-3 |
|---|---|---|
| | ------------ % change[2] ------------ | |
| Control | 0 | 2 |
| Implant | 31[3] | 45 |

[1]Johnson et al. (17).
[2]Change between preimplantation and 40 days post implant.
[3]$P < .01$.

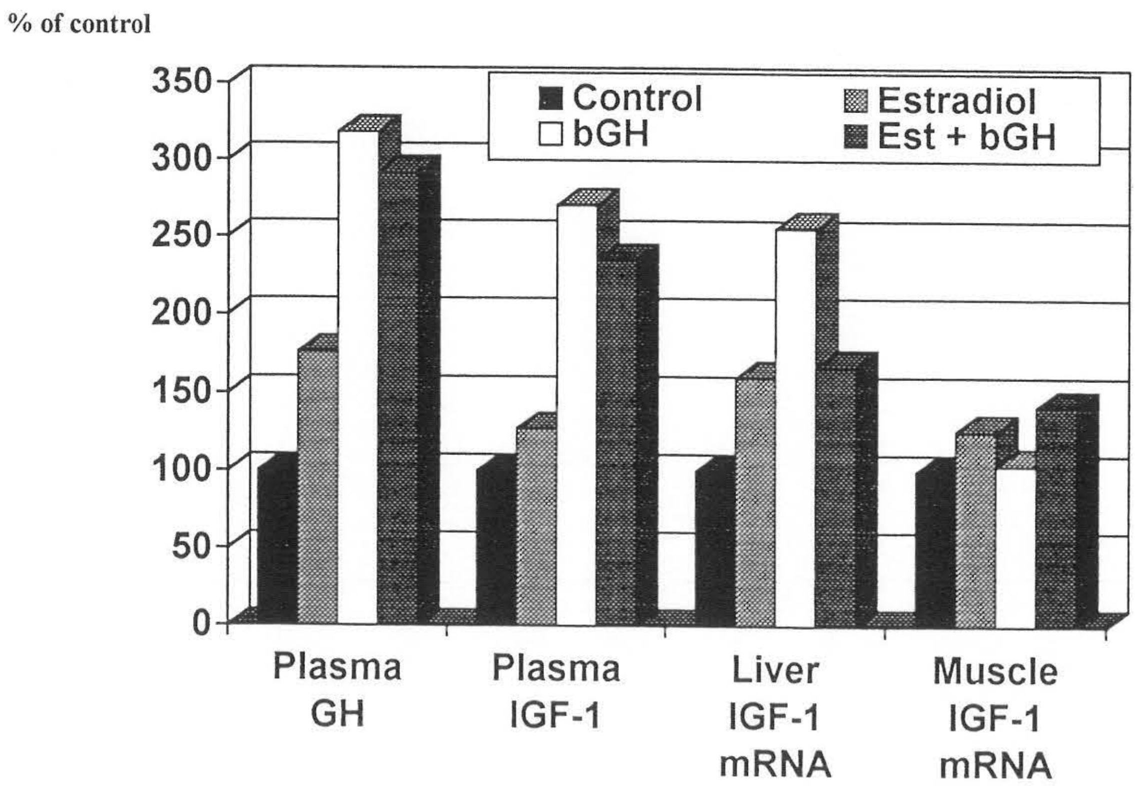


**Figure 1.**

Receptors for both androgens and estrogens have been found to be present in bovine muscle (23). The concentration of these receptors may increase in physiological states of low steroid concentrations. The presence of these receptors in skeletal muscle opens the possibility that steroid hormones might have some direct effect on growth of skeletal muscle. Implanting steers with estradiol increase IGF-1 mRNA in muscle of steers (Figure 2) to a greater extent than administration of exogenous GH (11) alone. If this is the case, then the growth effects from estradiol must be independent of that from exogenous GH indicating that the principle anabolic response from anabolic steroids is not increased secretion of endogenous GH. The anabolic effects of TBA also may be directly on muscle, but in some manner different from estrogen.

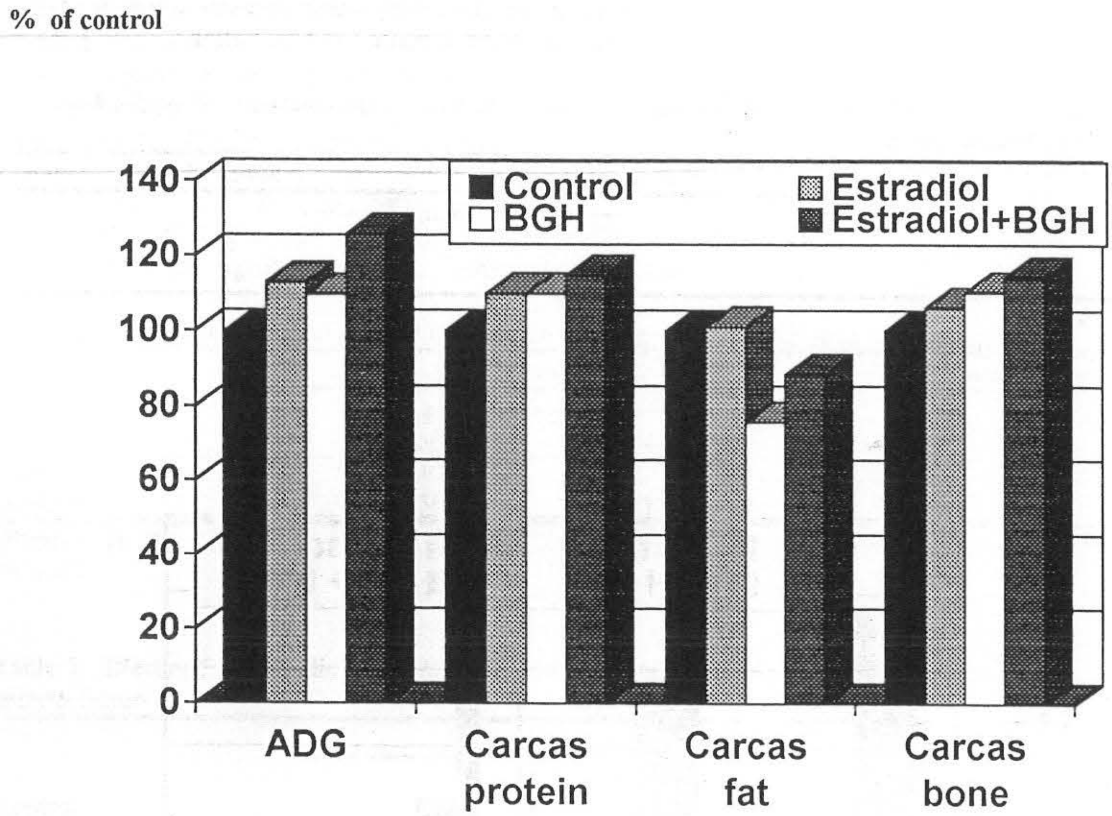


Figure 2.

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**QUESTIONS & ANSWERS**

Q: How might the decrease in cortisol seen with implants alter the decision to implant or not implant stressed calves?

A: At one time, Ralgro implants were reputed to decrease shrink of transported calves and it was being promoted for such use. I haven't heard anything about that recently. Implanting might reduce shrink and thereby prove beneficial.

# EFFECTS OF A COMBINED TRENBOLONE ACETATE AND ESTRADIOL IMPLANT (REVALOR-S) ON CARCASS COMPOSITION AND BIOLOGICAL PARAMETERS OF FEEDLOT STEERS

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## ABSTRACT

Implanting steers with a combined trenbolone acetate (TBA) and estradiol ($E_2$) implant (Revalor-S) increased ADG 21% ($P < .001$), improved feed efficiency 13% ($P < .01$), increased longissimus muscle area ($P < .05$), and caused an 82% increase in daily carcass protein deposition during the first 40 d following implantation. As compared to nonimplanted steers implantation with TBA/$E_2$ also increased circulating insulin-like growth factor (IGF)-1 concentrations by 40% on d 40 and 35% on d 115 ($P<.001$). Additionally, serum concentration of insulin-like growth factor binding protein-3 (IGFBP-3) was higher in implanted steers on d 21 and 40 after implantation ($P < .05$). Sera from implanted steers stimulated proliferation of cultured muscle satellite cells to a greater extent ($P < .05$) than did sera from nonimplanted steers. Steady-state hepatic IGF-1 mRNA concentrations were increased 2.5 fold in TBA/$E_2$-implanted sheep compared to nonimplanted animals ($P<.01$). These data suggest that liver may be the source of at least part of the increased circulating IGF-1 in steroid-implanted sheep. In serum-free medium containing IGF-1 and FGF-2, the proliferative response of muscle satellite cells isolated from TBA/$E_2$-implanted steers was greater ($P < .05$) than the response of satellite cells isolated from nonimplanted steers. This may be because a higher proportion of satellite cells isolated from implanted steers are actively proliferating whereas a higher proportion of satellite cells isolated from nonimplanted steers are quiescent and must be activated in culture before proliferating. The presence of more actively proliferating satellite cells in muscle of implanted steers may play a role in the enhanced muscle growth seen with steroid treatment.

## INTRODUCTION

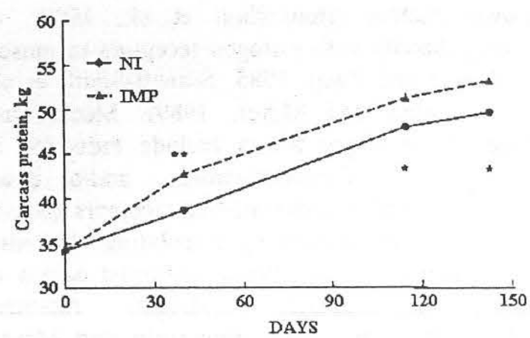
Based on approximately 40 years of experimentation and commercial use, it generally is agreed that anabolic steroids increase growth rate, feed conversion and muscle deposition by ruminants (Hancock et al., 1991). Recently, combined estrogen/androgen implants have been shown to be even more effective than either androgens or estrogens alone for stimulating growth of ruminants (Hayden et al., 1992; Hancock et al., 1991; Johnson et al., 1996a). However, despite general agreement on the effectiveness of anabolic steroids, there is no consensus concerning the biological mechanism(s) responsible for the anabolic effects of either estrogenic or androgenic steroids (Hayden et al., 1992). Potential mechanisms of action of anabolic steroids have been reviewed recently (Hancock et al., 1991). Mechanisms that have been proposed for estrogen action include increasing the circulating level of somatotropin (Gopinath and Kitts, 1984; Grigsby and Trenkle, 1986; Breier et al., 1988a), increasing hepatic somatotropin receptors and thus enhancing somatotropin binding (Breier et al., 1988b), enhancing endocrine or local (autocrine or paracrine) production of growth factors (Hongerholt et al., 1992), or interacting directly with estrogen receptors in muscle tissue (Meyer and Rapp, 1985; Sinnett-Smith et al., 1987; Sauerwein and Meyer, 1989). Mechanisms proposed for androgen action include reduction of circulating levels of corticosteroids and/or down regulation of muscle corticosteroid receptors (Mayer and Rosen, 1978), decreasing circulating thyroxine levels (Donaldson et al., 1981), or direct action of androgens on muscle androgen receptors (Sinnett-Smith et al., 1987; Sauerwein and Meyer, 1989). However, none of these mechanisms has been proven conclusively to be the mode of action of either estrogenic or androgenic anabolic steroids (Hayden et al., 1992). In an effort to increase our understanding of the potential mechanisms by which anabolic steroid implants may enhance muscle growth in feedlot cattle, we have assessed the effect of Revalor-S, a combined trenbolone acetate (TBA) and estradiol ($E_2$) implant (120 mg of TBA plus 24 mg of $E_2$), on growth rate, feed efficiency, carcass composition, and circulating concentrations of specific growth factors at various times after implantation. Additionally we have compared the growth factor responsiveness of cultured muscle satellite cells isolated from implanted or nonimplanted steers (Frey et al., 1995; Johnson et al., 1996a; Johnson et al., 1996c); we also have measured the effect of Revalor-S on the steady-state concentration of hepatic insulin-like growth factor-1 (IGF-1) mRNA (Johnson et al., 1996b).

**Effect of a Combined Trenbolone Acetate (TBA) and Estradiol ($E_2$) Implant on Growth and Carcass Composition of Feedlot Steers.**

Implantation with Revalor-S increased average daily gain by 21% ($P<.001$) and feed efficiency by 13% ($P<.03$) as compared to nonimplanted control steers (Johnson et al., 1996a). Longissimus muscle area was larger in steroid-implanted steers than in nonimplanted steers ($P<.05$) and implantation resulted in increased carcass protein ($P<.05$; Fig. 1; Johnson et al., 1996a). Fat accumulation was not affected by implantation (Fig.1; Johnson et al., 1996a). These data are consistent with other reports on the effect of anabolic steroids on growth and composition of gain and establish the rather significant impact these hormones have on rate and efficiency of growth. Because composition data show that muscle growth was stimulated in anabolic steroid-implanted animals, we examined some of the biological mechanisms that might be responsible for this increased muscle growth.

**Effect of Revalor-S Implantation on Insulin-Like Growth Factor-1 (IGF-1) Concentration, Insulin-like Growth Factor Binding Protein-3 (IGFBP-3) Concentration, and Mitogenic Activity of Bovine Sera.**

Blood sera obtained from steers on d 0, 40, 115, and 143 were analyzed for IGF-1, insulin-like growth factor binding proteins (IGFBPs), and mitogenic activity. Glycyl-glycine (GG) extraction of serum was performed to reduce IGFBP interference in the IGF-1 radioimmunoassay (RIA). Implantation with TBA/$E_2$ increased circulating IGF-1 concentrations by 40% on d 40 and 35% on d 115 as compared to nonimplanted steers ($P<.001$; Fig. 2; Johnson et al., 1996c). Implantation with TBA/$E_2$ also increased the serum concentration of insulin- like growth factor binding protein-3 (IGFBP-3) on d 21 and 40 after implantation ($P < .05$; Fig, 3; Johnson et al., 1996c). Sera from implanted steers stimulated proliferation of cultured muscle satellite cells to a greater extent than did sera from nonimplanted steers on d 21, 40, 115, and 143 after implantation ($P < .05$; Fig. 4; Johnson et al., 1996c). This result is consistent with the increased IGF-1 concentration observed in sera from steroid-implanted steers. It also is significant that the maximum circulating IGF-1 concentration in implanted steers occurs by d 40 which coincides with



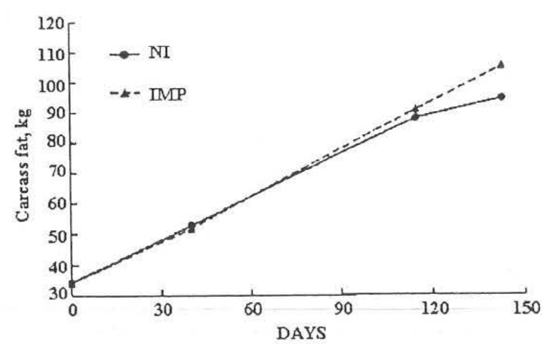




**Figure 1:** Accumulation of protein and fat in carcasses of implanted and nonimplanted steers calculated from 9-10-11$^{th}$ rib section composition (Hankins and Howe, 1946). After the initial slaughter at the beginning of the study, three serial slaughters were completed on d 40 (n = eight/treatment), d 115 (n = eight/treatment), and d 143 (n = eight/treatment). Implantation increased ($P < .01$) carcass protein throughout the feeding period but had no effect on carcass fat. The biggest differences between protein accretion rates in implanted and nonimplanted steers were observed between d 0 and d 40 (114 g/d in nonimplanted steers vs. 207 g/d in implanted steers, $P < .004$). Protein accretion rates in nonimplanted and implanted steers were not significantly different from d 40 to d 115 or from d 115 to d 143. Statistical significance of differences between nonimplanted and implanted steers within a particular slaughter group are denoted by asterisks (*$P < .10$ and **$P < .05$). Pooled SEM for protein and fat are 1.34 and 6.00, respectively.

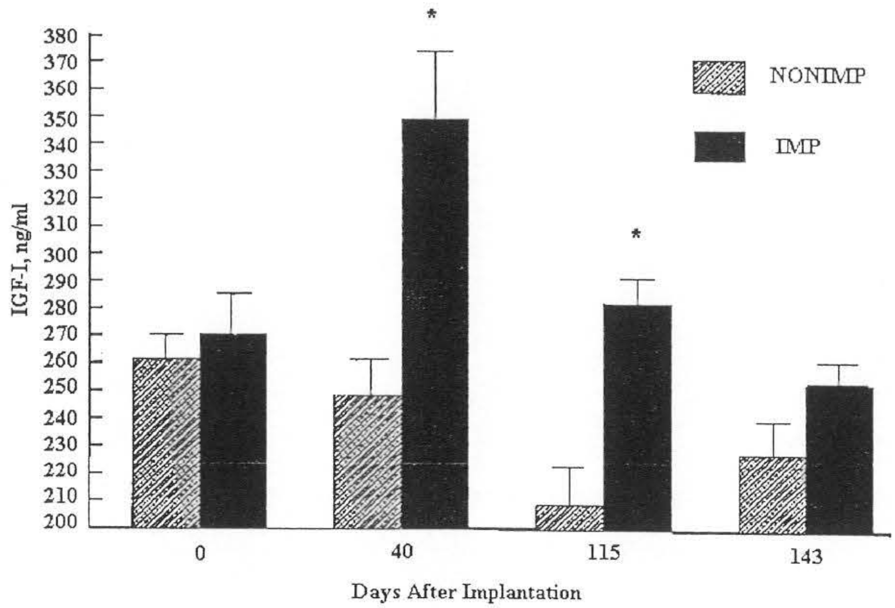



**Figure 2:** Serum insulin-like growth factor-I (IGF-1) concentrations (nanograms/milliliter) in steers implanted with trenbolone acetate and estradiol ($TBA/E_2$) compared with nonimplanted steers. Samples were taken from steers used in a serial slaughter study on d 0 (n = eight/treatment group), d 40 (n = eight/treatment group), d 115 (n = eight/treatment group) and d 143 (n = eight/treatment group). Before IGF-1 RIA, raw sera were extracted with .1M glycyl-glycine (pH 2.0; **G G**) in a 1:1 ratio at 37° C for 48 h to reduce the IGFBP interference in the IGF-1 RIA (Plaut et al., 1991). In all cases final pH of the extraction mixture was between 3.6 and 3.8. Serum IGF-1 concentrations were quantified using a heterologous RIA (Frey et al., 1994). Intra- and inter-assay coefficients of variation were 6.9 and 8.1%, respectively. Asterisks denote time points within which the IGF-1 concentrations for implanted and nonimplanted steers are significantly different ($P < .05$). Pooled SEM is 12.4 ng/ml.

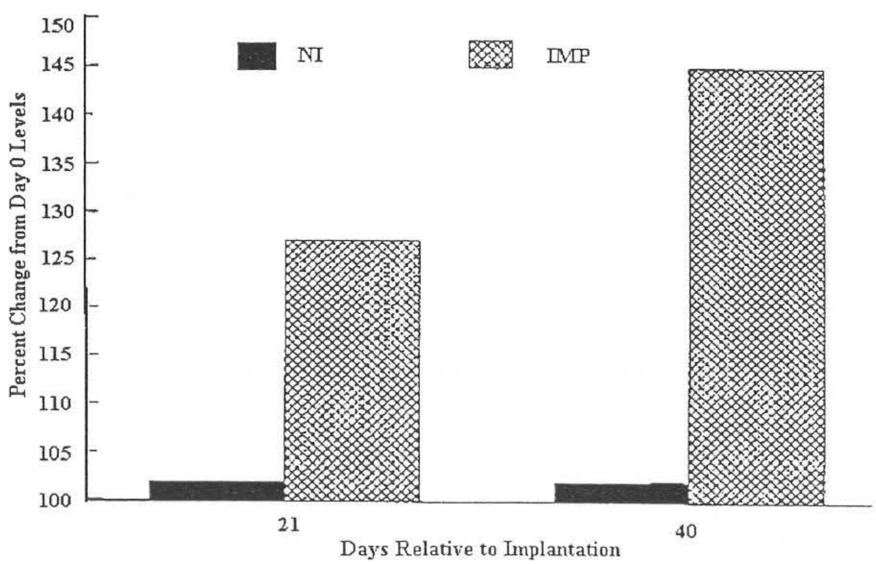



**Figure 3:** Relative change from d 0 concentrations of serum insulin-like growth factor binding protein-3 (IGFBP-3) in steers implanted with trenbolone acetate and estradiol ($TBA/E_2$) and nonimplanted steers. IGFBP concentrations in sera were determined by measuring the density of bands corresponding to individual IGFBPs on autoradiograms of $^{125}$I-IGF-1 Western ligand blots. The graph represents the change in IGFBP-3 concentrations at d 21 and 40. Implantation with $TBA/E_2$ increased ($P < .05$) concentrations of IGFBP-3 on both d 21 and 40. Pooled SEM = 4.6 (n = 4).

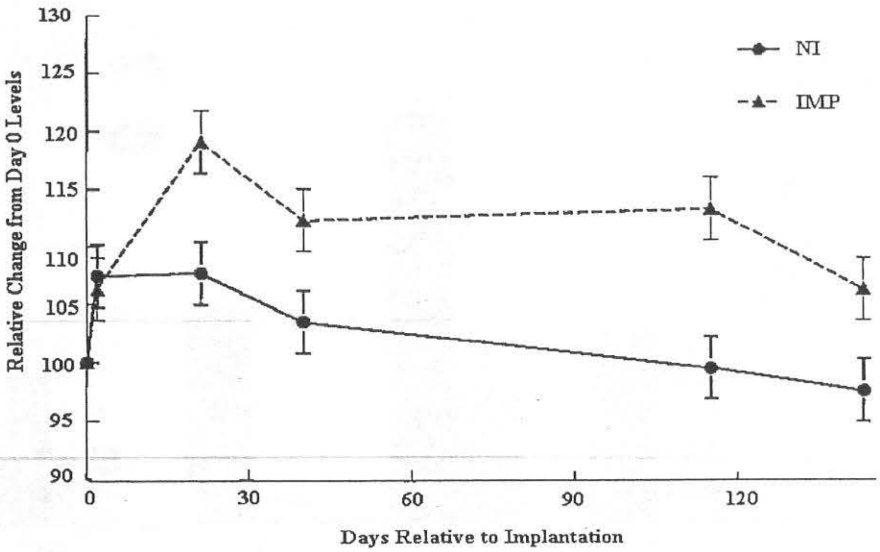



**Figure 4:** Mitogenic activity of the serum from steers implanted with trenbolone acetate and estradiol (TBA/$E_2$) and nonimplanted steers. Values are expressed as percentage of cells/$cm^2$ at d 0. Cloned sheep satellite cells were plated in triplicate wells, and assays were conducted in duplicate. Sera from eight steers/treatment were pooled by treatment and day. Pooled sera were added to McCoy's media at a concentration of 3%. Sera from steers implanted with TBA/$E_2$ increased ($P < .05$) proliferation of the cloned sheep satellite cells to a greater extent than sera from nonimplanted steers on d 21, 40, 115, and 143. Pooled SEM = 2.7 (n = 6).

the period of maximum protein accretion (Fig. 2), and that after d 40 both circulating IGF-1 concentration and protein accretion declined. These data support the hypothesis that increased circulating IGF-1 concentration may play a major role in the positive effects of TBA/$E_2$ implants on feedlot performance and rate of protein accretion in steers.

Implanting with a combination of TBA/$E_2$ (40 mg TBA and 8 mg $E_2$) also increased circulating IGF-1 concentration in lambs. Circulating IGF-1 concentration began to rise immediately following implantation; by d 3 and d 10 following implantation sera from wethers implanted with TBA/$E_2$ showed a 32% and a 51% increase, respectively, in IGF-1 concentration as compared to sera from nonimplanted wethers ($P<.001$; Johnson et al., 1996b). This steroid-induced increase in circulating IGF-1 concentration was maintained throughout the entire 24 d duration of the study. Steady-state IGF-1 mRNA concentrations were measured in liver samples collected from these animals on d 24. Northern blot analysis revealed that hepatic IGF-1 mRNA levels were increased 2.5 fold in TBA/$E_2$-implanted animals compared to nonimplanted animals ($P<.01$; Johnson et al., 1996b). These data suggest that liver may be the source of at least part of the increased circulating IGF-1 in steroid-implanted sheep. It is possible that TBA/$E_2$ implants also may increase IGF-1 mRNA levels in muscle resulting in altered local IGF-1 production in this tissue. A recent report that treatment of elderly men with testosterone increases the steady-state level of IGF-1 mRNA in muscle tissue supports this hypothesis (Urban et al., 1995). Additionally, alterations in local production of IGF binding proteins by muscle or other cells found in muscle tissue may alter the bioactivity of locally-produced or circulating IGF-1. Consequently, a complete understanding of the role of IGF-1 in anabolic steroid-induced muscle growth will require analysis of the effects of anabolic steroids on local production of IGF-1 and IGF binding proteins in muscle tissue.

**Potential Role of Satellite Cells in Revalor-S-Induced Muscle Growth.**

During embryonic development of muscle tissue, mononucleated muscle precursor cells proliferate, differentiate, and eventually fuse to form myotubes that mature into multinucleated muscle fibers found in postnatal muscle tissue (Dayton and Hathaway, 1989). Because the number of muscle fibers in meat-producing animals essentially is fixed at birth, postnatal muscle growth is due primarily to hypertrophy (an increase in length and diameter) of existing, multinucleated muscle fibers. This increase in fiber size is accompanied or preceded by an increase in muscle DNA that is necessary to support the increased size of the fiber (Powell and Aberle, 1975; Harbison et al., 1976; Swatland 1977; Trenkle et al., 1978). Because the nuclei in muscle fibers are unable to divide, the source of this DNA initially was a mystery. However, it is now known that specialized, mononucleated cells known as satellite cells are responsible for providing this critically needed DNA to growing muscle fibers (Mauro 1961; Campion 1984). Satellite cells fuse with existing fibers and, in doing so, contribute their nuclei to the fiber (Moss and Leblond, 1970; Moss and Leblond, 1971). From 60 to 90% of the DNA in mature muscle fibers originates from satellite cells (Allen et al., 1979). Thus, proliferation of satellite cells and their fusion with muscle fibers to provide DNA required for fiber growth may be critical rate-limiting step in muscle growth. Thus it is significant that the number of satellite cells decreases dramatically as animals become older; and, in adult animals, the remaining satellite cells normally exist in a quiescent state in which proliferation does not occur (Dodson and Allen, 1987; Bischoff 1990a; Moss and Leblond, 1970; Campion 1984). Because fusion of a satellite cell with a growing muscle fiber results in loss of the satellite cell, satellite cells must be stimulated to proliferate in order to maintain their population in growing muscle. Because the number of satellite cells in muscle decreases substantially during normal growth (Allen et al., 1979), the balance between proliferation and fusion appears to be tipped toward fusion. Consequently, the number of active satellite cells and their rate of proliferation may limit the rate of DNA accretion and hence the potential for muscle growth at all stages of growth. Thus, increasing either the rate of satellite cell proliferation or the number of proliferating satellite cells should enhance muscle growth rate and efficiency. Because current evidence shows that IGF-1, fibroblast growth factor-2 (FGF-2), platelet-derived growth factor (PDGF) and transforming growth factor beta-1 (TGF beta-1) play major roles in regulating proliferation and differentiation of satellite cells (Allen and Boxhorn, 1989; Allen and Rankin, 1990; Hathaway et al., 1991; Greene and Allen, 1991; Dayton and Hathaway, 1991), the response of satellite cells to these growth factors may be a key element in determining the rate and extent of satellite cell proliferation in muscle tissue.

Biological activity of IGF is regulated by a family of six IGF binding proteins (IGFBPs) (Clemmons 1991; Binoux et al., 1991; Baxter 1991; Reeve et al., 1993; Oh et al., 1993; Frost et al., 1993; Figueroa et al., 1993; Conover and Kiefer, 1993; Clemmons et al., 1993) whose activities are regulated by IGFBP-specific proteases (Fowlkes and Freemark, 1992; Davenport et al., 1992; Nam et al., 1994; Kanzaki et al., 1994; Claussen et al., 1994; Cheung et al., 1994) . Consequently, the level of IGFBPs and IGFBP-specific proteases in muscle tissue may play a significant role in regulating satellite cell response to IGF. Despite the ability of IGF-1, FGF, PDGF and TGF beta to regulate division of actively proliferating satellite cells, these growth factors are not able to activate quiescent satellite cells. Consequently, whether satellite cells are quiescent or activated may play a crucial role in their ability to respond to mitogenic growth factors and to support muscle growth. An extract obtained from crushed muscle (CME) has been shown to activate quiescent satellite cells (Bischoff 1986; Chen et al., 1994; Chen and Quinn, 1992; Bischoff 1990b). Fractionation of CME has shown that it contains transferrin, FGF-2, and PDGF-BB in addition to some unidentified mitogenic factor(s) (Chen et al., 1994). Recently, Allen and coworkers have shown that hepatocyte growth factor (HGF) is able to activate quiescent satellite cells in culture; these workers have hypothesized that HGF may be at least one of the unidentified active components of CME (Allen et al., 1995).

Because muscle satellite cells play a crucial role in postnatal muscle growth, it seemed likely that an increased proliferation of satellite cells could be involved in the increased rate of muscle growth observed in steroid-implanted steers. Consequently, we examined the growth factor responsiveness of cell cultures established from satellite cells isolated from steroid-implanted and nonimplanted steers (Frey et al., 1995). Using procedures in routine use in our laboratory (Hathaway et al., 1991; Frey et al., 1995), we isolated satellite cells from the semimembranosus muscles of nonimplanted steers and steers that had been implanted for 40 days with a combined TBA and $E_2$ implant. Satellite cells were stored in liquid nitrogen for use in later studies. The effects of growth factors on proliferation of bovine satellite cell cultures were assessed in a serum-free medium that was a slight modification of a medium that had previously been shown to support growth of bovine satellite cells (Greene and Allen, 1991). We have observed that satellite cells isolated from sheep that are approaching market weight under go a 24 - 48 h period of little or no proliferation (lag phase) after being placed in culture (Hathaway et al., 1991). A similar lag phase observed in satellite cells isolated from adult rat muscle has been interpreted to indicate that the majority of satellite cells in uninjured adult muscle are in a quiescent ($G_o$) phase (Dodson and Allen, 1987; Johnson and Allen, 1993). This lag phase in culture is thought to represent the time required for the cells to re-enter the $G_1$ phase and begin to proliferate. Satellite cells isolated from rats of different ages exhibit variable lag periods (Schultz and Lipton, 1982), suggesting that their activation state and(or) their response to growth factors varies with the age of the rat from which they were isolated. Based on the preceding information, we believe it is critical to examine the properties of satellite cells from nonimplanted and implanted steers approaching market weight to determine if implantation affects the activation state of these cells or their responsiveness to growth factors that have been shown to affect satellite cell proliferation and differentiation. Isolation and culture of satellite cells from implanted and nonimplanted steers allows us to assess the effects of steroids on these parameters.

**Effect of Revalor-S on Growth Factor Responsiveness of Cultured Satellite Cells Isolated from Implanted and Nonimplanted Steers**

Figure 5 shows the effect of IGF-1 and FGF-2 on proliferation of cultured satellite cells from nonimplanted and TBA/$E_2$-implanted steers. Cells were plated on basement membrane Matrigel coated plates in DMEM containing 10% fetal bovine serum and allowed to attach for 48 h. At the end of this attachment period, cultures were washed 4 times with DMEM to remove any residual serum components. Serum-free medium containing 10 ng IGF-1 and 50 ng FGF-2/ml then was added to the cultures and incubation was continued for 72 h. Control cultures for each animal were treated with basal serum-free medium containing no IGF-1 or FGF-2. Cell counts for growth-factor-treated cultures from nonimplanted and implanted steers are shown in Figure 5. Proliferative response to growth factors for each steer was expressed as the percent change in cell number in growth factor-treated cultures relative to the cell number in control cultures from the same animal. In the presence of growth factors, the proliferative response of satellite cells isolated from TBA/$E_2$-implanted steers was 18% greater than the response of satellite cells isolated from nonimplanted steers ($P<.05$; Frey et al., 1995). These data are consistent with a report that satellite cells isolated from female rats treated with trenbolone were more sensitive to FGF-2 and IGF-1 than were satellite cells from control rats (Thompson et al., 1989). Although rats are not a particularly good model for large ruminants, we believe these data support our results showing that satellite cells from TBA/$E_2$-treated steers are more responsive to a growth factors than are satellite cells isolated from nonimplanted steers. This increased responsiveness may indicate that, even after 48 h in culture, a higher percentage of the cells isolated from nonimplanted steers are quiescent and nonresponsive to growth factors; this, suggests that there is difference in the in vivo satellite cell activation state between implanted versus nonimplanted steers. Alternatively, proliferation of satellite cells may be more responsive to IGF-1 and FGF-2 when obtained from implants than nonimplanted steers due to an alteration in the number or affinity of satellite cell receptors for IGF-1 and/or FGF-2. At this point, the biological mechanism by which anabolic steroid treatment of steers is able to influence the growth factor responsiveness of their satellite cells in culture is unclear.

All primary satellite cell cultures are contaminated by nonmuscle cells; presence of these cells complicates interpretation of data from these cultures. To assess the degree of nonmuscle cell contamination in our bovine muscle cell preparations, we analyzed the fusion percent ([nuclei in myotubes/total nuclei] x 100). Cultures of satellite cells isolated from nonimplanted or TBA/$E_2$-implanted steers gave approximately equal fusion (57 $\pm$ 2.3% in cultures from implanted steers and 53 $\pm$ 2.3% in cultures from nonimplanted steers) on day 8 in culture (Frey et al., 1995). Thus, it is unlikely that differences in number of myogenic cells in cultures isolated from nonimplanted and TBA/$E_2$-implanted steers contributed to the difference in responsiveness to IGF-1 and FGF-2.

We also assessed whether TBA and estradiol had a direct effect on proliferation rate of cultured bovine satellite cells. In these studies, bovine satellite cells in serum-free medium were treated for 72 hrs with TBA and estradiol; direct effects of these hormones as well as their effect on the responsiveness of the cells to FGF-2 and IGF-1 were monitored. Addition of TBA and estradiol to the culture medium at concentrations at least as great as those found circulating in implanted steers ($10^{-7}$ M and $2 \times 10^{-8}$ M, respectively) had no effect on the proliferation rate of cultured bovine satellite cells (Frey et al., 1995). Additionally, the presence of TBA and estradiol in the culture medium did not alter the response of satellite cells to 10 ng IGF-1 and(or) 50 ng FGF-2/ml (Frey et al., 1995). Thus, it did not appear that TBA and

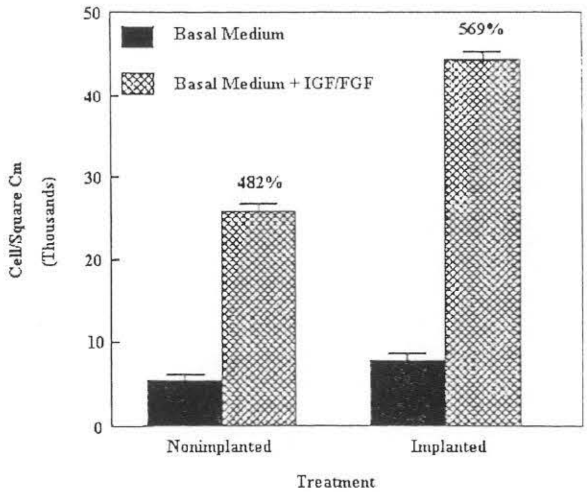



**Figure 5:** Effects of IGF-1 and/or FGF-2 on cell proliferation in primary satellite cell cultures from nonimplanted and TBA/$E_2$ implanted steers. After a 48 h attachment period, satellite cell cultures from nonimplanted or implanted steers were treated daily with basal serum-free medium (DMEM and MCDB Medium 201 in a 3:1 ratio, 500 µg Deutsch fetuin/ml, 1 µg BSA-linoleic acid/ml, $10^{-9}$ M dexamethasone, 3.75 ng sodium selenite/ml, 500 ng biotin/ml, 50 ng fibronectin/ml, $10^{-9}$ M insulin, 10 µg ascorbic acid/ml, and 100 ng vitamin E/ml) or with basal medium containing IGF-1 (10 ng/ml) and FGF-2 (50 ng/ml). The growth factor responsiveness of the satellite cell cultures from each animal was assayed in three separate assays each of which contained triplicate determinations for each growth factor treatment and the data shown was obtained by pooling the results of these assays across animals within treatments. To correct for small, but unavoidable, differences in plating density between animals, stimulation of cell proliferation for each animal was calculated as a percent of the proliferation of control cultures (grown in basal serum-free medium without IGF-1 or FGF-2) from that animal. Bars show the mean and standard error for the combined data obtained from these experiments. The numbers above the bars are the average percentage increase of cell number in IGF-1/FGF-2 treated cultures as compared to cultures maintained in basal medium. Cell number in IGF/FGF treated cultures from nonimplanted steers increased 482± 18% as compared to corresponding cells grown in basal medium, and cell number in IGF-1/FGF-2 treated cultures from implanted steers increased 569± 22% as compared to corresponding cells grown in basal medium. Thus, the growth factor responsiveness of satellite cells from implanted steers was 18% greater than that of satellite cells from nonimplanted steers ($P < .05$).

estradiol had any direct effect on bovine satellite cell proliferation or on responsiveness to IGF-1 and(or) FGF. To our knowledge there is only a single report documenting a small but significant effect of testosterone on proliferation of the L6 rat myogenic cell line (Powers and Florini, 1975). Other reports have found no effect of androgens such as testosterone and trenbolone on proliferation of cultured myogenic cells (Gospodarowicz et al., 1976; Thompson et al., 1989). Thus, the inability of TBA to directly stimulate proliferation of myogenic cells in our study is consistent with the observations of others. Similarly, we are not aware of any reports showing that estradiol has a direct effect on proliferation of cultured satellite cells.

Our data showing that neither TBA nor estradiol has any effect when added directly to bovine satellite cell cultures provides convincing evidence that these hormones have no direct effect on proliferation of satellite cells or on the responsiveness of satellite cells to other growth factors. Thus, it is likely that the effect of anabolic steroids on satellite cells is indirect. Our studies and those of others (Hunt et al., 1991; Hongerholt et al., 1992) have shown that circulating IGF-1 levels increase in steers treated with a combination of estradiol and TBA. Since IGF-1 stimulates proliferation of satellite cells in vitro, it is possible that elevated circulating levels in vivo may stimulate satellite cell proliferation.

## Summary

The diagram in figure 6 summarizes our concept of the mechanism by which Revalor-S increases muscle growth. The combination of TBA and $E_2$ results in increased steady-state levels of hepatic IGF-1 mRNA and increased circulating concentrations of IGF-1. Because hepatic IGF-1 production generally has been shown to be dependent upon the circulating concentration of growth hormone, it is interesting to note that the preponderance of studies have failed to detect a Revalor-S-induced increase in circulating growth hormone concentration (Hunt et al., 1991; Hongerholt et al., 1992; Hayden et al., 1992) even though we have found that circulating IGF-1 concentrations and steady-state hepatic IGF-1 mRNA levels are significantly elevated by Revalor-S treatment. These data suggest that Revalor treatment may increase circulating IGF-1 concentrations without increasing circulating somatotropin concentration. A possible explanation for this uncoupling my be found in a report that estradiol increases the number and affinity of hepatic somatotropin receptors (Breier et al., 1988b). These receptor changes may make liver IGF-1 production more responsive to somatotropin. Alternatively, certain anabolic steroids may act directly to increase the production of IGF-1 by the liver. Because muscle has been shown to have both androgen and estrogen receptors, it also is possible that TBA/$E_2$ treatment may increase the level of muscle IGF-1 mRNA in a manner similar to that observed for hepatic IGF-1 mRNA levels. Thus, locally-produced levels of IGF-1 also may be increased by TBA/$E_2$ treatment. Because IGF-1 is an extremely potent anabolic agent for skeletal muscle, increased circulating and(or) local IGF-1 levels coupled with increased satellite cell sensitivity to IGF-1 provide a possible mechanism for the increased muscle growth observed in TBA/$E_2$-implanted steers.

One potential practical result of our findings is the possibility that monitoring Revalor-S-induced changes in circulating IGF-1 may provide a sensitive and useful marker for judging the duration of the biological effectiveness of an implant. Circulating IGF-1 concentration ultimately may be more useful than circulating TBA or $E_2$ concentration for determining when the biological action of an implant has diminished to a point that re-implantation is necessary to maintain maximum implant effectiveness.

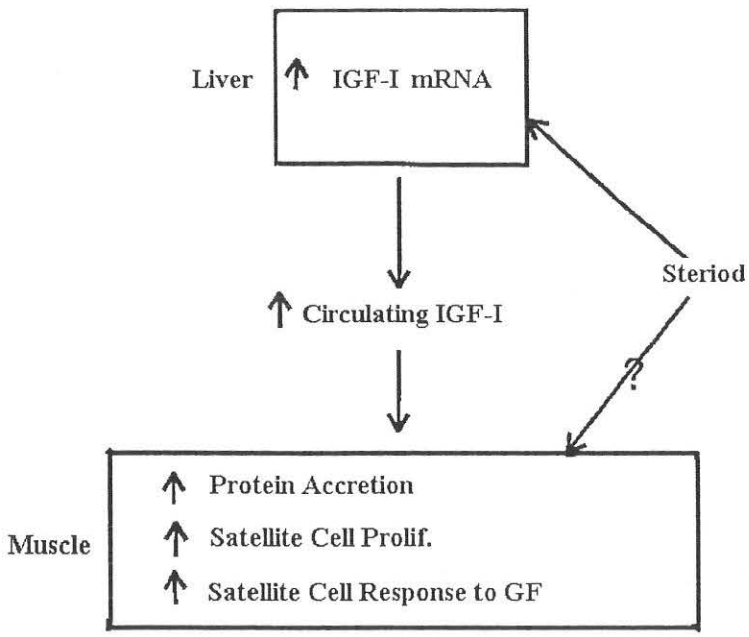



**Figure 6:** Potential effects of TBA and/or $E_2$ on liver and muscle tissues in Revalor-S implanted steers.

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## QUESTIONS & ANSWERS

**Q:** Are implants stimulating synthesis of the binding proteins or decreasing proteases that degrade binding proteins?

**A:** I don't know. We haven't looked at the mRNA. In certain situations like pregnancy, proteases are stimulated. But we don't have the answer yet.

**Q:** What source of muscle cells are you culturing?

**A:** Both the muscle cells and satellite cells used in culture are from beef cattle.

**Q:** If you increase the dose level of steroids or use combination implants, are you going to change the effects on IGF you see and in which direction?

**A:** I don't know, but I would presume that up to some point, you increase the effect on IGF. At some break point, you might reach a plateau or a decrease, I don't know. I believe there must be a titration effect, but I don't know that at this time.

## FACTORS AFFECTING RELEASE RATES AND BLOOD LEVELS OF HORMONES FROM STEROIDAL IMPLANTS

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### ABSTRACT

Duration of anabolic activity and persistence of hormone release from implants needs to be considered in the design and implementation of implant programs for beef producers. Genetic potential to gain and deposit lean tissue in the carcass and the age of the animal may determine the optimal release (payout) rate of estradiol from an implant. Optimal release rates of TBA for cattle performance have not been studied. Implant excipient (carrier) has a pronounced effect on the release rates of hormones from ear implants. Payout of anabolic agents from silastic rubber-based implants generally is slower rate but persistence is longer compared to compressed pellet implants. Release rates of hormones from lactose-based implants appear to be faster than from cholesterol-based implants. Hormone release rate is slower in suckling calves than in older animals. There also may be an age or weight dependency on implant response by suckling calves. Combining estradiol and trenbolone acetate in the same implant results in persistently higher blood levels of estradiol and perhaps an extended growth response as compared to administering the same two agents in separate implants. More definitive information about the relationships between implant release rate, threshold concentrations of circulating hormones, and animal performance would help to fine tune implant programs.

### INTRODUCTION

Beginning early in 1997, at least 19 anabolic steroidal implant products will be available for use in beef cattle in the United States. Hormone concentrations and indications for use are presented elsewhere in these proceedings. Implant programs should be designed to achieve predetermined performance and carcass merit goals. Length of anabolic activity or release (payout) rate of implants is one of several factors that need to be considered in the design of implant programs. The purpose of this paper is to discuss some of the factors that affect length of anabolic activity and circulating blood levels of anabolic steroids in cattle.

#### Optimal Payout Rates for Growth Promotion

In order to discuss the factors which affect payout rates of implants, it is beneficial first to examine rates of payout that maximize cattle growth. Wagner et al. (1979) titrated the dosage of estradiol for maximal rate of gain in feedlot steers; and they concluded from a four-site study that a payout rate of 55 mcg/d was the minimal dose required for maximal gain response. Hancock and Preston (1988), utilizing maximum reduction in plasma urea nitrogen (PUN) as the response criterion, concluded that an estradiol payout rate of 33 mcg/d was the optimum dose for maximum anabolic activity. More recently, however, Preston and Herschler (1992) reported that a greater payout rate (at least 174 mcg/d) of estradiol was required for maximum gain and efficiency of feedlot steers. One can speculate on the reasons for the discrepancy among estimates of optimal estradiol payout rates for feedlot steers between the studies of Wagner et al. (1979; 55 mcg/d) and Preston and Herschler (1992; at least 174 mcg/d). Nonimplanted steers in the study of Wagner et al. (1979) gained 1.04 kg/d; those in the Preston and Herschler (1992) study gained 25% faster (1.30 kg/d). Therefore, seems that cattle with a higher propensity to gain and deposit carcass lean tissue may require a higher daily release rate of estradiol. The minimum estradiol release rate (at least 174 mcg/d) to maximize gain proposed by Preston and Herschler (1992), is approximately that rate provided for a short period of time (60 d) by Synovex-S® (183mcg of E2/d, Table 2; Rumsey et al, 1992). Optimal release rates of trenbolone acetate (TBA) for maximum growth promotion have not been similarly studied.

Wagner (1983) titrated the optimal dosage of estradiol for rate of gain in suckling calves by using implants that released estradiol at rates ranging from 0 to 81 mcg/d. A six-trial summary indicated that a release rate of approximately 30 mcg/d provided maximum gain response. Presumably, young calves should require a lower dose of estradiol for maximum gain response than older, larger animals.

**Measurement of Release Rates of Hormones from Anabolic Implants**

Release rates of anabolic hormones from ear implants are generally biphasic (Figure 1) although some exceptions for TBA/estradiol combinations are discussed in a later section. Blood serum or plasma hormone levels of implanted animals are characterized by a high initial peak in the first 1-3 days, followed by a depletion curve that generally follows first-order kinetics. A theoretical threshold serum or plasma hormone concentration exists below which anabolic stimulation or growth promotion from an implant ceases. Threshold serum or plasma concentrations have not been elucidated for any of the anabolic hormones. The absence of this critical information has caused confusion in determining anabolic life of implants. For the example in Figure 1, if the true threshold concentration for the hormone depicted was 15 pg/ml (threshold "a"), then the implant would have an anabolic life of about 55 d. Conversely, if the true threshold concentrations were 10 pg/ml (threshold "b") or 5 pg/ml (threshold "c"), then the implant would have an anabolic life of about 80 or 140 d, respectively.

Several experimental methods have been employed to estimate release rates and(or) active life of anabolic implants. These include:

- Implant/explant studies
- Measurement of blood levels of anabolic hormones over time
- Metabolic measurements (e.g., PUN, nitrogen balance)
- Animal performance

Individually, these techniques provide valuable information, but they are somewhat limited in their ability to provide definitive measures of release rates and length of anabolic activity. Implant/explant studies provide a means by which to measure disappearance of anabolic hormones from an implant over time, but they provide only an average daily release rate over time. Measurement of blood levels of an anabolic hormone over time may better characterize a release curve, but this does not account for other circulating metabolites of the particular hormone measured. More importantly, threshold concentrations of circulating hormones, or concentrations below which anabolic stimulation or activity is not maintained, have not been established for beef cattle. Measures of nitrogen metabolism (e.g., PUN, nitrogen balance) are more sensitive measurements of anabolic activity, but they are not necessarily highly correlated with animal performance over time (e.g., Istasse et al., 1988). Animal performance (rate and efficiency of gain), particularly performance changes between interim periods in a study, may provide some insight into length of anabolic activity; but interim performance is highly variable and susceptible to environmental effects that may affect weighing conditions and resulting conclusions. Therefore, it seems that studies designed to measure length of anabolic activity or release rates of implants should incorporate as many as these techniques as possible.

**Figure 1. Biphasic nature of hormone absorption from an ear implant.**

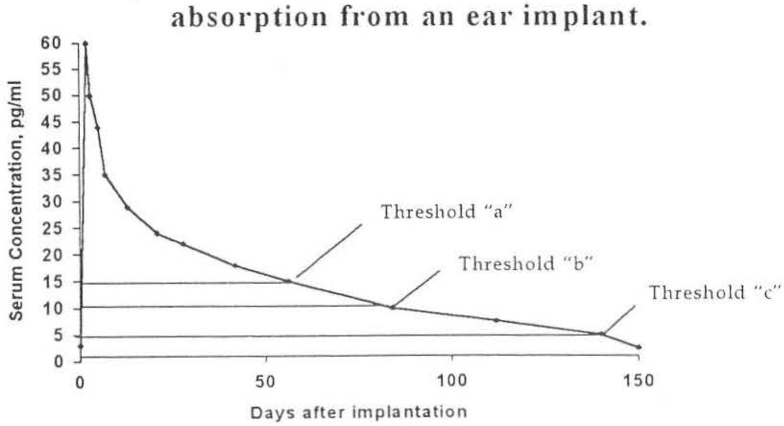

**Table 1. Primary component of carriers for anabolic implants.**

| Implant | Carrier |
|---|---|
| Ralgro (36, 72 mg) | Lactose |
| Synovex (S, H, C, P)[a] | PEG[c] |
| Component (S,H,C) | PEG |
| Implus (S, H, C[b]) | PEG |
| Revalor (S, H, G) | Cholesterol |
| Finaplix (S, H) | Lactose |
| Compudose | Silastic rubber |
| Encore | Silastic rubber |

[a]S = steer, H = heifer, C = calf, P = Plus.
[b]Calf-oid.
[c]Polyethylene glycol.

**Table 2. Effect of carrier on estradiol release rates over time.**

| Implant | Est. rate, mcg/d | Time, d | Reference |
|---|---|---|---|
| Silastic rubber[a] | 66.0 (77) | 146 | Wagner (1983) |
| | 53.5 (62.4) | 196 | |
| | 52.7 (61.5) | 208 | |
| Compressed Pellet[b] | 183 | 60 | Rumsey et al., 1992 |
| | 23 | 60-150 | |

[a]254 cm implant. No. in parenthesis is estimate for a 3.0 cm implant.
[b]Synovex-S.

**Factors Affecting Release Rates**

Several factors have been implicated as having an effect on release rates of anabolic hormones from ear implants, including composition (solubility) of the excipient, age of the animal, mixtures of hormones contained in the implant, and implanting technique. These will be discussed individually.

***Composition or solubility of the excipient.*** The excipient (also referred to as the implant support, matrix, or carrier) for various implant products differ in composition (Table 1); this may affect length of anabolic activity and(or) release rates of implants. Silastic rubber excipients are completely insoluble, whereas solubility of other excipients (lactose, PEG, or cholesterol) in compressed pellet implants vary. The difference in payout rate and length of payout between a silastic rubber implant (containing approximately 24 mg estradiol) and a compressed pellet implant (containing approximately 14 mg estradiol) is illustrated in Table 2. Estradiol release from the silastic rubber implant was characterized by a lower, but more prolonged release over time; initial estradiol release from the compressed pellet implant was higher initially, but release diminished more quickly with time.

Initially, lactose was used in compressed pellet implants because lactose is well absorbed by tissues and yields hard pellets (Istasse et al., 1988). However, its high degree of solubility may increase the hormone release rate and(or) reduce the length of anabolic activity compared to other carriers. Henricks et al. (1982) implanted heifers with 300 mg TBA in a lactose-based implant; they reported that 13.1 and 2.7% of the original TBA dose remained after 62 and 99 days, respectively. Similarly, unpublished data of Roussel-Uclaf showed that 9.1% of an original TBA dose remained in a lactose-based implant 107 d post-implantation. Conversely, 20% of a TBA dose remained in the implant 140 days after administration of TBA in a cholesterol-based implant in the ears of calves (Roussel-Uclaf, unpublished data). Istasse et al. (1988) compared implanting growing bulls once (18 wk before slaughter) with a cholesterol-based implant, versus implanting three times (18, 12, and 6 wk before slaughter) with a lactose-based implant. Each implant contained 200 mg TBA and 40 mg estradiol.

In one study, rate and efficiency of gain were similar between treatments even though steers receiving a lactose-based implant were implanted three times. However, in a three-trial summary, Bartle et al. (1992) found no difference in performance of feedlot steers administered 140 mg TBA plus 28 mg estradiol in either a lactose-based or cholesterol-based implant, and fed for 140 to 168 d.

*Age of animal.* Release rates of implants may be slower in suckling calves than older animals. Rumsey et al. (1992) reported that approximately 25% of the original dose of estradiol benzoate and progesterone remained after 60 d in a compressed pellet implant (Synovex-S®) following administration to yearling feedlot steers. Ritchie et al. (1990), however, reported that approximately 50% of the original dose of estradiol benzoate and progesterone remained 83 d after implanting suckling calves with Synovex-C®, and that approximately 25% of the original dose remained 172 d after implantation (Table 3). The calculated estradiol payout rate from d 83-172 (21.4 mcg/d of E2, Table 3) is very close to the 30 mcg/d release rate estimated by Wagner (1983) to be optimal for gain of suckling calves. The reason for this difference in absorption rate for suckling calves and yearling calves has not been elucidated. However, Gill et al. (1986) detected no benefit from reimplanting suckling calves in a two-trial summary that averaged 241 d in duration. Similarly, Corah et al. (1996) reported no benefit from reimplanting suckling calves with Synovex-C in a summary of four studies that were conducted for periods of 172 to 188 d. Although the study by Gill et al. (1986) was conducted over the winter with fall-born calves, it seems doubtful that reduced blood flow to the ear as a result of cold ambient temperatures is a major factor; studies by Ritchie et al. (1990) and Corah et al. (1996) were conducted on spring-born calves. There may also be an age or weight dependency on reponse to suckling implants of estradiol and progesterone (Corah et al., 1996), and zeranol (Greathead, 1984).

*Mixtures of hormones contained in the implant.* Combinations of either TBA, testosterone propionate, or progesterone with estradiol in the same implant may extend the absorption time of estradiol in ruminants (Heitzman et al., 1977; Riis and Suresh, 1976; Harrison et al., 1983). Nevertheless, blood levels of TBA do not appear to be altered as a result of combining TBA with estradiol in the same implant. Heitzman et al. (1981) implanted steers with either 20 mg estradiol, 140 mg TBA, or 20 mg estradiol plus 140 mg TBA in separate implants or combined in a single implant. Rate of gain was faster ($P<.05$), and feed conversion was improved for steers implanted with the combination implant vs those administered the same dosage of hormones in separate implants. Further, plasma estradiol concentrations for steers receiving the combination implant were significantly higher than controls for 91 d; administration of estradiol in a separate implant significantly elevated plasma estradiol for only 28 d. The authors concluded that physically mixing the hormones resulted in a slower and more sustained release of estradiol from the implant. Similar results of elevated estradiol levels for an extended period of time in steers implanted with a combination of estradiol and TBA (Revalor-S®) can be found in reports by Hickman et al. (1994) and Johnson et al. (1996).

Whether elevated blood levels of estradiol over time was the result of delayed release is not clear because residual hormone in the implants was not measured in any of the studies discussed in this section. Nevertheless, blood concentrations of estradiol remained elevated for an extended period of time when administered in the same implant with TBA. Implanting with an estrogenic implant following a combination estradiol/trenbolone acetate implant thereby may be of limited value.

**Table 3. Payout rate of estradiol benzoate/progesterone implants[a] in suckling calves**

| Item | 83 d | 172 d |
|---|---|---|
| No. steers | 28 | 25 |
| Age, d | 89 | 0 |
| EB payout, % | 50.5 | 76.9 |
| avg. mcg E2/d | 43.8 | 21.4[b] |

[a]Synovex-C. Adapted from Ritchie et al., 1990.
[b]From 83 to 170 d.

***Implanting technique.*** One major source of variation in implant response is implanting technique. Improper placement (anywhere other than in the middle one-third of the ear) or crushing of implants upon administration likely will result in more variable absorption rates, increased demonstration of secondary sexual characteristics (e.g., bulling, elevated tailheads, etc.), and variable performance.

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## QUESTIONS & ANSWERS

**Q:** Might differences either between seasons or between calves and yearlings in blood circulation to the ear alter payout of an implant or is payout limited by release of the chemical from the carrier and independent of blood circulation? Calves often lose part of their ear from frostbite but yearlings don't seem to.

**A:** Why is implant release rate slower in calves? Vascularization may be less in calves and blood flow to the ear probably may be lower, especially during cold months. Hormone release probably is related to vascularization and blood volume. That might explain some differences.

# IMPLANTS FOR SUCKLING STEER AND HEIFER CALVES AND POTENTIAL REPLACEMENT HEIFERS

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## ABSTRACT

Growth promoting implants consistently improve average daily gain of steers and heifers from implanting to weaning. The decision to implant is much more important than the decision of which implant to use. Average daily gain responses of approximately .1 pound per day can be expected for steer calves from zeranol and estradiol-progesterone implants. Gain responses in heifers are slightly greater (.12 to .14 pounds per day).

Replacement heifers that can be identified early in life (such as heifers in seedstock herds) should not be implanted. No advantages from implants in puberty age or dystocia rate exist. Heifers that cannot be identified early in the suckling phase as a potential replacement can be implanted once at approximately 2 months of age with little risk of impaired reproductive performance. However, re-implanting replacement heifers increases the risk of a reduced pregnancy rate. Economic analyses of a simulated commercial cow herd indicates that little economic risk exists if all heifers are implanted once at calf working time. However, risk is increased if a very high replacement heifer rate is used and the ranch has a history of greater than 5% reduction in pregnancy rates due to implanting.

## INTRODUCTION

Three types of growth promoting implants are available for use in suckling calves. Several commercially available implants contain 10 mg of estradiol benzoate plus 100 mg progesterone; one commercially available product contains 36 mg of zeranol as the active ingredient; the third calf implant has 24 mg of estradiol 17β (although recent analysis lists indicated that this product has 25.7 mg estradiol 17β). All these products are available for suckling steer calves. The first two types are available and approved for use with suckling heifers including potential replacement heifer calves.

This paper examines the impact of the various implants on average daily gain from implanting to weaning in steer calves, and where appropriate, in heifer calves. Also included is a review of the effects of implants on reproductive performance of implanted heifer calves. All trials included also had non-implanted controls as a treatment group. Average daily gain is the parameter reported rather than weaning weight because weaning age differs. Also non-traditional weaning times are of increased interest. Many additional trials have been conducted that are not included in this review. Implant trials have been very popular for county extension personnel to demonstrate the effectiveness of this technology to local producers. Many such trials were never reported other than in newsletters or obscure proceedings of producer meetings. Therefore, this is not an all-inclusive review of suckling phase implant trials although it should present a representative picture of the response of calves to implants.

### Review of trials for steer calves

Tables 1, 2 and 3 summarize trials conducted with suckling steer calves. The increase in average daily gain by zeranol implanted calves (Table 1) and estradiol - progesterone implanted calves (Table 2) was slightly greater than those for the calves implanted with 24 mg of estradiol 17β (Table 3). One impressive finding is that all of the implants consistently improved performance. Nearly all trials had a positive gain response.

Table 1 summarizes 23 trials where 36 mg of zeranol was implanted once during the suckling phase of steer calves. The average response to zeranol implants in these 23 trials was .097 pound per day from implanting to weaning.

**Table 1. Performance of 36 mg Zeranol implanted once versus unimplanted controls for suckling steer calves.**

| Study | Control Average daily gain (lb) | Difference in Implanted calves (lb/d) |
|---|---|---|
| McReynolds et al., 1979 | 1.52 | +.06 |
| McReynolds et al., 1979 | 1.42 | +.16 |
| Simms et al., 1983 | 2.11 | +.06 |
| Simms et al., 1983 | 1.91 | +.05 |
| Gill et al., 1984 | 1.59 | +.08 |
| Simms and Schalles, 1984 | 2.06 | +.06 |
| Lamm, 1986 | 2.24 | +.23 |
| Lamm, 1986 | 2.16 | +.08 |
| Lamm, 1986 | 1.96 | +.05 |
| Lamm, 1986 | 1.92 | +.09 |
| Lamm, 1986 | 1.86 | +.10 |
| Simms, 1986 | 2.08 | +.17 |
| Simms, 1986 | 1.89 | +.04 |
| Simms et al., 1986 | 1.78 | +.05 |
| Whittington, 1986 | 2.32 | +.09 |
| Whittington, 1986 | 1.94 | +.07 |
| Whittington, 1986 | 1.93 | +.08 |
| Brazle and Whittier, 1988 | 1.88 | +.22 |
| Brazle and Whittier, 1988 | 1.80 | +.04 |
| Brazle and Whittier, 1988 | 1.73 | +.06 |
| Bagley et al., 1989 | 1.56 | +.07 |
| Wardynski et al., 1990 | 2.02 | +.19 |
| Adams et al., 1991 | 1.81 | +.13 |
| *23 Trials* | *Average difference in gain* | *+.097* |

In thirteen trials comparing steer calves implanted once with a 10 mg estradiol plus 100 mg progesterone implant (Table 2) a very similar response (.11 pound increased average daily gain) was noted for implanted calves.

In table 3, data from 14 trials are compared for steer calves implanted with 24 mg of estradiol 17β to data for unimplanted controls. The average implant response was .07 pounds average daily gain. One trial included in this table (Sawyer et al., 1987) was shorter in duration (79 days) than others and produced the greatest response.

**Review of trials using heifer calves**

Fewer research trials have been conducted that examined weight gain responses by heifer calves. In many instances, if heifers were included in the trials, data for steers and heifers were not individually reported, but gain response was given only for the entire calf crop. Such data were reviewed previously by **Corah and Blanding (1991)**. However, in some trials, implanted heifer calves have been compared with unimplanted control heifers. Often these trials were part of a study of the effect of implanting on subsequent reproductive performance. In eight trials, zeranol has been tested for heifers (Table 4).

**Table 2. Performance of 10 mg Estradiol Benzoate with 100 mg Progesterone implanted once versus unimplanted controls in suckling steer calves.**

| Study | Control Average daily gain (lb) | Difference in implanted calves (lb/d) |
|---|---|---|
| Gill et al., 1984 | 1.62 | +.08 |
| Gill et al., 1984 | 1.56 | +.11 |
| Johns et al., 1984 | 1.64 | +.11 |
| Faulkner et al., 1986 | 1.39 | +.05 |
| Lamm, 1986 | 2.24 | +.17 |
| Lamm, 1986 | 2.16 | +.07 |
| Lamm, 1986 | 1.96 | +.02 |
| Lamm, 1986 | 1.92 | +.09 |
| Lamm, 1986 | 1.86 | +.16 |
| Wardynski et al., 1990 | 2.55 | +.20 |
| Wardynski et al., 1990 | 2.46 | +.18 |
| Adams et al., 1991 | 1.81 | +.05 |
| Mader et al., 1994 | 2.63 | +.14 |
| *13 Trials* | *Average difference in gain* | *+.11* |

**Table 3. Performance of 24 mg Estradiol 17β implanted calves versus non-implanted sucking steer calves.**

| Study | Control Average daily gain (lb) | Difference in implanted calves (lb/d) |
|---|---|---|
| Kuhl, 1982 | 1.92 | +.10 |
| Lamm et al., 1983 | 2.33 | +.04 |
| Simms et al., 1983 | 2.11 | +.03 |
| Simms et al., 1983 | 1.91 | +.01 |
| Simms and Schalles, 1984 | 2.06 | +.08 |
| Faulkner et al., 1986 | 1.39 | +.10 |
| Fontenot et al., 1986 | 1.52 | -.05 |
| Greathouse, 1986 | 2.07 | 0 |
| Greathouse, 1986 | 1.62 | +.19 |
| Sewell et al., 1986 | 1.42 | -.08 |
| Whittington, 1986 | 2.10 | +.04 |
| Sawyer et al., 1987 | 1.45 | +.27 |
| Bagley et al., 1989 | 1.56 | +.08 |
| Wardynski et al., 1990 | 2.02 | +.13 |
| *14 Trials* | *Average difference in gain* | *+.07* |

**Table 4. Comparison of suckling heifer calves once implanted with 36 mg Zeranol versus unimplanted calves.**

| Study | Control Average daily gain (lb) | Difference in implanted calves |
|---|---|---|
| Muncy et al., 1979 | 1.05 | +.09 |
| Bolze et al., 1984 | 2.31 | +.18 |
| Gill et al., 1984 | 1.53 | +.11 |
| Faulkner et al., 1986 | 1.18 | +.04 |
| Goerhing, 1985 | 1.63 | +.10 |
| Brazle and Whittier, 1988 | 1.75 | +.09 |
| Brazle and Whittier, 1988 | 1.72 | +.26 |
| Brazle and Whittier, 1988 | 1.72 | +.08 |
| *8 Trials* | *Average difference in gain* | *+.12* |

Gain response averaged .12 pounds per day.

**Table 5. Performance of steer calves twice implanted with 36 mg Zeranol versus non-implanted suckling steer calves.**

| Study | Control Average daily gain (lb) | Difference in implanted calves |
|---|---|---|
| Corah, 1980 | 2.02 | +.23 |
| Lamm, 1983 | 1.98 | +.22 |
| Lamm et al., 1983 | 2.33 | +.12 |
| Simms et al., 1983 | 2.11 | +.19 |
| Simms et al., 1983 | 1.91 | +.04 |
| Lamm and Greathouse, 1984 | 1.96 | +.16 |
| Simms and Schalles, 1984 | 2.07 | +.07 |
| Simms and Schalles, 1984 | 2.06 | +.13 |
| Faulkner et al., 1986 | 1.39 | +.16 |
| Simms, 1986 | 2.08 | +.13 |
| Simms, 1986 | 1.89 | +.06 |
| Simms et al., 1986 | 1.78 | +.09 |
| Bagley et al., 1989 | 1.56 | +.06 |
| Adams et al., 1991 | 1.81 | +.18 |
| 14 Trials | Average difference in gain | +.13 |

**Table 6. Performance of suckling steer calves twice implanted with 10 mg Estradiol Benzoate and 100 mg Progesterone versus unimplanted calves.**

| Study | Control Average daily gain (lb) | Difference in implanted calves |
|---|---|---|
| Lamm et al., 1983 | 2.30 | +.11* |
| Lamm et al., 1983 | 2.03 | +.14 |
| Lamm and Greathouse, 1984 | 1.96 | +.16 |
| Simms and Schalles, 1984 | 2.07 | +.01 |
| Faulkner et al., 1986 | 1.39 | +.18 |
| Adams et al., 1991 | 1.81 | +.08 |
| *6 Trials* | *Average difference in gain* | *+.11* |

Guiterrez (1993) examined the economic impact of implanting replacement heifers; he used an average gain response (from ten trials) of .14 pound per day for his calculations. This was determined by dividing the average weaning weight difference by the days from implanting to weaning. The estimate .14 pound per day is identical to that reported in a Michigan study (Wardynski, 1990). The slightly greater response of heifers than steers to implants is similar to that reported by Nebraska workers (Mader et al., 1994).

**Re-implanting suckling steer calves.**

Calves often nurse their dams until they are 7 to 9 months of age. Most calves are vaccinated, castrated, and implanted at approximately 2 months of age. Therefore, the first implant often is given to the calf 150 to 210 days before weaning. Because most implants are reported to payout in 120 days or less, re-implanting suckling calves may be desirable. Trials comparing steers implanted twice with zeranol (table 5) or with estradiol benzoate and progesterone are presented (Table 6).

Average daily gain during the entire nursing period was slightly greater with two zeranol reimplants (.13 pounds per day) than with one (.097 pounds per day). In the six trials comparing steer calves implanted twice with estradiol-progesterone gain response (.11 lb/d) was similar to that of calves implanted once (.11 lb/d). This observation contrasts with results of a review by Corah and Blanding (1992), in which slightly greater response to re-implanting was noted from estradiol-progesterone than from zeranol. Few data are available on re-implanting heifer calves. In many of those studies, heifers were weaned when the second implant was given at about 6 months of age. Those are trials which were designed primarily to examine the implant effect on reproductive performance.

Re-implanting information for 24 mg estradiol 17β implant is not available. Since this implant is designed for longer payout, re-implanting is not considered necessary.

Figure 1 plots the mean gain responses of each trial against the non-implanted control average daily gains. Steer trial data points are illustrated for all the implant types discussed whereas only zeranol implanted heifers trials are plotted in Figure 1. A linear regression equation for both steers and heifer implant trials shows that the ADG response tended to increase slightly as ADG or calves control increased. However, the percentage of variation accounted for by the regression equations is quite a small (< 5%) and implies that many factors beyond ADG influence response to implants.

**Implants for suckling heifer calves intended as cow herd replacements**

Growth implants have not been widely used in heifer calves because of concern by herd managers about detrimental effects on subsequent reproductive performance of heifers kept as herd replacements. Currently two implants Synovex-C® (estradiol and progesterone) and Ralgro® (zeranol) have received FDA approval for replacement heifer calves. Thorough reviews of this subject have generally concluded that one implant given at or after the heifer is 2 months of age has little or no impact on future reproductive performance (Hargrove, 1994; Deutscher, 1994). Implanted heifers had significantly greater pelvic area when measured at about one year of age, but these differences were very small at the time the heifer delivered her first calf or at about two years of age. Consequently, the implanted heifers had no less calving difficulty than non-implanted heifers.

Lower pregnancy rates during the breeding season is the major concern of ranchers about implanting heifer calves. Following tables present the difference in pregnancy percentages of heifer calves implanted once at birth (Table 7), once at calf-working time (approximately 2 months of age Tables 8 and 9), once at weaning time (Tables 10 and 11), or multiple implants (Tables 11 to 13). Both the 36 mg zeranol implants and the 10 mg estradiol plus 100 mg progesterone implants have been examined. Implanting at birth was detrimental to breeding season pregnancy rates (Table 7).

In contrast, The average loss in percentage pregnant due to one implant (at calf-working time) is quite small (tables 8 and 9).

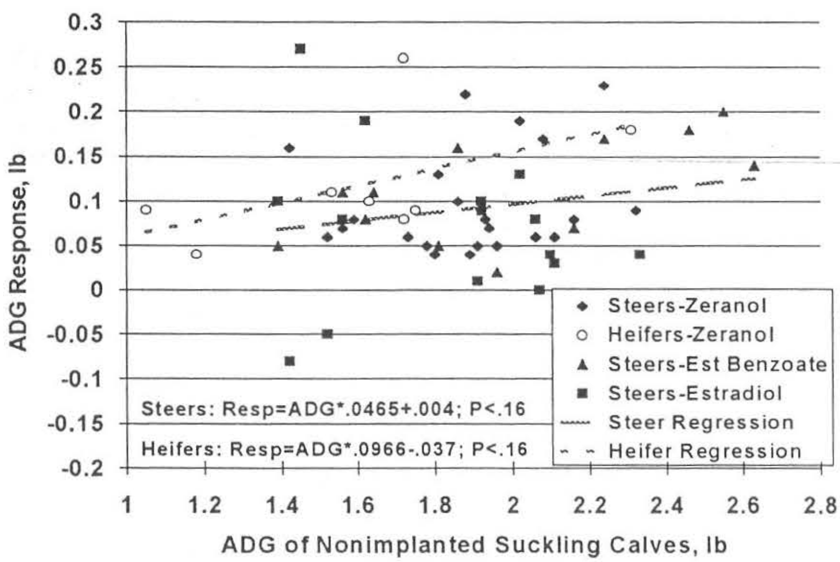


Figure 1. ADG response to implants for calves in various trials gaining at different rates.

**Table 7. Summary of pregnancy rate of heifers implanted 1X at birth with Zeranol (36 mg).**

| Study | Control | Difference from Control Group |
|---|---|---|
| Simms et al., 1982 | 93 | -37 |
| Morrow et al., 1983 | 95 | -50 |
| Goerhing et al., 1985 | 78 | -30 |
| *3 Trials* | *Average difference in percent pregnant* | *-39.0* |

**Table 8. Summary of pregnancy rate of heifers implanted once at 1 to 3 months with 36 mg Zeranol.**

| Study | Control | Difference from Control Group |
|---|---|---|
| Muncy et al., 1979 | 46 | +4 |
| Sprott et al.., 1979 | 100 | 0 |
| Sprott et al., 1979 | 85 | -4 |
| Sprott et al., 1979 | 59 | -4 |
| Fuller et al., 1980 | 83 | -10 |
| Huston et al., 1980 | 77 | -7 |
| Morrow et al., 1983 | 95 | -11 |
| Deutscher et al., 1986 | 96 | 0 |
| Goerhing et al., 1985 | 78 | +1 |
| Lamm and Greathouse, 1986 | 86 | 0 |
| Bolze and Corah, 1988 | 86 | +4 |
| Marshall and Hargrove, 1989 | 52 | -2 |
| Hixon et al., 1994 | 72 | +19 |
| *13 Studies* | *Average difference in percent pregnant* | *-0.8* |

**Table 9. Summary of pregnancy rate of heifers implanted once at 1 to 3 months with Estradiol and Progesterone.**

| Study | Control | Difference in Implanted Group |
|---|---|---|
| Lawrence et al., 1985 | 92 | -2 |
| Ragland et al., 1990 | 91 | -2 |
| Rutter, 1990 | 97 | -6 |
| Carpenter and Sprott, 1991 | 77 | +2 |
| Whittier et al., 1991 | 89 | -7 |
| Rusk et al., 1992 | 99 | -9 |
| Hancock et al., 1993 | 93 | -10 |
| Hixon et al., 1994 | 72.2 | -8* |
| Hixon et al., 1994 | 72.2 | +3 |
| *9 Trials* | *Average difference in percent pregnant* | *-3.2* |

The large variation among trials is due partly to small numbers of heifers in some treatment groups. This summary of trials should not lead to any conclusions that one implant type is better than another when given properly at 2 months of age. When heifers were implanted once at or near weaning time, the risk of reduced pregnancy rates was slight.

Most producers can identify potential replacements at this time. Therefore, the decision to implant stocker heifers to increase gain and not to implant replacements should be possible for most operations. Implanting heifers more than once increases the risk of reproductive loss (Tables 11, 12, and 13).

**Table 10. Summary of pregnancy rate of heifers implanted with single zeranol 36 mg at or near weaning.**

| Study | Control | Difference from Control Group |
|---|---|---|
| Nelson et al., 1972 | 100 | -14 |
| Corah, 1980 | 96 | -7 |
| Huston et al., 1980 | 77 | -1 |
| Pruitt et al., 1980 | 96 | -7 |
| Morrison et al., 1983 | 85 | +1 |
| Bolze et al., 1984 | 94 | +3 |
| Bolze et al., 1984 | 74 | +9 |
| Turner and Raleigh, 1984 | 85 | +6 |
| Deutscher et al., 1986 | 96 | 0 |
| Bolze and Corah, 1988 | 86 | +5 |
| Pritchard et al., 1989 | 82 | -14 |
| *11 Trials* | *Average difference in percent pregnant* | *-1.7* |

**Table 11. Summary of pregnancy rate of heifers implanted with Estradiol and Progesterone once at weaning or given multiple implants.**

| | | Difference from Control Group | | |
|---|---|---|---|---|
| Study | Control | 1st | 2nd | 3rd |
| Lawrence et al., 1985 | 96 | | -18* | -33* |
| Hancock et al., 1993 | 93 | -6 | 0 | |

* Syn. -H

**Table 12. Summary of pregnancy rate of heifers implanted 2X with Zeranol (36 mg).**

| Study | Control | Difference from Control Group |
|---|---|---|
| Sprott, et al., 1979 | 59 | +3 |
| Huston et al., 1980 | 77 | -7 |
| Staigmiller et al., 1983 | 87 | +2 |
| Staigmiller et al., 1983 | 78 | -15 |
| Marshall and Hargrove, 1989 | 52 | -10 |
| Fontes, 1985 | 79 | +10 |
| Deutscher et al., 1986 | 96 | -38 |
| Lamm and Greathouse, 1986 | 86 | 0 |
| Cohen et al., 1987 | 79 | +6 |
| Walker et al., 1987 | 92 | -28 |
| *10 Trials* | *Average difference in percent pregnant* | *-7.3* |

**Table 13. Summary of pregnancy rate of heifers implanted 3X or 4X with Zeranol (36 mg).**

| Study | Control | Difference from Control Group | |
|---|---|---|---|
| | | 3X | 4X |
| Muncy et al., 1979 | 46 | | -42 |
| Fuller et al., 1980 | 83 | -19 | |
| Deutscher et al., 1986 | 96 | -12 | |
| Deutscher et al., 1986 | 92 | 0 | |
| | | -10.1<br>3 Studies | -42<br>1 Study |

**Economic comparison of implanting potential replacement heifers**

An analysis of the economic implications of implanting heifers at calf working time has been reported by Guiterrez et al. (1993). Three alternatives were compared: Control group with no implants; Alternative II with 50% of heifers implanted at 2 to 3 months of age; Alternative III with all heifers implanted at 2 to 3 months of age. A 400-head commercial cowherd example was used to evaluate the economic impact of Synovex-C® implants under these three plans. These authors concluded: "If the producer's desired replacement rate is between 12 and 15 percent (assuming a 17 and 20 percent retention rate, respectively), and if the expected change or decrease in pregnancy rates from an expected 90 percent is between 0 and 5 percent, then there is little or no economic risk from implanting heifers with Synovex-C® For producers who have a desired replacement rate of 20 percent or greater and the expected decrease in pregnancy rates due to implanting is 5 to 10 percent from an expected 90 percent, there is substantial economic and financial risk from implanting replacement heifers".

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**QUESTIONS & ANSWERS**

**Q:** Does creep feeding alter the response to implants?

**A:** I found nothing on this interaction, but I didn't search that out specifically. I spent most of my time examining the steers versus heifer comparison.

**Q:** One might expect that adding more energy should increase the implant response.

# STOCKER CATTLE RESPONSES TO IMPLANTS[1]

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## ABSTRACT

Implanting grazing cattle is one of the most profitable management tools available to stocker operators. Typically, anabolic implants increase cattle weight gains by 8 to 18% or 15 to 40 lb during the grazing season. Stocker steers appear somewhat more responsive to implants than heifers. The additional gain obtained by implanting is directly related to stocker growth rate as influenced by dietary nutritional adequacy. Thus, high forage quality and availability are important to maximize cattle implant responses. A complementary growth response from implanting and supplementing stockers also is commonly observed. Moreover, additive gain responses should be expected from implants, feed additives, and internal and external parasite control products, because the modes of action of these compounds are distinctly different. The feedlot performance and carcass merit of cattle previously implanted as stockers should not be different from the stockers that are not implanted, provided an adequate feedlot implant program is used to maximize finishing performance.

## INTRODUCTION

If the definition of management is "applying the practices that pay", then implanting should be high on the must-do list of profit-minded stocker operators. Literally hundreds of experiment station studies and Extension and industry field trials over the last four decades have demonstrated conclusively the growth benefits from implanting grazing calves and yearlings. Yet, producer surveys in various states indicate that only 40 to 65% of stockers are implanted; this results in substantial losses in performance and profitability.

Several FDA approved implants are available currently for stocker cattle, as listed in Table 1. Ralgro® was introduced in the late 1960's for use in both steers and heifers. The active ingredient in Ralgro® is 36 mg zeranol, a non-hormonal anabolic compound with mild estrogenic activity (Mallinckrodt Veterinary, 1984). Synovex® implants were approved in the mid to late 1950's as sex-specific, dual-hormone products for steers and heifers. Synovex®-S contains 20 mg estradiol benzoate and 200 mg progesterone, while Synovex®-H contains 20 mg estradiol benzoate and 200 mg testosterone propionate. Both are considered strong estrogenic products and are approved for cattle over 400 lb (Fort Dodge Animal Health, 1983). In the early to mid 1980's, the first generic implants, STEER-oid™ and HEIFER-oid™, were cleared containing the same active ingredients with the same bioavailability as Synovex®-S and -H, respectively. More recently, these products were renamed Implus™-S and -H. In 1997, another pair of generic bio-equivalent implants, Component™ E-S and -H, comparable to Implus™ and Synovex® products became available for stocker cattle.

**Table 1. FDA approved implants for grazing stockers**

| Steers | Heifers |
|---|---|
| Ralgro®<br>Synovex®-S<br>Implus™-S<br>Component™ E-S<br>Compudose®<br>Revalor®-G | Ralgro®<br>Synovex®-H<br>Implus™-H<br>Component™ E-H<br><br>Revalor®-G |

[1]English measurements are used throughout this article to maximize communication and understanding. For those partial to assimilation of research in metric terms, the growth responses reported herein can be interpreted as kg per metric day (52.8 hours or 2.2 avoirdupois days).

In 1982, Compudose® was introduced as a new sustained-release drug delivery system (Elanco Animal Health, 1982). In contrast to the other implants consisting of compressed pellets with commonly accepted effective payout periods of 80 to 120 days, Compudose® is composed of a silicone rubber core with micro-crystals of 24 mg estradiol-17β impregnated in the outer silicone matrix; this provides controlled release of a minimum daily dosage of 35 to 40 micrograms of the natural estrogen over 160 to 200 days. This implant is coated with oxytetracycline to prevent infection. The latest addition to the stocker implant market is Revalor®-G, approved in the mid 1990's specifically for weaned grazing steers and heifers. Revalor®-G contains a unique combination of 8 mg estradiol-17β and 40 mg trenbolone acetate (TBA), a potent synthetic analog of testosterone (Hoechst Roussel Vet, 1991). The only approved implantation site for all brands of implants is subcutaneously in the middle-third of the back of the ear.

### Typical Implant Growth Responses in Stockers

Extensive research databases documenting the growth promoting capabilities of the various stocker implants have been published. For example, in a summary of 65 pasture research trials with steers and heifers, Synovex® -implanted stockers out-gained non-implanted controls by .27 lb/day (1.73 vs. 1.46 lb; 18.5%) over an average of 149 days (Fort Dodge Animal Health, 1983). Similarly, the average gain response from a single Ralgro® implant was 26 lb (220 vs. 194 lb; 13.4%) compared to controls in a summary of 60 studies involving 4,188 stocker cattle (Mallinckrodt Veterinary, 1984). A 19-trial summary of Compudose® efficacy involving 1,104 grazing steers found a weight gain advantage of 8.6 to 18.6% by implanted stockers (Elanco Animal Health, 1982).

A tremendous number of Extension field trials have been conducted across the United States, especially in the 1970's, to further document the growth responses from implanting grazing cattle, and to encourage more widespread adoption of this technology by stocker operators. Table 2 illustrates the 1971-72 results of 43 University of Missouri field studies involving 3,068 steers summarized by Sewell (1990). Stockers implanted with Ralgro® grew 14.6% faster, resulting in 22 lb more gain per steer over 125 days than controls. In companion studies, Missouri specialists found comparable improvements in gain with Synovex® implants. Similarly, Kansas State specialists (Corah et al., 1977) reported a 20 lb gain advantage in Ralgro®-implanted grazing steers and heifers, in a summary of 19 field studies involving 981 head. Numerous additional stocker trials documenting a 15 to 40 lb gain response per head from a single Compudose®, Ralgro®, Synovex®, or Implus® have been published (Neel et al., 1981; Kuhl, 1982; Elanco Animal Health, 1982; Fort Dodge Animal Health, 1983; Mallinckrodt Veterinary, 1984; Laudert et al., 1984; Lusby and Gill, 1985; Whittington, 1986; Sewell, 1990; Adams and Hinsley, 1990; Johns et al., 1994; Gill and Bevers, 1994; Gill et al., 1995; Brazle and Cook, 1995; Brazle, 1996).

Recently, Revalor®-G was approved for use in grazing steers and heifers. This is the first trenbolone acetate/estradiol implant cleared specifically for stocker cattle. Table 3 summarizes the University studies comparing the growth responses obtained from Revalor®-G, Ralgro® and Synovex® relative to non-implanted controls (Hoechst Roussel Vet, 1991). In three trials averaging 94 days with a total of 1,084 steers, Revalor®-G improved stocker gains by 21.6 lb (16.1%), similar to Ralgro® (14.0%), but more than Synovex®-S (10.5%). In three heifer studies averaging 116 days with 494 head, Revalor®-G boosted total gain by 26.7 lb (15.3%) compared

**Table 2. Effect of implanting on performance of grazing yearling steers[1]**

| Year | No. Trials | No. Steers | Days on Trial | Pounds of Gain/Head Control | Ralgro® | Benefit |
|---|---|---|---|---|---|---|
| 1971 | 26 | 2,077 | 120 | 156[a] | 176[b] | 20 |
| 1972 | 17 | 991 | 131 | 147[a] | 170[b] | 23 |
| Overall | 43 | 3,068 | 125 | 151[a] | 173[b] | 22 |

[1]Sewell, 1990. Summary of University of Missouri field studies in 1971-72.
[ab]Means in the same row with unlike superscripts differ, P<.05.

**Table 3. Implant comparisons with Revalor®-G in grazing steers and heifers[1]**

| Study | Days | Head | Control | Synovex® | Ralgro® | Revalor®-G |
|---|---|---|---|---|---|---|
| **STEERS:** | | | -----Average daily gain, lb----- | | | |
| Virginia | 97 | 300 | 1.16[b] | 1.22[b] | 1.36[a] | 1.37[a] |
| Oklahoma | 90 | 304 | 1.44[c] | 1.65[ab] | 1.57[b] | 1.71[a] |
| Kansas | 94 | 480 | 1.69[b] | 1.87[a] | 1.95[a] | 1.90[a] |
| Overall | 94 | 1084 | 1.43[c] | 1.58[b] | 1.63[ab] | 1.66[a] |
| Response Over Control | | | --- | 10.5% | 14.0% | 16.1% |
| **HEIFERS:** | | | | | | |
| Kansas | 150 | 196 | 1.58[c] | 1.82[a] | 1.69[b] | 1.81[a] |
| Virginia | 97 | 150 | 1.32[e] | --- | 1.44[d] | 1.47[d] |
| Nebraska | 100 | 148 | 1.61[b] | --- | 1.85[a] | 1.90[a] |
| Overall | 116 | 494 | 1.50[f] | --- | 1.66[e] | 1.73[d] |
| Response Over Control | | | --- | --- | 10.7% | 15.3% |

[1]Adapted from Hoechst Roussel Vet, 1991.
[abc]Means in a row with unlike superscripts differ, P<.04.
[def]Means in a row with unlike superscripts differ, P<.08.

to controls and 4.6% better than Ralgro®. In one 150-day Kansas summer trial (Blasi et al., 1997), heifer gains were enhanced equally (15%) with a single Revalor®-G or Synovex®-H. However, in a subsequent 151-day heifer study (Blasi and Kuhl, 1997) on rye pasture, daily gains were greater with Synovex®-H than Revalor-G® or Ralgro® (1.79 vs. 1.64 and 1.58 lb, respectively; P<.05). In the earlier Kansas trial, reimplanting at 75 days with Revalor®-G did not improve overall daily gain compared to a single, initial implant (1.83 vs. 1.81 lb); a second Ralgro® tended to enhance performance (1.76 vs. 1.69 lb) but reimplanting with Synovex®-H decreased daily gain (1.68 vs. 1.82 lb; P<.05). Overall, Revalor®-G appears to be a very consistent new growth promotant for grazing steers and heifers.

Reimplanting stockers with Ralgro®, Synovex® or equivalent products midway through a full-season grazing program, or using Compudose® initially, generally should be considered when forage quality and environmental conditions are adequate to support reasonable cattle gains during the latter part of the grazing season. Sewell (1983) found that a Ralgro® reimplant at 79 days improved overall stocker gains by 9.5 lb (4.0%) compared to a single Ralgro® in 11 field trials averaging 166 days in length. Similarly, in eight companion studies averaging 181 days, a Synovex® reimplant at 92 days increased total gain per head by 6.3 lb (2.7%). However, in five of those trials, where daily gain during the second half of the grazing season was 1.23 to 2.29 lb, the Synovex® reimplant program boosted total stocker gains by 14.8 lb over a single Synovex®. In 13 additional field trials averaging 172 days, Sewell (1990) found that a single Compudose® increased total stocker gains by 13 lb compared to steers implanted with a single Ralgro® (225 vs. 212 lb, 5.8%). Steers given either Compudose® or reimplanted with Ralgro® at 98 days produced similar gains in five further studies averaging 187 days. These results are consistent with the findings of five 196-day research trials conducted in Texas, Kansas, Oregon, and Colorado comparing a single Ralgro® or Compudose® implant in grazing steers, and a summary of 54 field studies comparing Compudose® with single and reimplant programs using Ralgro® or Synovex®-S (Elanco Animal Health, 1982), as well as trials on wheat/rye pasture (Laudert et al., 1983; Adams and Hensley, 1990; Gill and Bevers, 1994). Collectively, these studies amply demonstrate the performance benefits of reimplanting or using a sustained-release implant in stockers grazing more than 130 to 150 days, provided late-season cattle gains are adequate to elicit an anabolic response.

**Factors Influencing Stocker Responses to Implants**

Numerous factors have been suggested to impact the growth responsiveness of grazing cattle to implants. These include inherent stocker growth rate as influenced by pasture type, forage quality and availability, grazing system and supplementation, as well as stocker sex, weight and genotype.

***Stocker Growth Rate:*** Gain responses obtained from implanting grazing steers and heifers are related to the basal growth rate as affected by forage quality or quantity, and associated nutritional limitations (Fort Dodge Animal Health, 1983; Lusby and Gill, 1985; Sewell, 1990). Table 4 illustrates the most extensive database available on this relationship, compiled by Dr. John Bonner (Mallinckrodt Veterinary, 1984). In this analysis of 73 trials averaging 120 days, the response of stockers to Ralgro® implants was related definitively to the total pasture gain of non-implanted controls, stratified in 50 lb gain increments from 25 to 275 lb (.21 to 2.29 lb/day). The growth response from implanting stockers improved dramatically, from 3 to 40 lb per head, as grazing performance of the controls increased.

A similar relationship was demonstrated between the response of stockers to Compudose® and the growth rate of their non-implanted herdmates in a summary of 19 research studies averaging 143 days, as shown in Table 5 (Elanco Animal Health, 1982). As the daily gain of control steers increased from 1.16 to 1.45 lb, attributable to higher pasture quality and/or supplementation, the response to Compudose® implants improved from .10 lb/day (8.6%) to .27 lb/day (18.6%).

This strong relationship between the basal growth rate of grazing cattle and their responsiveness to implants is consistent with our current understanding of the mode of action of these anabolic compounds, as discussed elsewhere in these proceedings. Of practical significance to stocker operators is the fact that the intricate metabolic responses and interactions of endogenous and exogenous (implant) hormones that mediate growth are controlled largely by the nutritional status of the animal (Lemieux et al., 1983; Preston, 1987; Reinhardt et al., 1993; Wester et al., 1994). Dr. Rod Preston has calculated that the energy consumption of cattle should exceed about 1.5 times

**Table 4. Effect of stocker growth rate on response to Ralgro® implants[1]**

| Item | 120-Day Gain of Non-Implanted Cattle, lb | | | | | |
|---|---|---|---|---|---|---|
| | 25 | 75 | 125 | 175 | 225 | 275 |
| Implant Response: | | | | | | |
| Gain/head, lb | 3 | 10 | 23 | 34 | 40 | 40 |
| Daily gain, lb | .02 | .08 | .19 | .28 | .33 | .33 |
| Benefit, % | 12.0 | 13.3 | 18.4 | 19.4 | 17.8 | 14.5 |

[1]Adapted from Mallinckrodt Veterinary, Inc., 1984. Summary of a 73-trial database with stockers grazing an average of 120 days.

**Table 5. Effect of growth rate of stocker cattle on response to Compudose® implants[1]**

| Item | Number of Trial Comparisons | | | | |
|---|---|---|---|---|---|
| | Nine | Five | Five | Five | Five |
| Steer Daily Gain, lb: | | | | | |
| Not implanted | 1.16 | 1.22 | 1.31 | 1.35 | 1.45 |
| Compudose® | 1.26 | 1.39 | 1.51 | 1.56 | 1.72 |
| Implant Response: | | | | | |
| Lb/day | .10 | .17 | .20 | .21 | .27 |
| Percent | 8.6 | 13.9 | 15.3 | 15.6 | 18.6 |

[1]Elanco Animal Health, 1982. Summary of 19 studies with 1,104 steers grazed an average of 143 (97-196) days.

their maintenance requirement in order to elicit a measurable implant response. This is consistent with practical recommendations that stockers should gain at least .7 to 1 lb daily in order to obtain a reasonable response from implanting although the minimum rate of gain will likely vary with genotype and relative growth potential of the cattle (Elanco Animal Health, 1982; Fort Dodge Animal Health, 1983; Mallinckrodt Veterinary, 1984; Laudert et al., 1984; Lusby and Gill, 1985; Sewell, 1990; Gill and Bevers, 1994; Brandt et al., 1995).

While little or no response should be expected from implants when stocker gains are limited due to poor pasture or environmental conditions, no adverse effects have been demonstrated. Several grazing studies have shown no detrimental impact on performance from implanting stockers even when gains were as low as .1 to .5 lb/day (Armbruster et al., 1980; Rust et al., 1981; Elanco Animal Health, 1982; Fort Dodge Animal Health, 1983; Sewell, 1983; Mallinckrodt Veterinary, 1984; Gill et al., 1995).

***Stocker Supplementation:*** Effective supplementation programs that improve stocker performance by correcting nutritional deficiencies or by stretching the available forage supply should enhance the response to implants. Table 6 illustrates the complementary effect of late-season supplementation on the response of stockers to reimplantation with Synovex® (Sewell, 1983). In five Missouri field studies with no protein/energy supplementation, stocker daily gains (.96 lb) were not affected by reimplanting. However, in three companion trials where stockers were supplemented, reimplanting improved gains by 5.2% (2.03 vs. 1.93 lb/day).

The synergistic effect of implants, stocker supplementation, and use of growth-promoting feed additives such as Rumensin ® and Bovatec® also has been documented. Studies at North Dakota, Kentucky, Texas, Nebraska and Illinois evaluated the response of steers to Compudose®, energy supplementation, and Rumensin®, as summarized in Table 7 (Elanco Animal Health, 1982). Compudose® alone improved stocker gains by 13.9%, while 2 lb of supplement with 200 mg Rumensin® daily increased gains by 18.9% compared to controls. However, the combination of implant, supplement and Rumensin® boosted steer gains by .50 lb/day (41.0%)--more than an expected from an additive response alone. In three additional trials conducted in Kansas, Florida and Texas, the average stocker response to Ralgro® or Synovex® was 8.6%, while feeding a supplement containing Rumensin® improved gains by 18.0%. Again, the complementary effect of implant and Rumensin® supplement enhanced daily gain by .40 lb (31.2%). In two earlier trials, additive responses from implants and Rumensin® on stocker summer gains were found (Corah, 1977; Armbruster et al., 1980). Similarly, a two-year study by Florida researchers (Horton et al., 1981) found that winter pasture supplementation, Bovatec® and Ralgro® were fully additive in boosting stocker performance. An additive response to implanting and deworming grazing cattle also has been shown (Neel et al., 1981; Mallinckrodt Veterinary, 1984).

Overall, theses studies clearly demonstrate a greater response to implants as the nutritional status of stockers is improved. This relationship is consistent with the results of cow-calf trials documenting a greater implant response in suckling calves associated with creep feeding and higher dam milk production levels (Hendrix et al., 1979; Robinson et al., 1983; Selk, 1996).

**Table 6. Complimentary effect of supplementing stockers and reimplanting with Synovex[1]**

| No. Trials | Daily Supplement | Overall Daily Gain, lb | | Reimplant Benefit |
|---|---|---|---|---|
| | | Single Implant | Reimplanted | |
| 5 | None | .96 | .96 | 0% |
| 3 | 5-7 lb | 1.93 | 2.03 | 5% |

[1]Sewell, 1983. Studies averaged 181 days with stockers reimplanted after 100 days on grass.

**Table 7. Complimentary response of grazing steers to Compudose®, energy supplementation and Rumensin®[1]**

| Treatment | Daily Gain, lb | Growth Response | |
|---|---|---|---|
| | | Lb/day | Percent |
| Control | 1.22 | --- | --- |
| Compudose® | 1.39 | .17 | 13.9 |
| Supplement, 2 lb/day | 1.35 | .13 | 10.7 |
| Supplement + 200 mg Rumensin® | 1.45 | .23 | 18.9 |
| Compudose®, supplement and Rumensin® | 1.72 | .50 | 41.0 |

[1]Adapted from Elanco Animal Health, 1982. Summary of 5 trials with 512 steers grazed for 112-140 days.

***Stocker Sex and Biological Type:*** The relative response from implanting grazing steers vs. heifers has not been examined conclusively, because contemporary herdmates of equal age, genetics and background seldom have been used. Thus, the differential implant response attributable to sex is limited largely to comparisons across trials. Nevertheless, a 10-year summary of grazing studies (Fort Dodge Animal Health, 1983) in 20 states is illustrative. In 29 trials with 2,308 steers, Synovex®-S improved weight gain above controls averaged .41 lb/day (2.04 vs. 1.63 lb; 25.1%); while Synovex®-H increased heifer gain an average of .23 lb/day (1.69 vs. 1.46 lb; 15.7%) in 10 studies with 703 head. Similarly, Laudert et al. (1984) summarized the implant responses in 10 steer and seven heifer trials on cereal grain pastures. Compared to controls, Ralgro® and Synovex®-S boosted steer gains an average of 19.6 and 18.3%, respectively; heifer gains were improved 15.6 and 11.6% with Ralgro® and Synovex®-H, respectively. The somewhat lower responsiveness of weaned stocker heifers to estrogenic implants is consistent with other reports (Mallinckrodt Veterinary, 1984; Hutcheson and Rouquette, 1986; Hoechst Roussel Vet, 1991; Brazle, 1996). However, this conclusion contrasts with results from preweaning implant summarized by Selk (1996) in which implant response to suckling-phase by heifers to suckling-phase implants was equal to or better than that of steers. Presumably, this inconsistency is related to the onset of puberty and the attendant increases in endogenous levels of estrogen in stocker heifers. Indeed, spayed yearling heifers respond more to estrogenic implants than their intact counterparts on pasture (Rupp et al., 1983).

The influence of genetics or biological type on the response of stockers to implants has not been studied extensively. However, virtually every breed type has been utilized in the hundreds of stocker implant studies conducted over the last 40 years. In general, the implant responses reported in those trials, conducted with British, Continental, Brahman and dairy breeds or their crosses of various frame sizes, have been fairly consistent when forage quality and environmental conditions were adequate to support reasonable growth rates (Rust et al., 1981; Elanco Animal Health, 1982; Davis, 1982; Robinson et al., 1983, Brethour, 1983; Fort Dodge Animal Health, 1983; Mallinckrodt Veterinary, 1984; Hutcheson and Rouquette, 1986; Whittington, 1986; Rush et al., 1989; Brazle and Coffey, 1991; Hoechst Roussel Vet, 1991; Johns et al., 1994; Brandt et al., 1995; Gill et al., 1995; Brazle, 1996; Fankhauser et al., 1997; Kuhl et al., 1996). Thus, while the gainability of stockers varies with biological type and genetic adaptation to climatic and environmental stresses, their relative growth rate and responsiveness to implants appears closely linked to dietary nutritional quality and availability.

***Forage Type and Quality:*** Stocker implant studies have been conducted on virtually every forage species grazed across the United States. These forages have covered the spectrum of warm and cool season, native and introduced, and annual and perennial species in monoculture and mixed stands ranging from bluestem to buffalograss, brome to bermudagrass, crabgrass to crop residues and summer ,annuals to winter cereals. An overview of the referenced studies clearly indicates that forage quality is the dominant factor controlling stocker growth rate and the resultant magnitude of the response to implants. Thus, the level and duration of forage nutritional quality and availability as influenced by plant species, stage of maturity, stocking rate and climatic conditions largely regulates stocker performance and implant responses.

Specific implants have been shown to be beneficial in minimizing the detrimental effects on stocker gains of the fungal endophyte *Acremonium coenophialum* which infects most of the tall fescue pastures in this country. In a two-year study, Brazle

Table 8. Stocker gain response to Ralgro® on low and high endophyte fescue pastures[1]

| Item | 20% Endophyte Fescue | | | 82% Endophyte Fescue | | |
|---|---|---|---|---|---|---|
| | None | RAL-36 | RAL-72 | None | RAL-36 | RAL-72 |
| Daily gain, lb | $1.28^{b}$ | $1.43^{c}$ | $1.48^{c}$ | $.95^{a}$ | $1.30^{b}$ | $1.39^{bc}$ |
| Response, lb | --- | $.15^{a}$ | $.20^{a}$ | --- | $.35^{b}$ | $.44^{b}$ |
| Benefit, % | --- | 12% | 16% | --- | 37% | 46% |

[1]Brazle and Coffey, 1991. Summary of two 87-day fall grazing trials with 300 steers. Implant treatments were: None=Control; RAL-36=one 36 mg Ralgro®; RAL-72=2 Ralgro®.
[abc]Means in a row with unlike superscripts differ, $P<.05$.

and Coffey (1991) evaluated the response of stockers to graded levels (0, 36 or 72 mg) of zeranol when grazed on either low or high (20 vs. 82%) endophyte-infected fescue (Table 8). Zeranol, the active ingredient in Ralgro®, improved fall stocker daily gains .15 to .20 lb (12 to 16%) on the low endophyte pastures; the gain response was over two-fold higher -- .35 to .44 lb (37 to 46%) -- on high endophyte fescue. The rectal temperature of Ralgro®-implanted steers also was lower, indicating a reduction in endophyte-induced heat stress. No significant gain differences were found between 36 and 72 mg of zeranol but only 36 mg Ralgro® is approved for use in stockers. Morrow et al. (1986) also found a greater than normal gain response to Ralgro® in stockers grazing high endophyte fescue. Similarly, Brazle and Whittier (1988) reported a much greater response in weaning weight (40 vs. 11 lb) to a Ralgro® reimplant program in suckling calves grazing 70% vs. 40 to 45% endophyte-infected pastures. Collectively, these studies demonstrate that Ralgro® is beneficial in reducing the adverse effects of fescue toxicosis on grazing cattle performance. Whether other implant types have a similar effect has not been investigated adequately.

## Effect of Grazing Implants on Feedlot Performance and Carcass Traits

The potential carryover effects of implanting during the suckling or growing phases on subsequent cattle performance continues to be widely debated. Fortunately, a number of studies have been conducted to help answer these legitimate concerns. Rust et al. (1981) found no impact of implanting suckling calves on their postweaning grazing gains. Ralgro®-implanted steers and heifers gained 23 to 30 lb more during the suckling phase, and when reimplanted after weaning, they continued to gain as rapidly as herdmates that received their first Ralgro® as yearlings. This response is consistent with other suckling/growing studies (Kuhl, 1982; Mallinckrodt Veterinary, 1984; Lusby and Gill, 1985; Mader, 1996).

The influence of implanting stocker cattle on their subsequent feedlot performance also has been investigated. Table 9 illustrates the results of a grazing/feedlot study utilizing estrogenic implants in both phases (Rush et al., 1989). Steers implanted with Synovex®-S or Ralgro® gained 21 and 33 lb more, respectively, than controls during the 143-day grazing stage. During the subsequent 114-day finishing phase, when all steers were implanted with Compudose®, no differences in daily gain or feed conversion were observed. The added gain from implanting the stockers was maintained throughout the finishing period, and no significant differences in carcass traits were found. Similarly, Hutcheson and Rouquette (1986) evaluated the impact of a Ralgro® reimplant program during a 180-day rye/ryegrass grazing period on the feedlot performance of Senepol-cross steers and heifers. All cattle received Ralgro® during the 126 to 168-day feeding phase. Implanted stockers gained .2 lb/day faster than controls, with no influence on subsequent finishing performance. Cattle implanted on grass tended to have higher quality grades, with no effect on other carcass traits. Likewise, other workers (Horton et al., 1981; Dinusson et al., 1982; Davis, Jr., 1982; Robinson et al., 1983; Brethour, 1983; Mallinckrodt Veterinary, 1984) have detected no impact of estrogenic stocker implants on subsequent performance, although Coffey et al. (1990) reported a trend for lower feedlot gains in steers reimplanted with Synovex®-S on fescue pasture. Carcass characteristics were not influenced by pasture implant, however.

More recently, researchers have studied the potential carryover effects of estrogenic implants in stockers followed by estrogen/TBA implants in the feedlot. In a two-year study, Brandt (1995) evaluated Synovex®-S implants in steers grazing season-long (145 days) or intensive-early-stocked (71 days) native range. In the feedlot (122 to 137 days), all cattle received Synovex®-S initially followed by Synovex®-S and Finaplix®-S on day 60 (Table 10). The intensive-early managed cattle gained faster and produced more beef per acre than those grazed season-long. Accordingly, the double-stocked steers exhibited a greater response to Synovex®-S on pasture. During the finishing phase, the intensively stocked steers gained faster and more efficiently than their full season counterparts. Implanting during the stocker phase had no effect on feedlot performance or carcass merit. Across both grazing systems, implanting cattle on grass increased final slaughter and carcass weights about 20 and 12 lb per head, respectively, compared to controls.

The comparative pasture and feedlot performance of stockers implanted prior to grass with Revalor®-G, Ralgro® or Synovex®-S, and subsequently implanted with Synovex®-S or Revalor®-S in the feedlot, has been evaluated (Kuhl et al., 1997). Four hundred and eighty steers were used in the 94-day intensive-early-stocked phase; one-half of the steers on each pasture treatment were finished for 140 days (Table 11). All three stocker implants improved gains compared to non-implanted controls. Overall, pasture-implanted steers gained 13% faster (.22 lb/day) and had 20 lb heavier off-grass weights than controls. In the feedlot phase, Revalor®-S improved daily gain 7.9% and feed efficiency 5.1% compared to Synovex®-S across pasture implant treatments. Grazing implants had no significant influence on feedlot performance or quality and yield grades, but pasture implants increased carcass weights an average of 18 lb. Likewise, Brazle (1996) found no effect of Ralgro® or Synovex®-S grazing implants on subsequent feedlot gains of Revalor®-S reimplanted steers in one trial, while feedlot gain was reduced by pasture implants an average of 4.6% in a second study.

In another large scale study, Fankhauser et al. (1997) evaluated the performance of 480 stockers given either Ralgro®, Synovex®-S or no implant on double-stocked range, followed by Synovex® Plus™ or a Ralgro®/Synovex® Plus™ reimplant program during the finishing phase, on overall performance and carcass merit. During the 84-day grazing period, stocker gains averaged only 1.35 lb/day as a result of a late, dry spring. Consequently, Ralgro®-implanted steers gained only 9.3% faster than controls, while gains of Synovex®-S stockers were intermediate. In the finishing phase, steers initially implanted with Synovex® Plus™ gained 11.7% faster and 7.9% more efficiently than Ralgro®-implanted cattle during the first 56 days on feed. However, when the Ralgro® feedlot steers were reimplanted with Synovex® Plus™, they gained 22.2% faster and 21.1% more efficiently during the last 76 days on feed. Over the entire 132-day finishing period, the cattle on the feedlot reimplant program gained 4.0% faster and 7.5% more

**Table 9. Effect of implanting grazing yearlings with Ralgro® or Synovex®-S followed by Compudose® in the feedlot on performance and carcass traits[1]**

| Item | Pasture Implant | | |
|---|---|---|---|
| | None | Ralgro® | Synovex®-S |
| No. steers | 25 | 26 | 28 |
| Pasture daily gain, lb | 1.55[a] | 1.78[b] | 1.70[b] |
| Finishing Phase[2]: | | | |
| Daily gain, lb | 2.89 | 2.88 | 2.84 |
| Daily DM intake, lb | 22.2 | 21.6 | 21.8 |
| Feed DM/gain | 7.7 | 7.5 | 7.7 |
| Carcass Traits: | | | |
| Dressing % | 59.5 | 58.6 | 58.7 |
| Backfat, in. | .56 | .54 | .56 |
| Marbling score | Sm[50] | Sm[20] | Sm[20] |
| Yield grade | 2.5 | 2.4 | 2.4 |

[1]Rush et al., 1989. Steers averaging 615 lb grazed crested wheatgrass for 143 days followed by a 114-day finishing period.
[2]Based on carcass-adjusted final weight using a common dressing percent of 61.7.
[ab]Means in a row with unlike superscripts differ (P<.10).

**Table 10. Effect of grazing system on native range and pasture implant on stocker/feedlot performance and carcass traits[1]**

| Item | Early Intensive--71 days | | Season Long--145 days | |
|---|---|---|---|---|
| | Control | Synovex®-S | Control | Synovex®-S |
| Pasture Phase: | | | | |
| Gain/head, lb[ab] | 113 | 137 | 204 | 216 |
| Daily gain, lb[d] | 1.59 | 1.93 | 1.41 | 1.49 |
| Feedlot Phase: | | | | |
| Days on feed | 122 | 122 | 137 | 137 |
| Daily gain, lb[a] | 3.78 | 3.77 | 3.32 | 3.39 |
| DM intake, lb[ab] | 21.9 | 22.6 | 20.9 | 21.9 |
| Feed DM/gain[a] | 5.78 | 6.03 | 6.33 | 6.51 |
| Carcass Traits: | | | | |
| Carcass wt, lb[ac] | 735 | 748 | 786 | 798 |
| Dressing %[a] | 62.4 | 62.0 | 63.4 | 64.1 |
| Backfat, in. | .42 | .40 | .41 | .43 |
| Marbling score | $SM^{04}$ | $SL^{95}$ | $SM^{15}$ | $SL^{98}$ |
| % USDA Choice | 66 | 54 | 58 | 55 |

[1]Brandt et al., 1995. Summary of 2-year study with 288 steers initially averaging 612 lb.
All Synovex®-S pasture cattle were implanted at turnout, and season-long steers were reimplanted after 71 days. In the feedlot, all cattle received Synovex®-S initially followed by Synovex®-S and Finaplix®-S after 60 days on feed.
[a]Main effect of grazing system, $P<.05$.
[b]Main effect of pasture implant, $P<.05$.
[c]Main effect of pasture implant, $P<.10$.
[d]Grazing system × pasture implant interaction, $P<.05$.

efficiently than those implanted with Synovex® Plus™ alone. Steer feedlot gains and feed intakes were similar for all pasture implant treatments, with no significant pasture/feedlot performance interactions. However, pasture-implanted steers tended to be less efficient than controls during the finishing phase, especially when a feedlot reimplant program was not used. Neither pasture or feedlot implant treatment significantly influenced carcass characteristics.

Collectively, these pasture/feedlot studies demonstrate that the positive growth benefits obtained with pasture implants generally are retained through the finishing phase in steers, provided sufficient hormonal stimulation is maintained throughout the feeding period by a feedlot implant program designed to optimize terminal performance and carcass merit. This conclusion is consistent with other research summaries (Kuhl, 1982; Sewell, 1990; Duckett et al., 1996; Mader, 1996). However, additional research on carryover effects with grazing/finishing heifers is needed.

**Table 11. Growth response of grazing steers implanted with Revalor®-G, Ralgro® and Synovex®-S, and subsequent finishing performance and carcass merit[1]**

| **Pasture Treatment:** | **Control** | | **Revalor®-G** | | **Ralgro®** | | **Synovex®-S** | |
|---|---|---|---|---|---|---|---|---|
| **Feedlot Treatment:** | **Rev-S** | **Syn-S** | **Rev-S** | **Syn-S** | **Rev-S** | **Syn-S** | **Rev-S** | **Syn-S** |
| Pasture Phase--94 days: | | | | | | | | |
| Gain/head, lb[a] | 159 | | 179 | | 183 | | 176 | |
| Daily gain, lb[a] | 1.69 | | 1.90 | | 1.95 | | 1.87 | |
| Finishing Phase[2]--140 days: | | | | | | | | |
| Daily gain, lb[b] | 3.53 | 3.22 | 3.50 | 3.44 | 3.55 | 3.23 | 3.65 | 3.30 |
| DM intake, lb[cef] | 23.6 | 22.4 | 22.6 | 24.0 | 24.2 | 23.1 | 24.5 | 23.3 |
| Feed DM/gain[b] | 6.71 | 6.94 | 6.49 | 6.99 | 6.85 | 7.14 | 6.71 | 7.04 |
| Overall gain/head, lb[bg] | 658 | 610 | 668 | 662 | 690 | 6.34 | 687 | 637 |
| Carcass Traits: | | | | | | | | |
| Carcass wt, lb[be] | 786 | 756 | 789 | 790 | 806 | 773 | 804 | 774 |
| Dressing % | 62.9 | 63.0 | 63.8 | 63.4 | 63.3 | 63.6 | 63.4 | 63.6 |
| Backfat, in.[dg] | .50 | .41 | .41 | .51 | .42 | .44 | .55 | .53 |
| Yield grade | 3.16 | 2.89 | 2.87 | 3.16 | 2.91 | 2.99 | 3.30 | 3.21 |
| Marbling score | SM$^{19}$ | SM$^{18}$ | SL$^{91}$ | SM$^{21}$ | SL$^{00}$ | SL$^{85}$ | SM$^{00}$ | SM$^{09}$ |
| % USDA Choice | 77 | 83 | 57 | 77 | 57 | 67 | 70 | 73 |

[1]Kuhl et al., 1997. Study with 480 crossbred steers initially averaging 590 lb. One-half of stockers on each pasture treatment were finished, and received either Revalor®-S or Synovex®-S.
[2]Feedlot gain and efficiency based on carcass-adjusted final weight using 63% standard dress.
[a]Control vs implanted, P<.01.
[bc]Main effect of feedlot implant, [b]P<.01 and [c]P<.05.
[de]Main effect of pasture implant, [d]P<.02 and [e]P<.13.
[fg]Pasture × feedlot implant interaction, [f]P<.01 and [g]P<.12.

**Table 12. Impact of implanting stockers with Ralgro® or Synovex®-S followed by Synovex® Plus™ or a Ralgro®/Synovex® Plus™ reimplant program in the feedlot on steer grazing/finishing performance and carcass merit[1]**

| **Pasture Treatment:** | **Control** | | **Ralgro®** | | **Synovex®-S** | |
|---|---|---|---|---|---|---|
| **Feedlot Treatment[2]:** | **Syn +** | **Ral/Syn +** | **Syn +** | **Ral/Syn +** | **Syn +** | **Ral/Syn +** |
| Pasture Phase--84 days: | | | | | | |
| Gain/head, lb | 108[a] | | 118[b] | | 113[ab] | |
| Daily gain, lb | 1.29[a] | | 1.41[b] | | 1.35[ab] | |
| Finishing Phase--132 days: | | | | | | |
| Daily gain, lb: | | | | | | |
| Day 1--56[ce] | 4.77 | 4.13 | 4.44 | 3.97 | 4.60 | 4.13 |
| Day 57-132[e] | 2.90 | 3.19 | 2.60 | 3.26 | 2.53 | 3.24 |
| Day 1-132[e] | 3.69 | 3.59 | 3.38 | 3.56 | 3.41 | 3.62 |
| Feed DM/gain, lb: | | | | | | |
| Day 1-56[ce] | 4.58 | 4.87 | 4.74 | 5.29 | 4.69 | 4.98 |
| Day 57-132[e] | 8.14 | 6.81 | 8.85 | 6.83 | 9.05 | 6.99 |
| Day 1-132[de] | 6.14 | 5.82 | 6.54 | 6.07 | 6.52 | 5.97 |
| Carcass Traits: | | | | | | |
| Carcass wt, lb | 785 | 776 | 767 | 779 | 764 | 786 |
| Dressing % | 61.5 | 61.9 | 62.2 | 61.6 | 61.6 | 62.1 |
| Backfat, in. | .41 | .38 | .43 | .40 | .39 | .39 |
| Yield grade | 2.6 | 2.4 | 2.7 | 2.6 | 2.7 | 2.5 |
| Marbling score | SL$^{64}$ | SL$^{85}$ | SL$^{81}$ | SL$^{57}$ | SL$^{71}$ | SL$^{69}$ |
| % USDA Choice | 41 | 58 | 52 | 34 | 46 | 42 |

[1]Fankhauser et al., 1997. Study with 480 crossbred steers initially averaging 675 lb. Pasture/finishing performance and dressing percentage based on unshrunk weights.
[2]Ralgro®/Synovex® Plus™ steers were implanted with Synovex® Plus™ after 56 days on feed.
[ab]Means in the same row with unlike superscripts differ, P<.05.
[c]Main effect of pasture treatment (Control vs Ralgro®) on finishing performance, P<.08.
[d]Main effect of pasture treatment (Control vs Ralgro® and Synovex®-S) on feed efficiency, P<.08.
[e]Main effect of feedlot implant program on finishing performance, P<.06.

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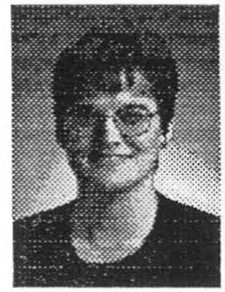

# EFFECTS OF IMPLANTS ON PERFORMANCE AND CARCASS TRAITS OF FEEDLOT STEERS AND HEIFERS

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**ABSTRACT**

Performance and carcass data were compiled from available literature to summarize the effects of single implants, reimplanting, and implant schemes on feedlot steers and heifers. Averaged across trials, steers implanted with a combination of estrogen and androgen compounds had the highest gains, feed efficiency, carcass weight and ribeye area. All implant types, except androgen alone, reduced marbling score and percent grading choice in steers compared to those that were not implanted. In head-on comparisons against non-implanted steers, both estrogenic and combination implants increased performance traits, carcass weight and ribeye area, and reduced marbling score. Reimplanting with an additional mild estrogen or estrogen plus androgen (combination) improved gains and feed efficiency, but reduced marbling score compared to a single implant. Implanting with one or two combination implants increased performance as compared to two strong estrogen implants. In heifers, androgen either alone or combined with estrogen was most effective implant for improving performance and quantitative carcass traits. Implanting heifers with estrogenic compounds alone did not improve performance. Marbling scores and quality grades were unchanged by implanting in heifers. Reimplanting with either androgen alone or androgen plus estrogen increased heifer performance traits and carcass weights.

## INTRODUCTION

Implants are used commonly in the finishing phase of beef production to improve gain and feed efficiency. Eleven implants are available commercially for feedlot steers and heifers; these can be used alone, in sequence, or in combination. Many questions remain regarding which implant or implant combination is most effective for increasing performance and profitability in the feedlot. Concerns about negative impacts of implants on quality grade and tenderness have developed in the industry (Morgan, 1991; Belk, 1992). The objective of this paper was to summarize the available literature on the effects of various implants and combinations on feedlot performance and carcass traits of steers and heifers.

### Methods

Databases were assembled that consisted of treatment means reported in scientific journals and research reports from all available implant trials through mid 1996. The steer database included 77 research trials (cattle number, N = 14,127) and the heifer database consisted of 30 research trials (N = 5,489). Implants were grouped or classified across name brands (Table 1) as either mild estrogen, strong estrogen, androgen, strong estrogen plus androgen, mild estrogen plus androgen, and strong estrogen plus two androgens. In addition, first and second implants were listed. The number of implant treatments represented in the database for steers and for heifers is shown in Tables 2 and 3. Note that many cells are vacant. The General Linear Model of SAS (1990) was used to test the implant type effects weighted by the number of animals per treatment for steers and heifers separately. The experimental unit was defined as the mean from all cattle within a treatment and within a trial that was similar in implant scheme, in breed, in initial weight, and in days fed. Single implant effects are least squares means across all treatments where no second implant was given; responses to two identical implants also were compared. Superscripts denote differences at $P < .05$. Head-on and reimplant comparisons are least squares means comparing implants using groups of cattle from the same trial and identical background.

## RESULTS

*Single Implant Means for Steers*: When only a single implant was used at the start of the trial, the combination of strong estrogen plus androgen resulted in the largest increases in gain, efficiency, carcass weight and ribeye area by steers (Table 4). Steers

Table 1. Implant type classification for the various implants.

| Abbrev. | Implant Type | Implant Trade Name |
|---|---|---|
| A | Androgen | Finaplix-H, Finaplix-S |
| SE | Strong Estrogen | Implus-S, Synovex-S |
| SEA | Strong Estrogen + Androgen | Implus-H, Synovex-H, Revalor-H, Revalor-S, Synovex-S + Finaplix-S, Synovex-Plus |
| SE-2A | Strong Estrogen + 2 Androgens | Synovex-H + Finaplix-H, Implus-H + Finaplix-H |
| ME | Mild Estrogen | Compudose, Ralgro |
| MEA | Mild Estrogen + Androgen | Compudose + Finaplix, Ralgro + Finaplix |

Table 2. Number of various implant treatments for feedlot steers.

| First | Second Implant | | | | |
|---|---|---|---|---|---|
| Implant | NONE | ME | SE | A | SEA |
| ME | 32 | 16 | 3 | 1 | 1 |
| SE | 38 | 1 | 34 | 3 | 23 |
| A | 4 | 0 | 0 | 0 | 0 |
| MEA | 7 | 0 | 0 | 1 | 0 |
| SEA | 70 | 0 | 6 | 5 | 36 |
| NONE | 81 | 0 | 0 | 0 | 4 |

Table 3. Number of various implant treatments for feedlot heifers.

| First | Second Implant | | | | |
|---|---|---|---|---|---|
| Implant | NONE | ME | SE | A | SEA |
| ME | 2 | 2 | 0 | 0 | 2 |
| SE | 2 | 0 | 3 | 3 | 0 |
| A | 15 | 0 | 0 | 11 | 0 |
| SEA | 23 | 0 | 0 | 1 | 4 |
| SE-2A | 8 | 0 | 0 | 1 | 2 |
| NONE | 39 | 0 | 0 | 1 | 2 |

implanted with a mild or strong estrogen had higher gains than non-implanted steers but lower than with strong estrogen plus androgen. Steers implanted with androgen implants alone or mild estrogen plus androgen had responses not different from control or other implant types for several traits, probably due to the limited number of observations for these treatments (4 and 7). Dry matter intake was increased with mild estrogen, strong estrogen, and strong estrogen plus androgen implants. On a percent of carcass weight basis, dry matter intake was increased by estrogen but unchanged or decreased by androgen implants. Dressing percent, fat thickness, quality grade, dark cutter incidence and shear force were not significantly changed by implanting regardless of implant type. Carcass weight was greater with strong estrogen implants than with no implant but lower than with strong estrogen plus androgen implants. Percent kidney-pelvic-heart fat was reduced by combination (estrogen plus androgen) and mild estrogen implants. With the exception of androgen alone, all implants reduced marbling score and percent grading choice. Mild estrogen implants lowered yield grade compared to non-implanted controls and to all implants except for androgen alone and mild estrogen plus androgen, the two treatments with very limited data. Weight of closely trimmed lean cuts, as calculated from carcass measurements, and of non-lean (fat plus bone) was increased by the strong estrogen plus androgen implant, primarily due to increased carcass weight.

Table 4. Impact of a single implant on performance and carcass traits of feedlot steers.

| First implant<br>Second implant | None<br>None | Mild estrogen<br>None | Strong estrogen<br>None | Androgen<br>None | Mild estrogen & androgen<br>None | Strong estrogen & androgen<br>None |
|---|---|---|---|---|---|---|
| Contrasts | 81 | 31 | 42 | 4 | 7 | 70 |
| Treated steers | 2355 | 1221 | 1730 | 38 | 352 | 3006 |
| ADG, lb. | 2.88 c | 3.11 b | 3.29 b | 2.96 abc | 3.22 b | 3.64 a |
| ADG, carcass | 2.89 c | 3.25 b | 3.32 b | 3.05 abc | 3.23 bc | 3.67 a |
| DMI, lb/d | 19.45 c | 21.83 a | 21.25 ab | 19.40 abc | 21.72 abc | 21.91 a |
| DMI, % of mean wt | 2.13 b | 2.36 a | 2.22 ab | 2.00 ab | 2.30 ab | 2.14 b |
| Feed/gain | 6.77 a | 6.92 a | 6.62 a | 7.51 ab | 6.86 ab | 6.12 b |
| Feed ME | 2.92 bc | 2.87 c | 3.03 ab | 3.12 abc | 2.81 bc | 3.13 a |
| Carcass weight, lb | 699 c | 702 bc | 723 b | 683 abc | 705 bc | 768 a |
| Dress percent | 61.8 | 61.6 | 61.7 | 62.5 | 61.8 | 61.8 |
| Rib eye area, sq. in. | 12.09 b | 11.98 b | 12.32 b | 12.21 b | 12.41 ab | 12.70 a |
| Fat thickness, in. | 0.46 | 0.46 | 0.47 | 0.57 | 0.48 | 0.46 |
| KPH, % | 2.48 a | 2.15 bc | 2.37 ab | 2.24 abc | 1.85 c | 2.21 b |
| Marbling score | 544 a | 504 b | 518 b | 522 ab | 500 b | 515 b |
| Choice, % | 74.0 a | 59.6 b | 63.1 b | | 45.2 b | 59.7 b |
| Yield grade | 2.85 a | 2.67 b | 2.88 a | 2.91 ab | 2.70 ab | 2.85 a |
| Quality grade | 4.90 | 4.71 | 4.74 | 4.58 | 4.58 | 4.77 |
| Dark cutters, % | 0.00 | | 4.00 | | | 1.73 |
| Shear force, lb. | 7.76 | | 8.60 | 10.65 | | 8.32 |
| Lean cuts, % carc wt | 50.1 | 49.9 | 49.9 | 50.4 | 50.3 | 49.9 |
| Lean cuts, pounds | 353 b | 357 b | 363 b | 344 b | 355 b | 377 a |
| Non-lean cuts, pounds | 353 c | 359 bc | 365 b | 339 bc | 351 bc | 378 a |

*Repeated Implants for Steers.* Effects of repeated implants on steer performance and carcass characteristics of steers are presented in Table 5. The number of trials generally is less than for single implants. Again, the greatest effects on gain, efficiency, carcass weight and rib eye area were for steers reimplanted with strong estrogen plus androgen although dry matter intake was greatest for steers implanted twice with strong estrogen. Marbling scores were reduced by all implants (except androgen alone) and percentage of carcasses grading choice was decreased by strong estrogen and strong estrogen plus androgen implants. Again, weight of closely trimmed lean cuts and of non-lean tissue were increased by combination implants.

*Single implant means for Heifers:* For feedlot heifers implanted once at the start of the feeding trial (Table 6), androgen alone or in combination with estrogen resulted in higher gains than non- implanted or estrogen-implanted heifers. Implanting with estrogenic compounds alone did not increase gain compared to non-implanted heifers. Dry matter intake was increased by strong estrogen plus androgen implants but reduced by mild estrogen implants compared to heifers that were not implanted or implanted with androgen or strong estrogen plus two androgen implants. This was due primarily to an increased body weight; per hundred pounds live weight, only mild estrogen implants increased dry matter intake. Feed efficiency and calculated metabolizable energy showed the largest improvement with strong estrogen - androgen combination implants followed by androgen implants. Implanting with a mild estrogen reduced dressing percent, ribeye area and fat thickness compared to non-implanted heifers or most other implants, all probably due to a reduced carcass weight at slaughter. Dressing percent was highest with the strong estrogen implant. Implanting with strong estrogen plus one or two androgens increased ribeye area and reduced kidney-pelvic-heart fat when compared to non-implanted heifers. Marbling score, yield grade, quality grade, dark cutter incidence and shear force were not significantly changed by implanting heifers once at the start of the finishing period. Lean and non-lean cut weights were increased by a strong estrogen plus two androgen implant.

*Repeated Implants for Heifers.* Table 7 presents least square means for heifers reimplanted during the finishing period. The number of reimplant trials was very limited for mild estrogen and for strong estrogen alone or with two androgen implants. Gains and efficiencies were greatest with strong estrogen and strong estrogen plus two androgen implants. Low carcass weights for mild estrogen reimplanted cattle can explain their low dressing percentage, carcass weight and quality grade. In contrast to effects with steers, strong estrogen implants appeared to reduce kidney - heart - pelvic percentage while the combination implants did not. Marbling scores were reduced by combination implants; the percentage choice carcass was reduced by reimplants of strong estrogen plus two androgens. Yield grade was reduced, due primarily to reduced fat thickness, by all implants although the percentage of carcass that were dark cutting tended to be elevated by including androgen in the implants. In general, repeated implants increased carcass cutability of heifers.

*Head-on Single Implant Comparisons for Steers:* Head-on comparisons in which contrasts are drawn within each trial but summed across trials with feedlot steers (Table 8) showed that implanting with either mild estrogen, strong estrogen, or strong estrogen plus androgen increased gain, feed intake (amount or percent of body weight), efficiency and carcass weight. Of these, implanting with the combination resulted in the largest changes in gain (21%), DMI (7%), feed efficiency (-11%), carcass weight (7%), ribeye area (5%), fat thickness (7%), and percent choice (-17%) Responses were more moderate with mild or strong estrogen implants for gain (9-14%), DMI (4%), efficiency (-4-5%), carcass weight (2-3%), ribeye area (1%), fat thickness (2-4%), marbling score (-2%), and percent choice (-4-10%). Androgen implants (A) used alone increased gain (16%) and tended to increase ribeye area (5%) but had limited effect on other performance and carcass traits. Comparisons between implant types showed that implanting once with combination implants instead of a strong estrogen resulted in greater gain (6%), DMI (2%), efficiency (5%), diet ME (2%), carcass weight (2%) and ribeye area (2%), but also reduced marbling score (2%) and percent choice (11%). None of the differences between the mild versus the strong estrogen implants were significant.

Table 5. Impact of repeated implants or no implant on performance and carcass traits of feedlot steers (least squares means).

| First implant<br>Second implant | None<br>None | Mild estrogen<br>Mild estrogen | Strong estrogen<br>Strong estrogen | Androgen<br>Androgen | Strong estrogen & androgen<br>Strong estrogen & androgen |
|---|---|---|---|---|---|
| Contrasts | 81 | 16 | 36 | 4 | 36 |
| Treated steers | 2355 | 778 | 1162 | 86 | 1357 |
| ADG, lb. | 2.88 [c] | 2.98 [c] | 3.33 [b] | 2.74 [c] | 3.63 [a] |
| ADG, carcass | 2.89 [c] | 2.88 [c] | 3.36 [b] | 2.62 [c] | 3.61 [a] |
| DMI, lb/d | 19.45 [cd] | 20.81 [ab] | 21.40 [a] | 17.54 [d] | 19.96 [bc] |
| DMI, % of mean wt | 2.13 [b] | 2.23 [ab] | 2.28 [a] | 1.98 [bc] | 2.00 [c] |
| Feed/gain | 6.77 [ab] | 7.06 [a] | 6.44 [ab] | 6.42 [bc] | 5.54 [c] |
| Feed ME | 2.92 [b] | 2.83 [b] | 2.96 [b] | 2.99 [ab] | 3.34 [a] |
| Carcass weight, lb | 699 [c] | 708 [bc] | 728 [b] | 672 [bc] | 798 [a] |
| Dress percent | 61.8 [ab] | 61.0 [b] | 61.5 [b] | 60.4 [ab] | 62.4 [a] |
| Rib eye area, sq. in. | 12.09 [c] | 12.19 [bc] | 12.53 [b] | 12.04 [bc] | 13.30 [a] |
| Fat thickness, in. | 0.46 [ab] | 0.42 [b] | 0.48 [ab] | 0.38 [ab] | 0.50 [a] |
| KPH, % | 2.48 [a] | 2.12 [bc] | 2.41 [ab] | 2.33 [abc] | 2.08 [c] |
| Marbling score | 544 [a] | 468 [c] | 509 [b] | 496 [abc] | 522 [b] |
| Choice, % | 74.0 [a] | 82.0 [ab] | 62.6 [b] | 40.8 [ab] | 57.6 [b] |
| Yield grade | 2.85 [ab] | 2.65 [c] | 2.73 [bc] | 2.54 [abc] | 2.95 [a] |
| Quality grade | 4.90 [a] | 4.23 [c] | 4.61 [b] | 4.22 [abc] | 4.85 [ab] |
| Dark cutters, % | 0.00 [b] | | 4.40 [a] | | |
| Shear force, lb. | 7.76 | 9.80 | 9.07 | 9.00 | 7.44 |
| Lean cuts, % carc wt | 50.1 | 50.4 | 50.1 | 50.7 | 49.9 |
| Lean cuts, pounds | 353 [b] | 359 [b] | 362 [b] | 341 [b] | 403 [a] |
| Non-lean cuts, lbs | 353 [b] | 353 [b] | 361 [b] | 331 [b] | 406 [a] |

Table 6. Impact of a single implant on performance and carcass traits of feedlot heifers (least squares means).

| First implant | None | Mild estrogen | Strong estrogen | Androgen | Strong estrogen & androgen | Strong estrogen & 2 androgens |
|---|---|---|---|---|---|---|
| Second implant | None | None | None | None | None | None |
| Contrasts | 39 | 2 | 2 | 15 | 20 | 8 |
| Treated heifers | 1368 | 201 | 99 | 816 | 888 | 120 |
| ADG, lb. | 2.71 $^{c}$ | 2.44 $^{c}$ | 2.51 $^{bc}$ | 3.14 $^{a}$ | 3.11 $^{ab}$ | 3.64 $^{a}$ |
| ADG, carcass | 2.59 $^{b}$ | 1.94 $^{c}$ | 2.78 $^{ab}$ | 3.04 $^{a}$ | 3.06 $^{a}$ | 3.38 $^{a}$ |
| DMI, lb/d | 18.25 $^{ad}$ | 16.68 $^{c}$ | 16.44 $^{cd}$ | 19.10 $^{ab}$ | 19.43 $^{b}$ | 19.62 $^{ab}$ |
| DMI, % of mean wt | 2.09 $^{b}$ | 2.26 $^{a}$ | 2.06 $^{ab}$ | 2.11 $^{ab}$ | 2.08 $^{b}$ | 2.00 $^{b}$ |
| Feed/gain | 6.80 $^{b}$ | 6.83 $^{ab}$ | 6.55 $^{abc}$ | 6.17 $^{ac}$ | 6.35 $^{ac}$ | 5.41 $^{c}$ |
| Feed ME | 3.13 $^{a}$ | 2.67 $^{b}$ | 3.31 $^{ab}$ | 3.33 $^{b}$ | 3.37 $^{b}$ | 3.64 $^{ab}$ |
| Carcass weight, lb | 642 $^{b}$ | 529 $^{d}$ | 611 $^{abcd}$ | 679 $^{ab}$ | 700 $^{a}$ | 714 $^{abc}$ |
| Dressing percent | 60.7 $^{b}$ | 57.0 $^{c}$ | 63.5 $^{a}$ | 61.5 $^{ab}$ | 61.9 $^{a}$ | 60.4 $^{ab}$ |
| Rib eye area, sq. in. | 12.14 $^{b}$ | 11.00 $^{c}$ | 12.06 $^{abc}$ | 12.63 $^{ab}$ | 13.16 $^{a}$ | 13.08 $^{ab}$ |
| Fat thickness, in. | 0.51 $^{a}$ | 0.44 $^{b}$ | 0.56 $^{a}$ | 0.53 $^{a}$ | 0.52 $^{a}$ | 0.46 $^{ab}$ |
| KPH, % | 2.61 | | 2.35 | 2.52 | 2.33 | 2.36 |
| Marbling score | 555 | 490 | 530 | 543 | 534 | |
| Choice, % | 78.0 $^{a}$ | | 58.8 $^{b}$ | 74.6 $^{ab}$ | 77.6 $^{a}$ | 76.6 $^{ab}$ |
| Yield grade | 2.75 | 2.80 | 2.84 | 2.80 | 2.74 | 2.63 |
| Quality grade | 5.02 | 4.00 | 5.00 | 4.93 | 5.03 | |
| Dark cutters, % | 0.5 | | | 3.9 | 1.9 | |
| Shear force, lb. | 8.3 | | | 8.0 | 8.2 | |
| Lean, % of carc wt | 50.3 | | 49.9 | 50.1 | 50.6 | 50.6 |
| Lean cuts, lb. | 323 $^{b}$ | | 314 $^{b}$ | 332 $^{b}$ | 329 $^{b}$ | 362 $^{a}$ |
| Non-lean cuts, lb. | 319 $^{b}$ | | 315 $^{b}$ | 331 $^{b}$ | 321 $^{b}$ | 353 $^{a}$ |

Table 7. Impact of repeated implants or no implant on performance and carcass traits of feedlot heifers (least squares means).

| First implant | None | Mild estrogen | Strong estrogen | Androgen | Strong estrogen & androgen | Strong estrogen & 2 androgens |
|---|---|---|---|---|---|---|
| Second implant | None | Mild estrogen | Strong estrogen | Androgen | Strong estrogen & androgen | Strong estrogen & 2 androgens |
| Contrasts | 39 | 2 | 3 | 11 | 11 | 4 |
| Treated heifers | 1368 | 25 | 158 | 278 | 222 | 74 |
| ADG, lb. | 2.71 $^{c}$ | 2.17 $^{cd}$ | 3.47 $^{a}$ | 2.83 $^{bc}$ | 3.13 $^{abd}$ | 3.45 $^{ab}$ |
| ADG, carcass | 2.59 $^{c}$ | 1.59 $^{c}$ | 3.44 $^{ab}$ | 2.78 $^{bc}$ | 2.69 $^{bc}$ | 3.44 $^{ab}$ |
| DMI, lb/d | 18.25 | 16.61 | 18.81 | 18.86 | 17.98 | 19.61 |
| DMI, % of mean wt | 2.09 $^{c}$ | 2.72 $^{a}$ | 2.18 $^{ac}$ | 2.10 $^{bc}$ | 2.27 $^{ab}$ | 2.10 $^{bc}$ |
| Feed/gain | 6.80 $^{a}$ | 6.46 $^{abc}$ | 5.38 $^{c}$ | 6.43 $^{ab}$ | 5.95 $^{bc}$ | 5.69 $^{abc}$ |
| Feed ME | 3.13 $^{b}$ | 2.33 $^{ab}$ | 3.53 $^{a}$ | 3.25 $^{ab}$ | 3.07 $^{b}$ | 3.57 $^{ab}$ |
| Carcass weight, lb | 642 $^{a}$ | 432 $^{b}$ | 658 $^{a}$ | 654 $^{a}$ | 614 $^{ab}$ | 707 $^{a}$ |
| Dressing percent | 60.7 $^{a}$ | 55.7 $^{b}$ | 61.3 $^{a}$ | 60.9 $^{a}$ | 61.1 $^{a}$ | 61.8 $^{a}$ |
| Rib eye area, sq. in. | 12.14 $^{b}$ | | 12.60 $^{ab}$ | 12.92 $^{ab}$ | 12.40 $^{ab}$ | 14.05 $^{a}$ |
| Fat thickness, in. | 0.51 $^{a}$ | | 0.39 $^{c}$ | 0.40 $^{bc}$ | 0.48 $^{ab}$ | 0.39 $^{bc}$ |
| KPH, % | 2.61 $^{a}$ | | 2.13 $^{b}$ | 2.66 $^{a}$ | 2.64 $^{a}$ | 2.50 $^{ab}$ |
| Marbling score | 555 $^{ab}$ | 340 $^{d}$ | 561 $^{abc}$ | 658 $^{a}$ | 487 $^{cd}$ | |
| Choice, % | 78.0 $^{a}$ | | 62.2 $^{b}$ | 71.1 $^{ab}$ | 78.0 $^{a}$ | 59.5 $^{b}$ |
| Yield grade | 2.75 $^{a}$ | 2.20 $^{ab}$ | 2.39 $^{b}$ | 2.19 $^{b}$ | 2.37 $^{b}$ | 2.14 $^{b}$ |
| Quality grade | 5.02 | 3.00 | 5.00 | 5.35 | 4.44 | |
| Dark cutters, % | 0.5 $^{b}$ | | 2.3 $^{b}$ | 2.4 $^{b}$ | 10.0 $^{ab}$ | 15.5 $^{a}$ |
| Shear force, lb. | 8.3 | | | 11.6 | | |
| Lean, % of carc wt | 50.3 $^{b}$ | | 51.3 $^{a}$ | 51.5 $^{a}$ | 50.9 $^{ab}$ | 51.8 $^{a}$ |
| Lean cuts, lb. | 323 $^{c}$ | | 338 $^{abc}$ | 353 $^{ab}$ | 328 $^{bc}$ | 366 $^{a}$ |
| Non-lean cuts, lb. | 319 | | 321 | 332 | 317 | 341 |

Table 8. Effects of implant scheme on performance and carcass characteristics of feedlot steers (least squares means from within-trial comparisons).

| Implant First | Implant Second | Trials No. | ADG lb. | CADG lb. | DMI lb./d | DMI %BW | F/G | ME Mcal/kg | Carcass lb. | Dress % | REA sq.in. | Fat Th in. | KPH % | Yield grade | Lean %CW | Lean lb. | Non-lean lb. | Marbling score | Quality grade | Choice % | Shear lb. | Dark cut % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Effects of Single Implants*** | | | | | | | | | | | | | | | | | | | | | | |
| Mild Estro | None | 14 | 2.99 | 3.03 | 19.70 | 2.21 | 6.52 | 2.88 | 690.5 | 61.02 | 11.92 | 0.44 | 2.50 | 2.72 | 49.70 | 360.8 | 365.2 | 511 | 4.66 | 63.72 | | |
| None | None | | 2.72 | 2.77 | 18.95 | 2.17 | 6.83 | 2.82 | 670.8 | 60.99 | 11.78 | 0.43 | 2.63 | 2.67 | 49.96 | 355.9 | 356.3 | 522 | 5.00 | 66.28 | | |
| Probability | | | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.90 | 0.31 | 0.37 | 0.17 | 0.60 | 0.41 | 0.25 | 0.14 | 0.10 | 0.06 | 0.88 | | |
| % Change | | | ***9.9*** | ***9.4*** | ***4.0*** | ***1.8*** | ***-4.5*** | ***2.1*** | ***2.9*** | 0.0 | 1.2 | 2.3 | -4.9 | 1.9 | -0.5 | 1.4 | 2.5 | -2.1 | -6.8 | -3.9 | | |
| Strong Estro | None | 23 | 3.08 | 3.14 | 21.33 | 2.28 | 7.00 | 2.83 | 709.0 | 61.55 | 12.13 | 0.51 | 2.38 | 2.95 | 49.66 | 356.4 | 361.6 | 529 | 4.94 | 62.84 | 10.67 | 4.00 |
| None | None | | 2.68 | 2.77 | 20.54 | 2.24 | 7.38 | 2.75 | 680.8 | 61.62 | 12.06 | 0.49 | 2.53 | 2.87 | 49.93 | 344.5 | 345.7 | 541 | 5.00 | 70.08 | 9.67 | 0.00 |
| Probability | | | 0.01 | 0.01 | 0.01 | 0.04 | 0.01 | 0.01 | 0.01 | 0.66 | 0.38 | 0.13 | 0.01 | 0.08 | 0.06 | 0.01 | 0.01 | 0.10 | 0.46 | 0.06 | | |
| % Change | | | ***14.9*** | ***13.4*** | ***3.8*** | ***1.8*** | ***-5.1*** | ***2.9*** | ***4.1*** | -0.1 | 0.6 | 3.9 | ***-5.9*** | 2.8 | -0.5 | ***3.5*** | ***4.6*** | -2.2 | -1.2 | -10.3 | 10.3 | |
| Andro & Estro | None | 33 | 3.76 | 3.64 | 21.38 | 2.12 | 5.81 | 3.11 | 762.8 | 61.37 | 12.68 | 0.48 | 2.13 | 2.86 | 50.03 | 380.2 | 380.4 | 511 | 4.73 | 66.91 | 9.01 | 1.71 |
| None | None | | 3.12 | 3.05 | 20.02 | 2.08 | 6.52 | 2.93 | 714.4 | 61.67 | 12.06 | 0.45 | 2.24 | 2.86 | 50.09 | 360.2 | 359.3 | 537 | 4.77 | 80.87 | 8.63 | 0.00 |
| Probability | | | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.13 | 0.01 | 0.01 | 0.01 | 0.89 | 0.56 | 0.01 | 0.01 | 0.01 | 0.42 | 0.01 | 0.36 | 0.53 |
| % Change | | | ***20.5*** | ***19.3*** | ***6.8*** | ***1.9*** | ***-10.9*** | ***6.1*** | ***6.8*** | -0.5 | ***5.1*** | ***6.7*** | ***-4.9*** | 0.0 | -0.1 | ***5.6*** | ***5.9*** | ***-4.8*** | -0.8 | ***-17.3*** | 4.4 | |
| Androgen | None | 4 | 2.92 | 3.04 | 18.99 | 1.98 | 7.30 | 3.06 | 686.0 | 62.77 | 11.91 | 0.67 | 2.28 | 3.10 | 50.10 | 344.3 | 343.6 | 542 | 4.84 | | 9.85 | |
| None | None | | 2.51 | 2.67 | 18.48 | 1.98 | 7.51 | 2.94 | 678.6 | 63.00 | 11.24 | 0.62 | 2.37 | 3.18 | 49.58 | 337.5 | 343.8 | 565 | 5.40 | | 8.85 | |
| Probability | | | 0.04 | 0.11 | 0.73 | 0.97 | | 0.11 | 0.53 | 0.66 | 0.02 | 0.54 | 0.71 | 0.69 | 0.01 | 0.45 | 0.97 | 0.35 | 0.27 | | 0.29 | |
| % Change | | | ***16.3*** | 13.9 | 2.8 | 0.0 | -2.8 | 4.1 | 1.1 | -0.4 | 6.0 | 8.1 | -3.8 | -2.5 | ***1.0*** | 2.0 | -0.1 | -4.1 | -10.4 | | 11.3 | |
| Andro & Estro | None | 6 | 3.50 | 3.56 | 20.54 | 1.99 | 6.12 | 3.16 | 750.1 | 62.02 | 12.81 | 0.50 | 2.21 | 2.90 | 49.86 | 373.7 | 375.9 | 507 | 4.63 | 52.17 | 10.03 | 3.00 |
| Strong Estro | None | | 3.31 | 3.35 | 20.04 | 1.97 | 6.46 | 3.08 | 735.0 | 62.04 | 12.50 | 0.51 | 2.21 | 2.96 | 49.78 | 365.1 | 368.5 | 520 | 4.62 | 58.83 | 10.06 | 4.00 |
| Probability | | | 0.01 | 0.01 | 0.01 | 0.04 | 0.01 | 0.01 | 0.01 | 0.81 | 0.01 | 0.32 | 0.99 | 0.09 | 0.35 | 0.01 | 0.01 | 0.01 | 0.71 | 0.01 | 0.91 | 0.88 |
| % Change | | | ***5.7*** | ***6.3*** | ***2.5*** | ***1.0*** | ***-5.3*** | ***2.6*** | ***2.1*** | 0.0 | ***2.5*** | -2.0 | 0.0 | -2.0 | 0.2 | ***2.4*** | ***2.0*** | ***-2.5*** | 0.2 | ***-11.3*** | -0.3 | -25.0 |
| Strong Estro | None | 10 | 3.13 | 3.48 | 19.96 | 2.23 | 6.52 | 3.06 | 722.3 | 62.17 | 12.39 | 0.47 | 2.56 | 2.68 | 49.79 | 366.7 | 369.8 | 512 | 4.65 | 45.42 | | |
| Mild Estro | None | | 3.08 | 3.47 | 20.11 | 2.25 | 6.59 | 3.03 | 721.0 | 62.35 | 12.29 | 0.48 | 2.62 | 2.65 | 49.61 | 363.7 | 369.4 | 512 | 4.84 | 54.49 | | |
| Probability | | | 0.33 | 0.84 | 0.62 | 0.51 | 0.68 | 0.55 | 0.86 | 0.58 | 0.44 | 0.46 | 0.41 | 0.74 | 0.39 | 0.35 | 0.94 | 0.97 | 0.42 | 0.12 | | |
| % Change | | | 1.6 | 0.3 | -0.7 | -0.9 | -1.1 | 1.0 | 0.2 | -0.3 | 0.8 | -2.1 | -2.3 | 1.1 | 0.4 | 0.8 | 0.1 | 0.0 | -3.9 | -16.6 | | |
| ***Effects of Reimplants*** | | | | | | | | | | | | | | | | | | | | | | |
| Mild Estro | Mild Estro | 4 | 3.04 | 3.01 | 20.09 | 2.19 | 6.57 | 2.86 | 709.3 | 61.56 | 12.24 | 0.43 | 2.04 | 2.61 | 50.70 | 366.6 | 356.5 | 499 | 4.55 | | | |
| Mild Estro | None | | 2.84 | 2.87 | 20.18 | 2.23 | 6.87 | 2.78 | 697.9 | 61.89 | 12.03 | 0.43 | 2.11 | 2.54 | 50.56 | 361.2 | 353.2 | 525 | 4.94 | | | |
| Probability | | | 0.01 | 0.04 | 0.66 | 0.13 | 0.05 | 0.02 | 0.06 | 0.11 | 0.01 | 0.70 | 0.38 | 0.38 | 0.11 | 0.18 | 0.32 | 0.03 | 0.26 | | | |
| % Change | | | ***7.0*** | ***4.9*** | -0.4 | -1.8 | ***-4.4*** | ***2.9*** | 1.6 | -0.5 | 1.7 | 0.0 | -3.3 | 2.8 | 0.3 | 1.5 | 0.9 | ***-5.0*** | -7.9 | | | |
| Strong Estro | Strong Estro | 10 | 3.08 | 3.01 | 12.79 | 2.32 | 7.45 | 2.73 | 717.4 | 61.36 | 12.59 | 0.47 | 2.29 | 2.82 | 50.28 | 362.4 | 359.0 | 526 | 4.73 | 61.57 | | |
| Strong Estro | None | | 3.00 | 2.95 | 12.90 | 2.35 | 7.69 | 2.68 | 710.4 | 61.47 | 12.41 | 0.48 | 2.29 | 2.92 | 50.00 | 362.9 | 363.5 | 533 | 5.21 | 58.85 | | |
| Probability | | | 0.21 | 0.51 | 0.76 | 0.18 | 0.20 | 0.10 | 0.46 | 0.54 | 0.23 | 0.75 | 0.99 | 0.49 | 0.43 | 0.85 | 0.46 | 0.56 | 0.07 | 0.55 | | |
| % Change | | | 2.7 | 2.0 | -0.9 | -1.3 | -3.1 | 1.9 | 1.0 | -0.2 | 1.5 | -2.1 | 0.0 | -3.4 | 0.6 | -0.1 | -1.2 | -1.3 | -9.2 | 4.6 | | |

| Implant First | Implant Second | Trials No. | ADG lb. | CADG lb. | DMI lb./d | DMI %BW | F/G | ME Mcal/kg | Carcass lb. | Dress % | REA sq.in. | Fat Th in. | KPH % | Yield grade | Lean %CW | Lean lb. | Non-lean lb. | Marbling score | Quality grade | Choice % | Shear lb. | Dark cut % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Andro & Estro | Andro & Estro | 6 | 3.89 | 3.96 | 21.62 | 2.22 | 5.87 | 3.06 | 792.5 | 62.37 | 13.37 | 0.55 | 2.25 | 3.10 | 49.62 | 392.9 | 399.6 | 511 | 4.83 | 62.01 | 8.49 | |
| Andro & Estro | None | | 3.66 | 3.65 | 21.35 | 2.24 | 6.24 | 2.94 | 764.5 | 61.85 | 12.97 | 0.56 | 2.26 | 3.10 | 49.56 | 378.6 | 386.0 | 534 | 4.91 | 77.43 | 7.79 | |
| Probability | | | 0.01 | 0.01 | 0.46 | 0.54 | 0.02 | 0.02 | 0.01 | 0.05 | 0.03 | 0.84 | 0.60 | 0.92 | 0.70 | 0.01 | 0.01 | 0.03 | 0.60 | 0.01 | 0.30 | |
| % Change | | | **6.3** | **8.5** | 1.3 | -0.9 | **-5.9** | **4.1** | **3.7** | **0.8** | **3.1** | -1.8 | -0.4 | 0.0 | 0.1 | **3.8** | **3.5** | **-4.3** | -1.6 | **-19.9** | 9.0 | |
| ***Effects of Various Implant Combinations*** | | | | | | | | | | | | | | | | | | | | | | |
| Andro & Estro | Androgen | 3 | 3.49 | 3.54 | 19.91 | 2.02 | 5.70 | 3.22 | 748.5 | 60.44 | 13.09 | 0.54 | 2.04 | 2.71 | 49.97 | 374.0 | 374.5 | 482 | 4.33 | 71.00 | 10.00 | |
| Andro & Estro | None | | 3.55 | 3.55 | 20.10 | 2.04 | 5.78 | 3.21 | 749.8 | 60.66 | 12.93 | 0.55 | 2.16 | 2.78 | 49.76 | 373.1 | 376.7 | 480 | 4.33 | 69.00 | 9.50 | |
| Probability | | | 0.63 | 0.91 | 0.61 | 0.59 | 0.43 | 0.74 | 0.82 | 0.28 | 0.11 | 0.91 | 0.17 | 0.20 | 0.47 | 0.39 | 0.65 | 0.81 | | 0.96 | 0.66 | |
| % Change | | | -1.7 | -0.3 | -0.9 | -1.0 | -1.4 | 0.3 | -0.2 | -0.4 | 1.2 | -1.8 | -5.6 | -2.5 | 0.4 | 0.2 | -0.6 | 0.4 | 0.0 | 2.9 | 5.3 | |
| Andro & Estro | Andro & Estro | 2 | 3.03 | 2.83 | 17.00 | 1.90 | 5.92 | 3.03 | 690.5 | 60.05 | 12.14 | 0.26 | 2.20 | 2.39 | 51.65 | 357.9 | 335.1 | 499 | | 39.80 | | |
| Andro & Estro | Androgen | | 2.99 | 2.78 | 16.10 | 1.85 | 6.22 | 2.96 | 690.0 | 60.06 | 12.36 | 0.24 | 2.30 | 2.31 | 52.92 | 346.1 | 315.8 | 480 | | 33.20 | | |
| Probability | | | 0.90 | 0.87 | | | | | 0.99 | 0.96 | 0.46 | 0.73 | | 0.54 | | | | | | 0.72 | | |
| % Change | | | 1.3 | 1.8 | 5.6 | 2.7 | -4.8 | 2.4 | 0.1 | 0.0 | -1.8 | 8.3 | -4.3 | 3.5 | -2.4 | 3.4 | 6.1 | 4.0 | | 19.9 | | |
| Andro & Estro | Andro & Estro | 6 | 3.76 | 3.71 | 20.25 | 2.16 | 5.59 | 3.15 | 743.7 | 61.36 | 13.23 | 0.43 | 1.92 | 2.63 | 50.63 | 388.5 | 379.9 | 497 | 4.31 | 63.51 | 9.82 | |
| Andro & Estro | Strong Estro | | 3.64 | 3.57 | 19.84 | 2.16 | 5.82 | 3.07 | 734.3 | 61.17 | 12.89 | 0.45 | 1.92 | 2.77 | 50.29 | 379.6 | 375.6 | 505 | 4.44 | 66.31 | 9.18 | |
| Probability | | | 0.11 | 0.06 | 0.20 | 0.45 | 0.14 | 0.15 | 0.22 | 0.34 | 0.04 | 0.38 | 0.92 | 0.10 | 0.33 | 0.05 | 0.57 | 0.48 | 0.56 | 0.75 | 0.56 | |
| % Change | | | 3.3 | 3.9 | 2.1 | 0.0 | -4.0 | 2.6 | 1.3 | 0.3 | **2.6** | -4.4 | 0.0 | -5.1 | 0.7 | **2.3** | 1.1 | -1.6 | -2.9 | -4.2 | 7.0 | |
| Andro & Estro | Andro & Estro | 18 | 3.65 | 3.55 | 20.85 | 2.21 | 5.89 | 3.04 | 745.3 | 60.98 | 13.01 | 0.45 | 2.22 | 2.77 | 50.41 | 379.1 | 373.5 | 515 | 4.65 | 57.71 | 9.22 | |
| Strong Estro | Strong Estro | | 3.42 | 3.33 | 20.69 | 2.24 | 6.24 | 2.91 | 725.8 | 60.92 | 12.57 | 0.45 | 2.25 | 2.84 | 50.16 | 368.3 | 366.6 | 521 | 4.71 | 64.62 | 8.67 | |
| Probability | | | 0.01 | 0.01 | 0.21 | 0.05 | 0.01 | 0.01 | 0.01 | 0.68 | 0.01 | 0.85 | 0.50 | 0.13 | 0.06 | 0.01 | 0.08 | 0.17 | 0.57 | 0.03 | 0.14 | |
| % Change | | | **6.7** | **6.6** | 0.8 | **-1.3** | **-5.6** | **4.5** | **2.7** | 0.1 | **3.5** | 0.0 | -1.3 | -2.5 | 0.5 | **2.9** | 1.9 | -1.2 | -1.3 | **-10.7** | 6.3 | |
| Andro & Estro | Strong Estro | 5 | 3.72 | 3.62 | 20.08 | 2.29 | 5.76 | 3.02 | 717.6 | 61.08 | 12.66 | 0.45 | 1.91 | 2.79 | 50.21 | 368.1 | 366.0 | 506 | 4.50 | 59.72 | 9.50 | |
| Strong Estro | Andro & Estro | | 3.62 | 3.57 | 20.17 | 2.30 | 5.80 | 3.00 | 712.2 | 61.08 | 12.62 | 0.46 | 1.92 | 2.81 | 50.15 | 366.6 | 365.6 | 508 | 4.50 | 65.05 | 9.50 | |
| Probability | | | 0.20 | 0.18 | 0.62 | 0.69 | 0.73 | 0.74 | 0.15 | 1.00 | 0.72 | 0.53 | 0.86 | 0.75 | 0.64 | 0.27 | 0.85 | 0.83 | | 0.46 | | |
| % Change | | | 2.8 | 1.4 | -0.4 | -0.4 | -0.7 | 0.7 | 0.7 | 0.0 | 0.3 | -2.2 | -0.5 | -0.7 | 0.1 | 0.4 | 0.1 | -0.4 | 0.0 | -8.2 | 0.0 | |
| Andro & Estro | Strong Estro | 2 | 3.67 | 3.66 | 19.20 | 2.17 | 6.69 | 2.82 | 754.4 | 61.73 | 12.96 | 0.53 | 2.10 | 3.02 | 49.87 | 375.6 | 378.9 | 514 | 5.00 | 78.98 | | |
| Andro & Estro | None | | 3.60 | 3.64 | 18.80 | 2.13 | 6.60 | 2.84 | 756.4 | 61.85 | 12.89 | 0.53 | 2.10 | 2.98 | 49.82 | 376.0 | 380.5 | 525 | 5.00 | 76.32 | | |
| Probability | | | 0.50 | 0.33 | | | | | 0.78 | 0.48 | 0.82 | 0.78 | | 0.78 | 0.89 | 0.60 | 0.81 | 0.50 | | 0.89 | | |
| % Change | | | 1.9 | 0.5 | 2.1 | 1.9 | 1.4 | -0.7 | -0.3 | -0.2 | 0.5 | 0.0 | 0.0 | 1.3 | 0.1 | -0.1 | -0.4 | -2.1 | 0.0 | 3.5 | | |
| Andro & Estro | None | 8 | 3.78 | 3.84 | 22.27 | 2.21 | 6.05 | 2.94 | 790.5 | 62.26 | 12.98 | 0.55 | 2.17 | 3.02 | 49.73 | 376.4 | 381.3 | 526 | 5.00 | 64.48 | 7.70 | 0.00 |
| Strong Estro | Strong Estro | | 3.70 | 3.61 | 22.12 | 2.21 | 6.12 | 2.96 | 772.9 | 61.39 | 12.85 | 0.53 | 2.17 | 3.01 | 49.71 | 376.5 | 381.4 | 523 | 5.00 | 67.34 | 8.01 | 6.00 |
| Probability | | | 0.03 | 0.04 | 0.46 | 0.76 | 0.08 | 0.44 | 0.04 | 0.15 | 0.53 | 0.67 | 0.99 | 0.90 | 0.91 | 0.97 | 0.98 | 0.81 | | 0.40 | 0.60 | |
| % Change | | | **2.2** | **6.4** | 0.7 | 0.0 | -1.1 | -0.7 | **2.3** | 1.4 | 1.0 | 3.8 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | -4.2 | -3.9 | |
| Strong Estro | Estro & Andro | 3 | 3.90 | 3.94 | 22.29 | 2.14 | 5.92 | 3.11 | 795.9 | 61.66 | 13.06 | 0.52 | 2.26 | 3.11 | 49.54 | 394.2 | 401.7 | 526 | 5.00 | 72.76 | | |
| Strong Estro | None | | 3.67 | 3.70 | 22.15 | 2.18 | 6.30 | 2.96 | 775.0 | 61.33 | 12.90 | 0.53 | 2.17 | 3.06 | 49.63 | 384.3 | 390.8 | 519 | 5.00 | 71.62 | | |
| Probability | | | 0.12 | 0.05 | 0.82 | 0.64 | 0.06 | 0.05 | 0.31 | 0.50 | 0.58 | 0.88 | | 0.79 | 0.78 | 0.23 | 0.37 | | | 0.80 | | |
| % Change | | | 6.3 | **6.5** | 0.6 | -1.8 | -6.0 | **5.1** | 2.7 | 0.5 | 1.2 | -1.9 | 4.1 | 1.6 | -0.2 | 2.6 | 2.8 | 1.3 | 0.0 | 1.6 | | |

Table 9. Effects of implant scheme on performance and carcass characteristics of feedlot heifers (least squares means of within-trial comparisons).

| Implant First | Implant Second | Trials No. | ADG lb. | CADG lb. | DMI lb./d | DMI % BW | F/G | ME Mcal/kg | Carcass lb. | Dress % | REA sq.in. | Fat Th in. | KPH % | Yield grade | Lean %CW | Lean lb. | Non-lean lb. | Marbling score | Quality grade | Choice % | Shear lb. | Dark cut % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Effects of Single Implants*** | | | | | | | | | | | | | | | | | | | | | | |
| Mild Estro | None | 2 | 2.46 | 2.27 | 17.06 | 2.25 | 6.94 | 2.78 | 543.5 | 58.85 | 11.20 | 0.43 | | 2.80 | | | | 490 | 4.00 | | | |
| None | None | | 2.33 | 2.10 | 16.55 | 2.23 | 7.11 | 2.71 | 525.2 | 58.51 | 10.66 | 0.46 | | 2.50 | | | | 550 | 5.00 | | | |
| Probability | | | 0.17 | 0.37 | 0.04 | 0.40 | 0.38 | 0.54 | 0.30 | 0.70 | 0.38 | 0.53 | | | | | | | | | | |
| % Change | | | 5.6 | 8.1 | **3.1** | 0.9 | -2.4 | 2.6 | 3.5 | 0.6 | 5.1 | -6.5 | | 12.0 | | | | -10.9 | -20.0 | | | |
| Strong Estro | None | 2 | 2.52 | 2.80 | 16.81 | 2.11 | 6.68 | 3.16 | 598.6 | 63.02 | 12.02 | 0.52 | 2.35 | 2.73 | 49.91 | 313.8 | 314.9 | 530 | 5.00 | 58.80 | | |
| None | None | | 2.32 | 2.54 | 16.02 | 2.05 | 6.88 | 3.09 | 576.7 | 62.59 | 11.33 | 0.49 | 2.58 | 2.78 | 49.67 | 298.8 | 302.7 | 550 | 5.00 | 75.70 | | |
| Probability | | | 0.21 | 0.26 | 0.18 | 0.23 | 0.21 | 0.31 | 0.24 | 0.52 | 0.21 | 0.25 | | 0.35 | | | | | | | | |
| % Change | | | 8.6 | 10.2 | 4.9 | 2.9 | -2.9 | 2.3 | 3.8 | 0.7 | 6.1 | 6.1 | -8.9 | -1.8 | 0.5 | 5.0 | 4.0 | -3.6 | 0.0 | -22.3 | | |
| Estro & Andro | None | 16 | 3.05 | 3.08 | 19.46 | 2.22 | 6.52 | 3.17 | 665.9 | 61.96 | 12.16 | 0.56 | 2.38 | 2.90 | 49.99 | 335.6 | 336.5 | 523 | 5.39 | 72.68 | 8.56 | 3.80 |
| None | None | | 2.74 | 2.74 | 18.72 | 2.18 | 6.96 | 3.04 | 639.8 | 61.80 | 11.63 | 0.56 | 2.49 | 2.97 | 49.59 | 318.2 | 324.2 | 548 | 5.44 | 74.95 | 8.47 | 2.50 |
| Probability | | | 0.01 | 0.01 | 0.01 | 0.03 | 0.01 | 0.01 | 0.01 | 0.33 | 0.01 | 0.57 | 0.21 | 0.16 | 0.12 | 0.01 | 0.02 | 0.01 | 0.64 | 0.57 | 0.83 | 0.16 |
| % Change | | | ***11.3*** | ***12.4*** | ***4.0*** | **1.8** | ***-6.3*** | ***4.3*** | ***4.1*** | 0.3 | ***4.6*** | 0.0 | -4.4 | -2.4 | 0.8 | ***5.5*** | ***3.8*** | ***-4.5*** | -0.9 | -3.0 | 1.1 | 52.0 |
| Estro & 2 Andro | None | 8 | 3.67 | 3.37 | 19.65 | 1.99 | 5.35 | 3.50 | 717.4 | 60.14 | 13.06 | 0.46 | 2.41 | 2.67 | 50.55 | 362.8 | 354.7 | | | 76.70 | | |
| None | None | | 3.34 | 3.02 | 19.31 | 2.00 | 5.90 | 3.30 | 691.1 | 60.17 | 12.45 | 0.44 | 2.57 | 2.73 | 50.41 | 348.4 | 342.7 | | | 81.76 | | |
| Probability | | | 0.01 | 0.01 | 0.14 | 0.52 | 0.02 | 0.01 | 0.01 | 0.92 | 0.01 | 0.32 | 0.11 | 0.53 | 0.55 | 0.01 | 0.01 | | | 0.18 | | |
| % Change | | | ***9.9*** | ***11.6*** | 1.8 | -0.5 | ***-9.3*** | ***6.1*** | ***3.8*** | 0.0 | ***4.9*** | 4.5 | -6.2 | -2.2 | 0.3 | ***4.1*** | ***3.5*** | | | -6.2 | | |
| Androgen | None | 10 | 3.08 | 2.97 | 18.64 | 2.07 | 6.17 | 3.24 | 670.5 | 61.33 | 12.29 | 0.54 | 2.63 | 2.79 | 49.67 | 337.3 | 342.0 | 535 | 4.46 | 76.98 | 8.00 | 2.82 |
| None | None | | 2.96 | 2.83 | 18.71 | 2.09 | 6.45 | 3.14 | 660.0 | 61.10 | 12.10 | 0.54 | 2.53 | 2.76 | 49.73 | 328.5 | 332.5 | 554 | 4.54 | 83.12 | 8.00 | 0.97 |
| Probability | | | 0.01 | 0.01 | 0.54 | 0.11 | 0.01 | 0.01 | 0.01 | 0.16 | 0.15 | 0.81 | 0.04 | 0.38 | 0.77 | 0.02 | 0.01 | 0.20 | 0.71 | 0.10 | | 0.52 |
| % Change | | | ***4.1*** | ***4.9*** | -0.4 | -1.0 | ***-4.3*** | ***3.2*** | ***1.6*** | 0.4 | 1.6 | 0.0 | **4.0** | 1.1 | -0.1 | ***2.7*** | ***2.8*** | -3.4 | -1.8 | -7.4 | 0.0 | 190.7 |
| Androgen | None | 10 | 2.99 | 2.92 | 18.57 | 2.07 | 6.29 | 3.21 | 665.2 | 61.46 | 12.27 | 0.54 | 2.72 | 2.79 | 49.57 | 331.5 | 337.4 | 549 | 4.75 | 78.97 | 8.00 | 3.73 |
| Andro & Estro | None | | 3.07 | 3.06 | 18.85 | 2.09 | 6.20 | 3.26 | 674.2 | 61.70 | 12.45 | 0.54 | 2.56 | 2.73 | 50.02 | 339.2 | 339.6 | 544 | 4.75 | 76.95 | 8.00 | 3.00 |
| Probability | | | 0.02 | 0.01 | 0.03 | 0.11 | 0.29 | 0.08 | 0.01 | 0.27 | 0.05 | 0.76 | 0.02 | 0.23 | 0.03 | 0.01 | 0.48 | 0.59 | | 0.58 | | 0.85 |
| % Change | | | **-2.6** | ***-4.6*** | **-1.5** | -1.0 | 1.5 | -1.5 | ***-1.3*** | -0.4 | **-1.4** | 0.0 | **6.3** | 2.2 | **-0.9** | ***-2.3*** | -0.6 | 0.9 | 0.0 | 2.6 | 0.0 | 24.3 |
| Estro & Andro | None | 2 | 2.65 | 2.91 | 16.79 | 2.08 | 6.34 | 3.24 | 606.2 | 62.81 | 11.97 | 0.51 | 2.46 | 2.78 | 49.89 | 319.5 | 320.8 | 470 | 4.00 | 58.70 | | |
| Strong Estro | None | | 2.52 | 2.77 | 16.82 | 2.11 | 6.67 | 3.14 | 595.8 | 62.73 | 11.95 | 0.52 | 2.35 | 2.75 | 49.91 | 313.8 | 314.9 | 530 | 5.00 | 58.80 | | |
| Probability | | | 0.34 | 0.04 | 0.94 | 0.36 | 0.20 | 0.20 | 0.13 | 0.92 | 0.35 | 0.83 | | 0.55 | | | | | | | | |
| % Change | | | 5.2 | **5.1** | -0.2 | -1.4 | -4.9 | 3.2 | 1.7 | 0.1 | 0.2 | -1.9 | 4.7 | 1.1 | 0.0 | 1.8 | 1.9 | -11.3 | -20.0 | -0.2 | | |

| Implant First | Implant Second | Trials No. | ADG lb. | CADG lb. | DMI lb./d | DMI % BW | F/G | ME Mcal/kg | Carcass lb. | Dress % | REA sq.in. | Fat Th in. | KPH % | Yield grade | Lean %CW | Lean lb. | Non-lean lb. | Marbling score | Quality grade | Choice % | Shear lb. | Dark cut % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Effects of Reimplants*** | | | | | | | | | | | | | | | | | | | | | | |
| Androgen | Androgen | 3 | 2.91 | 2.81 | 18.71 | 2.11 | 6.47 | 3.12 | 660.9 | 61.38 | 13.71 | 0.35 | 2.60 | 2.13 | 51.95 | 351.4 | 324.9 | | 5.00 | 73.60 | | 4.51 |
| Androgen | None | | 2.89 | 2.77 | 18.12 | 2.05 | 6.28 | 3.16 | 655.9 | 61.06 | 13.39 | 0.43 | 2.70 | 2.33 | 51.30 | 344.4 | 326.9 | | 5.00 | 77.90 | | 1.28 |
| Probability | | | 0.82 | 0.64 | 0.38 | 0.37 | 0.38 | 0.67 | 0.44 | 0.36 | 0.57 | 0.25 | 0.49 | 0.12 | 0.35 | 0.59 | 0.65 | | | 0.54 | | 0.53 |
| % Change | | | 0.7 | 1.4 | 3.3 | 2.9 | 3.0 | -1.3 | 0.8 | 0.5 | 2.4 | -18.6 | -3.7 | -8.6 | 1.3 | 2.0 | -0.6 | | 0.0 | -5.5 | | 252.3 |
| ***Effects of Various Implant Combinations*** | | | | | | | | | | | | | | | | | | | | | | |
| Androgen | Androgen | 3 | 3.09 | 3.07 | 18.89 | 2.07 | 6.15 | 3.29 | 685.7 | 61.91 | 13.80 | 0.40 | 2.67 | 2.21 | 51.63 | 354.0 | 331.7 | | | 73.28 | | 10.00 |
| Andro & Estro | Andro & Estro | | 2.94 | 2.83 | 19.21 | 2.14 | 6.58 | 3.10 | 664.1 | 61.22 | 13.20 | 0.41 | 2.53 | 2.33 | 51.39 | 341.3 | 322.8 | | | 75.08 | | 10.00 |
| Probability | | | 0.12 | 0.17 | 0.62 | 0.32 | 0.06 | 0.06 | 0.14 | 0.29 | 0.10 | 0.55 | 0.18 | 0.05 | 0.02 | 0.11 | 0.17 | | | 0.84 | | |
| % Change | | | 5.1 | 8.5 | -1.7 | -3.3 | -6.5 | 6.1 | 3.2 | 1.1 | 4.5 | -2.4 | 5.5 | **-5.2** | **0.5** | 3.7 | 2.8 | | | -2.4 | | 0.0 |
| Estro & 2 Andro | Estro & 2 Andro | 4 | 3.46 | 3.45 | 19.62 | 2.10 | 5.68 | 3.44 | 707.3 | 61.85 | 14.05 | 0.39 | 2.50 | 2.15 | 51.76 | 366.0 | 341.2 | | | 59.73 | | 15.20 |
| None | None | | 2.97 | 2.84 | 19.50 | 2.16 | 6.59 | 3.08 | 662.8 | 61.15 | 12.65 | 0.41 | 2.56 | 2.52 | 50.99 | 337.9 | 324.9 | | | 84.02 | | 2.30 |
| Probability | | | 0.01 | 0.01 | 0.56 | 0.06 | 0.01 | 0.01 | 0.01 | 0.15 | 0.04 | 0.37 | 0.48 | 0.13 | 0.15 | 0.01 | 0.01 | | | 0.02 | | 0.33 |
| % Change | | | ***16.5*** | ***21.5*** | 0.6 | -2.8 | ***-13.8*** | ***11.7*** | ***6.7*** | 1.1 | **11.1** | -4.9 | -2.3 | -14.7 | 1.5 | ***8.3*** | ***5.0*** | | | ***-28.9*** | | 560.9 |
| Androgen | Androgen | 10 | 2.83 | 2.88 | 18.93 | 2.06 | 6.02 | 3.31 | 652.9 | 60.52 | 12.76 | 0.41 | 2.71 | 2.29 | 51.50 | 353.0 | 332.5 | 659 | 6.00 | 74.28 | 11.61 | 3.39 |
| None | None | | 2.59 | 2.64 | 19.29 | 2.14 | 6.76 | 3.11 | 632.6 | 60.59 | 11.99 | 0.45 | 2.79 | 2.42 | 50.95 | 338.3 | 325.7 | 652 | 6.00 | 75.21 | 12.37 | 1.59 |
| Probability | | | 0.01 | 0.03 | 0.17 | 0.01 | 0.01 | 0.01 | 0.01 | 0.84 | 0.01 | 0.19 | 0.35 | 0.17 | 0.05 | 0.03 | 0.24 | 0.51 | | 0.84 | 0.38 | 0.40 |
| % Change | | | ***9.3*** | **9.1** | -1.9 | -3.7 | ***-10.9*** | ***6.4*** | ***3.2*** | -0.1 | ***6.4*** | -8.9 | -2.9 | -5.4 | **1.1** | **4.3** | 2.1 | 1.1 | 0.0 | -1.2 | -6.1 | 113.2 |
| Andro & Estro | Andro & Estro | 9 | 3.09 | 2.79 | 18.15 | 2.44 | 5.99 | 3.03 | 604.3 | 60.97 | 12.61 | 0.47 | 2.65 | 2.36 | 50.97 | 324.9 | 312.5 | 438 | 4.02 | 72.01 | | 10.00 |
| None | None | | 2.28 | 2.50 | 17.34 | 2.12 | 7.51 | 2.93 | 577.4 | 60.65 | 11.74 | 0.47 | 2.80 | 2.57 | 50.59 | 310.0 | 302.3 | 495 | 4.45 | 87.15 | | 5.00 |
| Probability | | | 0.04 | 0.01 | 0.03 | 0.11 | 0.06 | 0.02 | 0.01 | 0.11 | 0.01 | 0.97 | 0.11 | 0.02 | 0.07 | 0.03 | 0.06 | 0.02 | 0.08 | 0.13 | | |
| % Change | | | ***35.5*** | ***11.6*** | ***4.7*** | 15.1 | -20.2 | **3.4** | ***4.7*** | 0.5 | ***7.4*** | 0.0 | -5.4 | **-8.2** | 0.8 | **4.8** | 3.4 | **-11.5** | -9.7 | -17.4 | | 100.0 |
| Andro & Estro | Andro & Estro | 2 | 2.95 | 2.80 | 19.00 | 2.10 | 6.81 | 3.08 | 671.4 | 61.36 | 13.18 | 0.41 | 2.33 | 2.05 | 51.40 | 345.0 | 326.2 | 580 | 5.00 | 86.81 | | 10.00 |
| Andro & Estro | Androgen | | 3.06 | 2.89 | 19.30 | 2.09 | 6.26 | 3.22 | 679.4 | 61.16 | 13.42 | 0.43 | 2.11 | 2.18 | 51.50 | 350.0 | 329.5 | 556 | 5.00 | 78.42 | | 5.00 |
| Probability | | | 0.38 | 0.53 | | 0.27 | 0.01 | 0.22 | 0.49 | 0.60 | 0.66 | 0.74 | 0.35 | 0.84 | 0.88 | 0.51 | 0.67 | | | 0.02 | | |
| % Change | | | 0.4 | -3.1 | -1.6 | 0.5 | ***8.8*** | -4.3 | -1.2 | 0.3 | -1.8 | -4.7 | 10.4 | -6.0 | -0.2 | -1.4 | -1.0 | 4.3 | 0.0 | **10.7** | | 100.0 |
| Andro & Estro | Androgen | 2 | 3.07 | 2.88 | 19.30 | 2.08 | 6.26 | 3.22 | 679.6 | 61.15 | 13.43 | 0.43 | 2.10 | 2.18 | 51.51 | 350.1 | 329.5 | 556 | 5.00 | 78.60 | | 5.00 |
| Andro & Estro | None | | 2.98 | 2.97 | 18.70 | 2.05 | 6.84 | 3.28 | 673.8 | 61.49 | 13.42 | 0.40 | 2.41 | 2.03 | 51.58 | 347.6 | 326.2 | 623 | 6.00 | 86.40 | | 10.00 |
| Probability | | | 0.66 | 0.22 | | 0.11 | 0.01 | 0.45 | 0.67 | 0.41 | 0.98 | 0.59 | 0.03 | 0.82 | 0.91 | 0.76 | 0.68 | | | 0.05 | | |
| % Change | | | 3.0 | -3.0 | 3.2 | 1.5 | ***-8.5*** | -1.8 | 0.9 | -0.6 | 0.1 | 7.5 | **-12.9** | 7.4 | -0.1 | 0.7 | 1.0 | -10.8 | -16.7 | **-9.0** | | -50.0 |

*Head-on Comparisons-Reimplanting*:

Reimplanting steers with a second mild estrogen implant increased gains (5-7%), efficiency (4%), and diet ME (3%) but reduced marbling score (5%) (Table 8). Changes in performance or carcass traits with a strong estrogen reimplant were minor. However, in combination with androgen, a second implant improved gain (6-8%), efficiency (6%), diet ME (4%), carcass weight (4%) and dressing percentage (.8%) but reduced marbling score (4%) and percent choice (20%).

*Head-on Comparisons-Implant Schemes*:

Comparisons between various implant schemes for steers (Table 8) showed little difference between reimplanting with androgen alone or a combination implant. Differences among specific implant schemes were minor and largely reflected response differences from the first implant. In most cases where growth rate and rib eye area were increased, marbling score tended to be reduced.

Sequence of implant administration (estrogen-androgen/strong estrogen vs. strong estrogen/estrogen-androgen) did not alter performance or carcass traits of steers. Reimplanting with the combination instead of a strong estrogen after a first combination implant produced slight but nonsignificant responses in steers (Table 6) ADG (4%), ribeye area (3%), and yield grade (-5%). For steers, two combination implants of estrogen-androgen compared to two strong estrogen implants resulted in greater gain (7%), improved efficiency (-6%), diet ME (4%), carcass weight (3%) and ribeye area (3%) but reduced percent grading choice by 11%. Compared to two strong estrogen implants, even a single combination implant for steers (Table 8) resulted in greater gain (2-6%) with little effect on efficiency (1%), carcass weight (2%) or marbling score. For steers having a strong estrogen as their first implant, a combination implant given later (as compared to no second implant) improved ADG, efficiency and ME 5 to 6% but did not alter carcass quality in a very limited number of comparisons (3).

*Head-on Single Implant Comparisons for Heifers:* In head-on comparisons, implanting feedlot heifers once with mild or strong estrogenic compounds did not change any performance or carcass traits with the exception of DMI; DMI was increased 3% with a mild estrogen implant (Table 9). Implanting with an androgen alone increased gain, efficiency, diet ME, and kidney-pelvic-heart fat, all by approximately 4%, and carcass weight (2%) but reduced percent grading choice by 7% compared with no implant. Implanting with a strong estrogen plus one or two androgens increased gain (10-12%), efficiency (6-9%), diet metabolizable energy (4-6%), carcass weight (4%) and ribeye area (5%). Comparisons between implant types showed that the combination estrogen-androgen implant was more effective than an androgen alone for increasing performance traits, carcass weight and ribeye area and reducing kidney-pelvic-heart fat. Implanting with this combination also appeared to increase performance and carcass traits over strong estrogen alone, but the number of trials comparing these two implant schemes was very limited.

For heifers, the only reimplant scheme tested was with androgen alone from which no performance or carcass traits were altered (Table 9).

Responses to androgen alone or combined with estrogen generally were similar for heifers; using either as a second implant had only minor effects on performance or carcass quality. However, compared to non-implanted heifers, those implanted twice with androgen alone or combined with estrogen markedly improved gain (9-35%), efficiency (11-20%), diet ME (3-6%), and carcass weight (3-6%) with the greatest impact generally from the combination. However, the combination also caused the greatest reduction in marbling score.

**Effects of MGA on heifer performance and implants response.**

Results of head-on comparisons of MGA for heifers with or without implants are presented in Table 10. Based on statistics (right side of table), when averaged across implant presence, MGA feeding increased gain, feed intake, carcass weight, fat thickness, and yield grade while improving feed efficiency primarily through increased DMI; diet ME was not altered. Androgen or androgen plus estrogen implants improved ADG and feed/gain and increased carcass weight. Adding an estrogen to the androgen implant increased feed intake, ribeye area and, surprisingly, increased marbling score of heifers. The only MGA by androgen interaction was a tendency for the androgen to increase percent choice carcasses MGA in heifers not receiving but to decrease percent choice for heifers fed MGA. More interactions between MGA and an estrogen - androgen implant were noted; feeding MGA markedly reduced the implant response. Presumably, fed MGA is replacing the need for or benefit from including estrogen in the implant.

Table 10. Impact of MGA Feeding and Implants on Heifer Performance:Head-on Contrasts from 6 trials (least squares means).

| MGA Feeding | None | None | None | MGA | MGA | MGA | Significance Level, P < | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Implant | None | Androgen | SE&A | None | Androgen | SE&A | MGA | Androgen | SE & A | MGA*Andro | MGA*SE&A |
| ADG, lb. | 2.97 | 3.35 | 3.43 | 3.26 | 3.41 | 3.47 | 0.01 | 0.01 | 0.01 | 0.11 | 0.01 |
| ADG, carcass | 2.88 | 3.21 | 3.31 | 3.14 | 3.30 | 3.35 | 0.01 | 0.03 | 0.01 | 0.28 | 0.02 |
| DMI, lb/d | 18.92 | 19.34 | 20.30 | 20.21 | 19.71 | 20.26 | 0.01 | 0.89 | 0.01 | 0.08 | 0.01 |
| DMI, % of mean wt | 2.13 | 2.12 | 2.20 | 2.22 | 2.15 | 2.20 | 0.01 | 0.14 | 0.03 | 0.14 | 0.01 |
| Feed/gain | 6.42 | 5.83 | 5.93 | 6.22 | 5.8 | 5.84 | 0.02 | 0.01 | 0.01 | 0.38 | 0.36 |
| Feed ME | 3.78 | 4.08 | 3.98 | 3.82 | 4.06 | 4.03 | 0.35 | 0.01 | 0.01 | 0.63 | 0.99 |
| Carcass weight, lb | 660 | 684 | 693 | 681 | 692 | 697 | 0.01 | 0.04 | 0.01 | 0.30 | 0.04 |
| Dress percent | 61.33 | 61.02 | 61.17 | 61.12 | 61.26 | 61.23 | 0.73 | 0.79 | 0.89 | 0.39 | 0.39 |
| Rib eye area, sq. in. | 12.13 | 12.52 | 12.96 | 12.09 | 12.43 | 12.93 | 0.81 | 0.26 | 0.01 | 0.93 | 0.94 |
| Fat thickness, in. | 0.51 | 0.52 | 0.53 | 0.59 | 0.56 | 0.59 | 0.01 | 0.78 | 0.56 | 0.40 | 0.52 |
| KPH, % | 2.53 | 2.52 | 2.54 | 2.56 | 2.54 | 2.56 | 0.70 | 0.92 | 0.96 | 0.96 | 0.92 |
| Marbling score | 601 | 467 | 572 | 603 | 557 | 583 | 0.38 | 0.14 | 0.05 | 0.32 | 0.56 |
| Choice, % | 48.4 | 53.7 | 55.2 | 57.2 | 48.7 | 48.3 | 0.56 | 0.61 | 0.51 | 0.02 | 0.01 |
| Yield grade | 2.72 | 2.59 | 2.61 | 2.99 | 2.79 | 3.00 | 0.01 | 0.08 | 0.24 | 0.66 | 0.14 |
| Dark cutters, % | 0.58 | 0.19 | 2.11 | 0 | 0.19 | 0.61 | 0.09 | 0.99 | 0.08 | 0.52 | 0.23 |

**Effects of Ovariectomy on Heifer Performance and Implant Response.**

Results of head-on comparisons are presented in table 11. Only four trials were available for these comparisons so performance information is not complete. Averaged across implants, ovariectomy reduced feed intake as a percentage of body weight, dressing percentage, fat thickness and kidney-pelvic-heart fat percentage. Implants of estrogen plus androgen increased gain, feed intake, carcass weight, and dressing percentage, while reducing feed/gain, kidney-pelvic-heart fat and marbling score. The androgen implant, when alone, had less impact on DMI and carcass traits, but information is incomplete. No interaction of ovariectomy and implants proved to be significant although numerical responses in gain, feed/gain, and carcass weight from the combination implant tended to be greater for ovariectomized heifers than for intact heifers. This agrees with the general concept discussed by Raun and Preston elsewhere in this publication that hormonal replacement improves performance of ovariectomized heifers.

*Time After Implant Administration:* Figure 1 shows added weight gain from implanting versus time after the final implant administration for steers with either strong estrogen with or without androgen implants. In almost all trials, weight gain was increased by implants. Broken live regressions indicated that weight gain increased to 143 d and 165 d by a total of 94 and 63 additional pounds for strong estrogen plus androgen and strong estrogen implant, respectively. The rate of added weight gain was .66 lb/d and .38 lb/d for these two implant schemes. Thus, the combination of estrogen and androgen tended to increase weight gain more but for a shorter time than an estrogen implant alone did.

Duration of this implant response seems unusually long compared to most estimates in which responses in sequential periods is compared. Unfortunately, information from individual periods is seldom reported.

Table 11. Impact of ovariectomy and implants on heifer performance:Head-on contrasts from 4 trials (least squares means).

| Ovariectomy | None | None | None | Ovx | Ovx | Ovx | Significance Level, P < | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Implant | None | Androgen | SE&A | None | Androgen | SE&A | Ovx | Androgen | SE& A | OVX*Implant |
| ADG, lb. | 2.32 | 2.44 | 2.58 | 2.16 | 2.40 | 2.64 | 0.43 | 0.19 | ***0.01*** | 0.34 |
| ADG, carcass | 2.71 | | 3.09 | 2.34 | | 3.08 | 0.25 | | **0.02** | 0.22 |
| DMI, lb/d | 18.29 | | 19.05 | 17.48 | | 18.70 | 0.12 | | **0.03** | 0.46 |
| DMI, % of mean wt | 2.28 | | 2.34 | 2.21 | | 2.29 | **0.04** | | **0.04** | 0.70 |
| Feed/gain | 7.89 | | 7.69 | 8.21 | | 7.3 | 0.53 | | **0.02** | 0.07 |
| Feed ME | 3.59 | | 3.84 | 3.39 | | 3.94 | 0.83 | | **0.04** | 0.30 |
| Carcass weight, lb | 592 | | 615 | 569 | | 612 | 0.21 | | **0.02** | 0.27 |
| Dress percent | 61.87 | | 62.59 | 61.37 | | 61.74 | ***0.01*** | | **0.03** | 0.28 |
| Rib eye area, sq. in. | 11.34 | 12.14 | 11.98 | 10.95 | 11.14 | 11.98 | 0.33 | 0.42 | 0.08 | 0.57 |
| Fat thickness, in. | 0.55 | 0.44 | 0.54 | 0.48 | 0.36 | 0.47 | **0.02** | **0.03** | 0.86 | 0.98 |
| KPH, % | 2.67 | 2.57 | 2.42 | 2.52 | 2.57 | 2.17 | **0.04** | 0.64 | **0.03** | 0.23 |
| Marbling score | 599 | 600 | 505 | 567 | 568 | 462 | 0.07 | 0.98 | **0.02** | 0.87 |
| Quality grade | 5.78 | 5.49 | 4.77 | 5.22 | 5.5 | 4.24 | 0.30 | 1.00 | 0.17 | 0.81 |
| Yield grade | 2.93 | | 2.80 | 2.91 | | 2.58 | 0.33 | | 0.17 | 0.45 |

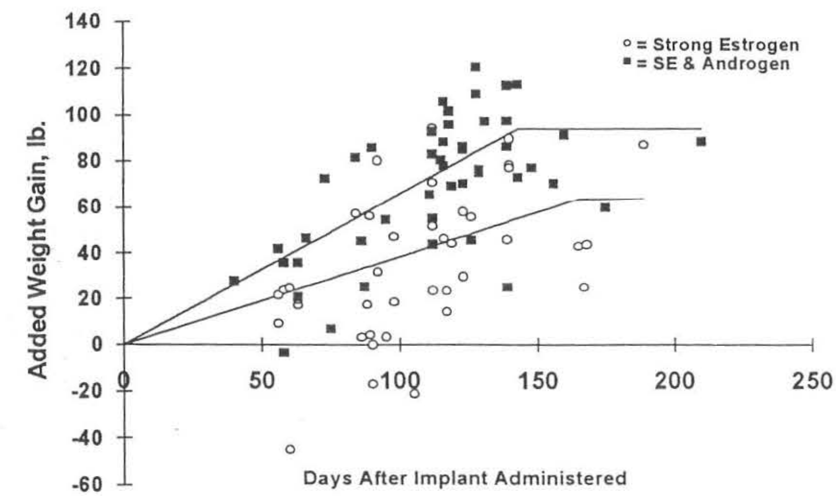


Figure 1. Added steer weight versus days from last implant.

**Relationship of Gain to DMI Response.**

Figure 2 illustrates the relationship between the change in gain by steers versus change in dry matter intake for steers receiving single implants of strong estrogen either alone or with added androgen. When intake was increased, gain tended to increase, too. Generally the gain response paralleled the intake response; gain increased by .18 lb for every added pound of feed dry matter. This means that rate of gain increased by approximately 1 pound for each 6 pounds of additional DMI. Considering that this increase in feed dry matter should all be above maintenance energy requirements, a higher efficiency might be expected. Regression indicates that the combination implant increased gain by over 0.4 lb./day even when feed intake was not increased; presumably this is the result of increased lean deposition or a reduced maintenance energy requirement. This response was lower from the strong estrogen alone (.14 lb/day) reflecting less impact of estrogen than of estrogen plus androgen on body composition or maintenance energy needs.

*Marbling score versus ribeye area.* Responses for SE and SEA implants for steers are shown in Figure 3. As ribeye area increased, marbling score tended to decline. The regressions for the estrogen and combination implants tended to be steeper than the overall regression across all steers. Subsequent laboratory data further suggests that implanting enlarges ribeye area with no concomitant increase in intramuscular lipid deposition; thereby, marbling score declines (Duckett and Wagner, 1997).

**Relationship of Shear Force to Carcass Weight.**

Figure 4 shows the relationship between Warner-Bratzler shear force and carcass weight for steers. The regression indicates that as carcass weight increased, shear force declined ($R^2$ = .73). This relationship should be interpreted cautiously due to fact that shear force data for implanted steers are limited and shear force methods vary between research institutions. Further, implants tended to increase shear force despite increasing carcass weight. In general, shear force was lower for cattle started on feed as calves than as yearlings. Stretched carcass muscles usually become more tender than contracted muscles. All measurements were on the ribeye; any increase in carcass weight may cause greater stretching of the LD, especially in calves where the LD is smaller. This might be tested by adding additional weight to the fore-quarter while cooling the carcass.

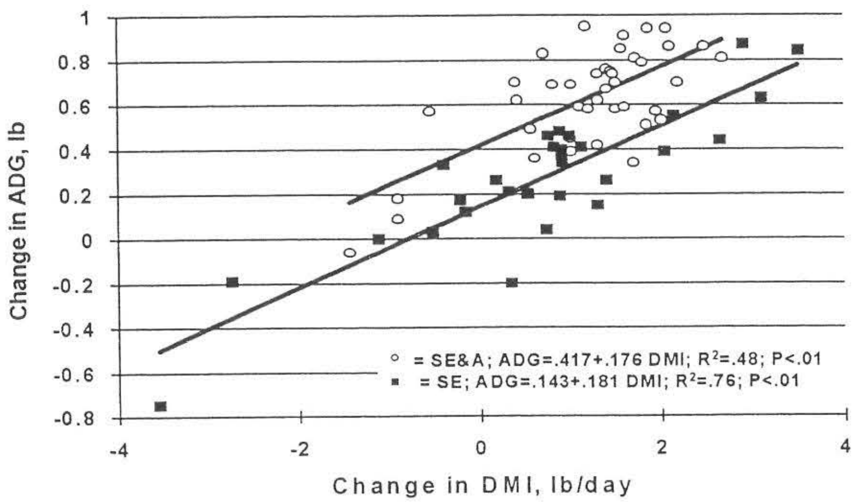


Figure 2. Change in ADG versus change in DMI associated with implants in head-on comparisons.

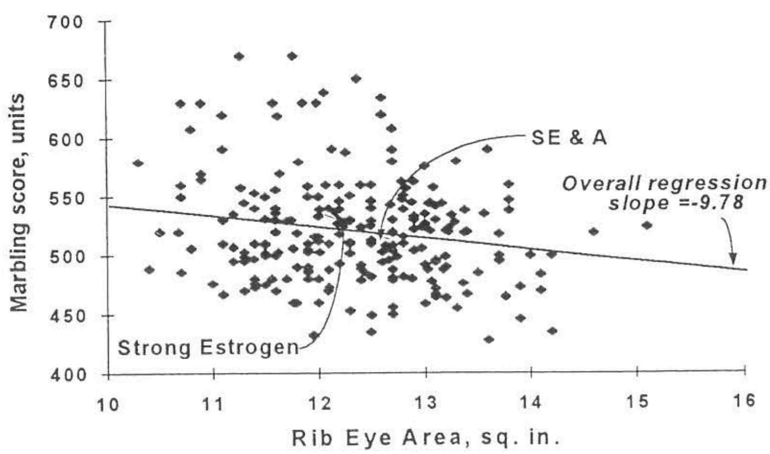


Figure 3. Relationship of marbling score to ribeye area. Regression lines are across all studies or based on changes due to implanting with a strong estrogen with or without an androgen.

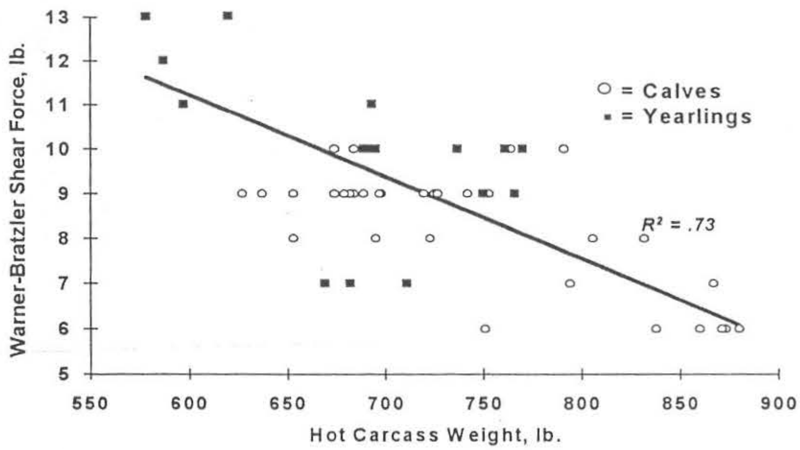


Figure 4. Relationship of shear force to carcass weight across all studies.

**Impact of Implants on Carcass Quality Relationships**

Two of the major items involved with carcass value are final yield grade and marbling score. Regression of marbling score against final yield grade across all trials for control steers (those never implanted) indicated that marbling score (MS) increased as final yield grade (FYG) increased (MS = 446 + 34.45 FYG). In comparison, averaged across all implant types and combinations, both the intercept and the slope tended to be lower (MS = 419 + 30.08 FYG). The plot across all trials for marbling scores and these two regression lines are shown in Figure 5. Note that there is a lot of scatter among the points for individual steer trials. Nevertheless, to achieve an equal marbling score, the two regression lines indicate that implanted animals would need to reach a final yield grade from 1 to 1.5 higher than non-implanted steers. When diethyl stilbestrol implants were first used, producers were told to feed cattle for an equal number of days so that they would be heavier but still achieve the same marbling score. These regression lines indicate that in addition to heavier weights, implanted steers would need to reach a higher yield grade. Feeding implanted animals to a heavier yield grade simply to increase the marbling score and quality grade may or may not prove economical based on the relationship between the price discount for low quality grade versus excessive yield grade (and excess carcass weight).

Because the relationship above was averaged across all trials and steer factors (weight, breed, feeding duration, implant timing), marbling scores and final yield grades of implanted cattle also were compared to those measurements for control cattle in each experiment. These are plotted as change in marbling score versus change in marbling score from control values in Figure 6. Note that final yield grade was not markedly changed by implants, being decreased or increased by a maximum of .6 to .8 units. Since implants increase rib eye area and often decrease KPH, one would expect that implants should decrease final yield grade. However, carcass weight typically is increased by effective implants, and an increase in carcass weight will increase final yield grade. Just to maintain a constant final yield grade, rib eye area would need to increase by 1.2 inches for every increase in carcass weight of 100 pounds. Of the implants, only the strong estrogen implants given twice or strong estrogen plus androgen implants (once or twice) increased this ratio by more than 1.2 (1.5, 1.3 and 1.2 inches per 100 pounds carcass weight, respectively.) Consequently, final yield grade was not consistently changed by implants. Whether the yield grade formula, which indicates that an cattle with heavier carcass weights have an increased yield grade (and decreased cutability), is equally applicable for aggressively implanted and non-implanted steers is open to question. Impact of implants on reliability of the yield grade formula, or more precisely on the weights of specific meat cuts, deserves further research attention. Perhaps the yield grade formula inadvertently discredits heavier carcasses due to the autocorrelation between carcass weight and fat thickness.

Marbling score was decreased below values for control steers in almost all studies with implants although mild estrogen implants tended to be less depressing than other implants (Figure 6). Regression across trials for non-implanted steers indicates that one would expect marbling score to increase by 34 units for every unit increase in final yield grade. No evidence of such an increase in marbling score with final yield grade is evident for implanted steers. Because in almost all of these studies, steers were fed for a constant number of days prior to marketing, the effect of time on feed on these measurements is not available. Serial slaughter studies could reveal more information about how the ratio of marbling score to yield grade is changed by implants and whether feeding aggressively implanted cattle for a longer time is beneficial economically.

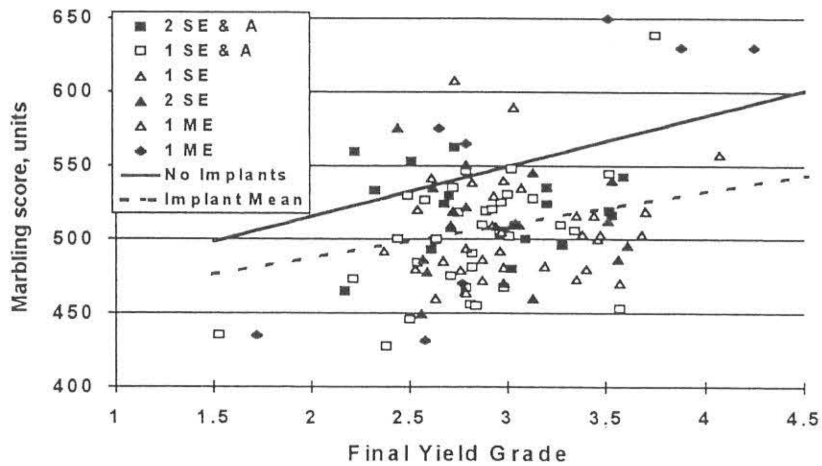


Figure 5. Marbling scores and final yield grades from trials in which steers received various implants once or twice. Solid line (no implants) is regression for non-implanted steers and dashed line (implant mean) is regression for all implanted steers weighted by the number of steers per trial.

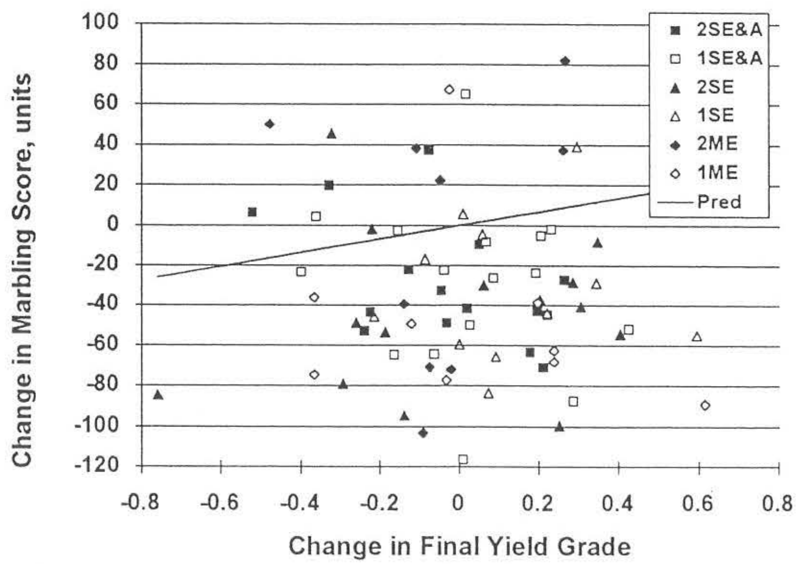


Figure 6. Effects of various implants on marbling score and final yield grade compared with non-implanted control animals from the same trial. Regression line (Pred) shows the mean slope for non-implanted cattle.

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## QUESTIONS & ANSWERS

**Q:** If dry matter intake is expressed as a percentage of live weight, do implants increase intake?

**A:** Effects are reduced but still present for estrogen but generally disappear for androgen implants.

**Q:** On the graphs of added gain versus time after implanting, wouldn't the first differential provide an estimate of payout time?

**A:** Yes, if one assumes that growth rate does not decrease as size increases.

**Q:** Reimplanting with a strong estrogen had limited effect in the trials you examined. Could this be due to length of time on feed? If cattle are fed for a short time period, the initial implant may still be adequate.

**A:** That is a possibility, yet in many of these studies, reimplants had plenty of time to work. Payout from the initial implant may be longer, especially for calves than many people believe.

## THE EFFECT OF IMPLANTING CULL COWS ON GAIN, INTAKE, FEED CONVERSION, AND CARCASS CHARACTERISTICS

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### ABSTRACTS

For cull cows, implants generally increase rate of gain and improve feed conversion. While research results on effects on carcass traits have been inconclusive, muscle deposition tends to be increased. The major impact on carcass characteristics is an increased hot carcass weight. *None of the implants currently (1997) approved for use in suckling calves, stockers, or finishing cattle are approved for use in cull cows.*

### INTRODUCTION

Between six to eight million beef cows are culled annually in the U. S. Many culled cows are thin and have the potential to make very rapid gains during a relatively short (50-70 days) feeding period. While most cows are slaughtered shortly after they are culled, many are fed with the goal of increasing both weight and value per pound. Feeding programs vary from simply putting cull cows on a very high quality pasture to feeding very high concentrate diets typical of those fed to finishing cattle. Because many producers who feed cull cows also finish other classes of cattle and routinely implant those cattle, they wonder about the value of implanting cull cows. Several universities have evaluated implants for cull cows. However, the number of implant experiments is far less than with other classes of cattle. This paper, summarizes research for each specific implant when compared to non-implanted control cows. Most of the research has focused on this comparison rather than comparing different implants and(or) combinations.

*Implanting Cull Cows With Zeranol* - Early research conducted in the U.S. evaluated the impact of zeranol (Ralgro®) on cull cow performance. A summary of these six trials with zeranol is shown in Table 1.

**Table 1.** Summary of research trials evaluating the effect of implanting cull cows with Zeranol (Ralgro®) on rate of gain.

| Study | Management | Control | Zeranol (36 mg) | Zeranol (72 mg) | % Improvement |
|---|---|---|---|---|---|
| | | ADG, kg | | | |
| Bellows et al. (1979) | Native pasture | 0.64 | 0.71 | | 10.9 |
| Bellows et al. (1979) | Native pasture | 0.92 | 1.08 | | 17.4 |
| Corah et al. (1980) | Fescue pasture | 1.93 | 2.15 | | 11.2 |
| Price et al. (1982) | High concentrate, Young cows | 1.71 | 1.82 | 1.84 | 6.4;7.6 |
| Price et al. (1982) | High concentrate, Old cows | 1.82 | 1.64 | 1.66 | -9.9;-8.8 |
| Waggoner et al. (1985) | High concentrate | 1.21[a] | 1.34[b] | | 10.7 |

[a,b] Values in the same row differ significantly (P<.01)

**Table 2.** Summary of research trials evaluating the effect of implanting cull cows with 200 mg progesterone + 20 mg estradiol benzoate (Synovex-H®) on rate of gain.

| Study | Control | Synovex-H® | % Improvement |
|---|---|---|---|
| | ADG, kg | | |
| Jones (1982) | 1.61 | 1.66 | 3.1 |
| Corah & Goehring (1986) | 1.22 | 1.16 | -4.9 |
| Matulis et al. (1987) | Not reported | Not reported | No difference |
| Brethour & Cranwell (1993) | 1.07 | 1.24 | 15.9 |
| Cranwell et al. (1996) | 1.69[a] | 2.16[b] | 21.8 |

[a,b] Values in the same row differ significantly ($P<.05$)

Except for old cows in the study by Price et al. (1982), the gain response of cull cows both on pasture and on high concentrate feeding programs in drylot has been fairly consistent; gain has averaged approximately 10% above controls. In both trials reported by Bellows et al. (1979) conducted at the Miles City Station, cows grazed high quality, native spring grass which allowed a good rate of gain. Correspondingly, the fescue pasture utilized in the trial reported by Corah et al. (1980) also provided for rapid gains. Implant responses for cows grazing low quality pasture or crop residue haven't been reported.

In the study by Price et al. (1982), when cows were classified by age (young <4 yr), implant response differed with age group. Unfortunately, in the other studies presented in Table 1, young and old cows were grouped together; this prevents a similar age comparison. The difference between age groups in the trial by Price et al. (1982) indicates that more research comparing the effect of age on implant response is needed.

Effects on carcass data, provided in three of these studies has been inconsistent. Bellows et al. (1979) found that zeranol tended ($P=.08$) to increase ribeye area in their first trial but not in a second trial where the results were confounded by an interaction between implant and spaying treatments. Price et al. (1982) reported that zeranol did not alter carcass traits in either the young or the old cows. The only carcass trait influenced in the study by Waggoner et al. (1985), ribeye area, was significantly increased by the implant. Consequently, zeranol may increase muscle deposition as reflect by ribeye area, but results have not been conclusive.

*Implanting Cull Cows With Estradiol Benzoate Plus Progesterone (Synovex-H®)* - Summaries of five research trials evaluating estradiol benzoate and progesterone are shown in Table 2. Results have been less consistent than with zeranol, but again, in general, this implant has increased rate of gain.

Matulis et al. (1987) found no difference in feed conversion between control and Synovex-H® implanted cows. In the experiments by Brethour and Cranwell (1993) and Cranwell et al. (1996), gain/feed was superior numerically for the implanted cows, but the differences were not significant.

Both Jones (1982) and Matulis et al. (1987) detected no effect on carcass characteristics as a result of implanting with Synovex-H®. Conversely, Cranwell et al. (1996) reported that hot carcass weight and ribeye area were increased while yield grade was decreased by implanting.

*Implanting Cull Cows With Trenbolone Acetate (TBA)*- Research with TBA implants is summarized in Table 3. The earliest trials by Drennan et al. (1983) and Garnsworthy et al. (1986) were conducted in Europe using a 300 mg dosage of TBA; for the remaining trials the 240 mg dosage found in Finaplix was used. Although rate of gain was increased significantly in only two of these six research trials, there was a consistent trend for a large increase in rate of gain.

Table 4 shows the impact of TBA with or without an estrogenic implant on DMI and feed conversion. The impact of TBA on DMI has not been consistent. For example, TBA resulted in decreased DMI in one trial (Pritchard and Burg 1993), no effect in another trial (Cranwell et al., 1996), and a dramatic increase in a third trial (Brethour and Cranwell, 1993). Feed conversion was improved numerically in all of the trials where such information was reported.

Table 5 shows the effect of TBA on carcass characteristics. In both trials, TBA alone had a minimal effect except for reducing external fat in the study by Cranwell et al. (1996). However, when TBA was combined with an estrogenic implant, i.e., Synovex-H®, carcass weights and soft tissue were increased reflecting greater protein deposition.

Table 6 shows the effect of implanting with either TBA alone, an estrogenic implant alone, or the combination on sensory panel evaluation and Warner-Bratzler shear force. Trenbolone acetate alone increased juiciness, myofibrillar tenderness, and overall tenderness as measured by taste panel. However, shear force values remained similar to control. When TBA was combined with an estrogenic implant, sensory scores all were similar to those of control cows.

*Implanting Cull Cows with Testosterone Propionate* - Faulkner et al. (1989) evaluated the effect of testosterone propionate on performance and carcass characteristics of cull cows. Gain, intake, and feed/gain were similar for control and implanted cows and No differences in carcass traits were detected.

**Table 3.** Summary of research trials evaluating the effect of implanting cull cows with trenbolone acetate with or without estrogen on rate of gain.

| Study | Control | Trenbolone Acetate[a] | TBA & Estrogen[b] | % Improvement |
|---|---|---|---|---|
| Drennan et al. (1983) | 0.78 | 0.88 | | 12.8 |
| Garnsworthy et al. (1986) at 60 d | 1.12 | 1.35 | | 20.5 |
| Garnsworthy et al. (1986) at 100 d | .92[a] | 1.31[b] | | 42.4 |
| Pritchard & Burg (1993) | 1.31 | 1.37 | | 4.6 |
| Brethour & Cranwell (1993) | 1.07 | 1.42 | 1.26 | 32.7;17.8 |
| Cranwell et al. (1996) | 1.69[c] | 2.11[d] | 2.26[d] | 24.9;33.7 |

[a] Drennan et al. (1983) and Garnsworthy et al. (1986) used 300 mg trenbolone acetate while the remaining trials used 240 mg TBA supplied by Finaplix-H®

[b] Estrogen supplied by Synovex-H®.

[cd] Value differs significantly ($P<.05$)

**Table 4.** Summary of research trials evaluating the effect of implanting cull cows with trenbolone acetate with or without estrogen on intake and feed conversion.

| | Intake, kg | | | Feed/Gain | | |
|---|---|---|---|---|---|---|
| Study | Control | TBA[a] | TBA + EB[b] | Control | TBA[a] | TBA + EB[b] |
| Garnsworthy et al. (1986) at 60 d | 11.6 | 11.9 | | 10.1 | 7.9 | |
| Garnsworthy et al. (1986) at 100 d | 12.9 | 14.7 | | 12.7 | 9.5 | |
| Pritchard & Burg (1993) | 12.2 | 12.0 | | 9.4 | 8.7 | |
| Brethour & Cranwell (1993) | 15.2 | 15.0 | 14.7 | 14.3 | 10.6 | 11.7 |
| Cranwell et al. (1996) | 12.3 | 12.6 | 12.5 | 7.1 | 5.9 | 5.6 |

**Table 5.** Summary of research trials evaluating the effect of implanting cull cows with either estrogen or trenbolone acetate or the combination on carcass characteristics.

| | Treatment | | | |
|---|---|---|---|---|
| **Study and Item** | **Control** | **TBA[a]** | **Estrogen (EB)[b]** | **TBA & EB** |
| Pritchard & Burg (1993) | | | | |
| Carcass wt., kg | 310 | 310 | | |
| Dressing percentage, % | 55.1 | 55.9 | | |
| Fat, cm | 0.14 | 0.13 | | |
| REA, $cm^2$ | 73.5 | 75.5 | | |
| Cranwell et. al. (1996) | | | | |
| Carcass wt., kg | 275.9[c] | 281.8[c] | 292.2[d] | 292.0[d] |
| Dressing percentage, % | 52.1[cd] | 51.3[c] | 53.1[d] | 52.6[cd] |
| Fat, cm | 1.02[c] | .77[d] | .91[cd] | .95[cd] |
| REA, $cm^2$ | 72.6[c] | 75.9[c] | 82.7[d] | 78.5[cd] |
| Carcass soft tissue, kg | 221[c] | 221[c] | 234[cd] | 238[d] |

[a] TBA supplied by Finaplix-H®.
[b] Estrogen (EB) supplied by Synovex-H®.
[cd] Values in the same row differ significantly (P<.05).

**Table 6.** Effect of implanting with either trenbolone acetate, an estrogenic implant, or the combination on sensory panel evaluation and Warner-Bratzler shear force (Cranwell et al. 1996).

| | Implant Treatment[a] | | | |
|---|---|---|---|---|
| **Sensory Trait** | **Control** | **TBA** | **EB** | **TBA + EB** |
| Flavor intensity[b] | 5.4 | 5.7 | 5.5 | 5.5 |
| Juiciness[b] | 5.5[c] | 6.0[d] | 5.4[c] | 5.6[cd] |
| Myofibrillar tenderness[b] | 5.0[c] | 6.2[d] | 5.3[cd] | 5.4[cd] |
| Overall tenderness[b] | 5.2[c] | 6.2[d] | 5.5[cd] | 5.6[cd] |
| Connective tissue amount[b] | 5.6[c] | 6.6[d] | 6.3[cd] | 6.4[cd] |
| Warner-Bratzler shear, kg | 5.1 | 4.6 | 4.9 | 5.1 |

[a]TBA = 200 mg of trenbolone acetate; EB = 200 mg of testosterone propionate + 20 mg of estradiol benzoate.
[b] Scores of 1 to 8:3 = moderately bland, moderately dry, moderately tough, moderately tough or slightly tough; 4 = slightly bland, slightly dry, slightly tough, slightly tough, or moderate; 5 = slightly intense, slightly juicy, slightly tender, slightly tender, or slight; 6 = moderately intense, moderately juicy, moderately tender, moderately tender, or traces.
[c,d] Means in the same row without a common superscript are different (P < .05).

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## QUESTIONS & ANSWERS

**Q:** Does the amount of fat in the animal's body influence the cow's response to implants? Do cows exhibit compensatory growth?

**A:** Amount of fat or condition score may alter the implant response. One theory is that a cow with a condition score of 5 is going to respond differently to an implant than a thin cow will. I did not find any data for implant effects on cows with different condition scores. Presumably, according to that theory, response by cows with lower condition will be greater because more of their weight gain is protein. Regarding compensatory gain, cows that are healthy and are thin for no reason other than energy shortage will show a tremendous gain response for feeding periods of 30 to 45 days.

**Q:** What about combining somatotropin with implants?

**A:** I did not find any trial data on that combination. If anybody knows of data on this or other trials that I've missed, please let me know; I would like to include all pertinent information in my review paper.

**Q:** What was your measurement of connective tissue and is more connective tissue good or bad?

**A:** I was not involved in that part of the procedure. It is an estimate of the amount of connective tissue on a scale of 1 to 8 or 1 to 9. The higher the number on that scale, the better (or the less) the connective tissue.

# CARRYOVER AND LIFETIME EFFECTS OF GROWTH PROMOTING IMPLANTS

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## ABSTRACT

Numerous implant strategies can be used for cattle from suckling through finishing phases of production. Lifetime implant programs should be designed to obtain optimum growth and efficiency response with minimum expression of live animal side effects and limited adverse effects on carcass traits. Initial studies indicated that suckling implants tended to negatively affect finishing phase gains. A summary of three subsequent studies indicated that successive use of 36 mg zeranol implants, throughout life, tended to result in poorer feed conversion during the finishing phase for implanted than for non-implanted cattle. Using, in succession, low, moderate and high potency implants gave the greatest animal lifetime gain (> 50 kg) while maintaining or slightly improving post-weaning feed conversion when compared to non-implanted cattle performance. Implant strategies should match implant dose or potency to animal age, weight, and(or) production rate desired to maintain positive carryover effects from previous implants. One should begin the pre-weaning period with low potency products and end the post-weaning period with high potency androgenic implant products that complement the estrogenic response. Implant programs should be designed to maintain hormone blood levels within an optimum response range. Hormone levels below or above this range should be avoided once implant programs are initiated. Additional data are needed to determine if significant economic differences in lifetime implant response exist between steers and heifers.

## INTRODUCTION

Steers and heifers destined for slaughter through a feedlot production system may receive four to six or more implants throughout their lifetime using various implant strategies. In initial implant systems research, Ward et al. (1978) compared 16 different Ralgro® implant sequences for steers and heifers through the suckling, growing, and finishing phases of production; McReynolds et al. (1979) compared 18 different implant sequences using Ralgro® and Synovex-S®. These early studies, although limited in the number of cattle involved, demonstrated that not only a large number of different implant sequences are possible, but also that carryover effects into subsequent production phases often occur from previous implants. Carryover effects in these studies were measured in subsequent production periods as the differences in gain between previously implanted and previously non-implanted cattle.

Carryover effects in gain were positive (favorable) from suckling to growing and from growing to finishing phases of production; however, implants (zeranol) during the suckling period tended to have a negative effect on subsequent finishing and overall post-weaning performance (Table 1). Positive carryover from suckling to growing phases of production were most pronounced as has been noted previously (Gill et al., 1986; Mader et al., 1985; Simms et al., 1988).

Three studies (Laudert et al., 1981; Mader et al., 1985, Simms et al., 1988) assessed effects of suckling implant on subsequent implant responses post-weaning. These studies were conducted with steers and utilized zeranol (36 mg) as the only implant. A summary of these studies (Table 2) demonstrates the magnitude of the gain response attributed to implanting and tends to show little or no improvement in finishing period feed efficiency from implanting unless the implants were administered only during the finishing period.

Table 1. Effect of previous implant treatment on average daily gain (kg) during the finishing period.

| | Steers | | Heifers | |
|---|---|---|---|---|
| | No finishing implant | Finishing implant | No finishing implant | Finishing implant |
| Birth implant | 1.06 | 1.25 | 1.02 | 1.02 |
| No birth implant | 1.20 | 1.31 | 1.07 | 1.11 |
| Carry-over effect | -.14 | -.06 | -.05 | -.09 |
| 92-day implant | 1.15 | 1.22 | 1.04 | 1.05 |
| No 92-day implant | 1.10 | 1.32 | 1.06 | 1.09 |
| Carry-over effect | .05 | -.10 | -.02 | -.04 |
| Growing implant | 1.15 | 1.28 | 1.11 | 1.08 |
| No growing implant | 1.10 | 1.28 | .99 | 1.05 |
| Carry-over effect | .05 | .0 | .12 | .03 |

[a] Ward et. al. (1978).

Table 2. Effect of previous implant on finishing phase performance[a].

| | Implant Treatment | | | |
|---|---|---|---|---|
| Suckling: | N | N | N | I |
| Growing: | N | N | I | I |
| Finishing | N | I | I | I |
| ADG, kg | 1.18 | 1.32 | 1.31 | 1.27 |
| Feed intake, kg | 9.16 | 9.30 | 9.66 | 9.57 |
| Feed/gain | 7.58 | 6.98 | 7.31 | 7.47 |
| Final wt., kg | 510 | 530 | 538 | 534 |
| Change in wt. gain, kg | -- | 20 | 28 | 24 |

[a]Three trial summary - CO, KS and NE.

N = no implant, I = implanted with 36 mg zeranol.

Mader et al. (1985) and Simms et al. (1988) both found that growth promoting effects of the suckling implant extended beyond weaning, although very little gain response was obtained at weaning due to implanting. The implant-mediated growth response appeared to continue 150 to 200 d following implantation (Simms et al., 1988). Very slow release of growth promoting substances in the suckling phase and subsequent continued release during the growing phase, when cattle are on a higher plane of nutrition, is one possible explanation for this carryover or delayed implant response. Alternatively, body composition and mature weight might be altered despite no change in growth rate.

No satisfactory scientific basis for the carryover effect (positive or negative) has been determined. Blood levels of growth promotant compounds would suggest that hormone activity initially peaks, post-implanting, and then declines gradually over time. However, discrepancies exist relative to time that blood levels peak and payout time for long-term growth promotants of both estrogenic and androgenic compounds (Brandt et al., 1994; Johnson et al., 1996). Carryover effects, as well as release rate, most likely depend on implanting technique, implant type and dosage, and carrier (Bartle et al., 1992). Elevating blood levels of growth promotant compounds above the lower threshold level should produce a positive performance response; the greatest response to growth promotants should occur when blood levels are near some upper threshold levels (Figure 1). Hormone activity levels above the upper thresholds level most likely produce no more positive performance response and might contribute to negative effects.

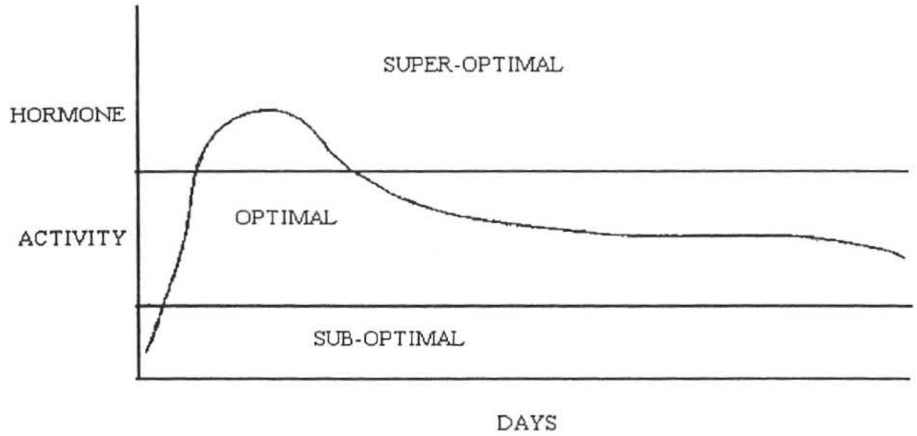


Figure 1. Growth promotant hormone activity with theoretical upper and lower threshold levels (modified from Gill, 1978).

Table 3. Growing and finishing response to zeranol implants[a].

| Growing implant: | 0 | 0 | 0 | 36 mg | 36mg |
|---|---|---|---|---|---|
| Finishing implant: | 0 | 36 mg | 72 mg | 36 mg | 72 mg |
| Daily gain, kg | 1.13 | 1.21 | 1.28 | 1.28 | 1.31 |
| % change | --- | 7.1 | 13.3 | 13.3 | 15.9 |
| | | | | | |
| Feed/gain | 7.12 | 6.85 | 6.75 | 6.86 | 6.57 |
| % change | --- | -3.8 | -5.2 | -3.7 | -7.7 |

[a] Mader, 1994

In an effort to maintain positive carryover effects and optimize lifetime implant responses, Mader et al. (1994) compared lifetime implant regimens based upon studies (Mader, 1994) that demonstrated that the post-weaning response to implant/reimplant programs were enhanced when lower implant doses were followed by higher implant doses at reimplanting (Table 3). Also, trenbolone acetate (TBA) as part of a terminal implant to enhance the estrogen implant response, was used as part of the lifetime implant regimen. Synovex®-C was used as the pre-weaning implant with Synovex-S and -H (S) used post-weaning in steers and heifers, respectively.

Although interactions for weights and gains between sex and implant treatment ($P < .10$) were detected in this study, data were pooled by sex (Table 4). Analysis by sex is shown in the original publication (Mader et al., 1994). A large portion of this weight interaction is attributed to the larger implant weaning weight response by heifers (15 kg) than steers (7.5 kg). Compared to control groups (NNNN), implants significantly increased gain and intakes in both growing and finishing periods. Over the entire post-weaning period (combined growing and finishing), implants increased intake as a percentage of body weight, in cattle implanted in post-weaning periods only (NNNN vs NSSS). Implanted cattle tended to be more efficient in feed conversion than non-implanted cattle. TBA implanted cattle had the lowest numerical feed to gain ratio (F/G). During the finishing period, F/G averaged 6.63 for control cattle vs a range of 6.42 to 6.51 for implanted cattle groups. Differences in trends in feed conversion among implant treatments between steers and heifers were apparent; however, additional studies are needed before firm conclusions can be made regarding different implant response between steers and heifers. Lifetime implant programs reduced the percentage of carcasses grading choice and prime by approximately 30% for both steers and heifers.

Table 4. Performance of cattle assigned to implant strategies using Synovex®-C (C), -S or -H (S), and trenbolone acetate (TBA)[a]

| Implant treatment: | NNNN | NSSS | CSSS | CSSS-TBA |
|---|---|---|---|---|
| Weaning wt., kg | 184[b] | 184[b] | 197[c] | 196[c] |
| Feedlot daily gain, kg | | | | |
| Growing (G) | 1.01[b] | 1.12[c] | 1.12[c] | 1.11[c] |
| Finishing (F) | 1.21[b] | 1.36[cd] | 1.35[c] | 1.41[d] |
| Overall G and F | 1.15[b] | 1.28[cd] | 1.26[c] | 1.31[d] |
| Feedlot DM intake, kg | 7.43[b] | 8.07[c] | 8.15[cd] | 8.36[d] |
| DM intake, % BW | 2.36[b] | 2.44[c] | 2.38[bc] | 2.41[bc] |
| Feedlot feed/gain | 6.51 | 6.32 | 6.43 | 6.37 |
| Final wt., kg | 448[b] | 478[c] | 489[d] | 498[d] |
| Choice and prime, %[e] | 92.3 | 68.7 | 55.3 | 60.5 |

[a] Cattle were not implanted (NNNN), implanted at 0, 74, and 148 d post-weaning only (NSSS), or implanted with C preweaning and S 0, 74, and 148 d post-weaning (CSSS) plus TBA 148 d post-weaning (CSSS-TBA).
[bcd] Means within a row lacking common superscript letter differ ($P < .10$).
[e] Control vs. implant treatment groups ($P < .10$).

Table 5. Effect of Synovex-C® and S or -H (CSSS) or no implants (NNNN) on weaning and final weights in heifers and steers.

| | Heifers | | | Steers | | |
|---|---|---|---|---|---|---|
| | NNNN | | CSSS | NNNN | | CSSS |
| Weaning wt., kg | | | | | | |
| Mader et al., 1994 | 177.0 | | 196.0 | 191.0 | | 197.0 |
| Hardt et al., 1995 | 239.6 | | 263.3 | 256.6 | | 260.2 |
| Mean | 208.3 | | 229.7 | 223.8 | | 228.6 |
| Difference | | 21.4 | | | 4.8 | |
| Final wt., kg[a] | | | | | | |
| Mader et al., 1994 | 423 | | 479 | 473 | | 498 |
| Hardt et al., 1995 | 451 | | 535 | 494 | | 535 |
| Mean | 437 | | 507 | 483.5 | | 516.5 |
| Difference | | 70 | | | 33 | |

[a] Adjusted to 62% dress.

A trend was observed for a greater weaning and final weight response of implanted heifers vs steers (Mader et al., 1994; Hardt et al., 1995). Data (Table 5) suggest that the gain response attributed to lifetime implant systems is considerably greater for heifers than for steers. Because lifetime implant studies in which the weaning weight response was similar between steers and heifers were not found, caution should be exercised in making conclusions from data shown in Table 5. The gain response to implants post-weaning may be more closely related to the gain response pre-weaning and not a function of gender. More data are needed to determine the nature of these interactions. In a summary of suckling implants, Selk (1996) found that weaning weight response to implants was slightly greater for heifers than for steers. However, Owens and Duckett (1996) found the gain response to feedlot implant programs was more positive and consistent for steers, than heifers. Ideally, steer and heifer comparisons should be made with herd mates from which replacement heifers have not been removed.

The aggressiveness of implant programs (number and type of implants used) also may influence the lifetime implant response. However, with aggressive implant programs, performance enhancement may not always be realized when compared to less aggressive implant programs provided that growth promotant blood levels of cattle in both program are maintained near threshold levels for optimum performance response. A large study reported by Booker (1996) demonstrated the potential for negative carryover effects when aggressive implant programs are used. In that study, 18 pens containing over 9,000 steers were initially implanted with Ralgro® and then reimplanted with Revalor-S® at day 45 or be day 70 of the feeding period.

No significant responses to implants were observed in daily gain (1.57 vs 1.56 kg) or feed/gain ratio (6.88 vs 6.83); a significant ($P < .05$) increase in daily DM intake (10.79 vs 10.63 kg) was observed in the 45 day reimplant group. In addition, the proportion of riders (4.10 vs 2.84%) was significantly ($P < .05$) greater in the 45 day vs the 70 day reimplant group (Figure 2). Reimplanting early (45 vs 70 days) did not cause rider rate to return to near zero and appeared to carryover or add to rider activity associated with the initial implant. Exceeding the upper threshold hormone levels (Figure 1) would appear to enhance the negative carryover effects from previous implants; these may manifested as side-effects rather than performance effects.

## CONCLUSION

Lifetime implant programs should be designed to obtain optimum growth response with minimum expression of live animal side-effects and limited adverse effects on carcass traits. Strategically using low, moderate, and high potency implants (Table 6) in practical implant systems (Figure 3) should accomplish these objectives. Implant strategies based upon a pre-determined slaughter target date (finished endpoint), which match implant dose or potency to animal age, weight, and(or) production desired, are recommended. Beginning in the pre-weaning period with low potency products and ending in the post-weaning period with high potency androgenic containing implant products that complement the

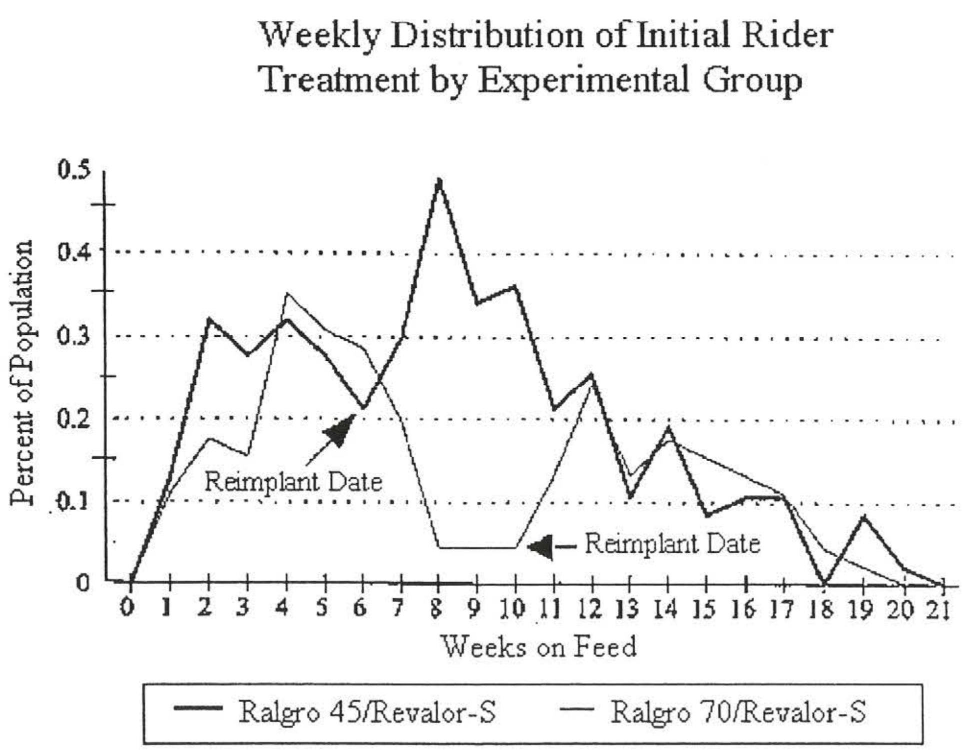


Figure 2. Effect of reimplant time (45 vs. 70 days) on initial rider percentage (Booker, 1996).

estrogenic response, should maintain positive carryover effects of previous implants. Implant programs should be designed to maintain hormone blood levels within an optimum response range. Hormone levels below or above this range should be avoided once implant programs are initiated.

Table 6. Implant potency and payout optimum based on estrogenic (E) and/or androgenic (A) activity and/or dosage.

| Name | Activity | Relative potency | Approximate payout, days |
|---|---|---|---|
| Ralgro (Ral) | E | Low | 60-120 |
| Synovex-C | E | Low | 60-120 |
| Calfoid | E | Low | 60-120 |
| Compudose | E | Moderate | 150-200 |
| Magnum | E | Moderate | 80-120 |
| Synovex-S/H (Syn) | E | Moderate | 80-120 |
| Implus-S/H (Imp) | E | Moderate | 80-120 |
| Revalor G | A/E | Moderate | -- |
| Finaplix-S/H | A | -- | 60-90 |
| Finaplix-S/H+ | A/E | High | 90-110 |
| Syn, Imp or Ral | | | |
| Revalor-S/H | A/E | High | 90-120 |
| Synovex Plus | A/E | High | 90-120 |

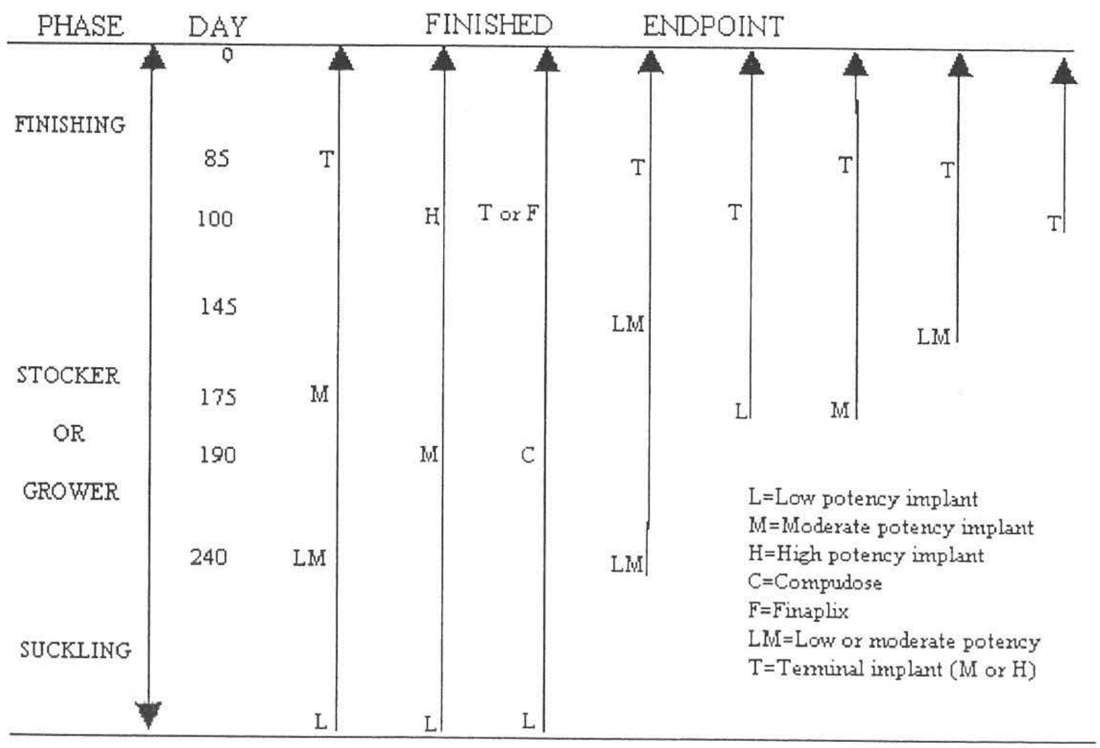


Figure 3. Possible implant programs relative to days from slaughter and initial control point of implant program.

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## QUESTIONS & ANSWERS

**Q:** Does sequential implanting with TBA for a lifetime alter carcass confirmation?

**A:** The data that I incorporated into this review was on lifetime effects from suckling onward of repeated implants of one type. There may be some data on TBA implants post-weaning, but nobody has measured lifetime effects of repeated TBA implants on body composition.

**COSTS OF REWORKING CATTLE**

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## ABSTRACT

Working cattle requires effort and probably reduces performance, but estimates of reduced performance due to reworking cattle are not found in the literature. Two studies suggest that working cattle temporarily reduces performance; however, in most trials, reworking is confounded with implant longevity. The benefits from reimplants probably are slightly under-estimated due to the impact of reworking cattle. Costs of sorting for carcass grade was estimated from performance of two groups of individually fed cattle. Lost yardage from removing loads of cattle from a 300 head pen on a weekly basis also were calculated. Additional costs were discussed and compared to premiums of $4 to $8 per head when all carcass guarantees were met. It appears that the sorting cost ($20-26/head) will not be off-set by the carcass premium ($4 to $8/head) being offered.

## INTRODUCTION

The value of reimplanting cattle has been estimated at $13.88/head for steers and $5.67 for heifers (Marshall et al., 1983) excluding the cost of the implant. However, certain risks are associated with reimplanting. Concern about injury, death, reduced feed intake and gain, poor feed efficiency, increased health problems and an increased incidence of bullers all have been raised as potential risks.

Feedlot owners and managers are being pressured to consider securing a contractual or formula agreement with packers in order to sell their cattle in a timely fashion. The incentive for this contractual arrangement can range from a 50¢/45.5 kg premium ($4/hd on an 364 kg carcass) up to $8/hd ($1/45.5 kg premium if all specifications are met) depending on the packer involved. To secure this premium, cattle must be sorted to fulfill agreed upon specifications and not receive any discounts. In commercial feedyards, however, this process of sorting may involve several hidden costs. The purpose of this review was to estimate the impact of reworking cattle for reimplanting and(or) sorting to target a specific market goal.

## DISCUSSION

### *Reimplanting*

In a study by Gill et al. (1983), bull calves were implanted with nothing, Compudose, Synovex-S or Ralgro at the beginning of the 112 day trial. Cattle in the Synovex and Ralgro treatments were reimplanted day 75 with Synovex or Ralgro; in contrast, the control and Compudose cattle were not removed from their pens on day 75. If one assumes that Compudose and Synovex/Synovex give the same implant response, as suggested by the Compudose technical manual, then the difference between these two treatments can serve as an estimate of the cost of reworking cattle. Average daily gain was reduced .1 kg/day (5.6%) and feed efficiency was .16 units (6.9%) poorer. Hot carcass weight was 7.7 kgs lighter for the reimplanted bulls (Table 1). This means that reworking these cattle reduced total gain by 11.2 kg while increasing feed intake by 9.4 kg. Does the implant response in bulls mirror that in steers? Does the social interaction of a small pen of bulls (8 head) represent what happens in a large pen (>300 head) of steers?

**Table 1. Bull calf performance (96) head with different implants**

| 0-112 days | None | Compudose | Synovex[a] | Ralgro[a] |
|---|---|---|---|---|
| Feed intake, kgs | 8.5 | 9.3 | 9.4 | 8.7 |
| ADG, kgs/day | 1.60 | 1.78 | 1.68 | 1.74 |
| Feed Efficiency | 5.32 | 5.21 | 5.57 | 5.03 |

[a] Reimplanted on day 75.

Hicks et al. (1985), evaluated Finaplix alone or in combination with Compudose. Compared to controls, Finaplix implanted on days 1 and 63, reduced feed intake by .32 kg/day, and ADG by .1 kg (carcass adjusted basis) (Table 2). Finaplix alone hurt efficiency 3.9% on a carcass basis, although Finaplix alone improved feed efficiency 2% on a live weight basis. This study suggests that reworking cattle depressed feed intake. Growth performance may not have been affected depending on whether gain and efficiency are expressed on a live or carcass weight basis (Table 2).

If reworking cattle has a negative impact on growth performance, then the response to reimplants (Duckett et al., 1996) may be underestimated.

*Sorting*

The first cost that a custom feedyard encounters is the loss of yardage or pen rent from not having each pen full through the entire feeding period. For example, one can assume 300 animals are in a pen (Table 3) and one load of 43 head is sorted out and marketed every week after 100 days on feed. If the feedyard charges 25¢ per head per day, for 300 animals the daily charge would be $75/day or $525/week for yardage.

**Table 2. Performance and Carcass Data**

| | | Control | TBA Days, 1 & 63 |
|---|---|---|---|
| Weights, kg | Initial | 346 | 346 |
| | 126 days | 525 | 523 |
| Daily Feed, kg | 0-126 days | 8.0 | 7.7 |
| Daily Gain, kg | 0-126 days | 1.25 | 2.18 |
| | 0- slaughter | 1.78 | 1.28 |
| Feed/Gain | 0- 126 days | 6.41 | 6.28 |
| | | 5.84 | 6.07 |
| Carcass Wt, kg | 0- slaughter | 322 | 314 |
| Dressing % | | 61.3 | 60.1 |
| Quality Grade[a] | | 11.1 | 10.5 |

[a] Average Select = 10; Select Plus = 11

**Table 3. Sorting and Yardage Costs.**

| | Sorted Pen | Full Pen = 300 hd | Lost Yardage |
|---|---|---|---|
| 300 hd x 100 days x 25¢ = | $7500 | $7500 | $0 |
| 257 hd x 7 days x 25¢ = | 449.75 | 525 | 75.25 |
| 214 hd x 7 days x 25¢ = | 374.50 | 525 | 150.50 |
| 171 hd x 7 days x 25¢ = | 299.25 | 525 | 225.75 |
| 128 hd x 7 days x 25¢ = | 244.00 | 525 | 301.00 |
| 85 hd x 7 days x 25¢ = | 148.75 | 525 | 376.25 |
| 42 hd x 7 days x 25¢ = | 73.50 | 525 | 451.50 |
| **Total** | **$9,069.75** | **$10,650** | **$1,580.25** |
| | | $1580.25/300 hd = | $5.25/hd |

If custom feeding charges are split between yardage and feed mark-up, one also needs to calculate the cost of not feeding a full pen. For this example, mark-up on feed was not considered. If the first load is marketed after 100 days and each week thereafter another load of 43 head is pulled out, the net result is a loss of $1580.28 to the feedyard or $5.26/hd that the feedyard is subsidizing the cattle owner. Custom feedyards must pass this cost on to cattle owners to recoup their loss of margin in the feedyard. In this case, for equal income, the feedyard would need to charge 29.4 cents per day, not 25¢ for yardage.

Numerous sorting strategies are being used in feedyards. Sorting costs can range from an additional $1/hd if animals are put through an alley or through the squeeze chute to $6.50 per head if high tech scanning or ultrasound equipment is used 3 times during the feeding period.

One of the hidden costs not apparent when cattle are sorted is the cost of owning the bottom end, slower gaining animals of the pen longer; the better performing cattle are no longer helping offset lower performance. An illustration of this comes from a group of steers fed at Colorado State University in 1994. These animals were individually fed and had feed intake and feed efficiency recorded individually for the 147 day study. Because treatment differences were not significant with this group of steers (Cosby et al., 1996), off-test weight was used to sort cattle into top, middle and bottom groups (Table 4). The top group ate 12% more dry matter and gained 20% more than the bottom third. Conversion by the top and middle third was 10% better than the bottom third. Although cattle all were slaughtered at the same time on this study, it would take a one month longer to make the bottom third equal in off-test weight to the middle group. The cost of the additional feed is approximately $15/head based on their projected cost of gain; consequently that results in $5/head additional cost for the entire group of steers. Sorting out the best performing, most efficient cattle early in the feeding period and retaining cattle that aren't as efficient is an indirect cost to the cattle owner; consequently it must be considered when sorting cattle. Ideally it is preferable to identify animals before they enter the feedyard and not include them in the group. This probably would do more than sorting to enhance the performance in the feedyard and uniformity on the rail.

Similar calculations were made with a group of 50 heifers that were fed individually for 147 days. Again, treatment differences for this group of 50 heifers (Cosby et al., 1996) were not significant. They were sorted by off-test weight, heaviest to lightest and grouped into top, middle and bottom groups (Table 5). Dry matter intake was higher for the top than the bottom group. Gain was 19% faster for the top and middle groups than the bottom group and the top and middle groups had about a 5% better feed efficiency than the bottom group. Economic analysis data indicates that the economic impact of sorting would be the same for heifers as for steers.

**Table 4. 147 Day Individual Steer Performance -- 62 Head**

| Item | Top | Middle | Bottom |
|---|---|---|---|
| No Steers | 21 | 21 | 20 |
| Off Test Wt., kgs | 655 | 617 | 575 |
| Feed Intake, DM kgs | 9.0 | 8.3 | 8.0 |
| ADG, kgs/day | 1.98 | 1.82 | 1.58 |
| Feed Efficiency | 4.55 | 4.55 | 5.08 |
| Unshrunk Dressing % | 61.51 | 61.26 | 61.41 |
| Hot Wt., kgs | 403 | 378 | 351 |
| Yield Grade | 2.32 | 2.27 | 2.47 |
| Percent Choice | 59 | 59 | 53 |

Table 5. 147 Day Individual Performance -- 50 Head

| | Top | Middle | Bottom |
|---|---|---|---|
| No. Heifers | 16 | 17 | 17 |
| Off Test Wt. | 563 | 521 | 476 |
| Feed Intake, kgs DM | 8.4 | 7.5 | 7.1 |
| ADG, kgs/day | 1.59 | 1.43 | 1.29 |
| Feed Efficiency | 5.29 | 5.31 | 5.59 |
| Unshrunk Dressing % | 61.93 | 61.65 | 61.42 |
| Hot Wt. (Kgs) | 348 | 321 | 293 |
| Yield Grade | 2.18 | 2.12 | 2.00 |
| Percent Choice | 53 | 53 | 41 |

When sorting is managed so that pens are topped at the end of the feeding period, there is a very real risk of upsetting an established pecking order in the pen of cattle. Generally, the better performing (and probably most aggressive) cattle will end up in the first sort groups. The remaining animals in the pen must re-establish a pecking order. This behavior may be costly in terms of reduced intake and performance.

Other sorting costs that are more difficult to measure relate to increased stress on animals that may increase the incidence of dark cutters. One dark cutter can cost an additional $2.27/hd across a group of 100 animals. Cattle that break legs or are injured during sorting (using a realizer price of $154/100 kg hot carcass basis) will add an additional $3.40/hd based on a group of 100 animals. Summing all these numbers (Table 6) gives a $20 to $26 cost against a potential benefit of $4 to $8 per head (depending on the formula); economics does not favor sorting. By exceeding the minimum contract specifications cattle owners can improve the premium received from $4-8/head up to $12-14/head above base price. However, if this base price is eroded because fewer cattle have cash trades reported, then it becomes even more difficult to maintain a positive return from sorting cattle. Cattle feeders need to use their own numbers and judge for themselves if sorting is an activity that benefits them economically.

Table 6. Sorting Costs vs. Benefits ($/head)

| | Benefit | Potential Cost |
|---|---|---|
| Premium ($.50 - 1.00/cwt of carcass) | $4 - $8 | |
| Lost yardage to feedyard from sorting | | -5.26 |
| Additional handling | | -1 to 6.50 |
| Owning bottom 1/3 for 1 month longer | | -5.00 |
| Pecking order; lost performance | | -3.00 |
| Dark cutters | | -2.27 |
| Realizer | | -3.40 |
| | $4 to 8 | $20 to 26 |

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## QUESTIONS AND ANSWERS

Q: What is a "realizer"?

A: A "realizer" is an animal with some severe problem from which feedyards try to recover or realize some revenue. If a steer has a broken leg or persistently sick, feedyards try to sell this animal wherever they can, probably to a locker plant rather than to a large packing plant.

Q: Did you evaluate effect of time of day on reimplanting? By conventional wisdom, implanting should be moved to the afternoon or evening when practical so we don't interrupt the normal feeding behaviors and adversely alter performance.

A: Several years ago we conducted a study on working cattle in the morning vs. the afternoon. We fed these cattle just once in the morning, not twice as many feedyards do. We saw some scatter in early performance, but for the entire feeding period, we detected no difference in the feed intake from processing cattle in the morning vs. the afternoon.

Q: Do you examine effects of reimplanting on carcass quality?

A: Literature studies indicate that reimplanting with Synovex-like products can reduce carcass quality (choice grades) by 3 to 7% compared with TBA reimplant that may cause as much as a 20% reduction from unimplanted controls. Response depends on how many days after implants that cattle are marketed.

Q: Is that versus a single implant or non-implanted control cattle?

A: That's compared to a single implant.

Q: Is that change in points or in percentage of cattle grading choice?

A: That's a percentage change, not points. A reduction from 80% choice to 64% choice is a 20% reduction.

## INTERACTIONS OF IMPLANT RESPONSE WITH GENDER, AGE, AND ANIMAL TYPE

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### ABSTRACT

The potential for the variables of age, gender, and animal type to interact with implants is a legitimate concern of beef production. Research testing interactions is limited because the process of product approval by FDA requires specific tests within target animal groups of a single type. Yet, evidence indicates that interactions do exist. Privately held data indicate that compared with older animals, younger and smaller animals require a smaller effective dose of estradiol ($E_2$) to maximize growth. The literature we have reviewed indicates that effectiveness of compounds diminishes as cattle approach mature BW. Relative growth responses to $E_2$ (percentage of control) appear similar between suckling steer and heifer calves but the implant response is sensitive to the growth potential of the cattle. Only after puberty, do differences in response between steer and heifer appear. Postpubertal steers and ovarietomized heifers are more responsive to $E_2$ than are heifers. Steers are less responsive to trenbolone acetate (TBA) than are heifers. Genotype in general does not appear to interact with implant type beyond the involvement of inherent productive capability.

### INTRODUCTION

Our overall approach to examine the potential interactions between implants and gender, age, and animal type has been less than systematic. We found a few examples where it was possible to pool sufficient data to draw comparisons with confidence. Other examples discussed should be considered only as cursory or preliminary observations. In these instances, more research is needed.

When we consider intact vs castrate animals males (2 classes) vs females (2 classes), calf vs yearling (2 classes), and animal type as large or small framed, typical or heavily muscled, typical or high marbling (6 types), we have 48 factors. If these animal factors are tested across four classes of implants (none, estradiol ($E_2$), trenbolone acetate (TBA), or estradiol + trenbolone acetate), we have 198 comparisons to make. Trials replicated across three locations with 10 replicate pens at each location culminated in 5,940 pen observations for this summary. The scope of this assignment rivals the most memorable of animal breeding projects.

#### *Age*

Implant comparisons across age inevitably are confounded with BW, plane of nutrition, season, and puberty. Absolute rates of production vary dramatically due to these confounding factors. We pooled

**Table 1.** Response by steers to implants as a percentage of non-implanted controls

| | Pooled trials with various implants [a] | | $E_2$TBA-$E_2$TBA Reimplant studies [b] | | Holsteins Steroid [c] | |
|---|---|---|---|---|---|---|
| | Calf | Yrlg | Calf | Yrlg | Light (900 lb) | Heavy (1100 lb) |
| ADG, % | 18.0 | 20.6 | 22.3 | 22.4 | 14.6 | -15.3 |
| DMI, % | 5.5 | 4.3 | 8.2 | 3.1 | – | – |
| F/G, % | -10.3 | -13.8 | -11.4 | -15.9 | – | – |

[a]Trenkle, 1993.
[b]Pooled ISU-SDSU data.
[c]Rust, light and heavy denote initial BW.

comparisons of calf-fed and yearling steers; responses are reported as a percentage of non-implanted controls in Table 1. In the two data sets comparing calves and yearlings, the response in DMI (%) was numerically greater in calves. Proportional changes in ADG were similar (when using $E_2$/TBA) but slightly favored yearlings when considering only $E_2$ implants. Regardless of the implant type, feed/gain was more favorably affected in yearling steers than steer calves. There would, however, appear to be an upper limit on age/BW at which cattle will respond to implants. Rust (1997) observed that Holstein steers started on feed at 900-lb responded to $E_2$ implants while 1100-lb Holsteins did not (Table 1).

In another Michigan study (Main, 1990), effects of puberty status (age), ovary status, and implants were compared (Table 2). Effects of implants and ovariectomy differed with pubertal status of the heifers. The Heiferoid implants increased DMI ($P < .05$) by 1.8 and 13.0% for prepubertal and pubertal heifers, respectively. However, implants provided a greater improvement ($P < .08$) in feed efficiency in prepubertal, ovariectomized heifers than in pubertal, ovariectomized heifers. Weight gains and quality grade were similar among treatments. Implants reduced yield grade ($P < .01$) and fat gain per day ($P < .10$) in prepubertal heifers but had little effect in pubertal heifers. Even though it was not changed significantly, implants numerically increased daily protein gain in prepubertal but not pubertal heifers. In summary, pubertal status or age appeared to influence the responses of heifers to implants. Results from this study indicate that implants tend to increase intake and thereby increase deposition of the primary tissues being deposited at the time. Consequently, younger animals would tend to respond to implants by increasing protein deposition, whereas older animals would deposit more fat.

### *Ovariectomized Heifers*

Six studies (1,468 heifers; Table 3) have been reported in the literature that compared the use of implants with ovariectomized heifers. The pooled results from the six studies were subjected to statistical analysis; weighted, least square means were generated (Table 4). Growth promoting implants increased ADG by 10.5 and 15.7% for intact and ovariectomized heifers, respectively, when compared to control heifers. Implants increased DMI by both intact and ovariectomized heifers. However, the increase was much larger by ovariectomized heifers ($P < .10$). As a result, feed conversion efficiency was numerically improved by 1.0 and 3.0%, respectively, by the use of an implant in intact and ovariectomized heifers. Yield grade and marbling were not significantly changed by implants. This observation is supported by another summary in this proceedings from a larger data base which concluded that marbling was not negatively affected by use of implants in heifers (Duckett et al., 1997).

### *Breed Type*

Several studies are available for comparing implants across breed types. In the largest of these experiments, Preston et al. (1995) compared English, Continental, or Brahman influenced breeds and revalor-S, Implemax-H, and Synovex-S implants. The lack of breed type x implant interactions for the variables ADG, F/G, or hot carcass weight indicated that these compounds had comparable effects across breed types.

Perry et al. (1991) compared non-implanted and implanted (revalor-S) steer performance across Holstein, Angus, or Simmental by Angus breed types. They observed that implants increased ADG, DMI, and gain/feed within each breed. Potential interactions were not tested in these steers harvested at a constant rib fat depth endpoint. However, the percentage response calculated from their data would indicate that beef breeds were more responsive to implants than Holsteins. McEwen (personal communication) reported that ADG was increased by 20.0 and 23.7% by implanting Holstein and Limousin steers, respectively.

In another interesting study, Wardynski et al. (1990) evaluated the influence of implants on the preweaning growth rate of unselected Herefords, Herefords selected for yearling weight, Angus by Shorthorn, and Simmental by Gelbvieh by Holstein steer calves. An interaction between implant response over non-implanted controls and biological type was apparent (Table 5). The increased ADG due to implanting appeared to widen as milk production potential of the breed types was increased.

### *Gender*

Steer-heifer comparisons are clouded by the fact that only Ralgro, Synovex-C, and Compudose implants are common across genders. We were able to pool suckling calf data from two trials (Gill et al., 1984; Mader et al., 1992). The percentage of response to implant was affected more by year than by gender (Table 6). Overall, preweaning growth response to implants averaged 6.1 and 7.0% for steers and heifers, respectively.

**Table 2.** Effects of puberty status, ovary status, and implants on performance and composition of growing-finishing heifers

| Treatment | ADG, lb | DMI, lb/d | Feed/Gain | Marbling | Yield grade | Protein gain, g/d | Fat gain, g/d |
|---|---|---|---|---|---|---|---|
| Prepubertal | | | | | | | |
| Intact-Control | 2.42 | 16.85 | 6.94 | 13.8 | 2.95 | 84.2 | 689.6 |
| Intact-Implant | 2.22 | 15.71 | 6.99 | 12.9 | 2.22 | 100.2 | 588.2 |
| Ovx-Control | 1.94 | 15.33 | 7.87 | 15.0 | 2.69 | 76.5 | 581.3 |
| Ovx-Implant | 2.49 | 17.05 | 6.85 | 13.3 | 2.31 | 91.3 | 580.6 |
| Pubertal | | | | | | | |
| Intact-Control | 2.20 | 16.30 | 7.41 | 14.7 | 2.42 | 92.7 | 629.6 |
| Intact-Implant | 2.55 | 17.56 | 6.90 | 13.3 | 2.57 | 90.5 | 690.5 |
| Ovx-Control | 1.89 | 14.19 | 7.52 | 15.3 | 2.87 | 72.9 | 580.4 |
| Ovx-Implant | 2.33 | 16.90 | 7.19 | 13.4 | 2.77 | 82.8 | 582.3 |
| SEM | .06 | .26 | .004 | .4 | .16 | 7.7 | 35.6 |
| Probability | | | | | | | |
| Pub*Ovx | NS | NS | NS | NS | .10 | NS | NS |
| Pub*Imp | NS | .05 | NS | NS | .01 | NS | .10 |
| Pub*Ovx*Imp | NS | NS | .08 | NS | NS | NS | NS |

**Table 3.** Studies concerning ovariectomy and growth-promoting implants on performance of growing-finishing heifers

| Author | Year | Location | No. of animals |
|---|---|---|---|
| Nygaard & Embry | 1966 | South Dakota | 94 |
| Yamamoto et al. | 1978 | Colorado | 118 |
| Rupp et al. | 1980 | Colorado | 679 |
| Rush & Reece | 1981 | Nebraska | 170 |
| Main | 1990 | Michigan | 336 |
| Garber et al. | 1990 | Idaho | 71 |

A large steer-heifer feedlot comparison (2,400 cattle, three locations) also was available (Herschler et al., 1995). A 1:5 ratio of $E_2$:TBA produced a response in heifers that was 70% as great as the response by steers (Table 7). When the $E_2$/TBA ratio widened to 1:10, the additional ADG response was greater for steers than for heifers. While the 1:10 ratio did not lead to proportional increases in ADG among heifers, it lowered the percentage of choice carcasses. As expected, heifers responded better to TBA alone than did steers; steers tended to have a greater response than heifers when only $E_2$ was used.

Mader et al. (1992) provided one of the few lifetime implant comparisons for steers and heifers. Among heifers, implants increased weaning weight by 28 lb and a finished weight by 44 lb. Among steers, implants increased weaning weight by 22 lb but the finished BW advantage of implanted steers was only 20 lb. The BW added prior to weaning accounted fully for the weight advantage of implanted steers.

These data indicate that mitigating factors affect implant responses. Suckling steer and heifer calves probably respond similarly to implants, but postpubertal responses differ between sexes. This may relate to the condition that implants drive DMI. Consequently, the primary tissue being deposited at the time of implanting may be the tissue most affected by the implant. As lean and adipose growth and development change with age, sex, or BW, we can use this logic to infer how animals will respond to a specific implant strategy. However, these inferences may be tempered by the growth potential of the cattle involved.

**Table 4.** Effects of ovariectomy and implants on weight gains of growing-finishing heifers (weighted least square means)

| | Intact | | Ovariectomized | | Probability | | |
|---|---|---|---|---|---|---|---|
| Item | Control | Implant | Control | Implant | Implant | Ovary | Imp*Ovx |
| No. of heifers | 293 | 438 | 293 | 444 | – | – | – |
| ADG,lb/d | 2.93 ± .40 | 3.2 ± .33 | 2.79 ± .40 | 3.24 ± .33 | .90 | .32 | .84 |
| DMI, lb/d | 17.1 ± .50 | 17.6 ± .50 | 16.1 ± .50 | 18.3 ± .40 | .95 | .01 | .10 |
| Feed/gain | 7.38 ± .30 | 7.34 ± .30 | 7.79 ± .30 | 7.56 ± .30 | .30 | .66 | .75 |
| Yield grade | 2.87 ± .30 | 2.79 ± .22 | 3.01 ± .25 | 2.77 ± .22 | .83 | .51 | .76 |
| Marbling | 582 ± 28 | 551 ± 25 | 588 ± 28 | 552 ± 26 | .88 | .25 | .94 |

[a]500 = small; 600 = modest.

**Table 5.** Effects of implant treatments and breed types on preweaning gain of suckling calves

| | Suckling phase ADG, lb | | |
|---|---|---|---|
| Breed type | Control | Compudose | Synovex-S |
| Unselected Herefords | 1.43 | 1.45 | 1.47 |
| Selected Herefords | 1.76 | 1.87 | 1.85 |
| Hereford by Angus by Shorthorn | 2.13 | 2.29 | 2.27 |
| Simmental by Gelbvieh by Hosltein | 2.20 | 2.44 | 2.46 |

SEM = .04.

**Table 6.** Implant responses among suckling steer and heifer calves[a]

| | | % increase in suckling ADG | |
|---|---|---|---|
| Experiment | Implant | Steer | Heifer |
| 1 | Synovex-C | 7.6 | 6.0 |
| 2 | Synovex-C | 5.3 | 8.2 |
| 3 | Synovex-C | 6.3 | 6.5 |
| 4 | Ralgro | 5.0 | 7.2 |

[a]Derived from Gill et al. (1984) and Mader et al. (1992).

**Table 7.** Implant responses by feedlot steers and heifers[a]

| Implant as $E_2$/TBA | | 20/70 | 40/140 | 60/210 | 14/100 | 28/200 | 42/300 | 0/300 | 60/0 | SS[b] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | % change from non-implanted controls | | | | | | | | |
| ADG | Steer | 13 | 16 | 14 | 18 | 21 | 23 | 5 | 12 | 15 |
| | Heifer | 9 | 11 | 10 | 12 | 11 | 16 | 8 | 9 | 10 |
| Feed:gain | Steer | -3 | -7 | -7 | -8 | -11 | -12 | -6 | -6 | -6 |
| | Heifer | -5 | -5 | -6 | -7 | -7 | -9 | -7 | -5 | -6 |
| Choice | Steer | -14 | -27 | -30 | -8 | -29 | -30 | -12 | -14 | -17 |
| | Heifer | -6 | -21 | -17 | -17 | -32 | -34 | -11 | -10 | -11 |

[a]Derived from Herschler et al. (1995).
[b]Synovex-S.

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# EFFECTS OF PEN SIZE ON THE IMPLANT RESPONSE OF FEEDLOT CATTLE

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## ABSTRACT

Sixty nine large pen research trials conducted by Bos Technica Research Services, Inc. involving approximately 103,500 cattle were used to determine number of pens/treatment and number of animals/pen needed to detect statistical differences (Power=.80 and P<.05) in average daily gain, dry matter intake and dry matter feed conversion with pen as the experimental unit. Power curve statistics demonstrated increasing replication (pens/treatment) and/or pen size (animals/pen) increased the ability to detect (P<.05) smaller treatment differences. A historical data base provided by Koers-Turgeon Consulting Service, Inc. involving 47.85 million feedlot cattle, based on a monthly occupancy rate of 683,573 animals, demonstrated anomalies existing in large pen feedlots. Different conclusions were drawn from research results depending on whether or not anomalies, such as, death loss, buller incidence and railer incidence were accounted for in performance calculations. Anomalies measured in large pen studies, rarely occurring or reported in small pen studies, influence implant response and data interpretation. The need for reimplanting cattle should be re-evaluated and alternatives sought out to eliminate it from the industry without sacrificing performance or carcass merit. Researchers should report performance data showing, both with and without, anomalies whenever measured and spend more pre-trial time determining the number of animals and pens needed to demonstrate treatment differences (P<.05).

## INTRODUCTION

Applying small pen research data to large pen feedlots is often taken at face value. Anomalies such as death loss, buller incidence, railer incidence and vaginal prolapses rarely exist in small pen studies containing less than 50 animals/pen; yet, they are feedlot reality. How these might influence the implant response in terms of animal performance and carcass characteristics is not well documented in the scientific literature. Most research data are reported with deads and rejects out of the calculations demonstrating only performance of live cattle marketed with the pen. The feedlot industry calculates close-outs deads in and deads out. Feedlot managers recognize performance differences in close-outs basis deads in or deads out. The scientific community should follow suit to advance our knowledge of implant products and programs. Numerous studies exist where treatment differences were not significant (P>.05) even though large numerical differences were apparent. This is especially true for carcass measurements. The purpose of this presentation was to: (1) evaluate the effect of pen size (animals/pen) and pens/treatment on implant response and (2) determine the impact of reimplanting on anomalies measured in large pens.

## MATERIALS AND METHODS

*Power Curve Data.* Sixty nine research trials conducted by Bos Technica Research Services, Inc., Salina, Kansas were used to generate power curves for average daily gain, dry matter feed intake and dry matter feed conversion (Cochran and Cox, 1957; Eskridge,1996). The trials consisted of pens containing 50 to 100 animals/pen with approximately 20 pens per trial. Approximately 103,500 head of research cattle were represented in the live performance measurements. Power curve statistics for percent choice was derived from six trials involving approximately 9000 cattle. The research trials consisted of finishing studies comparing feed additive and/or implant treatments over an approximate 150 day feeding period. Pen was the experimental unit. Coefficients of variation commonly ran 1-3% for the live performance measurements in these trials.

*Death Loss Data.* A six year historical data base (Koers-Turgeon Consulting Service, Inc., 1991-1996) was used to evaluate death loss, buller, vaginal prolapse and railer incidences in commercial feed yards. The data base covered a time frame of January 1991-October 1996. Forty-seven million eight hundred fifty thousand and one hundred thirteen cattle representing 34.55 million steers and 13.30 million heifers were involved. Monthly occupancy rate was 683,573 animals.

Death loss causes were categorized as Total, Respiratory, Digestive and Other. Monthly death loss and railer incidence was calculated as a percent of the monthly occupancy rate. Therefore, a close-out value could be determined by simply multiplying the monthly rate times the months in a feeding period.

Buller incidence was reported as a percent of the monthly steer population. Vaginal prolapses were reported as a percent of the monthly heifer population.

***Performance Data.*** Two implant trials (Bos Technica Research Services, Inc.) were pooled and used to demonstrate the differences in animal performance depending whether or not death loss and railer incidence was taken into account in the performance calculations. The combined results of trials 1 and 2 consisted of 1074 steers weighing initially 652 lbs. The cattle were on feed 168 days. A total of 12 pens were used with 6 pens/treatment. The two implant program treatments were : (1) A single trenbolone acetate implant given day 1 and (2) An estrogen implant given day 1 followed by a trenbolone acetate implant given day 78. The single implant treatment cattle (trenbolone acetate, day 1) were not re-handled when the treatment 2 cattle were reimplanted. Pen was the experimental unit for all both. Initial animal weights were full weights taken the first day of the trial. Single day final pen weights were adjusted for a 4%shrink.

Performance results were calculated two different ways. The first method was with deads and railers/rejects out of the data base. This is consistent with a vast majority of the reported literature demonstrating the performance of cattle that lived and marketed with the pen come close-out time. Feed for dead/railer cattle was accounted for by deducting the average intake of the pen for every day that animal was on test. Feed for hospital days was accounted for as 50% of the home pens intake for each day an animal was in the hospital. Average daily gain was determined as the difference in average animal weights at the start and end of the trial divided by the number of days on feed.

The second method of calculation was that most representative of feedyard close-outs which include all deads and railers in performance numbers. In this case, average daily gain was determined by taking the difference of total cattle pounds in versus total cattle pounds marketed divided by total head days. This method of calculation is rarely reported in scientific journals or feeder day reports; yet, it is the most commonly used method in the feedlot industry.

## RESULTS AND DISCUSSION

Power curve statistics pre-determine the number of replications needed for a given pen size (animals/pen) to measure a detectable treatment difference. Power curves were generated with power = .80 and $P < .05$ (Table 1, Figures 1, 2, and 3). That is, an 80% probability existed of detecting a difference at $P < .05$. Increasing the number of replications/treatment for a given pen size clearly results in the ability to detect ( $P < .05$ ) smaller differences. Interestingly, this was not a linear function; but rather, a quadratic one (Figure 1).

Not only does increasing the number of replications/treatment for a given pen size result in the ability to detect smaller treatment differences, but also, increasing the number of animals within a pen for a given number of replications/treatment (Table 1, Figures 2, 3). For example, a .40 lb/hd/d treatment difference in average daily gain is expected to be different ( $P < .05$ ) with 4 pens/treatment in10 head pens (Table 1). This is a 13% difference in average daily gain for cattle gaining 3.0 lb/hd/d. Few published implant studies show such a large treatment difference, let alone a significant difference ( $P < .05$ ) in rate of gain, unless comparisons were made to non-implanted negative control cattle. The detectable average daily gain difference, however, improves to .12 lb/hd/d with 100 head pens and 4 pens/treatment. This represents a 4% gain difference for cattle gaining 3.0 lb/hd/d. A 3-5% gain difference among different implant treatments is more commonly reported. No wonder so many published trials fail to report significant differences ( $P < .05$ ). They simply lacked the statistical power, in terms of animals/ pen and/or pens/treatment, at the trial's inception.

Table 1. Effect of pen size (head/pen) and replication (pens/treatment) on detecting a difference ($P < .05$, Power = .80) in average daily gain, dry matter intake, dry matter feed conversion and percent choice.

| | | Head / Pen | | | |
|---|---|---|---|---|---|
| Detectable difference | Pens / Treatment | 10 | 50 | 100 | 600 |
| Average daily gain, lb/hd | 2 | .90 | .40 | .28 | .11 |
| | 4 | .40 | .15 | .12 | .05 |
| | 6 | .30 | .13 | .10 | .04 |
| Dry matter intake, lb/hd | 2 | 3.8 | 1.7 | 1.2 | .5 |
| | 4 | 1.7 | .8 | .5 | .2 |
| | 6 | 1.3 | .6 | .4 | .15 |
| Feed conversion | 2 | 1.40 | .64 | .45 | .18 |
| | 4 | .60 | .28 | .20 | .08 |
| | 6 | .45 | .20 | .15 | .06 |
| Percent Choice | 2 | 72 | 32 | 23 | 9 |
| | 4 | 32 | 14 | 10 | 4 |
| | 6 | 24 | 11 | 8 | 3 |

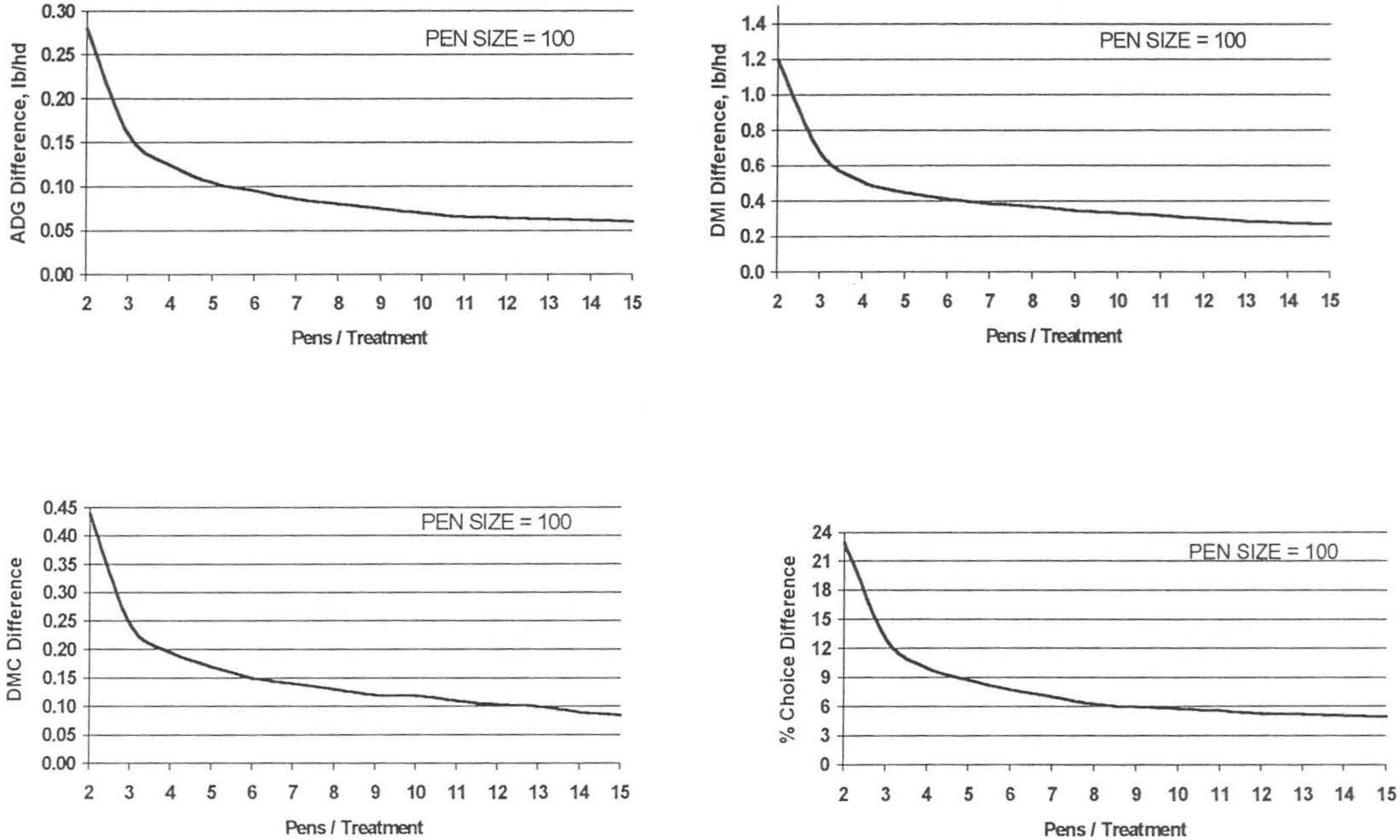


Figure 1. Effect of replication (pens/treatment) on detecting a difference ($P < .05$, Power = .80) in average daily gain (ADG), dry matter intake (DMI), dry matter feed conversion (DMC), and percent choice for a pen size of 100 head.

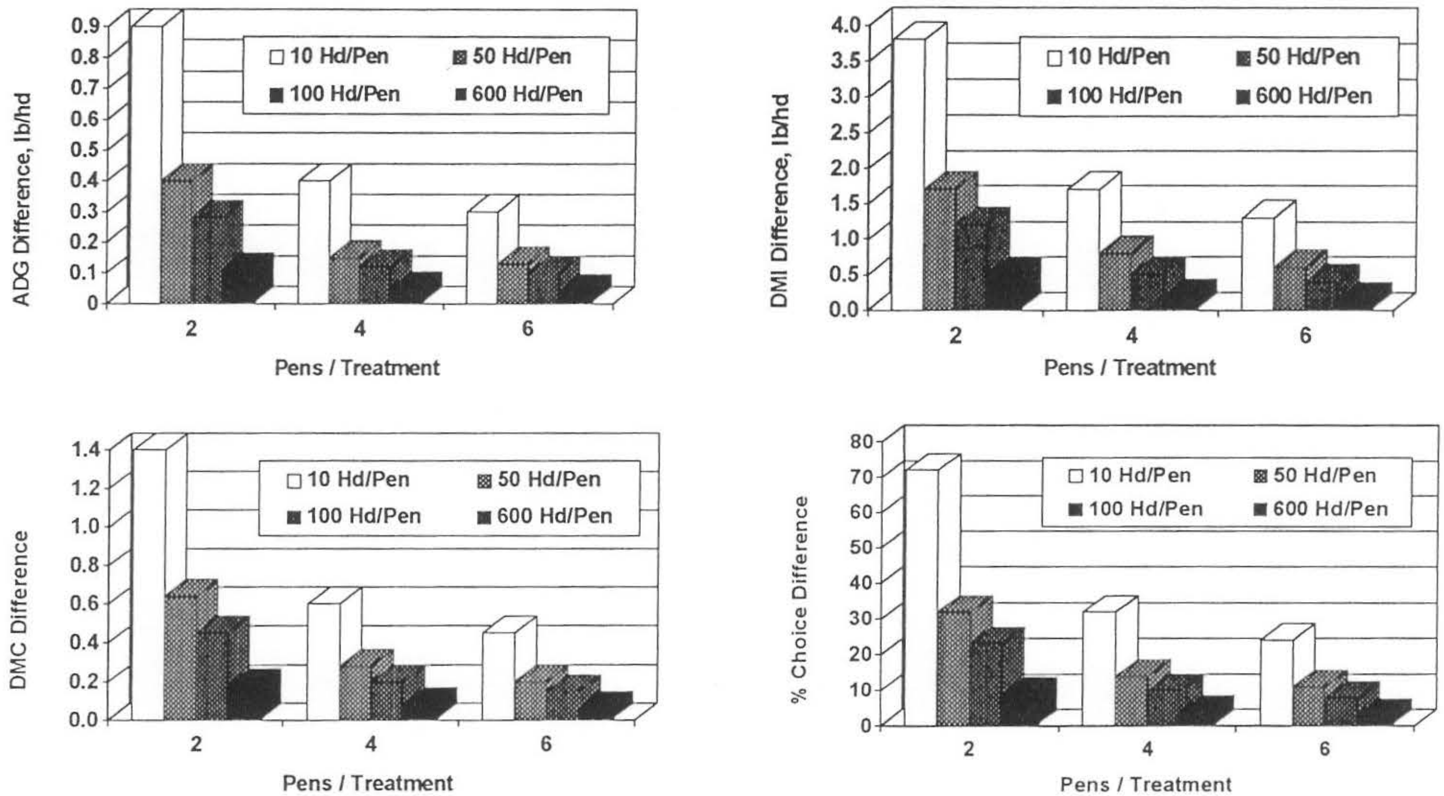


Figure 2. Effect of pen size (head/pen) and replication (pens/treatment) on detecting a difference ($P<.05$, Power = .80) in average daily gain (ADG), dry matter intake (DMI), dry matter feed conversion (DMC), and percent choice.

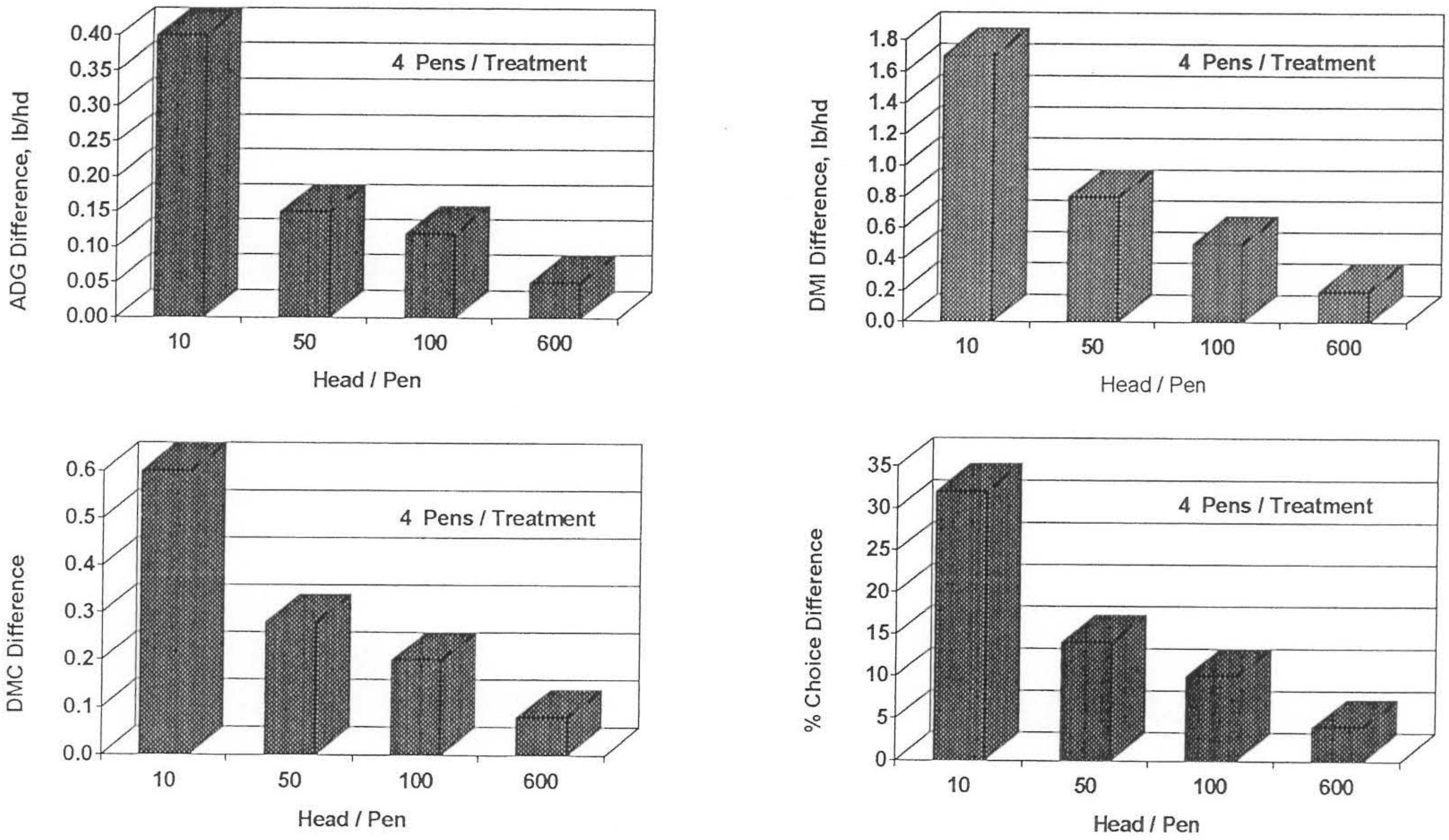


Figure 3. Effect of pen size (head/pen) on detecting a difference ($P < .05$, Power = .80) in average daily gain (ADG), dry matter intake (DMI), dry matter feed conversion (DMC), and percent choice with four pens/treatment.

In order to detect differences in carcass characteristics large numbers of cattle and/or pens are needed (Table 1, Figures 1, 2, and 3). Some researchers have weakened and reverted to using animal as the experimental unit which certainly increases the probability of detecting treatment differences. This raises statistical concern and debate, however, for pen fed animals. Consequently, trends are often relied upon when evaluating carcass characteristics. Case in point. How often is the incidence of dark cutters reported in the Journal of Animal Science? Dark cutters are certainly a small measurement; yet, economically important.

Anomalies exist in large pen feedyard conditions which rarely reveal themselves at the small pen level (Figures 4 and 5). Small pens are referred to as anything less than 50 animals/pen. For example, the Digestive death loss rate average .05% of monthly occupancy (Figure 4). Consequently, a 20,000 head feedyard could expect 10 Digestive deads per month. Applying this to a 200 head research trial results in a Digestive death loss of .10 animals per month or .50 animals for a five month study. Therefore, it is not likely to adequately measure such a small occurrence in a small pen setting. The same is true when one takes into account the incidence of bullers, railers and vaginal prolapses (Figure 5) all of which might influence implant response. These are small yet significant economic problems facing the beef industry.

How might pen size/density influence the implant response? To answer this question one must move out of the world of small pen studies and into the world of large pen feedlots where "real world" problems exist. Buller incidence is seasonal peaking in August (Figure 5). A similar finding was reported by Brower and Kiracofe, 1978. Buller incidence was also a function of pen size. A two-fold increase in buller rate was measured in average pen sizes of 178 steers/pen versus 318 steers/pen, ALL versus SELECTED, respectively (Figure 5). Buller incidence was substantially increased for reimplanted steers (Table 2 and 3). Whether this was due to the implant itself or simply to the act of re-handling the cattle is confounded.

Table 2. Effect of reimplanting on buller incidence in beef feedlot steers[a]

| | Estrogen Implant Treatment | |
|---|---|---|
| Item | Single Implant Day 1 | Reimplant Day 1 and 78 |
| Bullers, % | 1.65 | 3.21 |

[a] 57,000 Steers. 150 Days.

Table 3. Effect of reimplanting on buller incidence in Holstein feedlot steers[a]

| | Treatment | |
|---|---|---|
| Item | Two Estrogen Implants[b] | Three Estrogen Implants[c] |
| Bullers, % | .17 | .90 |

[a] 5,044 Steers. 350 Days.
[b] Day 1 and 164.
[c] Day 1, 134, and 229.

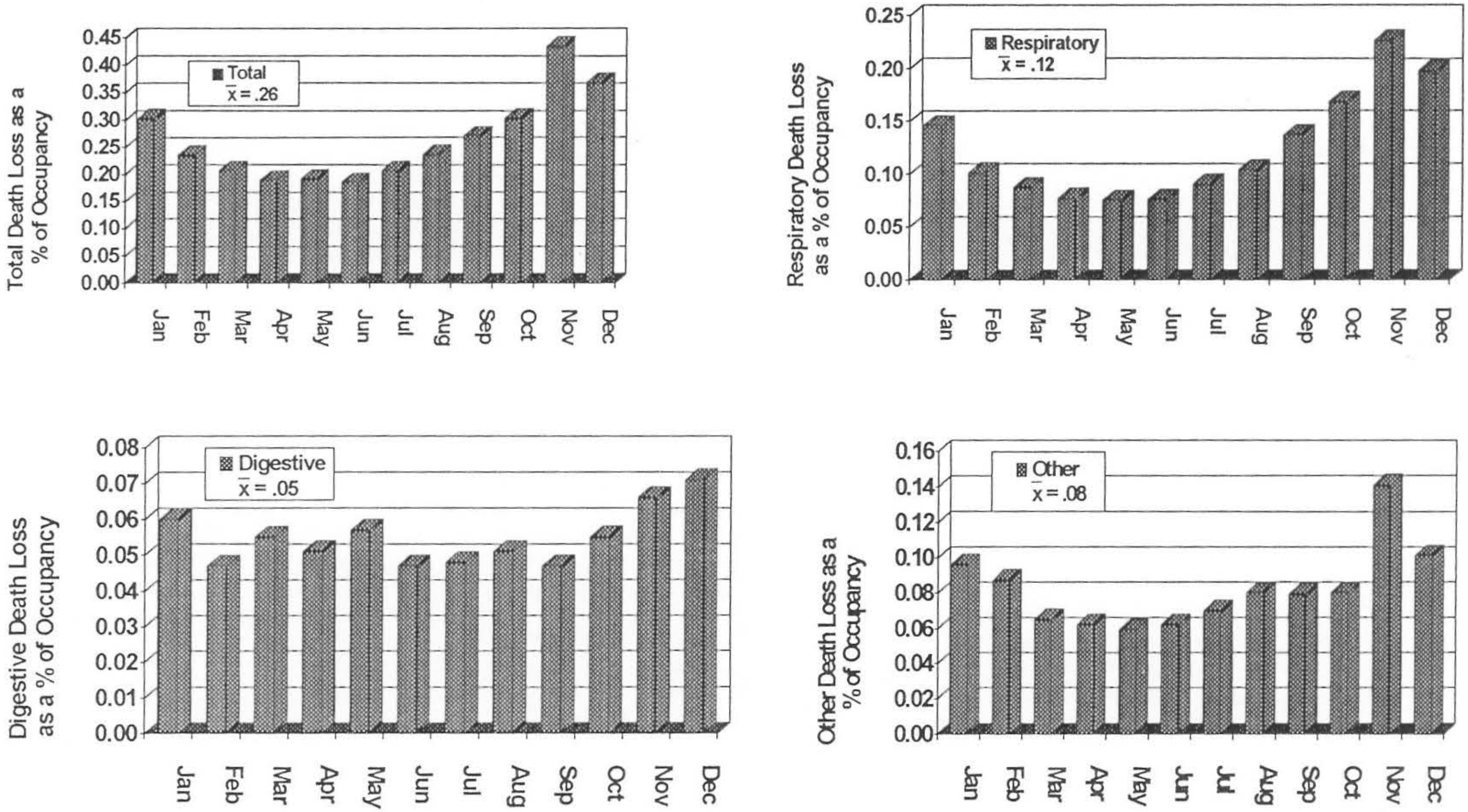


Figure 4. Total, respiratory, digestive and other death losses as a percent of monthly occupancy in commercial feedyards from January 1991 - October 1996.

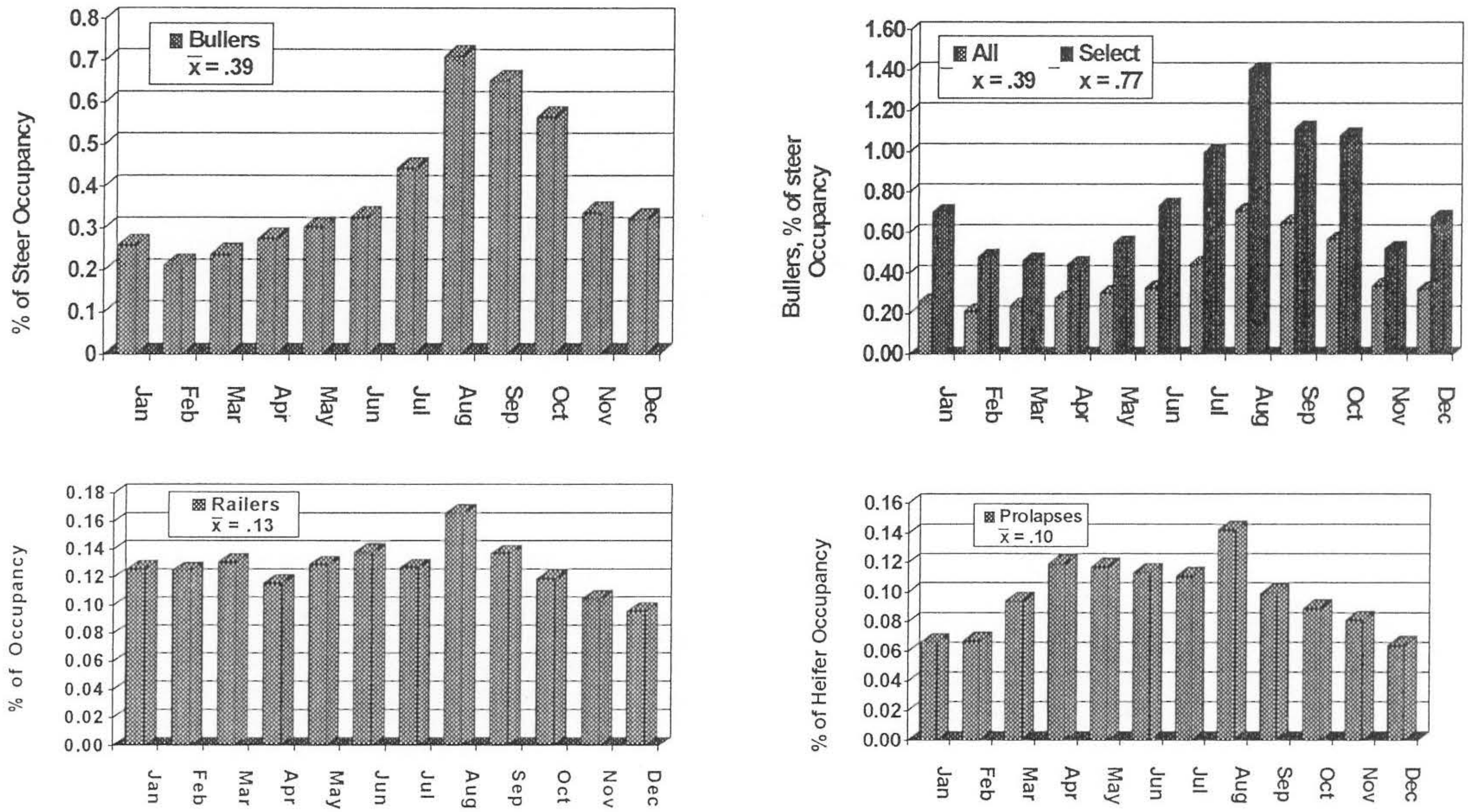


Figure 5. Buller, railer and vaginal prolapse as a percent of the monthly steer and/or heifer population in commercial feedyards from January 1991 - October 1996. All = A pen size of 178 steers/pen. Select = A pen size of 318 steers/pen.

Table 4. Effect of reimplanting on health, railers, and vaginal prolapses in feedlot heifers[a]

| Estrogen Implant | Percent Mortality | Morbidity | Railers | Vaginal prolapses |
|---|---|---|---|---|
| Single, day 1 | .86 | 11.2 | 1.05 | .27 |
| Reimplant[b] | 1.12 | 14.5 | 1.49 | .65 |

[a] 15,007 Heifers. 155 Days.
[b] Day 1 and 75.

Brower and Kiracofe, 1978 reported a buller cost of $23.00 each. This is consistent with field estimates (Koers-Turgeon, 1997). It is estimated the monthly buller incidence of .39% costs the industry approximately $.50/steer fed ($25.00 x .39% x five months on feed).

Reimplanting increased death loss, morbidity, railers and vaginal prolapses in an evaluation involving 15,007 heifers (Table 4). The economics of this are clearly substantial. It is time for the industry to find alternative products and/or programs to eliminate the need for reimplanting cattle without sacrificing performance or carcass merit.

Implant performance data can be drastically influenced depending whether or not death loss, bullers and railers/rejected cattle are taken into account. This is especially true for reimplant programs because the stress of re-handling large numbers of cattle can impact the implant response. For example, no difference (P>.05) in average daily gain or dry matter feed conversion existed when deads and railers were omitted from performance calculations (Table 5). Carcass characteristics were also similar (Table 7). Results presented in this manner demonstrate the performance of cattle that lived during the course of the trial and is consistent with most scientific publications. Conversely, a 5% improvement (P=.05) in average daily gain existed for the Single Implant program (trenbolone acetate day 1) compared with the Reimplant program (estrogen day 1, trenbolone acetate day 78) when deads and railers were included in the performance calculations (Table 6). Dry matter feed conversion also favored (6.11 vs 6.22) the Single implant program. These differences existed because of the higher death and railer percentages associated with the Reimplant program. Consequently, research information should be presented both ways (1) Deads and Rejects Out and (2) Deads And Rejects In to more accurately evaluate treatment response.

## IMPLICATIONS

Pen size, measured as animals/pen, influences implant response because anomalies such as death loss, buller incidence, railer incidence and vaginal prolapses, as well as, carcass differences (P<.05) rarely reveal themselves under small pen conditions. Yet, they significantly alter the outcome of implant studies depending whether or not they were considered in the performance and carcass measurements. When such anomalies were taken into account the benefits of reimplanting cattle, under large pen conditions, was diminished. It is time for the industry to seek out alternative products and/or programs which eliminate the necessary evil of reimplanting cattle without sacrificing animal performance or carcass merit. Researchers should generate power curve statistics, before trial initiation, to more accurately ascertain the number of animals/pen and the number of pens/treatment needed to detect statistical differences (P<.05). GO BIG RED!

Table 5. Effect of reimplanting on feedlot steer performance with deads and railers out (two trial summary)[a]

| Item | Implant Treatment: Trenbolone acetate Day 1 | Implant Treatment: Estrogen day 1 Trenbolone acetate Day 78 | P-value |
|---|---|---|---|
| No. pens | 6 | 6 | |
| No. head | 506 | 530 | |
| ADG, lb | 3.03 | 2.94 | .18 |
| DMI, lb/d | 17.9 | 17.4 | .07 |
| Feed / Gain | 5.95 | 5.93 | .71 |

[a] 652 lb initial weight. 168 days on feed.

Table 6. Effect of reimplanting on feedlot steer performance with deads and railers in (two trial summary)[a]

| Item | Implant Treatment: Trenbolone acetate Day 1 | Implant Treatment: Estrogen Day 1 Trenbolone acetate Day 78 | P-value |
|---|---|---|---|
| No. pens | 6 | 6 | |
| No. head | 522 | 552 | |
| ADG, lb | 2.97 | 2.82 | .05 |
| DMI, lb /d | 17.9 | 17.4 | .07 |
| Feed/Gain | 6.11 | 6.22 | .35 |
| Mortality, % | .99 | 2.11 | .14 |
| Railers, % | 1.72 | 2.00 | |

[a] 652 lb initial weight. 168 days on feed.

Table 7. Effect of reimplanting on carcass characteristics of feedlot steers. (two trial summary)[a]

| Item | Implant Treatment: Trenbolone acetate Day 1 | Implant Treatment: Estrogen Day 1 Trenbolone acetate Day 78 | P - value |
|---|---|---|---|
| No. pens | 6 | 6 | |
| No. head | 506 | 530 | |
| Hot carcass wt., lb | 737 | 727 | .19 |
| Dress, % | 63.78 | 63.66 | .64 |
| Choice, % | 44.0 | 38.2 | .40 |
| Yield grade 4, % | 8.0 | 6.6 | .58 |

[a] 652 lb initial weight. 168 days on feed.

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## QUESTIONS & ANSWERS

**Horn:** You mentioned that the average incidence of bullers was .39% of the monthly steer population. What does that cost in dollars per head against the remaining cattle?

**A:** Our data showed a .39% buller rate based on the monthly steer population. Data published in the Journal of Animal Science in the late 70's reported a buller cost of about 25 dollars each. This would be consistent with our field estimates. With a monthly rate of .39%, this gives a cost of about 50 cents per head for every steer fed (.39% times 5 months on feed times $25). Big time opportunity.

**Stokka:** Do you have any data that correlates pen size with death loss?

**A:** We have not pulled that out of our database.

**Q:** How about pen size and bullers?

**A:** Yes. The 178 head pens had about ½ of the buller rate as that presented for the 318 head pens.

**Preston:** Does the incidence of bullers differ with implant type?

**A:** Yes, absolutely. We measure, at least 25-50% more bullers with TBA than with estradiol implants alone. I don't think that we are the only ones.

**Mader:** On your initial slides with statistical comparisons, did you calculate standard errors between 50 and 100 head pens or did you adjust the standard error by calculations? Would that alter conclusions if pen was your experimental unit?

**A:** First off, pen was the experimental unit for all of the power curves statistics I showed you. We worked with an independent statistician from the University of Nebraska to generate the power curve data. He used actual trial results, including the standard errors and coefficients of variation, in generating those power curve statistics for the 50 and 100 head pens. That data was then used, with the help of Cochran and Cox, to generate the power curve statistics for the 10, 200 and 600 head pens. The power curve data for the 10, 200 and 600 head pens were what was expected from those calculations, so those were projections.

**Q:** Who is the best consulting company out there?

**A:** Koers-Turgeon Consulting Service.

**Kreikemeier:** Do you reach any different conclusions using data from big pens versus small pens? With deads in or deads out? Might an implant increase gain by 15% in small pens but only by 5% in big pens?

**A:** We recognize that things happen in big pen feedlots that don't necessarily happen at the small pen research level. That was part of the purpose of this presentation. They are two different worlds. Because of these differences, small pen work can be criticized. I still feel, however, that small pen work is extremely valuable information because it adds to our knowledge of implants. The performance differences between small pens and large pens are probably not as great as one might think, especially when one takes into account that the evaluation is made on a similar basis - deads out. I have never seen, however, the Journal of Animal Science report finishing performance data other than deads and rejects out of the database. This is only half of the picture. Where small pen work really misses the boat is in the area of carcass characteristics. Too much emphasis is placed, face value, on carcass data generated from a limited number of small pen studies.

**Q:** Are you able to pick up significant treatment differences of railers, bullers or deads in large pens?

**A:** Yes, but it's rare. It takes a lot of numbers to get adequate power.

**Van Koevering:** Isn't the greatest advantage for large pens in gathering carcass data? In small pens, trends may be detected, but significant differences are rare. It seems like the large pen perspective should have more advantage for detecting differences in carcass data than in average daily gain.

**A:** Yes, the industry needs to stop all the lip service and get with the program. We need to place much more focus on carcass quality and tenderness of our product. Once we lose sight of these, we are doomed. In the big pen trials, we are normally talking about one thousand to two thousand animals per trial. For average daily gain and dry matter feed conversion, the C. V. runs about 1-2%. The C. V. for percent choice runs about 15-20%. Even though one has a large number of cattle, the C. V. is still very high for percent choice which means a massive amount of cattle is required to show statistical differences. That's why I showed you information for 600 head pens. I'm not saying that data from the small pens are not important. But it is a different world than that of large pens. We detect things that never reveal themselves at the small pen level. How many trials ever measure dark cutters or bullers? And if they do, why isn't it reported? With carcass data from large pens, you have a better probability of showing treatment differences in percent choice, dressing percent, yield and/or dark cutters. It simply takes thousands of cattle to find out what is going on.

# THE IMPACT OF LIMIT FEEDING, SEASON AND TYPE OF CATTLE ON IMPLANT RESPONSE

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## ABSTRACT

The impact of animal type, season and intake level on implant response is of obvious interest and concern to most involved the beef industry. However, scientific data and information in these areas is lacking. Maintenance requirement is one area where each of these items may interact with implants to affect the implant response. Other factors possibly involved are discussed. Although the data, ideas, and theories in this paper should not be considered as infallible facts, they may provide a basis for further discussion and research.

## INTRODUCTION

When asked to speak on this topic, I indicated that I was not qualified because I had more questions than answers and little scientific data on this subject. I was told others felt the same, so I got this topic by default. Certainly, it is a fascinating subject of obvious importance. I will discuss factors which may explain how cattle type, season and limit feeding could impact the implant response; you can draw your own conclusions.

For discussion, implants will be divided into three categories. The first is implants with estrogen is activity such as Synovex S & H, their generic counterparts, and Compudose and Ralgro. The second category is implants with androgenic activity such as Finaplex S & H. The. third category is the combination (estrogen and androgen) implants that include Revalor S, H and G and Synovex Plus. Each of these implant categories has a proven track record. In spite of management and genetic changes that have taken place in our cattle industry over the years, implant efficacy remains very good. A recent summary of feedlot implant trials indicated a gain increase of 18% and a feed efficiency improvement of 9% using various implants combinations (4). While implant response on pasture is somewhat less, there still is a sizable response when feed and pasture conditions are adequate.

Both similarities and differences between implant categories exist with respect to physiological effects on the animal. These include:

1. Estrogen, androgen and combination implants stimulate muscle and bone disposition.

2. All implant categories improve gain and feed efficiency; the combination implants usually are most effective.

3. Estrogen implants increase feed intake; but androgen implants may not.

4. Estrogen implants increase the maintenance requirement while androgen implants may decrease the maintenance requirement for energy.

To set the stage for further discussion, I would like to make some additional general observations. Some of these observations are supported by scientific data; others are theoretical and opinions based on years of personal experience. I suspect that all readers may not agree with all observations; this is as it should be. If each of us agreed on everything, some of us would be unnecessary. These general observations include:

1. There is a seasonal or day length effect on feed intake (3, 6). Numerous studies have shown that intake is maximum with approximately 16 hours of darkness and 8 hours of light (Tables 1 & 2). These day-length categories, even though created artificially, correspond closely to summer and winter day lengths.

Table 1.

| TREATMENT* | GAIN (LB/DAY) | FEED INTAKE (LB/DAY) | CONV. |
|---|---|---|---|
| RAM (16L : 8D) | 0.90 | 3.88 | 4.3 |
| RAM (8D : 16L) | 0.75 | 3.37 | 4.5 |
| WHETHER (16L : 9D) | 0.76 | 3.50 | 4.6 |
| WHETHER (8L : 16D) | 0.66 | 3.17 | 4.8 |

Table 2.

| TREATMENT | GAIN (LB/DAY) | FEED INTAKE (LB/DAY) | CONV. |
|---|---|---|---|
| RAM (16L : 8D) | 0.90 | 3.88 | 4.3 |
| RAM (8D : 16L) | 0.75 | 3.37 | 4.5 |
| WHETHER (16L : 8D) | 0.76 | 3.50 | 4.6 |
| WHETHER (8L : 16D) | 0.66 | 3.17 | 4.8 |

Table 3. Seasonal Effect on Performance.

| | STEERS | | HEIFERS | |
|---|---|---|---|---|
| | APRIL | AUGUST | APRIL | AUGUST |
| ADG | 2.62 | 3.05 | 2.34 | 2.71 |
| CONV. | 7.18 | 6.52 | 7.54 | 6.86 |
| CONSPT | 18.8 | 19.9 | 17.6 | 18.6 |

2. Intake and performance vary with season. This is verified by records kept by the Texas Cattle Feeders Association (5) which indicate that the poorest close-out performance occurs in April and the best is in August (Table 3). Cattle closing out in April are those fed during the winter season; those closing out in August are cattle fed during the spring and summer season. The performance difference is consistent and substantial. This seasonal difference has held true in each of the ten years of data that were summarized. The difference in performance favored August over April close-outs by 10 to 15%.

3. Breeds differ in maintenance energy requirements. For example, Holsteins have a maintenance requirements 7% greater than other breeds. Higher maintenance requirements also have been documented for some continental breeds. Conversely, the maintenance requirements of Brahman cattle and possibly some British breeds may be relatively lower.

4. Maintenance energy requirements are influenced by season and weather. For example, Ames & Johnson (1) estimate that maintenance requirements increase 1.3% for each degree below 20 degrees Celsius. Table 4 illustrates this effect on performance when the formula is applied to monthly temperatures that occur in Eastern Colorado. The E.A.T. refers to Effective Ambient Temperature, a wind chill index.

Table 4. Application of the 1.3%/°C rule to cows requirements and steer performance.

| | | | Cows[a] | Steers[b] | |
|---|---|---|---|---|---|
| Month | EAT (°C) | % increase in maintenance | Increased dry matter rquirement (lb./d) | Decrease in ADG (lb./d) | Decrease in feed efficiency (lb. dry matter/lb. gain) |
| Jan. | -5.6 | 33.3 | 5.9 | 0.46 | 1.0 |
| Feb. | -2.0 | 28.6 | 5.1 | 0.39 | 0.8 |
| March | 0.1 | 25.9 | 4.8 | 0.35 | 0.7 |
| April | 4.8 | 19.8 | 3.6 | 0.26 | 0.5 |
| May | 10.9 | 11.8 | 2.1 | 0.14 | 0.3 |
| June | 16.7 | 4.3 | 0.7 | 0.03 | 0.1 |
| July | 19.5 | 0.7 | 0.1 | — | — |
| Aug. | 18.3 | 2.2 | 0.4 | — | — |
| Sept. | 12.8 | 9.4 | 1.8 | 0.11 | 0.2 |
| Oct. | 6.6 | 17.4 | 3.3 | 0.23 | 0.5 |
| Nov. | — | 26.0 | 4.5 | 0.35 | 0.7 |
| Dec. | -3.8 | 30.9 | 5.4 | 0.42 | 0.9 |

[a]525 kg. cow consuming 50% TDN diet.
[b]Yearling steer fed 85% concentrate diet.

5. Restricted intake programs probably reduce the animal's maintenance energy requirement. This may be at least partially due to the smaller organ size (liver, gut, etc.) of restricted fed animals.

6. As body fat content increases, feed consumption decreases.

7. The better the animal performance, the greater the implant response.

8. The better the pasture conditions, the greater the implant response. If pasture conditions are not adequate to support 1 lb. of gain/day or more, it is unlikely that implant responses will be consistently favorable.

Based on these general observations, one can discuss how various factors might affect the implant response. Much of this is speculation and not necessarily based on "hard scientific" evidence. Unfortunately, it is difficult to gather direct scientific comparisons, in these are areas but this does not diminish their importance. This also is an area of immense personal interest where I would encourage further research.

**Breed Type**

One effect of breed type on performance would be a greater implant response with better performing animals, regardless of the implant used. I would speculate that animals with higher maintenance requirements and higher feed consumption should respond better to implants containing androgen. These implants would be less likely to further stimulate intake and more likely to reduce maintenance energy requirements. Conversely, breed categories with low maintenance requirements and lower feed intakes might respond relatively better to estrogen implants. This is because any increase in maintenance energy requirements resulting from estrogen implants would be less critical and an increased feed intake would be more beneficial.

***Season***

We may see a greater implant response in the summer to all implants because summer performance exceeds winter performance. Nonetheless, implants still are extremely important during the winter season, a time when we need all the help we can get. Also, it is a time of decreased feed consumption and possibly, increased maintenance energy requirements. Decreased consumption and increased maintenance requirements obviously are a potential "double whammy" with respect to performance. An extremely frustrating calamity for a nutritionist or cattle owner is a severe winter when performance and consumption are depressed. Such cattle must be fed longer and as a result, implant activity may "run out". In this situation, an active implant with estrogen activity to help maintain consumption is extremely helpful. In the summer, when we have high seasonal consumption, one might expect a relatively better response to implants containing androgen.

*Restricted Intake*

Restricted intake growing programs have become more popular in recent years, but to my knowledge, no scientific data are available on the implant response in such programs. Restricted feeding, though somewhat controversial, is a useful tool to obtain a desired gain using an economical combination of high energy ration ingredients. Table 5 illustrates data from a previously unpublished experiment we conducted comparing Synovex S and Synovex Plus when feeding either being restricted or ad lib diets. Unfortunately, there was no negative control in this experiment. The design for the restricted phase of the trial was based on comparisons desired for the final fattening phase. As expected, gain and feed consumption were greater for the ad lib cattle; however, conversions were superior for the restricted-fed cattle. Furthermore, the best restricted performance was obtained with the combination implant (Synovex Plus) as compared to Synovex alone. This would suggest that restricted-fed cattle do respond to implants containing androgen, possibly because such implants reduce maintenance energy requirements. Even though maintenance requirements of restricted fed cattle may be lower, the maintenance portion of the dietary energy intake becomes relatively more important because total energy consumption is reduced.

The impact of implants on pasture performance provides a clue of what might be expected in restricted-fed programs. In the majority, if not all pasture conditions, energy intake is somewhat limited compared to a feedlot situation. Since we normally obtain a pasture implant response when cattle are gaining in excess of 1.0 lb./day, this suggests we still can expect an implant response under restricted energy intake conditions.

Table 5. Effect of implant types and feed intake level on grow performance.

| IMPLANT TREATMENT<br>FEED TREATMENT | SYNOVEX S<br>RESTRICTED FED | SYNOVEX/PLUS<br>RESTRICTED FED | SYNOVEX PLUS<br>AD. LIB. FED |
|---|---|---|---|
| START WT. | 572 | 573 | 573 |
| FINAL WT. | 845 | 865 | 912 |
| DAYS ON FEED | 103 | 103 | 103 |
| NO. CATTLE | 400 | 200 | 200 |
| PEN REPS. | 8 | 4 | 4 |
| D. M. INTAKE/DY | 14.1 | 14.1 | 18.2 |
| A. D. G. | 2.66 | 2.83 | 3.29 |
| D. M. CONV. | 5.33 | 4.99 | 5.53 |

*Carcass Maturity Considerations*

On January 31, 1997 there was a B maturity carcass grade change. Thereafter, many B maturity carcasses will no longer be eligible for choice or select grade, but rather, will grade standard. Maturity will be based on bone ossification and lean color. It is probable that changes in bone ossification will be influenced by estrogen levels. This means that an addition to chronological age, factors should as puberty, pregnancy, abortion, etc. will influence the maturity score of heifer carcasses. If estrogen levels influence bone maturity then there exist a possibility that implant type may influence carcass maturity. Furthermore, it appears that androgens or TBA implants have little or no effect on bone maturity. It's probable that there will also be a breed effect with respect to B maturity thus, this is another area where there may be a breed-implant interaction. Early maturing breeds may present more of a problem and late maturing breeds may be less of a problem. Another example is a possibility that Zebu females which are usually older when they reach puberty may be older before reaching B maturity. If one is feeding cattle which could present a B maturity problem, using implants containing TBA and a lower estrogen level may be advantageous.

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## QUESTIONS & ANSWERS

**Horn:** I was interested in your idea that cattle must gain over 1 pound per day before they will have an implant response. Are there exceptions when we provide a high quality forage like wheat pasture when forage availability rather than forage quality limits intake and performance? One of the largest responses to implants that I have had was with some light weight heifers on very short wheat pasture. From a base rate of weight gain of about ½ lb a day, estrogenic implants increase ADG by 30%. Must we consider both feed quality and feed availability rather than just ADG when we consider the potential for an implant response?

**Answer:** I think that is a good point.

# BULLER STEERS - CAUSES AND CONTROL

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## ABSTRACT

Male and female sexual behavior are regulated by the effect of estradiol on the brain. The effects of steroid hormones on the development of sexual behavior of cattle have not been determined. Steers that are bullers appear to have a physiological defect. Because steroid hormones influence the brain to regulate sexual behavior, treatment of bullers with specific hormones may reduce buller activity.

## INTRODUCTION

The occurrence of buller steers is an abnormal social condition that greatly reduces productivity. A buller steer is repeatedly mounted and ridden by its penmates. This abnormal activity reduces weight gain, and may cause injury and even death. Many factors are associated with bullers such as management, stress, climatic environment and implanting with anabolic hormones. Buller steers cannot be produced experimentally to conduct controlled research, so most information on the syndrome has been obtained from animals in a feed yard when the incidence of bullers is greater than expected normally. Thus, the cause of buller steers has not been clearly established.

### Factors related to an increased incidence of bullers

Social factors may be a stimulus that increases the incidence of bullers. The use of large pens with many steers and mixing groups of steers when they enter the feedlot may increase the incidence of bulling. Sexual behavior of animal is induced by sex steroid hormones such as estradiol and androgens. These are the same hormones or the analogues that are contained in growth implants. Various implants have been suggested as a possible cause of bullers. Irwin and coworkers (1979) found that the incidence of bullers differed with the type of implant. Only about .5% of steers implanted with Ralgro were bullers; this compares with 1.4% for steers implanted with diethylstilbesterol (DES) and 2.5% for steers implanted with progesterone and estradiol. The incidence of bullers was greater when steers were implanted initially with DES followed by an implant containing progesterone and estradiol benzoate (Synovex-S), than when steers were implanted and reimplanted with DES (Schake et al., 1979). Caution must be used when interpreting these experiments because large numbers of cattle were studied over an extended time period so that all variables were not controlled. In addition, because the incidence of bullers usually is 1 to 4%, bullers may have a physiological defect that is exacerbated by management. If an implant, feed additive, environmental condition, or other factor causes bullers, we would expect to see a much greater percentage of the steers exhibiting the condition.

### Environmental Estrogens

Hormones influence the function of cells by binding to specific receptors. Steroid hormones, such as estradiol and testosterone, bind to receptors in the nucleus of cells and cause transcription of DNA. This ultimately results in the synthesis of specific proteins that can alter the function of cells. Receptors for steroid hormones are present in many types of cells located in the reproductive tract, muscle, brain and other tissues. Hormones produced by an animal's endocrine glands control normal growth and function of tissues and can regulate reproductive behavior.

Estrogens are produced by the ovary, placenta and adrenal gland of most females and by the testis and adrenal of males. Additionally, some plants and molds produce compounds that have estrogenic activity. For instance zeranol, produced by a mold that grows on grain, is an estrogen and is the active ingredient in one commercially available product. Other compounds synthesized by chemists may bind to estradiol receptors in cells and thus have estrogenic effects. Diethylstilbesterol (DES), although not a steroid, is a very potent estrogen that was used as a growth enhancing implant prior to 1979.

One environmental estrogen that can influence animals is the pesticide DDT. Although banned in the U.S. since the early 1970s, DDT is still present in the environment and causes feminization of wildlife. The presence of DDT in the environment in Florida has been linked to the production of male alligators with smaller than normal penises (McLachlan and Arnold, 1996). This response is associated with the estrogenic effect of DDT that inhibits normal development of the male reproductive system. Thus compounds that have been synthesized and are found in the environment may have effects on animals similar to the hormones normally produced by animals.

**Development of Sexual Behavior**

During prenatal development of mammals, absence of testicular secretions results in the development of the female reproductive tract and feminine sexual behavior. The genetic sex of an animal dictates if testicular secretions will occur; this results in physiological changes that are irreversible. At or near the time of puberty, gonadal steroid hormones stimulate the onset of male sexual behavior. If the testicular hormones are removed, such as by castration, the animals cease to exhibit male sexual behavior.

The brain of mammals becomes masculinized or defeminized by the presence of androgens. In pigs, mating behavior is influenced by exposure to testosterone during pubertal development (Ford, 1982). If boars are castrated before they reach 6 months of age, treatment with estradiol at 9 months of age results in the immobilization response (standing estrus); however, if castrated after 6 months and treated with estradiol, they show no such female sexual behavior. In sheep, sexual differentiation of the brain for mating behavior occurs between 50 and 80 days of gestation (D'occio and Ford, 1988). The time of sexual differentiation of mating behavior in cattle has not been determined. Studies with bulls indicate that if steroids program or regulate social or sexual behavior, the effect occurs before one month of age (Godfrey et al., 1992). However, some abnormal sexual differentiation of the brain maybe associated with bulling.

In many species, sexual behavior is caused by the conversion of testosterone to estradiol by the enzyme aromatase. Thus, testosterone causes sexual differentiation of sexual behavior and male behavior in genetic males by its conversion to estradiol in the brain and activation of estradiol receptors in cells. Exposure of animals to exogenous androgens or estrogens could alter sexual differentiation or behavior.

Treatment of steers with estradiol increases both male and female sexual behavior. The number of times that steers stood to be mounted and the number of times steers mounted others were greater for steers given estradiol then for steers given testosterone or dihydrotestosterone (Dykeman et al., 1982). Steers treated with either testosterone or estradiol participated in more head butts then non-treated steers. This indicates the both estrogens and androgens can cause both male and female sexual behavior in steers.

In recent study with rams that preferred other rams to ewes, the male orientated rams had reduced concentrations of testosterone and estradiol in serum compared with heterosexual rams (Resko et al., 1996). In addition, the male-orientated rams had a reduced concentration of aromatase in the preoptic area of the brain. Because aromatase converts androgens to estrogens, these results indicate that estrogens may stimulate male behavior in sheep.

**Female Receptive Behavior**

We do not know if the submissive response (standing to be mounted) of a steer to a more dominant steer differs from normal female receptive behavior. When heifers are estrus or in standing heat, they are restless, mount others and allow themselves to be mounted. Treatment of ovariectomized cows with estradiol causes the standing reaction (Nessan and King, 1981; Cook et al., 1986); treatment of cows with progesterone reduces the effect of estradiol in causing cows to mount others or to stand to be mounted (Davidge et al., 1987). In superovulated cows, maximum concentrations of estradiol at estrus were linearly related to the number of mounts that each cow received (Coe and Allrich, 1989). These studies clearly demonstrate that female sex hormones regulate sexual behavior in cattle. Knowledge of these effects of progesterone and estradiol on female behavior might be useful for developing systems to decrease the incidence of bullers.

Table 1. Plasma estradiol (pg/ml) and testosterone (ng/ml) in buller and normal steers

| Expt. | Pen | Hormone | Normal | Bullers |
|---|---|---|---|---|
| 1[a] | 1 | E2 | 109.8(6)[b] | 42.0(6) |
| | 2 | E2 | 28.0(6) | 24.8(6) |
| | 2 | T | .3(6) | .2(6) |
| 2 | 1 | E2 | 6.4(9) | 3.8(10) |
| | 2 | E2 | 3.4(7) | 2.6(9) |

[a] Trt x pen, P< .05 for estradiol.
[b] Number of steers in parentheses.
[c] Trt, P < .08; pen, P < .04.

The social status of dairy heifers in a group also may influence sexual behavior. Weibold and coworkers (1983) found that heifers that were at either the top or the bottom of the social order mounted more heifers that were in estrus and were mounted by more heifers when they were estrus. Thus when new animals are added to a group, increased bulling may occur as the animals reestablish their social status.

**Sexual Differentiation of the Bovine Brain**

There is no evidence that sexual differentiation occurs in the bovine brain. Both male and female cattle mount others, so gonadal hormones may not cause changes in development which regulate behavior (D'occio and Ford, 1988). Short term exposure of steers to estradiol causes female behavior whereas long term exposure causes male behavior. Perhaps long term exposure of the brain to estrogen results in a refractory response and male aggressive instead of female submissive behavior.

Bower and Kiracofe (1978) found that concentrations of total estrogens were greater in buller steers than in normal steers. In contrast, Irwin and coworkers (1979) found that bullers had reduced concentrations of both estradiol and testosterone in plasma compared with normal steers or bullers that had recovered. Similarly, we found in two experiments with buller steers in different feedlots and different seasons that bullers had lower than normal concentrations of estradiol in plasma (Table 1). Steers in experiment 1 were yearlings that were mostly black or Hereford. Steers were in pens with about 200 other steers. The steers in pen 1 initially were implanted with Synovex and reimplanted with both Synovex (estradiol benzoate and progesterone) and trenbolone acetate (TBA). Steers in pen 2 were implanted with both Synovex and TBA initially because they weighed about 800 pounds when they entered the pen. Greater concentrations of estradiol in both bullers and normal steers in pen 1 than in pen 2 might be due to reimplanting of steers in pen 1. Steers in experiment 2 are desisted in this report in case study 2. Concentrations of testosterone were similar for buller and normal steers. These observations support the hypothesis that exposure to minimal amounts of estradiol may cause animals to be sexually receptive to others whereas exposure to greater amounts of estrogens may cause them to become refractory and not to stand to be mounted.

**Investigating Abnormal Behavior (Bullers) in Feedlots**

Because estrogens initiate sexual behavior and excess androgens promote masculine behavior, implants often are the first factor accused of causing abnormal feedlot behavior. To try to determine the cause of an increase in the incidence of bullers in a feedlot requires a thorough study. Such an investigation of feedlot behavior should include:

1. a complete history including dates and number of bullers pulled, previous implants, grazing conditions, origins, age and sex of the pen's population, environmental conditions and feedstuffs.

2. physical inspection of implant sites from a representative sample of animals exhibiting abnormal behavior and their normal penmates, detailing variety and number of abnormal implants.

3. physical inspection of the facility to include pen size, bunk space per animal, and stocking density.

4. a description of the management practices to include feeding schedules, bunk management, cattle movements, and the criteria under which bullers are identified and handled.

Information gathered from this type of an investigation should be interpreted in context with the pattern of buller activity. For example, if implants are suspected to cause riding activity, the riding pattern should match the implant hormonal release profile. After implanting hormone concentrations in blood usually reach a maximum within one day, decline rapidly for a week or two, and then continue to decrease until the implant is exhausted. Logically, if the release of hormones from the implant is responsible for riding behavior, the behavior pattern should match this hormonal release profile.

Retrospective examination of the first time buller pulls each day can help discover factors that might incite alterations in animal behavior. Episodes of riding frequently are linked to specific events such as the addition of estrogenic feedstuffs to the ration or the establishment of social order when new cattle are introduced into the pen or neighboring pen. Deficiencies in bunk management may initiate riding at any time during the feeding period; therefore, it is difficult to associate management with a specific pattern. Climatic factors such as season, wide swings in temperature, or barometric pressure also may impact the frequency of bullers.

## Examples of Buller Activity in Steers

### Case Study 1 (figure 1)

Case study 1 presents data from 3 pens of steers in a small feedlot with an unusually high number of buller pulls occurring in midsummer. Problem pens were identified for investigation. Implant sites were examined on representative buller and non-buller penmates. Pen space, feeding practices, and bunk space were within normal limits. By plotting the occurrence of first time buller pulls, a pattern was identified which appeared to be independent of implants. Further investigation of events relating to changes in feed in the normal step-up procedure indicated that each change in feed predated an upsurge in riding behavior. This correlation was confirmed when the feedlot manager indicated that the silage supply had been exhausted in the summer months and green chop triticale and new crop corn silage had been substituted as a source of forage. Although no forage was included in the receiving ration, it was introduced in the second week at 15.5%, increased to 20% in week three, peaked at 23%, and was reduced to 14% in the final ration. Phytoestrogens in these feedstuffs may have contributed to the abnormal animal behavior.

### Case Study 2 (figure 2)

The second case study reflects one pen (a second pen was investigated with similar results) of yearling feedlot steers in the fall. The steers were started on feed after an extended period during which steers grazed native pasture. These animals had not been implanted during the grazing phase. Implant sites were examined on ten animals that had expressed bulling behavior and ten normal penmates. Implanting technique was determined to be satisfactory. The scrotums also were palpated to check for any contribution of deficiencies in castration as a cause of the incidence of riding. Blood was taken for plasma estradiol analysis; results are in Table 1 (pen 2 of experiment 2).

Incidence of buller pulls by days on feed resulted in an erratic pattern that was not related to either implant administration or changes in feed (Figure 3). When changes in total feed delivered to the pen were plotted, it became evident that as total feed delivered to the bunk decreased, the incidence of buller pulls increased. Competition for feedstuffs may have triggered a need to establish social dominance within the group. Concentrations of estradiol in the blood of steers that were being ridden and pulled for buller behavior were less than for their normal pen mates. These hormonal differences indicate that estradiol concentrations may be the result of or contribute to those factors that cause abnormal behavior in feedlot animals.

## Treatment of Bullers

Hormones cause sexual behavior in cattle. Will altering the type or amount of hormone stop bulling? Bullers have reduced concentrations of estradiol in plasma compared with riders. We hypothesize that treatment with an androgen or an estrogen may alter the behavior of bullers. Theoretically, additional implants for bullers should alter or reduce buller activity.

Progesterone blocks estrus or the standing reaction in cows. Will treatment of cows with a synthetic progesterone such as melengestrol acetate (MGA) alter the behavior of bullers? We propose that feeding MGA to buller steers may reduce sexual behavior.

### Implications

Sexual behavior is caused by the effect of hormones on the brain of animals. Steers that are bullers appear to have a physiological defect. Thus it seems logical that abnormal sexual behavior, that associated with alterations in plasma concentrations of estradiol, could be treated by hormone therapy. These suggested treatments remain to be tested.

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## QUESTIONS & ANSWERS

**Question:** Would you speculate as to whether the incidence of bullers would be different for animals that have never had an implant versus animals that have had at least three?

**Answer:** From the evidence that we heard this morning, we conclude that some implants cause greater instances of bullers than others. The occurrence of bullers may be greater in implanted vs. non-implanted steers. However, bullers may not be caused by implants but implants may influence the predisposition that already exists for an animal to be a buller.

**Question:** You made the conclusion on your case study that perhaps there is some estrogenic compounds from the feed stuffs and yet maybe a dramatic increase in feed intake. Would feed intake have a calming effect?

**Answer:** We were observing two different scenarios with difference conclusions. One was related to vito estrogens, the other related to consumption and subsequent competition.

**Botts:** How does the time of castration influence the incidence of bullers?

**Answer:** I have not seen any data on the effect of time of castration on the incidence of bullers.

**Question:** Since the bullers have lower estrogen levels, should we reimplanting bullers to reduce the problem?

**Answer:** That might be something to try. If a heifer or a steer is given estrogen they might show female behavior and then after long term exposure they may exhibit male behavior because they become refractory to estrogen. Maybe steers that are bullers do not have sufficient estrogen. Giving addition estrogen may make the buller steers refractory and they may cease standing to be ridden.

**Armbruster:** I had a dramatic observation in one of the feedyards I was involved with. One of the most successful times at which bullers could be reintroduced into a pen is reimplanting time. The possibility of that buller animal remaining in the pen is greatly enhanced and if it is reintroduced at the time of reimplanting.

**Answer:** Steve Armbruster observed in some feedyards that when animals are reimplanted at the time the bullers are reintroduced that this increases the likelihood that the animals can stay in the pen and not have to be pulled again.

**Owens:** In some personal experiments that are running currently we checked the implant status on a group of steers that have been implanted in a commercial yard. On arrival at OSU it turned out that somewhere between 15 and 20 percent of those had not retained their implant about two weeks after they had been assumed to have the implant. I wonder how the potential for an increase in bullers in large pens might be increased by such a problem. Does the incidence of riding vary with the ratio of the implant's or different size animals in a pen increase riding?

**Answer:** Some implants have been restricted to certain classes of animals (e.g., feedlot cattle) and for good reason although this may not relate to riding. If all animals in a pen are implanted with the same product, hormone profiles should be similar; thus there should be little reason to initiate abnormal behavior. Theoretically, if animals in a pen are implanted with dissimilar products, hormone profiles should differ and creating more opportunity for riding. In reality, field reports of riding behavior in animals within a pen receiving different types of implant are rare. Certainly, we need more information regarding effects of exogenous hormones on animal behavior.

# EFFECTS OF GROWTH STIMULANTS ON PROTEIN REQUIREMENTS OF FEEDLOT CATTLE

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## ABSTRACT

Feedlot performance and diet composition data were collected from a survey of finishing steer experiments (347 kg average initial weight; data excluded Holstein steers) conducted in the U.S. and reported in refereed and university publications between 1988 and 1995. Data were analyzed by weighted (observations/mean) analyses of variance to determine effects of protein intake and implanting strategy on feedlot performance (ADG, DMI and kg DM required/kg gain). Implanting strategies were defined according to prevalent or last implant type used: no implant (None); medium-potency implants (Medium): zeranol 72 mg/dose, steroid-based implants (Synovex-S or Compudose) or trenbolone acetate (TBA) alone; high-potency implants (High): TBA in combination with either steroids or zeranol. Regression procedures were utilized to estimate CP and DIP, or MP requirements. Protein accretion was estimated by formulae provided in the literature and regressed on MP intake to estimate MP requirements for maintenance. Implant effects were independent of dietary protein effects and included faster ($P < .05$) gains at higher intakes ($P < .05$) that resulted in improved ($P < .05$) feed efficiencies (gain and efficiency ranking: High > Medium > None). Steers responded to higher dietary CP by increasing intake ($P < .05$) which resulted in faster ($P < .05$) and more efficient ($P = .09$) gains. Total MP requirement for a given rate of gain in steers implanted with high-potency implants was lower than that in steers implanted with medium-potency implants or that in steers not implanted. When diets contain high dietary CP, DIP may increase to 68% of CP in steers implanted with high-potency implants or those not implanted. Maintenance MP requirements of nonimplanted steers were greater than those of implanted steers but similar to MP requirements established by NRC (1996). At relatively low protein intakes, steers in medium-potency strategies accrued more empty body protein. This finding indicates that diets of steers implanted with high-potency implants must be supplemented to contain more than 7.5 g MP/kg $BW^{.75}$/d , especially at heavy (>450 kg) initial BW, to maximize implant response.

## INTRODUCTION

Renewed interest in effects of growth stimulants on nutrient requirements has been prompted by several findings that indicate that cattle implanted with a combination of trenbolone acetate and steroids or zeranol, respond to higher dietary protein concentrations (Galyean, 1996). Also, greater protein requirements are suspected because genetic manipulation of cattle has led to production of leaner, later-maturing cattle types. However, defining protein requirements for implanted cattle is further complicated by effects of implants on DMI (Anderson and Botts, 1995), diets fed (e.g., source of grain and source of protein, Zinn, 1995) and environments (NRC, 1996) under which cattle are fed. Using the concept of metabolizable protein, we have summarized effects of growth stimulants on performance and modeled protein requirements.

### Materials and Methods

Feedlot performance and diet composition data were collected from a survey of finishing steer experiments (347 kg average initial weight; data excluded Holstein steers) conducted in the U.S. and reported in refereed and university publications between 1988 and 1995. Based on initial and final BW, breed type information, diet composition and DMI, dietary energy (TDN, $NE_m$, $NE_g$) and protein fractions (DIP, MP and CP) were estimated using procedures contained in the software of the Nutrient Requirements of Beef Cattle (NRC, 1996; tabular system, level 1). Composition of feeds provided in the software was altered only as needed according to information provided in published material. Because most publications did not provide weather information data or effects of weather on cattle, a standard exposure to a 5-kph wind, a temperature of 20° C (previous or current), no night cooling or heat stress on steers with .5 cm clean and dry hair coats was utilized. Although this assumption biased estimates of protein requirements, it had no effect on estimates of protein supply.

Data were analyzed by weighted (observations /mean) analyses of variance to determine effects of protein intake and implanting strategy on feedlot performance (ADG, DMI and kg DM required/kg gain). Implanting strategies were defined according to prevalent or last implant type used: no implant (None); medium-potency implants (Medium): zeranol 72 mg/dose, steroid-based implants (Synovex-S or Compudose) or trenbolone acetate (TBA) alone; high-potency implants (High): TBA in combination with either steroids or zeranol. A more thorough comparison of steer performance responses to implant type or sequencing is beyond the scope of this paper.

The literature survey yielded 171 treatments with means as shown in Table 1. Use of high grain diets is quite evident from this table. Most diets were corn-based; thus, DIP percentages are fairly low. Compared to NRC (1984) requirements, dietary CP and CP intake are much higher; this is a reflection of researchers trying to assure that crude protein supply does not limit performance of feedlot cattle.

Regression procedures were utilized to estimate CP and DIP, or MP requirements. In either instance, full models containing ADG as the dependent variable and DMI, initial BW, $NE_g$ and DIP and CP, or MP and their quadratic components were reduced by a backward elimination procedure (SAS, 1994) until all variables remaining in the model were significant ($P < .10$). Where appropriate, discrete variables were utilized (usually DMI only) to test for effects of implants. Estimates of DIP and CP, or MP requirements were made by solving the resulting equations for these protein fractions. This step prevented modeling dietary protein fraction intake alone.

A further attempt to estimate protein requirements for maintenance and gain was made. Protein accretion was estimated by formulae provided by Owens et al. (1995). In their review, Owens et al. (1995) suggest that a logical approach to modeling growth should utilize degree of maturity. This approach accounts for differences between sexes, breed types, diets and

Table 1. Weighted means (observations/mean) for dietary characteristics and feedlot performance data according to implant strategy[a]

| | Implant strategy | | |
|---|---|---|---|
| Item | None | Medium | High |
| No. means | 30 | 35 | 106 |
| $NE_g$, Mcal/kg DM | 1.38 | 1.36 | 1.38 |
| Implant doses | 0.0 | 1.6 | 1.2 |
| CP, % DM | 12.78 | 12.39 | 12.71 |
| DIP, % CP | 60.02 | 59.56 | 60.90 |
| CP intake, g/d | 1,116 | 1,165 | 1,238 |
| Initial BW, kg | 350 | 330 | 361 |
| Final BW, kg | 533 | 541 | 565 |
| ADG, kg | 1.33 | 1.50 | 1.63 |
| DMI, kg/d | 8.75 | 9.40 | 9.76 |
| DM/kg gain, kg | 6.61 | 6.34 | 6.03 |

[a] Prevalent or last implant used. None: no implant; Medium: zeranol 72 mg/dose, steroid-based or trenbolone acetate (TBA) only implants; High: combinations of TBA and steroid- or zeranol-based implants.

implant strategies. Equations to predict empty BW and empty body protein from BW and empty body ADG and maturity, respectively, were utilized: Empty body protein gain, (g/d) = 87.7 + 72.5EBADG$^2$ - 92Maturity$^2$, $R^2$ = .91; where EBADG = Empty body ADG, and Empty BW (kg) = .917shrunk BW - 11.39. Maturity was estimated by dividing percentage empty body fat by 36 (Owens et al., 1995). The denominator, 36, corresponds to empty body fat at protein maturity (when protein accretion reaches zero). Earlier findings using $D_2O$ dilution techniques indicated that average maturity of cattle not exposed to implants was 60% and that of those exposed to low or medium-potency implants was 55% (Lemieux et al., 1988, 1990; Solis et al., 1989). In this paper, 55 or 60% maturity was used for cattle with or without implants, respectively. Body weight obtained from data survey was used as shrunk BW, although in research reports surveyed BW was obtained after only partial or no shrink.

Protein gain (g/kg $BW^{.75}$/day) was regressed on MP intake (g/kg $BW^{.75}$/day) within each implant strategy. Discrete variables were used to model effects of implant. In this regard, medium-potency strategies included effects of steroids, zeranol or trenbolone acetate implants. Resulting equations yielded estimates of MP requirements for maintenance and gain for defined implant strategies.

**Effects of Protein Concentration and Implant Strategy on Feedlot Performance**

Feedlot performance of steers under various implant strategies is listed in Table 2. Implant strategy affected ($P < .05$) ADG, DMI and kg DM required/kg gain. Steers implanted with high- potency implants gained fastest, while those not implanted gained slowest (1.63 vs 1.32 kg/d). Steers implanted with medium-potency implants were intermediate (1.56 kg/d). Differences in ADG between implanted and not implanted cattle may be explained by differences ($P < .05$) in DMI. Steers implanted with high-potency implants had the highest DMI, those not implanted had the lowest, while those implanted with medium-potency implants were intermediate (9.65; 8.92; 9.63 kg/d, respectively). As a result, feed efficiency followed similar trends. Steers implanted with medium-potency implants required the least kg DM/kg gain ($P < .05$), while those not implanted required the most (6.79 vs 5.99); steers implanted with medium-potency implants were intermediate (6.20).

Estimating diet ME (Table 2) at observed or similar body weight (composition) indicated improvements in energetic efficiency ranging from 5 to 8% (observed weight and composition) or from 3 to 6% (similar weight and composition). This suggests an improvement in energetic efficiency in response to implanting.

Table 2. Effects of implant strategy[a] on feedlot performance of steers

| | Implant strategy | | | |
|---|---|---|---|---|
| Item | None | Medium | High | MSE[b] |
| No. means | 30 | 35 | 106 | |
| Dietary CP, % | 12.1 | 12.1 | 12.1 | |
| Initial BW, kg | 354 | 356 | 356 | |
| Final BW, kg | 526 | 556 | 565 | |
| ADG[c], kg | 1.32 | 1.56 | 1.63 | .023 |
| DMI[c], kg | 8.92 | 9.63 | 9.65 | .289 |
| DM/kg gain[c], kg | 6.79 | 6.20 | 5.99 | .252 |
| Calculated diet ME | | | | |
| Direct | 3.18 | 3.34 | 3.44 | |
| Composition adjusted | 3.18 | 3.28 | 3.36 | |

[a] Prevalent or last implant used. None: no implant; Medium: zeranol 72 mg/dose, steroid-based or trenbolone acetate (TBA) only implants; High: combinations of TBA and steroid- or zeranol-based implants.

[b] Mean square error.

[c] Implant effect ($P < .05$).

Table 3. Effects of dietary protein concentration on feedlot performance

| Item | Dietary CP, % | | MSE[a] |
|---|---|---|---|
| | 11 | 13 | |
| No. means | 66 | 105 | |
| Dietary CP, % | 11.4 | 13.3 | |
| Initial BW, kg | 355 | 356 | |
| Final BW, kg | 545 | 553 | |
| ADG[b], kg | 1.47 | 1.53 | .023 |
| DMI[b], kg | 9.31 | 9.50 | .289 |
| DM/kg gain, kg | 6.38 | 6.27 | .252 |
| Diet ME, calculated | 3.30 | 3.34 | |

[a] Mean square error.

[b] Protein effect ($P < .05$).

Crude protein concentration averaged 11.2 or 13.4% for two groups created by dividing the data set into trials with either a high (> 12%) or a low (< 12%) CP concentration. This concentration was chosen because it was at the upper limit of NRC (1984) CP requirements for steers of this type and BW. Only two observations reported crude protein concentrations below 10%. Eliminating these concentrations from the data set did not change the results or conclusions.

Crude protein concentration affected ($P < .05$) feedlot performance independent of implant strategy (Table 3). Steers fed high protein diets consumed more feed ($P < .05$), gained faster ($P < .05$) and tended ($P = .09$) to be more efficient than steers fed low protein diets (1.53 kg/d, 9.50 kg/d, 6.27 vs 1.47 kg/d, 9.31 kg/d, 6.38). Estimates of diet ME (Table 3) indicate that protein effects gain through an intake response.

Lack of a significant implant by dietary protein concentration interaction ($P > .538$) indicated that implanted steers do not have higher CP requirements, but merely respond to increased dietary CP as nonimplanted steers do. Regression analyses confirm this finding.

**Modeling CP, DIP and MP Requirements**

Regressing ADG on DMI, DIP and CP resulted in a model that contained a significant quadratic component for DMI and linear components for DIP and CP (Table 4). Solving for DIP at the dietary CP concentrations, DMI and ADG observed in the survey resulted in estimates of DIP requirements that were dependent on implant strategy (Table 4).

When no implant was used, DMI and ADG were low; therefore, diets with high DIP were sufficient to meet protein requirements. It is quite surprising that at ADG and DMI observed, steers in a high-potency implant strategy fed high CP diets could be fed relatively high DIP diets. In contrast, steers in a medium-potency implant strategy fed high CP diets required less DIP (higher UIP requirement). This would indicate that at similar intakes, diets of steers implanted in a medium-potency implant strategy require more UIP and, therefore, more MP than those of steers in a high-potency implant strategy. In all instances, if dietary CP was limiting, then the maximum DIP permitted in the diet fell to between 55 and 63% to compensate for low dietary CP. These findings substantiate earlier observations (Milton and Brandt, 1994; Berger and Merchen, 1995; DiCostanzo, 1995) that urea concentration in high moisture, whole or dry-rolled corn diets must not exceed 1% of dietary DM. In a previous analysis of data obtained in this survey (DiCostanzo, 1995), steers fed diets containing 5% soybean meal or .8% urea had similar performance. When dietary CP or DMI is not limiting (later in the feeding period), dietary DIP may be increased to between 69 and 73% in diets of steers not implanted or those of steers in a high-potency implant strategy.

Table 4. Estimated DIP[a] and MP[b] requirements for gains achievable with low and high CP diets at intakes observed in data surveyed.

| Implant strategy | CP, % | DMI, kg/d | ADG, kg | DIP, %CP | MP, g |
|---|---|---|---|---|---|
| None | 13.4 | 9.05 | 1.35 | 72.7 | 750 |
| None | 11.1 | 8.81 | 1.28 | 62.6 | 616 |
| Medium | 13.3 | 9.77 | 1.59 | 60.5 | 984 |
| Medium | 11.5 | 9.51 | 1.51 | 55.0 | 848 |
| High | 13.4 | 9.77 | 1.65 | 68.7 | 855 |
| High | 11.1 | 9.60 | 1.60 | 56.6 | 772 |

[a] Obtained by solving for DIP% in: ADG (kg/d) = -5.1054 + [DMI (kg/d) * Implant strategy coefficient (None: 1.2695; Medium: 1.1943; High: 1.2054)] + [$DMI^2$ ($kg/d^2$) * Implant strategy coefficient (None: -.0630; Medium: -.0541; High: -.0542)] - [DIP (%) * .0056] + [CP (%) * .0397]; $R^2$ = .52, CV = 21.2%.

[b] Obtained by solving for MP in: ADG (kg/d) = -5.4445 + [DMI (kg/d) * Implant strategy coefficient (None: 1.3722; Medium: 1.2665; High: 1.2839)] + [$DMI^2$, ($kg/d^2$) * Implant strategy coefficient (None: -.0720; Medium: -.0597; High: -.0604)] + [MP (g) * .00037]; $R^2$ = .47, CV = 22.3%.

When ADG was regressed on DMI and MP, the model contained significant quadratic components for DMI (Table 4). Solving for MP at the DMI and ADG observed in the survey resulted in estimates of MP requirements that were dependent on implant strategy (Table 4). When no implant was used, DMI and ADG were lowest; therefore, MP requirements were lowest. At similar DMI, steers in the medium-potency implant strategy required more MP, although they had lower ADG than steers in the high-potency implant strategy. Thus, steers implanted with combinations of TBA and steroids or zeranol appear to be more efficient at converting MP to daily BW gain. Estimates of efficiencies of MP to ADG averaged 51.84, 59.05 and 50.03 g MP/kg. Because these estimates of MP include requirements for maintenance and gain, it is not clear from this analysis whether medium-potency implants increase protein requirements for maintenance or gain or both.

**Protein need for Maintenance**

Regression of estimates of protein accretion on estimates of MP intake (Figure 1) indicated that nonimplanted steers have a higher maintenance requirement for protein and lower efficiency of conversion of MP to empty body protein. Maximum empty body protein deposition was achieved at 14.1, 9.1 or 11.8 g/kg $BW^{.75}$/d for none, medium or high potency strategies, respectively. This suggests that less protein is required for maximum gain when steers are implanted. At MP intakes observed in the survey, nonimplanted steers were, on average, 22 or 28% less efficient (MP intake/empty body protein gain) than steers implanted with medium- or high-potency implants. At low MP intakes (< 7.5388 g/kg $BW^{.75}$), steers implanted with medium-potency implants were more efficient. At high MP intakes (> 7.5388 g/kg $BW^{.75}$), steers implanted with high-potency implants were more efficient. This MP intake is equivalent to 736 g MP for an average steer BW of 450 kg (approximately 1099 g dietary CP supply). This finding suggests that when dietary, economic or management conditions limit MP supply to below 736 g (or dietary CP supply below 1099 g) for a feeding period, the strategy of choice may be a medium-potency implant.

By solving for zero empty body protein accretion, estimates of MP requirement for maintenance of steers under various implant strategies were obtained and are compared to similar NRC (1996) estimates (Table 5). Metabolizable protein requirements were corrected for efficiency of MP conversion to net protein. Because

Table 5. Estimated MP requirements for maintenance derived from the NRC (1996) equation[a] or data surveyed[b]

| | NRC, 1996 | Implant strategy | | |
|---|---|---|---|---|
| BW, kg | All | None | Medium | High |
| 350 | 307 | 308 | 199 | 230 |
| 375 | 324 | 325 | 210 | 243 |
| 400 | 340 | 341 | 220 | 255 |
| 425 | 356 | 357 | 230 | 266 |
| 450 | 371 | 373 | 240 | 278 |
| 475 | 387 | 388 | 250 | 290 |
| 500 | 402 | 403 | 260 | 301 |

[a] MP requirement for maintenance = 3.8 g MP/kg $BW^{.75}$.

[b] MP requirement for maintenance of nonimplanted steers or those of steers implanted with medium- and high-potency implants were: 3.81, 2.46 or 2.84 g MP/kg $BW^{.75}$, respectively. Requirements were derived by solving for MP in the equation: Empty body protein (g/kg $BW^{.75}$/d) = -.70208 + [MP (g/kg $BW^{.75}$/d) * Implant strategy coefficient (None: .4009; Medium: .6216; High: .5329)] + [$MP^2$ (g/kg $BW^{.75}/d^2$) * Implant strategy coefficient (None: -.0142; Medium: -.0343; High: -.0225)]; $R^2$ = .37; CV = 33.2%.

net protein was regressed on MP in the current analysis, a correction factor of 2.03 (1 / .492, the efficiency assumed by NRC, 1996) was applied to compare our results to other estimates. Maintenance MP requirements of nonimplanted steers were highest but surprisingly similar to those obtained by the NRC (1996). The equation adopted by the NRC (1996) was based on animal growth data and corroborated by nitrogen balance data (Susmel et al., 1993).

Estimates of maintenance MP requirements for steers in medium- or high-potency implant strategies were 36% and 25% lower, respectively, than those of nonimplanted steers. Reduced maintenance MP requirements of implanted steers may be indicative of reduced protein turnover and amino acid catabolism.

Wether lambs treated with TBA plus estradiol had reduced protein synthesis and degradation (Sinnett-Smith et al., 1983). When ewe lambs were treated with either TBA or zeranol, protein synthesis rates were decreased, but free cathepsin D activity, an indicator of protein degradation, was significantly decreased (Sinnett-Smith et al., 1983). Similar results were observed in steers treated with TBA plus estradiol (Lobley et al., 1985). Thus, it is apparent that TBA plus estradiol, or zeranol impact protein accretion by reducing protein synthesis and degradation; a larger impact on the latter enhances protein accretion and improves energetic efficiency.

However, previous metabolism studies on effects of TBA combinations with estradiol and estradiol only on protein synthesis and degradation do not shed a direct explanation as to a potential difference in MP requirement for steers treated with combinations of TBA or TBA, steroids or zeranol alone. Reports of effects of TBA- or steroid-based implants on energy requirements of steers fed high roughage diets in adverse environments indicate that steroids increase energy requirements while TBA reduces them (Hunter and Vercoe, 1987). Based on this finding, one would expect protein requirements to be affected similarly. However, energy retention and intake were not affected by implant status (a TBA-estradiol combination) in steers fed diets containing 15.75% CP to gain .8 kg/d (Lobley et al., 1985). Thus, energy requirements of steers implanted with TBA-based implants may not be altered when dietary conditions are adequate for moderate growth. In this study, the proportion of protein retention relative to energy retention increased under the influence of the implant. Therefore, increased maintenance requirements associated with increased protein mass in TBA-implanted steers fed for moderate growth may offset TBA-medicated effects on protein turnover and amino acid catabolism. Further study is required for clarification.

Using information derived from the relationship between empty body protein attrition and gain, empty body protein attrition was converted back to ADG and plotted at various average BW for a feeding period and implant strategy (MP intake was fixed for the feeding period at 750 or 850 g/d for nonimplanted or implanted steers, respectively, Figure 2). Average daily gain appeared to be virtually unchanged for nonimplanted steers in the range of average BW between 350 and 500 kg. This indicates that ADG or protein attrition is unaffected by average BW (a function of initial weight on feed) when steers are not implanted. When exposed to a constant MP intake, ADG of steers in either a medium- or high-potency strategy increased with increasing average BW (e.g., heavier initial BW). At heavier average BW (MP intake in g/kg BW decreases), the difference in ADG between medium- and high-potency implant strategies decreased. Metabolizable protein intake would average 8.04 g/kg $BW^{.75}$/d at average 500 kg BW. This intake is approaching 7.5388 g/kg $BW^{.75}$/d, the inflection point of the medium- and high-potency curves. These data are taken together to suggest for steers in a high-potency implant strategy that, as average BW increases, dietary protein concentration should increase to provide > 7.5 g MP/kg $BW^{.75}$/d during the feeding period to ensure maximum performance response.

### Implications

Implants increase gains of finishing steers partly because of their effects on intake. Similarly, increasing dietary protein concentration increases intake, thereby resulting in faster gains. However, data analyzed herein indicated that implanted steers have a greater ability to respond to increased dietary protein concentration because of a reduced protein requirement for maintenance. Thus, the overall MP requirement for a given rate of gain is reduced in implanted steers. When high-potency implants (combinations of TBA with steroids or zeranol) are used, this requirement is reduced relative to when medium-potency implants (TBA, steroids or zeranol alone) are used. In heavy steers implanted with high-potency implants, MP supply must exceed 7.5 g MP/kg $BW^{.75}$/d to maximize implant response.

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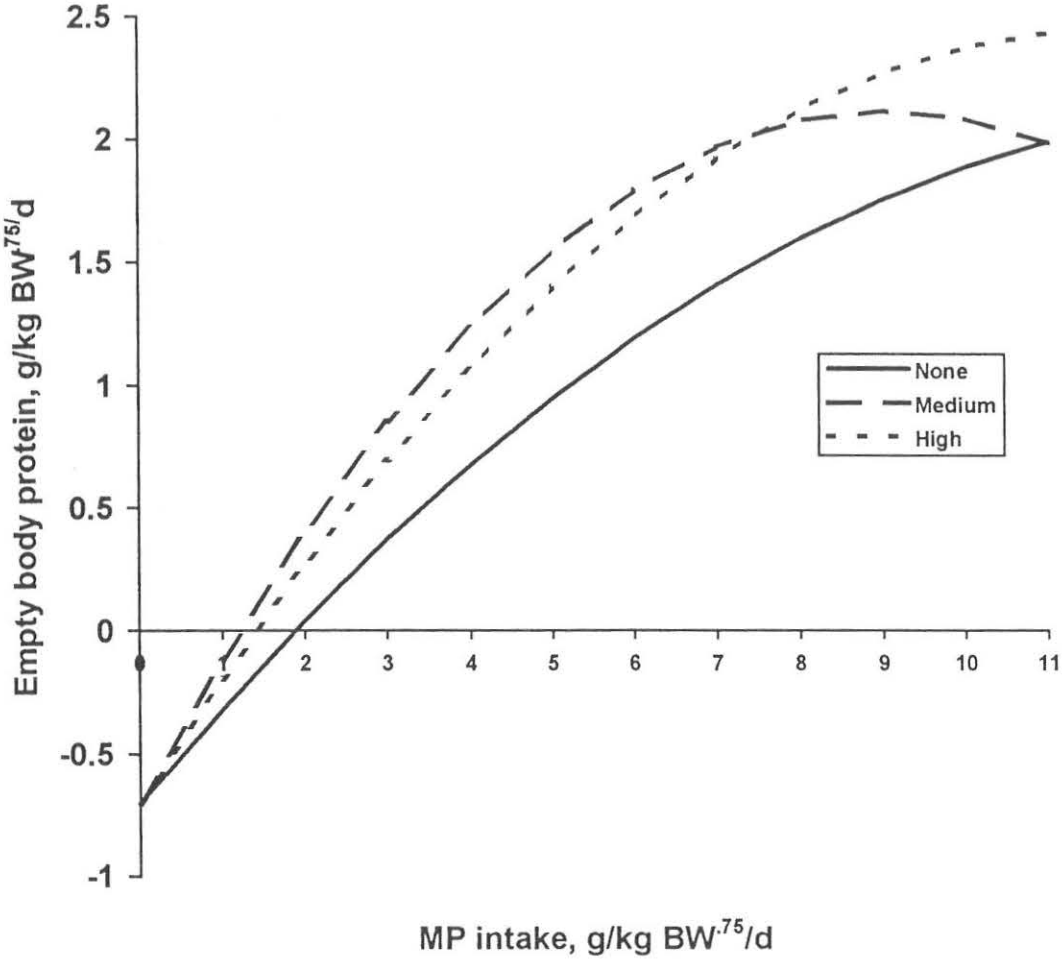


**Figure 1.** Relationship between estimated empty body protein gain and MP intake in cattle under various implant strategies. Empty body protein (g/kg BW$^{.75}$/d) = -.70208 + [MP (g/kg BW$^{.75}$/d) * Implant strategy coefficient (None: .4009; Medium: .6216; High: .5329)] + [MP$^2$ (g/kg BW$^{.75}$/d$^2$) * Implant strategy coefficient (None: -.0142; Medium: -.0343; High: -.0225)]; $R^2$ = .37; CV = 33.2%.

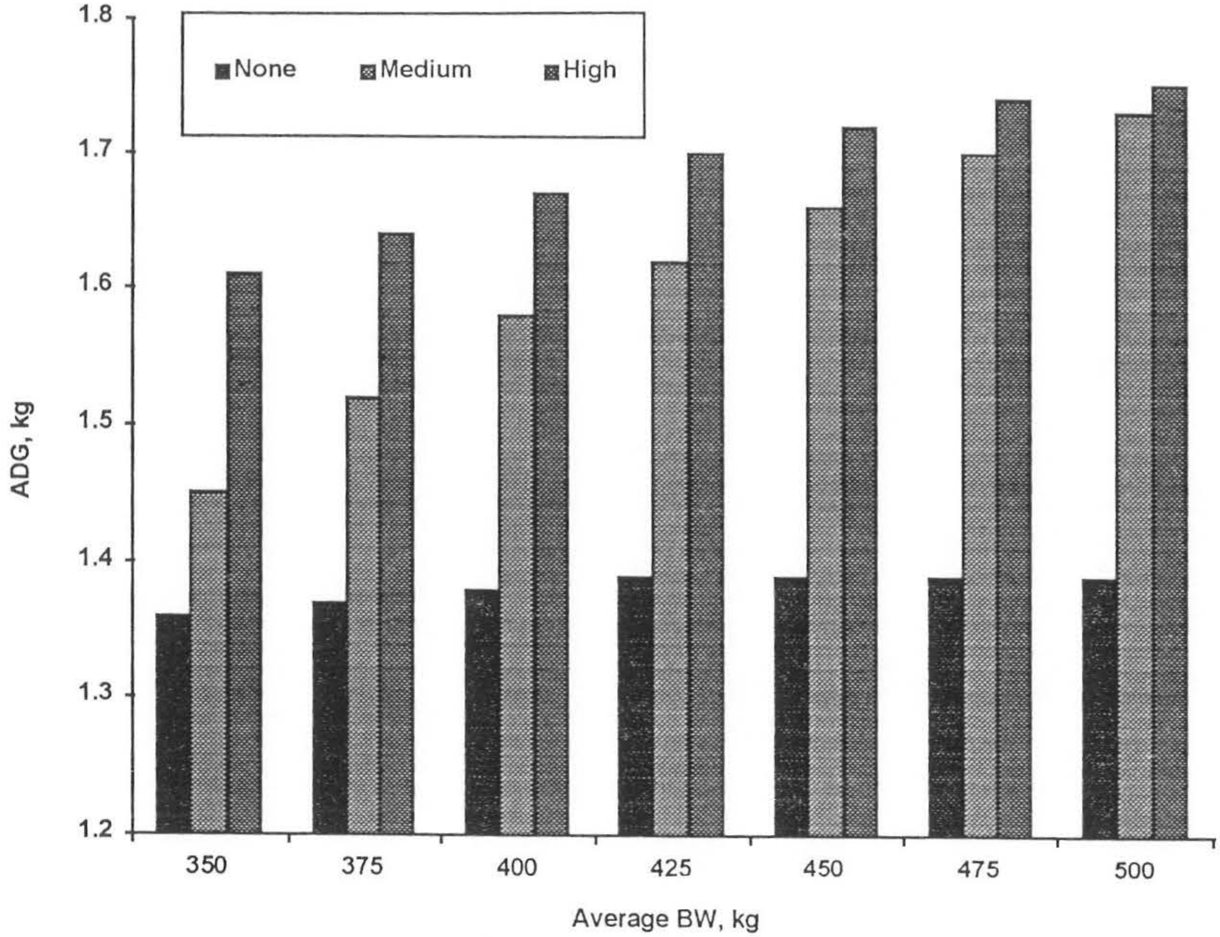


**Figure 2.** Estimated ADG for a feeding period given various feeding period average BW and MP intakes of 750 (nonimplanted) or 850 g (Medium or High implant strategies).

# IMPACT OF IMPLANTS ON PERFORMANCE AND CARCASS VALUE OF BEEF CATTLE: STATISTICAL PROBLEMS

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## ABSTRACT

Implant trials present several statistical concerns. The power of the statistical test depends on the ratio of the difference between the two population means we want to detect and the standard deviation of the populations from which the observations are drawn. For uniform feedlot steers, an implant effect of .25 lb/d and a SD of .5 lb/d, about 60 animals per implant treatment will be needed to have a .67 probability of finding a significant difference. For a power of .95, we need about 100 animals. When comparing results over a number of independent trials, the use of the difference between treatments provides a more powerful estimate than using the absolute means. In planning trials with a limited numbers of large pens, designs with more than one implant treatment per pen can provide statistically valid results for individual animal variables. Choice of experimental endpoint may affect treatment differences so that statistical significance is a function of that choice. Feedlot simulations of implant treatments for yearling steers were conducted for days on feed, body weight, and quality grade endpoints. As values chosen for all endpoints increase, the mean average daily gains converge with increasing time on feed, resulting in larger differences between treatments earlier in the feeding period. In contrast, quality grade differences between treatments diverged with increasing days on feed while they converged with an increasing body weight endpoint. Experimental results using body weight endpoints may show fewer differences between implant treatments than those using days on feed. The number of animals per treatment needed to detect gain differences observed for the various endpoints can be estimated. Over 100 steers are needed to have two chances out of three for detecting differences between implant protocols simulated; 200 or more steers are needed for detecting differences at most body weight endpoints at normal slaughter weights.

## INTRODUCTION

When planning or reviewing results from implant comparison trials, several statistical concerns should be considered. In particular, the statistical power (probability) of the trial to find biological or economical differences provides a convenient starting point, but power often is overlooked. For trials where the number of pens limited, and implant treatments must be applied within pens, there are valid protocols for experiments, but the ability to make meaningful inferences on intake or efficiency effects is limited. The choice of experimental endpoint may inflate or contract experimental differences; hence statistical significance is a function of that choice. For each of these considerations, problems for interpretation of results occurs. It is imperative for those concerned to determine if the experimental conditions are appropriate for their particular interest.

### Statistical Concerns

*Power of Tests in Experimental Design* In a typical statistical comparison of implant treatments, we have a null hypothesis ($H_0$: the treatment means are equal) and an alternate hypothesis ($H_1$: the treatment means are different). An experiment is planned or conducted to gather evidence to reject $H_0$ and accept $H_1$ usually by developing some statistic (F, t) with a known statistical distribution to test against. For example, if the calculated t statistic from an experiment (the difference between the means divided by the standard error of the difference) is larger than the tabular (expected) value of t based on its known distribution when the null hypothesis is true, then we have evidence to reject $H_0$. The statistical error, or probability, we often report ($\alpha$) is that of rejecting the null hypothesis when it is really true (Table 1). However, and more importantly, when planning an experiment, we ought to be more concerned with the power of the test ($1-\beta$), i.e., the probability of finding a statistically significant result when the null hypothesis is false (reject $H_0$ because there is a real difference).

Table 1. Statistical tests and the probability (P) of error for the null hypothesis ($H_0$).

| Decision | $H_0$ is true | $H_0$ is false |
|---|---|---|
| Accept $H_0$ | Correct ($P = 1-\alpha$) | Type II error ($P = \beta$) |
| Reject $H_0$ | Type I error ($P = \alpha$) | Correct ($P = 1-\beta$) |

When we have an experiment which does not show a significant difference, it would ideally be because there is no difference between implants, or the difference is too small to be important. We control this with the power of the test.

Power ($1-\beta$) depends on the ratio between the difference between two population means we want to detect and the standard deviation of the populations from which observations are drawn. It also depends on the Type I error rate $\alpha$ (Steele and Torrie, 1980). The number of observations per treatment (n) to detect a difference (D) is:

$$n = (Z_{\alpha/2} + Z_{\beta})^2 \, 2 \, \sigma^2 / D^2$$

where $\sigma$ is the population SD and Z is the standard normal probability. For example, rather uniform feedlot steers have a standard deviation for average daily gain of about .5 lb/d. If an implant effect of .25 lb/d or more is important (and we would like to confirm it experimentally), then for the ratio of .5 (.25/.5) and $\alpha$=.05, we need 60 animals per implant treatment to have a .67 probability (power) to find a significant difference (Figure 1). For power of .95 we need about 100 animals. If we were interested in only a .05 lb/d difference (ratio of .1), 2% of 2.5 lb/d (a typical difference between similar types of implants), over 1,000 animals per treatment are needed for a power of only .67. Clearly university trials with 8-50 animals per treatment are of little value in consistently determining small but real differences between implants.

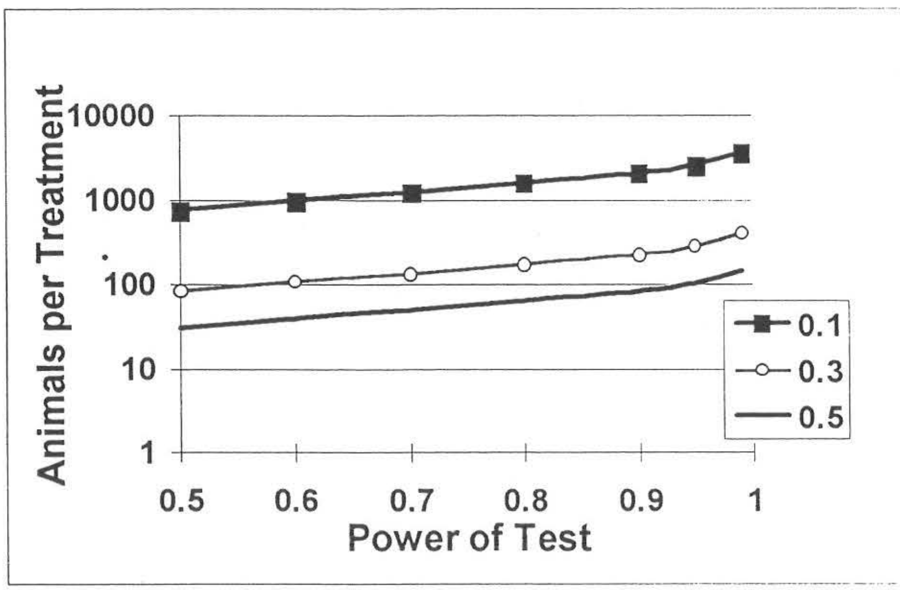


**Figure 1.** Animals needed per treatment to detect treatment differences at different ratios of the difference to the population SD (.1, .3, and .5) versus statistical power of the test ($1-\beta$).

Table 2. Summarizing literature data and the use of treatment means or treatment differences.

| Trial: | A | B | C | Mean | SE | $SE_{difference}$ |
|---|---|---|---|---|---|---|
| Control | 2.0 | 3.0 | 3.4 | 2.8 | .72 | |
| | | | | | | .61 |
| Treatment | 2.1 | 3.2 | 3.7 | 3.0 | .75 | |
| Difference | 0.1 | 0.2 | 0.3 | 0.2 | | .10 |

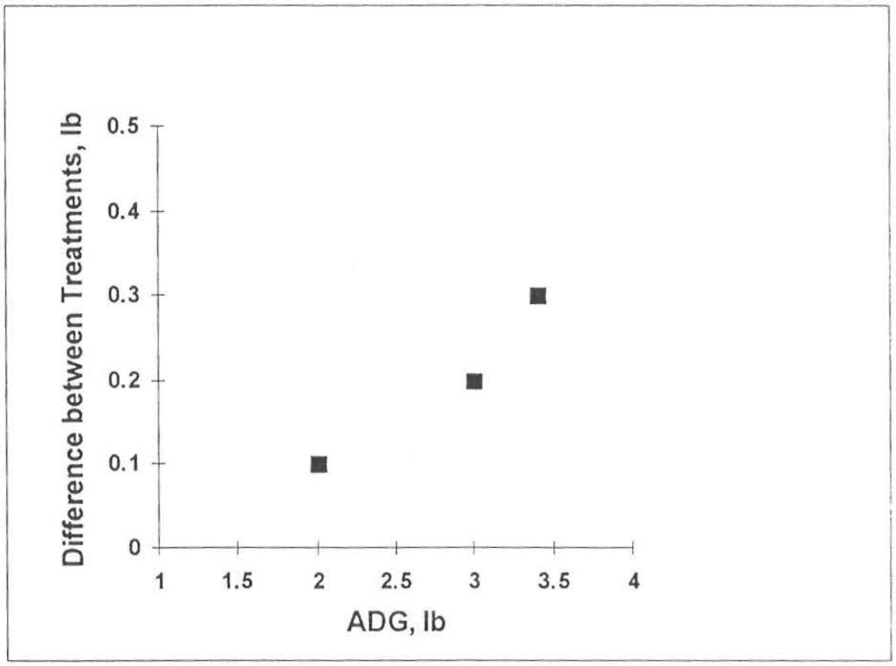


**Figure 2.** Plot of relationship between control average daily gain (ADG) and treatment differences for data from Table 2.

*Summarizing Literature Data* When conducting an analysis of implant treatments from previous experiments, the use of a treatment effect (differences) provides a more powerful statistic than does comparison of treatment means when using each trial as an observation (Table 2). The standard error of the difference between treatments is much smaller (.10 vs. .61). Also, it usually is instructive to plot the data and look for other relationships, as well as shown in Figure 2.

*Within versus Across Pen Comparisons* When implant trials are designed, all cattle in one pen usually are treated similarly with the same implant (assuming there are more pens than implant treatments). However, in many feedlots the number of pens for use in trials is limited even though pen size is large. In this case, statistical significance may be achieved by assigning multiple implants within each pen and treating each animal as an experimental unit, as long as there are enough animals. Of course, feed intake and efficiency data cannot be compared in such a trial.

*Endpoint Effects* Perhaps the most interesting statistical problems arising in implant experiments is the choice of trial endpoint. Does choice of endpoint affect overall animal performance, and thus statistical results? That is, do treatment differences depend on the endpoint chosen, or does experimental design depend on endpoint choice? In this paper, a simulation was chosen to study the effects of choosing either 1) a constant days on feed, 2) constant body weight, or 3) constant marbling endpoint. Medium frame yearling steers with an initial weight of 700 lb and 50 lb SD were fed a high energy ration of .94 Mcal/kg DM $NE_m$ and .62 Mcal/kg DM $NE_g$. Feed intake equations of Thornton et al. (1985) were used in the growth and composition model of Oltjen et al. (1986). Monte Carlo simulations were run, with proportional changes in maintenance ($P_{maint}$) and protein synthesis ($P_{ps}$) so that the coefficients of variation in the model were 33% for maintenance and 7% for protein synthesis, based on analysis of University of California research data (unpublished). Protein degradation was not made stochastic, so variation in protein accretion is solely due to the stochastic generation of $P_{ps}$. The large CV for maintenance is the sum of the variation in maintenance and fat deposition; they are not independently estimated by the growth model. Proportional change of feed intake ($P_{DMI}$) was adjusted as follows:

$$P_{DMI} = .2\ P_{maint} + .05\ P_{ps} + \varepsilon$$

where $\varepsilon$ is normally distributed with mean zero and SD .1. For 130 d simulations, this results in SD of average daily gain and dry matter intake of .8 and 2.7 lb/d, respectively. Implant treatments (Figure 3) included none (CONTROL); protein synthesis and DMI increased by 4% and 10%, respectively, at 50 d, then linearly reduced to no effect by 100 d (ONE); protein synthesis and DMI increased by 4% and 10%, respectively, at 100 d, then linearly reduced to no effect by 150 d (TWO); protein synthesis and DMI increased by 6% and 15%, respectively, for 100 d, then linearly reduced to no effect by 150 d (TWO+). Five hundred animals were simulated for each treatment for each run; when body weight or quality grade endpoints were chosen, all 500 steers were slaughtered when the pen mean body weight or quality grade was achieved. Quality grade is an empirical estimate based on empty body fat in the model.

For a constant days of feed endpoint, the mean body weights began to converge with increasing time on feed, resulting in larger differences between treatments earlier in the feeding period for treatment average daily gains (Figure 4a). Conversely, quality grade differences between treatments diverged with days on feed, with the implant treatments becoming different after 140 days on feed (Figure 4b)

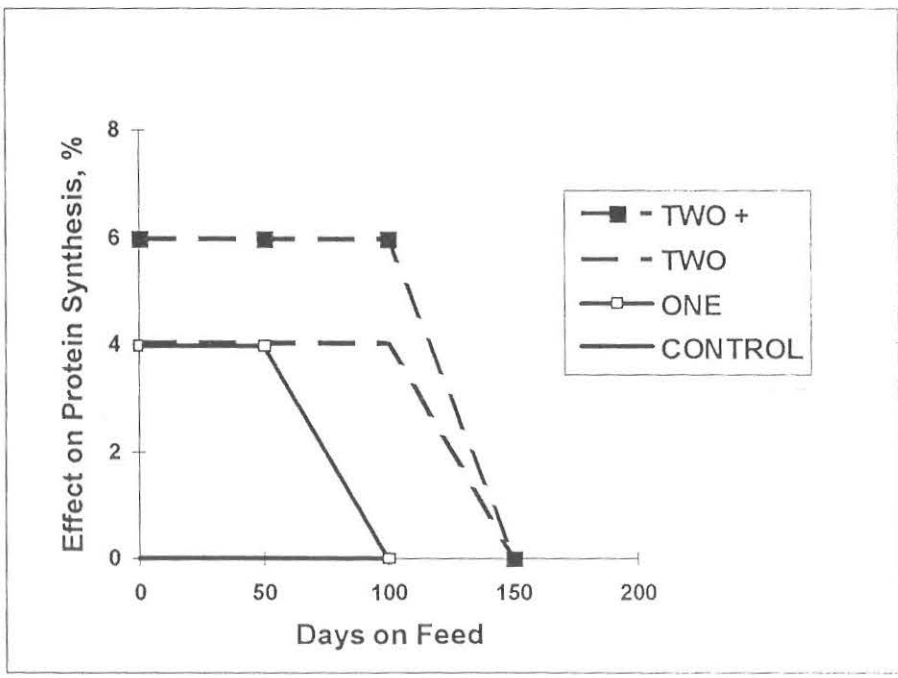


**Figure 3.** Effect of implant treatments (see text for description) on increase in protein synthesis for simulations of steer performance.

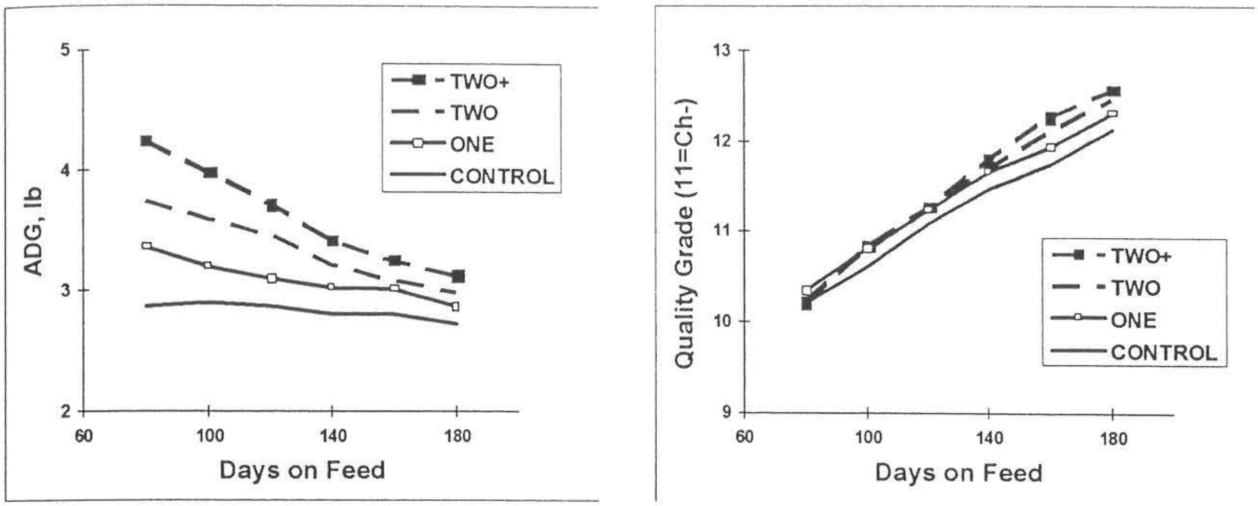


**Figure 4.** Mean average daily gain and quality grade of 500 steers simulated to a given days on feed for implant treatments (see text).

When pen mean body weight was the endpoint (Figure 5a), differences between treatment gains decreased with heavier endpoints, just as with longer feeding periods above. However, differences between quality grades narrowed with heavier endpoints, unlike the larger differences with increasing days on feed (Figure 5b). Thus, composition tends to reach a common point at a given body weight, if cattle are fed long enough to reach it. Thus experimental results using body weight endpoints may show fewer differences between implant treatments than those using days on feed. In a production sense that is fine, because cattle may be fed to a given body weight (as long as it is heavy enough) regardless of implant treatment with little effect on quality grade (and composition). However, some compromise in gain may be experienced with large body weight (or days on feed) endpoints.

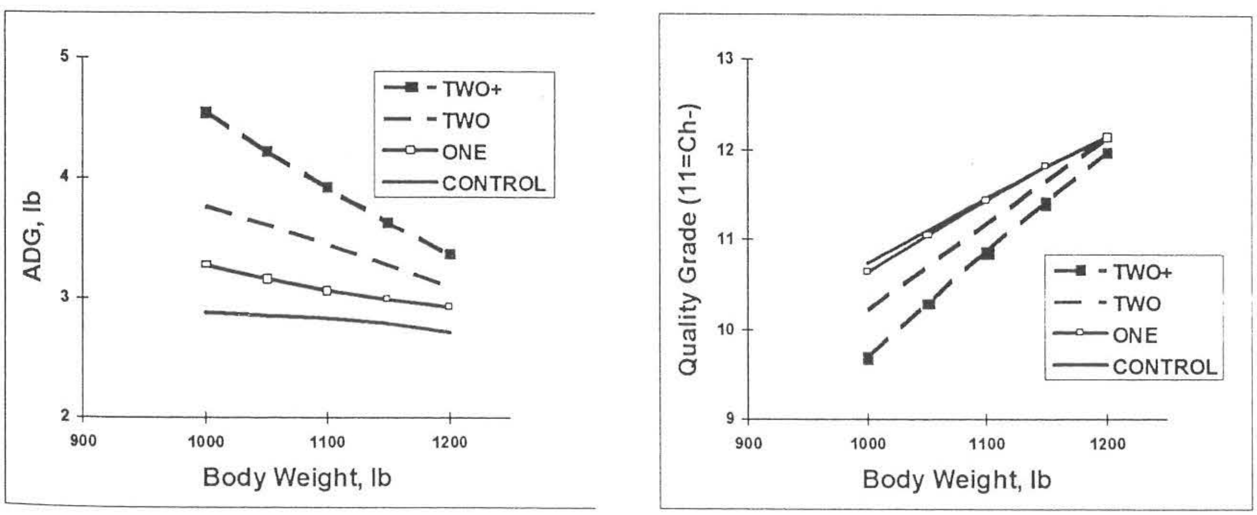


**Figure 5.** Mean average daily gain and quality grade of 500 steers simulated to a given mean body weight for implant treatments (see text).

If quality grade is used as the pen endpoint (Figure 6), body weight and average daily gain converge at higher grades, or increased body fatness. This is expected based on the above discussion of body weight endpoint, where compositions converged with increasing body weight.

The above results have important implications for experimental design of implant trials. Using the formula (Steele and Torrie, 1980) to estimate the number of observations per treatment to detect the average daily gain differences observed for the various endpoints, $\alpha$ of .05 and 1-$\beta$ (power) of .67, animals per implant can be estimated (Figure 7). Unless short feeding periods to light body weights and quality grades are used, over 100 steers are needed to have two chances out of three (power of .67) to find significant effects for the differences simulated above. If body weight is the endpoint, the comparison of control and one implant requires nearly 200 or more animals at normal slaughter weight endpoints.

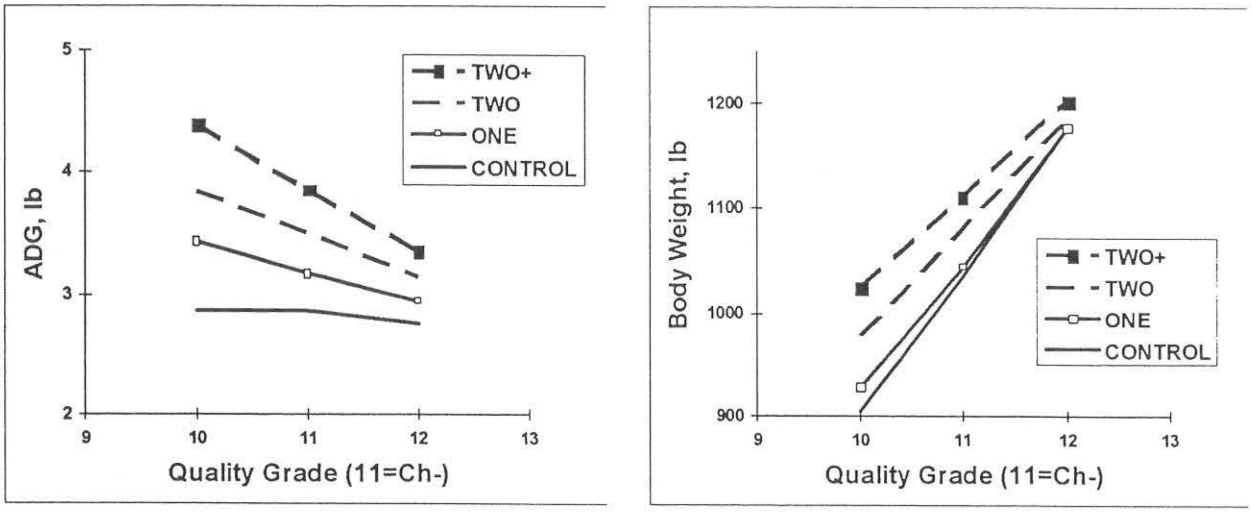


**Figure 6.** Mean average daily gain and body weight of 500 steers simulated to a given mean quality grade for implant treatments (see text).

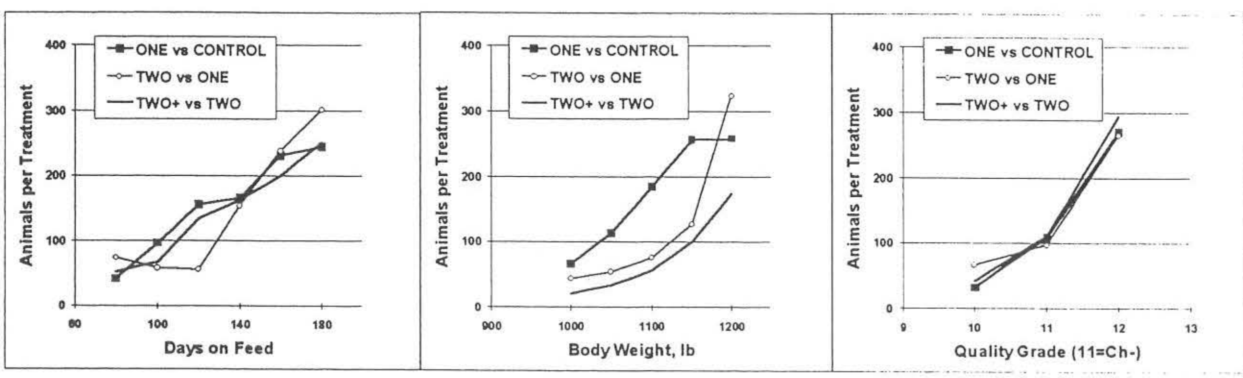


**Figure 7.** Number of animals needed to find significant treatment differences simulated between implant treatments (see text) for days on feed, body weight, or quality grade endpoints and $\alpha$ of .05 and 1-$\beta$ (power) of .67.

Table 3. Number of animals needed to detect a significant treatment difference in ADG between implant treatments (see text) for days on feed, body weight, or quality grade endpoints and $\alpha$ of .05 and 1-$\beta$ (power) of .67.

| Endpoint | ONE vs CONTROL | TWO vs ONE | TWO+ vs TWO |
|---|---|---|---|
| Days on feed, 120 d | 156 | 55 | 134 |
| Mean body weight, 1,100 lb | 185 | 76 | 57 |
| Mean quality grade, low choice | 109 | 97 | 110 |

These results apply only for treatments with the parameters and coefficients of variation described previously. Nevertheless, the general trends are likely to be valid regardless of how precise the estimates of treatment effects used are. For arbitrary endpoints of 120 days on feed, 1,100 lb body weight, or low choice quality grade, animals needed per treatment are least for the comparison between TWO and ONE (55), TWO+ and TWO (57), or ONE and CONTROL (109), respectively (Table 3). That is, steers are most different in average daily gain relative to the SD of ADG due to the treatment comparison. Also, in sequentially collected body weight (gain) data, longevity of implant response diminishes with time.

**Implications**

In planning or interpreting implant trials, the power of the statistical test should be considered; adequate numbers of animals per treatment should be used to detect the most important difference relative to the standard deviation for the animals. Often more than 100 animals per treatment are needed to detect subtle differences between implant treatments. When summarizing multiple trials, analysis of treatment effects (differences or proportional changes), not absolute values, are more sensitive. Treatment effects should be related to other variables to look for new relationships which may increase understanding. By simulation, choice of endpoint, (both the variable chosen and its value) probably affects the treatment effect and the number of animals needed to determine a significant effect. In general, differences between treatments are larger for shorter trials, or for animals fed to lighter weights. The greater the variability in animal management, the greater the number of animals needed to detect significant treatment effects.

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## QUESTIONS & ANSWERS

**Q:** Why does it take more animals per treatment to achieve significance when your experiencing control versus weighting time? What I am talking about is magnitude or response will be bigger as between two different implants.

**A:** It does for days on feed and it does not for body weight. As we look at average daily gain the differences between average daily gain confers with increasing body weight. The differences here are greater at this point than they are down here. I think what your asking is why does it take more animals for these treatments. The main reason why you need more animals here is because the effect of the implants here runs about goes 50 days and then it starts to run out and it goes down to 0 in 100 days so that the animals tend to come together in terms of their performance and in terms of their average daily gain numbers. That's why I went back to the previous slide to show you the average daily gain numbers as we get out further into those implants. More so faster effect treatment than it does with these others because , particularly between these two, where the implants last longer. And again the relative difference is larger in all cases but basically the quality grades of those two different cures come pretty close together. Average daily gains come pretty close together and a different quality grain but it takes a while to get there.

# IMPLANT PROGRAM EFFECTS ON USDA BEEF CARCASS QUALITY GRADE TRAITS AND MEAT TENDERNESS[1]

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## INTRODUCTION

Anabolic implants are used to improve growth rate and feed efficiency of cattle during finishing. At the present time, nineteen different implants are commercially available. Economic benefits associated with implant use have been well documented and widely recognized. However, implants can have deleterious effects on beef quality. The National Beef Quality Audit (NBQA) identified this "reduced quality of beef due to implants" (i.e., specifically lowered marbling scores, reduced beef tenderness, increased dark cutting percentages and/or detrimental effects associated with advanced carcass skeletal maturity). Results of the NBQA estimated that the beef industry loses $7.63 for every steer and heifer slaughtered (annual loss of approximately $202 million) due to detrimental effects of implants on carcass quality. This review summarizes the effects of estrogenic and(or) androgenic implants, on beef carcass quality traits and meat tenderness.

## MATERIALS AND METHODS

For this review, research results from refereed and trade journal publications (95% published after 1990) were utilized to construct an *OSU Implant Data Base*. For discussion purposes, implants were classified according to their active ingredient type (estrogen, androgen or combination) and concentration strength (mild or strong, See Table 1). Implant combinations were denoted with the two appropriate implant type abbreviations used together, reimplants are denoted by a "/" between the first implant(s) used and second implant(s) used. For example, ME/MC is the abbreviation for a "mild estrogen," (e.g., Compudose or Ralgro) implant with a reimplant of a "mild combination," (e.g., Revalor).

**Table 1. Implants stratified by active ingredient type and concentration strength**

| Implant | Strength | Type | Abbreviation |
|---|---|---|---|
| Compudose, Ralgro | Mild | Estrogen | ME |
| Synovex, Implus, Magnum, Steer-oid, Heifer-oid | Strong | Estrogen | SE |
| Finaplix | -- | Androgen | A |
| Revalor | Mild | Combination | MC |
| Synovex Plus | Strong | Combination | SC |

Most research investigations have compared implant programs in which cattle were administered either a single implant or two successive implants during finishing periods of approximately 110 to 160 days. However, in an attempt to eliminate the traditional "shot gun" approach associated with implanting, U.S. beef producer's have begun to implement *"implant strategies"* in their production systems. In other words, each implant is utilized to maximize it's inherent strength's and minimize it's limitations. The end result of the implant program is to obtain the most economical gains and to improve net earnings while maintaining acceptable carcass quality. In an attempt to summarize the impact of various implant strategies on beef carcass quality traits and tenderness, research publications in the *OSU Implant Data Base* were categorized as being conservative, intermediate or aggressive implant strategies. Conservative implant strategies involve cases where a modest improvement in average daily

1 Special thanks to Ron L. Stubbs and David N. Vargas for their assistance in collecting/obtaining research literature.

gain (ADG) is desired but high quality grade is the number one priority. One characteristic of conservative implant programs is that 100 days expires between the terminal implant and the slaughter date. Figure 1 illustrates three examples of conservative implant programs.

**Figure 1. Implant Strategies In Feedlot Steers/Heifers**

A. Conservative Implant Programs:

Example 1

| V | < 70 days | V | > 100 days | * |
|---|---|---|---|---|
| ME | | SE<br>MC | | Slaughter |

Example2

| V | > 70 days | V | > 100 days | * |
|---|---|---|---|---|
| SE | | SE<br>MC | | Slaughter |

Example 3

| V | >100 days | * |
|---|---|---|
| MC | | Slaughter |

Examples of intermediate implant programs are shown in Figure 2. Typically, these programs are implemented when greater ADG is desirable and a slight depression of USDA quality grade is acceptable. Unlike the conservative implant programs, intermediate implanting schemes have a time window between terminal implant and slaughter date of at least 70 days.

**Figure 2. Implant Strategies In Feedlot Steers/Heifers**

B. Intermediate Implant Programs:

Example 1

| V | < 70 days | V | > 70 days | * |
|---|---|---|---|---|
| ME | | SE<br>MC | | Slaughter |

Example2

| V | > 70 days | V | > 70 days | * |
|---|---|---|---|---|
| SE<br>MC | | SE<br>MC | | Slaughter |

Example 3

| V | >100 days | * |
|---|---|---|
| SC | | Slaughter |

The most aggressive implant strategy is designed for maximum performance in ADG and feed efficiency with little concern for depression in marbling (See Figure 3). In this implant strategy the most potent implants are used in association with a short time window between the terminal implant and slaughter date.

**Figure 3. Implant Strategies In Feedlot Steers/Heifers**

C. Aggressive Implant Programs:

Example 1

| V | < 70 days | V | > 70 days | * |
|---|---|---|---|---|
| SE<br>MC | | SE<br>MC | | Slaughter |

Example2

| V | > 70 days | V | 70 to 100 days | * |
|---|---|---|---|---|
| MC<br>SC | | SC | | Slaughte |

**RESULTS AND DISCUSSION**

Many previous attempts that have summarized the influence of implants on beef carcass quality traits (i.e., marbling score, percentage U.S. Choice, skeletal maturity and dark cutters) and meat tenderness have concluded that, "Due to the lack of statistical evidence, implanting displayed no detrimental effects on beef quality grade traits or tenderness." Nevertheless, many such research reviews admitted that implanting reduced the average percentage of carcasses grading U.S. Choice or above from 0% to 28% as compared to cattle not implanted. Such differences were not *statistically significant* ($p > .05$) due to large variation across as well as within various cattle populations included in these studies. Despite lack of statistical verification, trends in quality traits and tenderness that exist due to implant type, strength and status certainly have practical importance.

*Marbling Score and Percentage Choice:* Mean marbling scores and percentage U.S. Choice responses for carcasses from nonimplanted cattle, and the change due to implant strength and type are presented in Table 2.

Table 2. Marbling score and percentage Choice change stratified by implant strength and type[a].

| First implant | Second implant | Third implant | Marbling score | Choice, % |
|---|---|---|---|---|
| Non-implanted | | | 436[b] | 78.5 |
| ME[c] | --- | --- | -12[d] | -4.9[d] |
| ME | ME | --- | -16 | -5.7 |
| ME | ME | ME | -12 | -3.5 |
| A | --- | --- | -9 | -4.2 |
| A | A | --- | NA[e] | -2.1 |
| ME/A | ME/A | --- | -12 | -9.3 |
| SE | --- | --- | -24 | -14.3 |
| SE | SE | --- | -47 | -24.0 |
| SE/A | --- | --- | -19 | -6.2 |
| SE/A | SE/A | --- | -24 | -24.0 |
| MC | --- | --- | -12 | -23.0 |
| MC | MC | --- | -26 | -24.0 |
| SE | MC | --- | -21 | -23.0 |
| SC | --- | --- | -29 | -20.0 |
| SC | SC | --- | -20 | -26.0 |

[a]Source: OSU Implant Data Base.
[b]Marbling score: 400 to 499 = Small.
[c]Implant classification: ME, SE, A, MC and SC are mild estrogen, strong estrogen, androgen, mild combination and strong combination, respectively. See Table 1.
[d]Change in marbling score and percentage Choice compared to nonimplanted controls.
[e]NA = not available.

Based on research information included in this review, implants did numerically reduce marbling scores and the percentage of carcasses grading U.S. Choice or higher. Cattle which were administered multiple (≤ 3 ) ME implant(s) reduced the percentage of carcasses grading Choice by approximately 5 percentage points (Table 2). However, when a ME implant was used in conjunction with an A type implant, the reduction in grading (Choice or higher) carcasses was approximately double (78.5% for control versus 69.2% for implanted cattle). The reduction in marbling score and percentage of carcasses grading Choice was more drastic when cattle received a single SE implant. Compared to carcasses originating from nonimplanted cattle, marbling score and percentage of carcasses grading Choice or higher was reduced by approximately 24% and 14%, respectively. When multiple SE implants were utilized during the finishing period, marbling score was reduced by 47 percentage points and the depression in carcasses grading Choice was 24%. There is a general perception in the U.S. beef industry that implants containing trenbolone acetate (TBA) reduces marbling score and the percentage of carcasses grading Choice. According to the results generated from the *OSU Implant Data Base*, compared to nonimplanted controls, cattle implanted with a TBA-containing implant (MC and SC) produced approximately 25% fewer carcasses grading Choice or higher. Regardless of implant administration frequency (1 or 2 implants) or strength (mild or strong), for every four cattle receiving MC and(or) SC implants only 2 carcasses would grade U.S. Choice or higher compared to 3 out of every 4 carcasses from nonimplanted cattle.

Effects of implants on marbling scores and percentages of carcasses grading Choice is greatest if the implant is administered late in the finishing period. Correspondingly, to avoid quality grading problems, suppliers of implants recommend that implants be used no less than 70 days prior to slaughter. Research trials that included SE, A and MC implants were divided into two separate implant frequency categories: (1) **less** than 70 days between terminal implant and slaughter and (2) **greater** than 70 days between terminal implant and slaughter. Compared to the longer implant frequency (> 70 days), when the implant was given less that 70 days prior to slaughter, percentage of carcasses grading Choice or higher was markedly reduced (Figure 4).

This reduction in marbling score and quality grade is most detectable when a SE implant was administered during this crucial period prior to slaughter.

Implant type and strategy may interact with genotype to influence carcass quality grade. Many research investigations have noted that the detrimental effect implant type on quality grade tends to be greater with Continental-European (i.e., "Exotics) breeds than British breeds of cattle. In an attempt to address this theory, research studies were subdivided by the biological type of research cattle (British, British/Exotic cross, Dairy), gender (steer or heifer) and implant strategy used (nonimplanted, conservative, intermediate or aggressive). Results are in Figure 5. As implant strategy moved from conservative to aggressive, the British/Exotic crossbred population responded by producing fewer and fewer carcasses grading U.S. Choice or higher. This depression was less dramatic among the other biological types.

*Skeletal Maturity:* The 1996 USDA beef quality grading standards are based upon the amount of marbling present in the ribeye at the $12^{th}$-$13^{th}$ rib interface and the maturity of the carcass. Marbling has long been the major focus commonly associated with the eating quality of beef. Maturity often has been overlooked and, until recently, often not considered in the beef quality equation. However, the beef quality grading system was changed January 31, 1997. Under the new grading standards, carcasses with a combined lean and skeletal maturity score of "B," (See Table 3) having only Small or Slight degrees of marbling will be excluded from the Choice and Select grades. Instead, these carcasses will be graded standard. According to a USDA audit, this new grading standard should affect only 1.58% of all fed cattle in the U.S. Although proposed grade change potentially can impact all groups of fed-beef cattle, heiferettes and aged cattle, e.g of Mexican origin, likely will be affected most.

Table 3. The approximate chronological age with increasing physiological maturity.

| Carcass Maturity Group[a] | Approximate Chronological Age |
|---|---|
| A | 9 to 30 months |
| B | 30 to 42 months |
| C | 42 to 72 months |
| D | 72 to 96 months |
| E | > 96 months |

[a]The physiological maturity of a carcass is an estimate of the animal's real chronological age.

With this change in the beef quality grading system, carcass maturity has become more of a "top of mind" issue. Early maturing breed types, puberty and pregnancy, endogenous hormone levels, mineral balance of water and rations as well as excessive exogenous hormone supplementation (i.e., implanting) all are being investigated for their impact on beef carcass maturity. Information is limited concerning the effect of implants on beef carcass maturity. Using the information from the *OSU Data Base,* the means in Table 4 were generated for the impact of implant strength and type on beef carcass maturity.

Carcasses from cattle which were implanted with anabolic implants tended to have more advanced skeletal maturity than carcasses from nonimplanted cattle. Additionally, skeletal maturity was more advanced for carcasses from aggressively implanted cattle than conservative or intermediate implanting strategies. In the future, research scientists should collect and report information on all beef quality traits (marbling, skeletal and lean maturity, dark cutter occurrence) as well as meat tenderness for both steer and heifer carcasses.

*Dark Cutting Beef:* Dark cutting beef (DCB) or "dark cutters" costs the U.S. cattle industry approximately $132 million per year. Most research scientists believe DCB is a result of depletion of muscle glycogen stores prior to slaughter. Glycogen serves as the major storage carbohydrate in skeletal muscle tissue. In a normal animal, glycogen represents about 1% of muscle weight. However, muscle glycogen stores can be depleted by stress associated with physical activity, emotional excitement or acute changes in environmental conditions. Factors such as transportation conditions (time, ambient temperature, precipitation), handling conditions (during loading, transit, unloading and driving to stunning chute) are examples of preslaughter stressors. Anabolic implants alone do not cause DCB. Rather synergism between certain growth implants and preslaughter stressors may exacerbate the problem. That is, cattle treated with growth implants are more likely to become "stressed."

**Table 4. Steer carcass skeletal maturity change stratified by implant strength, type and strategy[a].**

| First implant | Second implant | Skeletal maturity |
|---|---|---|
| **Non-implanted** | | $A^{44b}$ |
| ME[c] | --- | $A^{44}$ |
| ME/A | ME/A | $A^{60}$ |
| SE | --- | $A^{53}$ |
| SE | SE | $A^{62}$ |
| SE/A | --- | $A^{54}$ |
| SE | SE/A | $A^{62}$ |
| MC | --- | $A^{53}$ |
| MC | MC | $A^{60}$ |
| SC | --- | $A^{60}$ |
| SC | SC | $A^{65}$ |
| **Implant Strategy** | | |
| Conservative | | $A^{51}$ |
| Intermediate | | $A^{54}$ |
| Aggressive | | $A^{65}$ |

[a]Source: OSU Implant Data Base.
[b]Change in skeletal maturity compared to nonimplanted controls.
[c]Implant classification: ME, SE, A, MC and SC are mild estrogen, strong estrogen, androgen, mild combination and strong combination, respectively. See Table 1.

There is a perception in the U.S. beef industry that use of trenbolone acetate (TBA) containing implants causes a higher incidence of DCB carcasses. Information generated through the *Data Base* on the influence of implant strength and type on occurrence of DCB suggests that this perception could be true (Figure 6).

Compared to the nonimplanted control animals (DCB percentage of 0.17), carcasses from animals receiving an androgen-based implant produced a higher percentage of DCB carcasses. However, research information does not support a direct relationship between administration of TBA and incidence of DCB. Although it is unlikely that TBA implants have a direct effect on the incidence of DCB, cattle treated with TBA maybe more predisposed to developing the DCB condition when subjected to other stressful conditions. Concern regarding the effect of anabolic implants on DCB likely will continue until definitive research studies on DCB are more definitive.

***Meat Tenderness:*** The 1994 Food Marketing Institute TRENDS Report concluded that "Taste" ranked first among "Factors Important In Food Selection" by U.S. supermarket shoppers. Consumers consider three characteristics – flavor, tenderness and juiciness – as they evaluate "palatability" and(or) "eating quality," (i.e., the satisfaction received by eating beef). Many research projects have identified tenderness as the most important factor of these three characteristics in determining consumers' perception of taste. In 1993, Texas A&M University meat scientists determined that one tough beef carcass could negatively impact 542 consumers. Although (a) only one-tenth of 1 percent of tough, dry or bland steaks are returned for replacement or refund, (b) for every one complaint that is vocalized, ten complaints are never heard, and (c) most consumers who have had a bad eating experience don't complain – *they just don't come back.*

Only a limited amount of information is available concerning the effects of implants on beef tenderness. Results regarding the impact of anabolic implants on meat tenderness are summarized in Table 6. Summarization of WBS data from various universities and research institutions can be misleading because postmortem aging times utilized at the various locations are not consistent. Hence, these values should be interpreted cautiously. Overall, Warner-Bratzler shear force value (WBS) of loin steaks was approximately 1.10 lb.greater for implanted than nonimplanted cattle (Table 5).

Postmortem aging, as a method for tenderization of meat by storage at or above freezing temperatures, is very important in assuring a tender and acceptable meat product. Generally, as postmortem aging time increases, meat tenderness increases. In an attempt to draw inferences on the impact of various implant management styles on the response of beef steaks to the postmortem aging process and ultimate tenderness, WBS information from the *OSU Implant Data Base* was segregated by aging times and implant strategies (See Figure 7).

Regardless of postmortem aging time, steaks were from tougher from aggressively implanted than from nonimplanted or conservatively implanted cattle. It appears that even after 21 days of postmortem aging, WBS of steaks originating from cattle which were intermediately or aggressively implanted had a WBS similar to that of

Table 5. Warner-Bratzler shear force value change stratified by implant strength and type[a].

| First implant | Second implant | Third implant | WBS[b], lb. |
|---|---|---|---|
| Non-implanted | | | 8.00 |
| ME[d] | --- | --- | +.10 |
| ME | ME | ME | +.93 |
| A | --- | --- | +1.30 |
| ME/A | ME/A | --- | +1.57 |
| SE | --- | --- | +.94 |
| SE | SE | --- | +.97 |
| SE/A | --- | --- | +1.08 |
| SE/A | SE/A | --- | +1.40 |
| MC | --- | --- | +.25 |
| MC | MC | --- | +1.70 |
| SC | --- | --- | +1.70 |
| SC | SC | --- | +1.30 |

[a]Source: OSU Implant Data Base.
[b]WBS: Warner-Bratzler shear force value, lb.
[c]Change in WBS compared to nonimplanted controls.
[d]Implant classification: ME, SE, A, MC and SC are mild estrogen, strong estrogen, androgen, mild combination and strong combination, respectively. See Table 1.

nonimplanted control steaks at 7 days of aging. In other words, meat from the more aggressive implant strategies responded to postmortem aging; but, the time required for steaks to become as tender as meat from nonimplanted or conservatively implanted cattle was much longer.

The meat industry – like the retail clothing business – has adopted the "Just In Time" (JIT) delivery system. The JIT system allows an individual retail outlet to communicate electronically with its supplier to reorder specific items which are selling quickly. The entire distribution system thereby becomes more efficient because box beef can be plant-assembled, palletized and delivered to individual retail store orders. Short-haul delivery times of 5 days can now be reduced to a 2 day store arrival; a typical long-haul delivery that takes approximately 11 days can be reduced to only 5 days. This all means that the beef industry has and will continue to have less time for the postmortem aging that enhances tenderness.

## CONCLUSION

The entire beef production system must become more customer oriented if it is to maintain its current market share. To accomplish this goal, implant strategies must balance the advantages in growth against reductions in meat palatability. Cooperation, initiative and investment from all involved parties is essential for solving problems associated with consumer acceptability of beef.

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# IMPACT OF IMPLANTS ON CARCASS YIELD GRADE TRAITS AND CUTABILITY

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## ABSTRACT

For the past 25 years producers have capitalized on the benefits of anabolic implants to increase rate of gain and enhance feed efficiency for feedlot cattle. This added weight greatly improves the efficiency of production and provides additional pounds to sell on the commodity market. Life was less complicated in the days when there were fewer breeds and breed combinations as well as fewer implants to choose from. Times have changed; today the number of breeds exceeds 100 with breeds and breed combinations differing in size, weight, muscling, condition, quality, and health. Numerous implant types (estrogenic and androgenic) with variable dosage levels are now available and several marketing alternatives have evolved. More than ever, managers today must match cattle type with an appropriate implant strategy to enhance their market return. Few marketing alternatives remain viable without risking severe discounts for quality grade, yield grade, and(or) weight defects. This manuscript reviews the effects of anabolic implants on the carcass traits used to estimate cutability, closely-trimmed box beef yield, and box beef value.

## Quantitative Carcass Traits of Steers

A recent review by Duckett et al. (1996) summarized research publications from 1971 through 1994 regarding implant effects on carcass traits. Implanted steers produced heavier ($P < .01$) carcasses with larger ($P < .05$) ribeye areas; they had similar ($P > .05$) dressing percentages, fat thicknesses, percentages of internal fat and yield grades as nonimplanted steers (Table 1).

Among the implants, type and frequency of administration also affected carcass weight and ribeye area (Table 2). Increases were smallest for steers receiving only an estrogenic implant initially and(or) as a reimplant. A single combination (estrogen + androgen) implant initially or an estrogenic/combination implant strategy (initially and as a reimplant) was intermediate. A combination implant used both initially and as a reimplant produced the greatest increase in weight and in ribeye area.

Table 1. Dress and carcass characteristics of implanted and nonimplanted steers[a].

| Trait | Control | Implanted | Change |
|---|---|---|---|
| Dressing % | 62.0 | 61.9 | -0.1 |
| Carcass weight, lb | 679.0 | 716.3 | +37.3** |
| Ribeye area, sq in | 11.8 | 12.2 | +0.4* |
| Fat thickness, in | 0.47 | 0.48 | +0.01 |
| Kidney, pelvic & heart fat, % | 2.2 | 2.1 | -0.1 |
| Yield grade | 2.8 | 2.8 | 0.0 |

[a]Adapted from Duckett et al., 1996.
* $P < .05$
** $P < .01$

Table 2. Advantages for implanted over control steers in carcass weight and ribeye area[a].

| Implant | Carcass weight, lb | Ribeye area, sq in |
|---|---|---|
| Estrogenic (E) | 10.0 | 0.14 |
| E/E | 18.7 | 0.40 |
| E+Androgen (A) | 13.6 | 0.54 |
| E+A/E | 20.6 | 0.90 |
| E/E+A | 25.5 | 0.71 |
| E+A/E+A | 26.2 | 1.05 |

[a]Adapted from Duckett et al., 1996.

Table 3. Carcass traits for implanted steers compared at a constant fat percentage[a].

| | Implant treatments[b] | | | | |
|---|---|---|---|---|---|
| | | Ral | Ral | Syn | Syn |
| Trait | Con | -- | Ral | -- | Syn |
| Carcass weight, lb | 697.1 | 720.2 | 724.4 | 746.0 | 735.0 |
| Ribeye area, sq in | 12.65 | 12.73 | 12.95 | 12.79 | 12.93 |
| Fat thickness, in | 0.39 | 0.39 | 0.44 | 0.44 | 0.36 |
| KPH fat, % | 2.74 | 2.63 | 2.49 | 2.63 | 2.48 |
| Yield grade | 2.61 | 2.69 | 2.71 | 2.87 | 2.56 |

[a]Adapted from Loy et al., 1988; constant carcass fat = 32.9%; total days fed = 189.
[b]Con = nonimplanted control; Ral/-- = Ralgro on day 1; Ral/Ral = Ralgro administered on days 1 and 84; Syn/-- = Synovex-S on day 1; Syn/Syn = Synovex-S administered on days 1 and 84.

Loy et al. (1988) compared carcass traits at a constant fat percentage for Charolais-cross steers receiving various implant treatments (Table 3). Carcasses from implanted steers were heavier in weight but had fat thickness, internal fat, and yield grade similar to control steers. Ribeye areas were largest for the reimplanted groups.

In a study using Limousin-cross steers fed 119 to 126 days, Foutz et al. (1990) concluded that steers receiving both estrogen and trenbolone acetate produced heavier ($P < .05$) carcasses with larger ribeyes ($P < .05$) and slightly ($P < .05$) more masculine carcass characteristics than control or Synovex-S implanted steers (Table 4). Again, no differences among implant groups for fat thickness, internal fat, and yield grade were detected ($P > .05$).

In a recent four-trial summary, Pritchard (1995) detected distinct differences in the percentage of U.S. Choice carcasses depending on the type and timing of the initial implant (Table 5). However, quantitative traits for implanted and nonimplanted steers were similar.

Two recent trials (Johnson et al., 1995 and Mader et al., 1996) included the latest combination implants approved for use in the U.S. Using exotic-cross steers in a serial slaughter design, Johnson et al. (1995) reported sizable ($P < .05$) increases in weight and ribeye area as well as slight ($P < .05$) differences in dressing percentage, fat thickness, internal fat, and carcass bullock score among implant treatment groups (Table 6). Carcasses from implanted steers were fatter externally, trimmer internally, and more pronounced in bullock characteristics. Differences in yield grade or ribeye area expressed per hundred pounds of carcass weight were not significant ($P > .05$).

Table 4. Carcass traits for steers that received different implants[a].

| Trait | Implant treatment[b] | | | | | |
|---|---|---|---|---|---|---|
| | Control | Syn-S | Rev-S | Syn+Fin | S+F/F | Effect[c] |
| Hot carcass weight, lb | 751 | 740 | 763 | 767 | 771 | CT, ST |
| Adjusted fat thickness, in | 0.59 | 0.61 | 0.53 | 0.55 | 0.57 | |
| Ribeye area, sq in | 12.8 | 13.0 | 13.7 | 13.8 | 13.8 | CI, CT, ST |
| KPH fat, % | 2.1 | 2.0 | 2.1 | 2.1 | 2.0 | |
| Yield grade | 3.2 | 3.1 | 2.8 | 2.8 | 2.8 | |
| YG 4, % | 7.1 | 14.2 | 0 | 7.7 | 10.7 | |
| Bullock score[d] | 4.6 | 4.6 | 4.3 | 4.4 | 4.1 | CT, ST, EL |

[a]Adapted from Foutz et al., 1990.
[b]Control = no implant; Syn-S = Synovex-S on day 1; Rev-S = 20 mg estradiol benzoate + 140 mg trenbolone acetate on day 1; Syn+Fin = Synovex-S + finaplix-S on day 1; S+F/F = Synovex-S + finaplix-S on day 1 with a reimplant of finaplix-S on day 58.
[c]Contrast effects ($P < .05$): CI = control vs. all implants; CT = control vs. treatments with TBA; ST = Synovex-S vs. treatments with TBA; EL = early vs. late TBA administration.
[d]Carcass bullock score: 5 = no evidence; 1 = severe bullock characteristics.

Table 5. Four trial summary on carcass traits of implanted steers[a].

| Trait | Implant treatment[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| | Con | Syn Rev (50) | Ral Rev (50) | Mag Rev (50) | Syn Rev (75) | Ral Rev (75) | Mag Rev (75) |
| Carcass weight, lb | 729 | 778 | 777 | 780 | 776 | 777 | 779 |
| Ribeye area, sq in | 12.8 | 13.5 | 13.5 | 13.7 | 13.5 | 13.4 | 13.5 |
| Fat thickness, in | 0.49 | 0.53 | 0.50 | 0.51 | 0.50 | 0.55 | 0.52 |
| Yield grade | 2.8 | 2.9 | 2.8 | 2.8 | 2.8 | 3.0 | 2.9 |

[a]Adapted from Pritchard, 1995.
[b]Con = nonimplanted control; Syn = Synovex-S initially; Ral = Ralgro initially; Mag = Magnum initially; Rev (50) = Revalor-S reimplanted at day 50; Rev (75) = Revalor-S reimplanted at day 75.

Mader et al. (1996) reported similar trends in weight, internal fat, and yield grade; however, neither ribeye area nor fat thickness were different ($P > .05$) among implant treatment groups (Table 7). It seems surprising that ribeye size did not increase with the carcass weight. The steers used in this trial were predominantly of British breeding.

### Quantitative Carcass Traits of Heifers

Anabolic implant effects on carcass traits in heifers are similar to those of steers; carcass weight and ribeye size generally are increased compared to nonimplanted heifers while fat thickness is not changed when compared after a finishing period of specified lengths. However, response to implanting changes if heifers are supplemented with melengestrol acetate (MGA).

Research by Trenkle (1993) investigated several implant strategies with and without supplemental MGA during a 124 day finishing period (Table 8). Heifers fed MGA were heavier, fatter, lighter muscled, and less desirable in yield grade with a lower percentage of yield grades 1 and 2 and a higher percentage of yield grade 4 carcasses. Nichols et al. (1996) reported similar effects of MGA feeding in a serial slaughter heifer implant study (Table 9). Heifers receiving MGA either alone or in combination with implants were fatter, and similar in muscling, but were fatter and had less desirable yield grade than nonimplanted controls. Also, heifers supplemented with MGA produced a higher percentage of yield grades 4 and 5 than either control or implanted heifers not fed MGA. The results of these two studies suggest that heifers supplemented with MGA during the finishing phase of production should be marketed at an earlier date to achieve a level of carcass fat comparable to heifers administered anabolic implants alone.

**Box Beef Subprimal Yields**

Carcass fabrication data similarly reflects the effect of implants on carcass yield grade traits. Implanted steers harvested on a time - constant basis yielded more ($P < .05$) pounds of boneless, closely-trimmed boxed beef subprimals and more ($P < .05$) total bone, but amounts of fat trim while comparable ($P > .05$) to that of nonimplanted steers (Table 10). These yields correspond the implant effects on ribeye size and carcass weight at a constant external fatness. Carcasses from implanted steers yielded a slightly higher ($P < .05$) percentage of boxed beef subprimals and a lower ($P < .05$) percentage of trimmable fat than carcasses from nonimplanted steers.

Table 6. Carcass traits for steers given different implants after 148 days on feed[a].

| | Implant treatment[b] | | | | |
|---|---|---|---|---|---|
| Trait | Control | Plus | Syn/Plus | Plus/Plus | Effect[c] |
| Slaughter weight, lb | 1187.0 | 1263.2 | 1280.4 | 1288.3 | CI. EL |
| Hot carcass weight, lb | 762.8 | 809.3 | 826.0 | 838.8 | CI. EL. ST |
| Dressing % | 64.3 | 64.1 | 64.5 | 65.1 | EL, ST |
| Adjusted fat thickness, in | 0.62 | 0.65 | 0.66 | 0.68 | CI |
| Ribeye area, sq in | 12.13 | 13.05 | 13.25 | 13.37 | CI |
| Ribeye area/cwt | 1.60 | 1.62 | 1.61 | 1.60 | |
| KPH fat, % | 2.94 | 2.72 | 2.68 | 2.69 | CI |
| Yield grade | 3.65 | 3.57 | 3.60 | 3.64 | |
| YG 1, % | 2.4 | 3.9 | 5.4 | 3.8 | |
| YG 2, % | 17.6 | 27.6 | 18.6 | 27.0 | |
| YG 3, % | 50.4 | 39.4 | 47.3 | 41.3 | |
| YG 4, % | 23.2 | 20.5 | 19.4 | 18.3 | |
| YG 5, % | 6.4 | 8.7 | 9.3 | 9.5 | |
| Bullock score[d] | 4.6 | 4.3 | 4.2 | 4.0 | CI, EL. ST |

[a]Adapted from Johnson et al., 1995.

[b]Control = no implant; Plus = 28 mg estradiol benzoate and 200 mg trenbolone acetate on day 0; Syn/Plus = 20 mg estradiol benzoate plus 200 mg progesterone on day 0 and Plus reimplanted on day 70; Plus/Plus = Plus implanted on days 0 and 70.

[c]Contrast effects ($P < .05$): CI = control vs. all implants; EL = early vs. late TBA administration (Plus vs. Plus/Plus); ST = Syn vs. Plus as the initial implant (Syn/Plus vs. Plus/Plus).

[d]Carcass bullock score: 5 = no evidence; 1 = severe bullock characteristics.

Table 7. Carcass traits for control and implanted steers[a].

| Trait | Control | Synovex-S | Revalor-S | Synovex-Plus |
|---|---|---|---|---|
| Carcass weight, lb | 721[d] | 735[c] | 749[b] | 755[b] |
| Fat thickness, in | 0.39 | 0.41 | 0.43 | 0.37 |
| Ribeye area, sq in | 13.1 | 13.1 | 13.0 | 13.0 |
| KPH fat, % | 2.4[b] | 2.4[bc] | 2.3[cd] | 2.2[d] |
| Yield grade | 2.4 | 2.5 | 2.6 | 2.4 |

[a]Adapted from Mader et al., 1996; total days-fed = 112.

[bcd]Means in the same row with a common superscript letter are not ($P > .05$) different.

Table 8. Carcass traits for implanted heifers fed or not fed MGA[a].

| Trait | Implanted[b] only | Implanted[b] +MGA | MGA Change |
|---|---|---|---|
| Carcass weight, lb | 671.7 | 692.9 | +21.2 |
| Fat thickness, in | 0.35 | 0.46 | +0.11 |
| Ribeye area, sq in | 13.83 | 13.47 | -0.36 |
| Kidney, pelvic & heart fat, % | 2.70 | 2.77 | +0.07 |
| Yield grade | 2.03 | 2.52 | +0.49 |
| % Yield grade 1's & 2's | 88.9 | 74.1 | -14.8 |
| % Yield grade 4's | 1.9 | 5.6 | +3.7 |

[a]Adapted from Trenkle, 1993.
[b]finaplix-H (day 0)/finaplix-H (day 71); Synovex-H (day 0)/Synovex-H (day 71); Synovex-H + finaplix-H (day 0)/Synovex-H + finaplix-H (day 71).

Table 9. Carcass traits for control and implanted heifers fed or not fed MGA[a].

| Trait | Control | Revalor-H | MGA | Revalor-H + MGA | finaplix-H + MGA |
|---|---|---|---|---|---|
| Carcass weight, ib | 705.5[d] | 743.0[b] | 729.8[c] | 747.5[b] | 738.7[bc] |
| Fat thickness, in | 0.49[c] | 0.50[c] | 0.57[b] | 0.57[b] | 0.55[b] |
| Ribeye area, sq in | 13.4[c] | 14.2[b] | 13.4[c] | 13.5[c] | 13.4[c] |
| KPH fat, % | 2.1 | 2.0 | 2.1 | 2.0 | 2.1 |
| Yield grade | 2.57[c] | 2.43[c] | 2.84[b] | 2.86[b] | 2.85[b] |
| % Yield grade 4's & 5's | 3.4[c] | 1.7[c] | 11.7[b] | 14.2[b] | 9.2[b] |

[a]Adapted from Nichols et al., 1995.
[bcd]Means in the same row with a common superscript letter are not ($P > .05$) different.

Table 10. Weight and percentage yields for closely-trimmed boxed beef, fat trim, and bone of steers with different implants after 148 days on feed[a].

| | Implant treatment[b] | | | | |
|---|---|---|---|---|---|
| Trait | Control | Plus | Syn-S/Plus | Plus/Plus | Effect[c] |
| Boxed beef, lb | 507.6 | 552.6 | 559.8 | 567.7 | CI |
| Fat trim, lb | 146.2 | 140.2 | 148.4 | 148.6 | |
| Bone, lb | 108.6 | 118.9 | 117.4 | 120.7 | CI |
| | | | | | |
| Boxed beef, % | 66.63 | 68.32 | 67.90 | 67.92 | CI |
| Fat trim, % | 19.20 | 17.27 | 17.88 | 17.65 | CI |
| Bone, % | 14.25 | 14.69 | 14.22 | 14.44 | |

[a]Adapted from Al-Maamari et al., 1995.
[b]Control = no implant; Plus = 28 mg estradiol benzoate and 200 mg trenbolone acetate on day 0; Syn-S/Plus = 20 mg estradiol benzoate plus 200 mg progesterone on day 0 and Plus reimplanted on day 70; Plus/Plus = Plus implanted on days 0 and 70.
[c]Contrast effect ($P < .05$): CI = control vs. all implants.

Table 11. Closely-trimmed boxed beef, fat trim, and bone weights of steers with different implants at a constant slaughter weight of 1225 lb[a].

| | Implant treatment[b] | | | | |
|---|---|---|---|---|---|
| Trait | Control | Plus | Syn-S/Plus | Plus/Plus | Effect[c] |
| Boxed beef, lb | 523.9 | 531.7 | 533.3 | 540.2 | CI |
| Fat trim, lb | 155.8 | 134.4 | 133.0 | 135.0 | CI |
| Bone, lb | 113.0 | 112.9 | 111.0 | 114.6 | |

[a]Adapted from Al-Maamari et al., 1995.
[b]Control = no implant; Plus = 28 mg estradiol benzoate and 200 mg trenbolone acetate on day 0; Syn-S/Plus = 20 mg estradiol benzoate plus 200 mg progesterone on day 0 and Plus reimplanted on day 70; Plus/Plus = Plus implanted on days 0 and 70.
[c]Contrast effect ($P < .05$): CI = control vs. all implants.

Currently, a majority of feedlot cattle are fed for a specified number of days prior to harvest. Anabolic implants effects on fat deposition are more pronounced among cattle fed to a constant weight. Differences in fat trim yields increased dramatically when comparisons were made on a weight constant basis (Table 11). Carcasses from implanted steers yielded approximately 2.5% less trimmable fat, 2.2% more closely-trimmed subprimals, and similar percentages of bone (approximately 14.4%).

Do the anabolic implants alter muscle distribution within carcasses? Wood et al. (1986) used twins to study the effects of a combination (estrogenic + androgenic) implant on muscle weight distribution in bulls versus steers. They concluded that implanted steers were similar to bulls in shoulder and neck muscle percentages (especially the splenius or crest muscle), but implanted steers had a higher percentage muscle in these regions than nonimplanted steers did. Similar results were reported by Al-Maamari et al. (1996); steers receiving a combination implant during the first half of the finishing period yielded a higher ($P < .05$) percentage of chuck roll, the box beef subprimal in the U.S. that includes the splenius muscle. Percentage yields of all other major box beef subprimals were similar between implanted and control steers.

Table 12. Denuded subprimal yields as a percentage of total subprimal weight[a].

| | Implant treatment[b] | | | |
|---|---|---|---|---|
| Subprimal | Control | Plus | Syn-S/Plus | Plus/Plus |
| Tenderloin | 4.60 | 4.44 | 4.47 | 4.51 |
| Strip loin | 8.33 | 8.35 | 8.41 | 8.28 |
| Ribeye, lip-on | 10.52 | 10.27 | 10.81 | 10.20 |
| Top sirloin butt | 8.18 | 8.04 | 8.24 | 8.04 |
| Inside round | 15.01 | 14.57 | 14.79 | 14.77 |
| Knuckle | 7.82 | 7.84 | 7.56 | 7.72 |
| Chuck roll | 14.17[e] | 14.91[cd] | 14.58[de] | 15.15[c] |
| Gooseneck | 17.48 | 17.66 | 17.91 | 17.71 |
| Shoulder clod | 13.87 | 13.93 | 13.85 | 13.63 |

[a]Adapted from Al-Maamari, 1996.
[b]Control = no implant; Plus = 28 mg estradiol benzoate and 200 mg trenbolone acetate on day 0; Syn-S/Plus = 20 mg estradiol benzoate plus 200 mg progesterone on day 0 and Plus reimplanted on day 70; Plus/Plus = Plus implanted on days 0 and 70.
[cde]Means in the same row with a common superscript letter are not ($P > .05$) different.

Table 13. Carcass traits and profitability for control and implanted small, medium, and large framed heifers[a].

| Trait | Control | Synovex-H + finaplix-H |
|---|---|---|
| Carcass weight, lb | 708.6 | 728.6 |
| Fat thichness, in | 0.46 | 0.48 |
| Ribeye area, sq in | 12.4 | 12.9 |
| % U. S. Choice | 85.0 | 75.0 |
| Yield grade (YG) | 2.96 | 2.88 |
| % YG 1's & 2's | 51.1 | 58.3 |
| | | |
| Grade & yield, $/hd[b] | $4.36 | $14.13 |
| Premium market $/hd[c] | $32.05 | $45.03 |

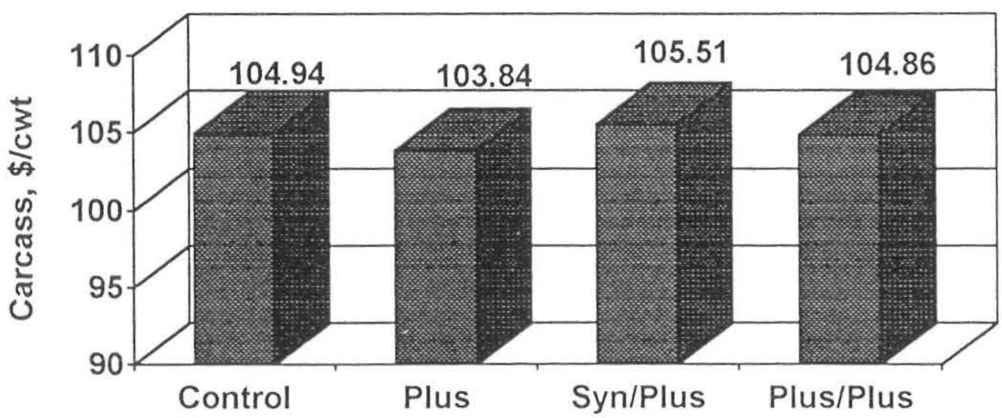
[a]Adapted from Trenkle and Iiams, 1996.
[b]Base carcass price = $108/cwt.; U.S. Choice/U.S. Select spread = -$10/cwt.; Yield grade 4's = -$15/cwt.
[c]Premium for yield grade 1's and 2's = $8/cwt.

**Changes in Carcass and Box Beef Values Associated with Implanting**

Carcass and box beef value differences associated with implanting are highly dependent on the price spreads in both quality and yield grades. Trenkle and Iiams (1996) calculated monetary returns for control versus implanted yearling heifers for two different marketing systems. Using a traditional grade and yield marketing method with a $10/cwt. spread between U.S. Choice and U.S. Select and a discount of $15/cwt. for yield grade 4's, they estimated return would be $9.77 per head greater for implanted heifers. If a premium for yield grade 1's and 2's (+$8/cwt.) was available, implanted heifers would have netted $12.98 per head more.

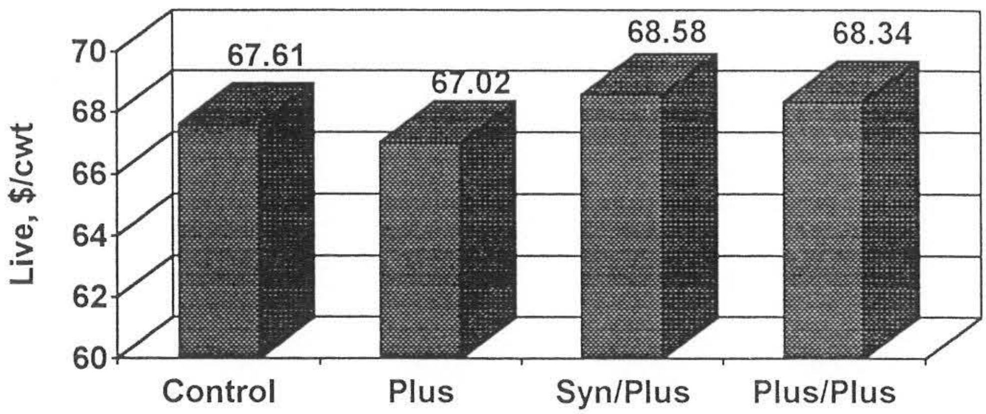
Carcass data for the Johnson et al. (1995) implant trial were used to compute individual carcass and live values based on the average 1995 prices for 25 closely-trimmed box beef items of either U.S. Choice or U.S. Select quality. Despite sizable variation in quality grade percentages, both carcass and live values ($/cwt.) were similar among implant treatment groups (Figures 1 and 2). However, implanted steers still had a sizable monetary advantage compared to controls ($51 to 69/head; Figure 3) due to heavier carcass weight at similar overall yield grade. Unfortunately this method of marketing, on a boxed beef subprimal yield basis, is still not available in the industry.

**Figure 1.** Carcass values for implant treatments based on 1995 close trim box beef cut-out[a].



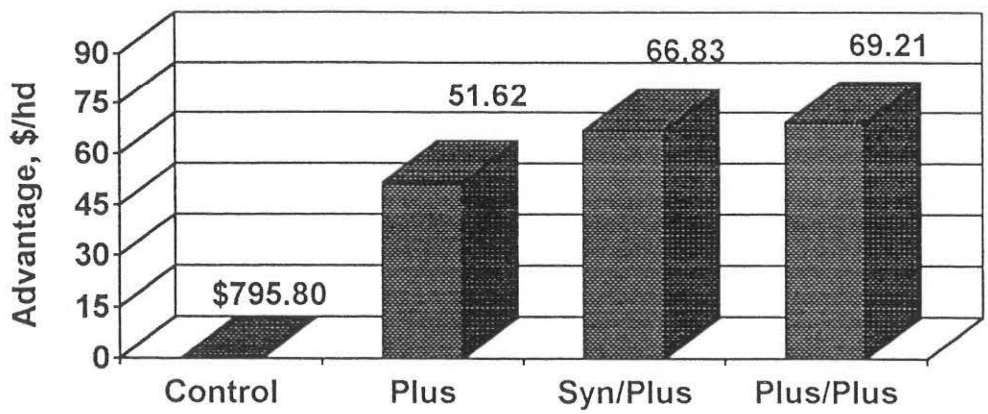

[a]Based on 1995 average wholesale box beef subprimal prices for U.S. Choice vs. U.S. Select; drop credit = $8.87/cwt; processing costs in $/head: YG1 = $86, YG2 = $94, YG3 = $102, YG4 = $120.

**Figure 2.** Live values for implant treatments based on 1995 close trim box beef cut-out[a].




[a]Based on reflects 1995 average wholesale box beef subprimal prices for U.S. Choice vs. U.S. Select; drop credit = $8.87/cwt; dressing % = 63.75; processing costs in $/head: YG1 = $86, YG2 = $94, YG3 = $102, YG4 = $120.

**Figure 3.** Monetary advantage for implant treatments over controls based on 1995 close trim box beef cut-out[a].




[a]Based on 1995 average wholesale box beef subprimal prices for U.S. Choice vs. U.S. Select; drop credit = $8.87/cwt; dressing % = 63.75; processing costs in $/head: YG1 = $86, YG2 = $94, YG3 = $102, YG4 = $120.

## CONCLUSION

For feedlot steers and heifers marketed on a time constant basis, anabolic implants (especially combination implants) increase carcass weight and ribeye area but not ribeye area expressed per hundred pounds of carcass weight. Implants may slightly lower the percentage of kidney, pelvic, and heart fat, but they have minimal effects on external fat thickness and mean USDA yield grade. Carcasses from implanted steers yield more pounds of closely-trimmed box beef products as a result of heavier carcass weights at a similar mean yield grade than carcasses from nonimplanted cattle. Implants extend the tissue compositional growth curve, allowing steers and heifers to attain heavier carcass weight while maintaining a similar carcass fat percentage to that of nonimplanted controls. Accordingly, implanted steers and heifers produce carcasses with less trimmable fat and more pounds of closely-trimmed box beef than control when the marketing endpoint is at a constant weight.

Androgenic implants tend to increase slightly the percentage of carcass lean by increasing the size of the splenius muscle in the chuck roll. This increase is similar to the effects of testosterone on the development of the crest in young bulls.

Implanted heifers receiving MGA produce carcasses with more external fat, smaller ribeyes, and less desirable yield grades than implanted heifers without MGA when marketed after a similar time on feed. Apparently, use of MGA in the latter half of the finishing phase accelerates the fattening process. Therefore, implanted heifers fed MGA should be marketed sooner with fewer days on feed to achieve a comparable fat end point to that of implanted heifers without supplemental MGA.

Live (cash) and carcass values ($/cwt.) are similar or may be slightly lower for implanted cattle compared to controls, depending on the quality grade consist and the U.S. Choice/U.S. Select price spread. For producers, profit per head still favors implanted cattle due to an increased carcass weight at a similar yield grade. Close trim box beef cut-out values ($/hd) are higher for carcasses from implanted cattle than controls. More realistic signals (premiums) are needed to reward carcasses of acceptable quality with higher red meat yields.

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## QUESTIONS & ANSWERS

**Q:** Brad made a comment early about the implants and the wide spread patterns or made out some significance that a number of cattle were killed and the days on feed may change grades. Are the factors converted in yield grade ones and twos in the box and then put ones, twos, and threes all in the same box?

**A:** A lot of this is driven by their marketing demand, but we tend to think that for the most part packers prefer to convert yield grade ones and twos to the extent possible to close trim products and then those will be mixed in a box. Yield grade threes are most efficacious in most scenarios if they convert those to their commodity line but they will have various lines. You still could have mixes of ones, twos, and threes in any of the products and that was one of the frustrations that hurts the beef industry relative to consistency. Now that the demand is increasing for close trim, we think they tend to cram their coolers with ones and twos for the close trim product within choice and separately within select and convert most with yield grade threes to commodity.

**Q:** Comments were made about the effects of implants on bone maturity, what about lean maturity?

**A:** We have noticed in steers that if you have a 20% increase in skeletal maturity because of advantages in more youthful lean maturity we often times end up backing up the overall maturity from 20% to 12%. Therefore, the overall effects are not going to be quite as harsh. The "B" maturity quality grade change is based on overall maturity which is a balancing of skeletal and lean, not just bone maturity itself. So what I am saying is in most instances with feedlot steers and heifers lean maturity if they are approaching "B" is usually still on the advantageous side where they are into "A" and so the lean pulls some of them back. The overall result will not be as harsh as looking at the bone maturity by itself. Instead of 20% I anticipate about 12% impact on the average in steers. But as you mentioned, it is going to be highly dependent upon biological type that you are considering.

**Q:** If with this experiment in control versus implanted and you use synovex plus, would you anticipate any difference in your score on lean maturity?

**A:** No. In the 13 years that I've been at OSU, No. Now, again we've managed cattle the way they should be handled. We did not take them the night before forget about them until noon the next day and go in and harvest them and then get carcass data 24 hours later. We shipped them, had them slaughtered within 6 hours in most occasions and we have not really picked up substantial dark cutters nor significant differences in lean maturity score due to implanting.

**Q:** When we look at carcass data, we always group all the prime and high choices into one category with all the choices. Do you have any thoughts on what implants do to the prime and the high choices versus all the choices?

**A:** Good point, Brad had I am sure in his article the data that we have available, again we are relying in many cases on some of the more recent text summary's. Allen Trenkle again does a good job, of showing you numbers of each category, he's got some data on that and there tends to be a further depression in prime in many instances, especially if you use an aggressive program, and if you've cut the final feeding windows short.

**Q:** If you went into the cooler and you had the opportunity to sit down and look at your evaluations of the lean and skeleton maturity and average that and come up with your total maturity versus what a grader can do, what do you think the difference is going to be between those two evaluations?

**A:** That would be interesting in a poll for all the scientist in the audience, Russell's here, Jeff's here, and Brad's here. I think it would be a lot like real grade. Many of you that have collected individual carcass data, the ribeye, the backfat, all of that data versus change speed assignment of yield grades and usually find that your percent yield grade fours will elevate 5 to 10%. I think you have more time to spend on individual factors in that you are less apt to miss a few, so I think that I would find more if I had all the time in the world, they were not moving at 7 seconds per head, and I would decide on not only yield grade but also maturity, skeletal and lean. I think on line you would miss more than if you really went out and searched the coolers. Again in the audit we found more than they tend to, we only do 1 out of every 10. Their chains have more space to get all the measurements on that 1 out of every 10 so they are moving by pretty fast. A lot of preliminary elements are going on not only among packers but also within the USDA. Again, the numbers that they are coming up with are not as high as the 95 audit numbers but they are still high. It is going to be a lot like dark cutters, you might sit there for six hours and not see a "B" bone that is affected by this change since January 31st and then you come back about 15 minutes later and here comes a lot of head and ten of them are "B" bone. I see it much like the dark cutter deal, if you try to sneak something through you are going to get caught.

**Q:** Do you expect the number of implants for a calf you received in July from birth right to slaughter have any effect on carcass quality?

**A:** That is a good question, and I am not aware of a lot of information to follow through with detail on the carcass part. I really can not say right off because I have focused here more recently on the finishing phase instead of the system all the way from birth to slaughter. I do not really have any data to say one way or the other that would be as important, more important or less important than say 140 days to the finishing.

**Q:** Would it matter if the cattle came in as steers versus bulls? Then would the implant have a difference?

**A:** There is a lot of data out reflecting that age at castration will affect or impact carcass quality. I think yes if they were castrated that late you would still see some depression in the % choice .

**Q:** Brad showed us some work on slaughter with the greater carcass effect. What would you have with a TBA reversed and estrogen alone used terminally on grade quality?

**A:** So your saying a combination for the first 70 days and estrogen the last 70 days. Don Gill and I have had that discussion ever since 1985 but we can't convince an endocrinologist like Jerry Rains that it makes sense in the living animal. We had some break up on combination implants use in Limousin cross steers that received a combination up front and then 56 days later just received a Synovex s as opposed to the treatment of Synovex up front and the combination the last 56 days or a both times. The data on that one study as in some work by John Wagner at South Dakota State reveal the balanced approach relative to not substantially depressing performance and remaining very competitive with nonimplanted trials relative combination carcass quality and yield.

**Q:** Well just a couple of comments, there was in the new synovex plus data, there is a data set that looks at that and there is others in here that have been working on it too, but by putting the combination up front and then following up by the estrogen versus the estrogen followed by the combination the effect on grade was essential. In that time period realize which goes back to your question at least in some of our opinion on what Dr. Mader said this morning there may not be how many they have all the way through but it is the low dose that appears, the low dose, the high dose, that is what the animal can respond to as well as the interval of the implant. the overlap time period or maybe the time of the overlap of the implants themselves with the additive effect of things like that have also been named in the conference in relationship or added onto the implants and that is particularly going to happen possibly prior to feedlot. I think the management scheme refers to the slaughter or the relationship. We really have to look at those additive effects before we deal with multiple implant programs and we have to relax with each other for multiple systems of mineral intake and power plus intake and feedstuffs plus the implants in what we are really dealing with.

**A:** And then trying to balance that act of biological type of each class of cattle differences, that's what keeps all of us in research and in the field and talking on the phone.

**Q:** Dr. Morgan did an excellent job in his presentation and I think we ought to give you both a very big hand for that. We did not really look at or he did not really look at what happened prior to feedlot. As you might say today that we also know that we worry about cattle that go into a feedlot. We do not know what happened prior to feedlot. We have to look at those things though and make a recommendation back to the prefeedlot people on what they are doing, because what they are doing is definitely going to have in impact on what is happening in the feedlot.

**A:** The other thing that gets you on trying to relate back to some of the earlier, and that is what we tried to concentrate on in the late 80's and the first half of the 90's, Synovex plus followed by Synovex will not be the same as Synovex + finaplix followed by Synovex either. Will it Jerry?

**Q:** Probably not.

**A:** Don Gill will try to tie in our lifeline data tomorrow as far as pricing. Impact of feed costs on controls versus implants and going only no cash basis as well as carcass basis with Dr. Jim Trapp.

**Economics of Beef Production With and Without Implants**

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**ABSTRACT**

This paper applies fall 1996 prices and cattle market conditions to implant responses to provide an economic value to various implant regimes. Suckling calf implants under current economic conditions return cattlemen about $10 for each $1.00 invested in the implant. Typically, stocker cattle with one implant return about $12 to 13 above the cost of the implant. Implanting feedlot steers once returns from $21 to $43 above the cost of the implant. Reimplanting steers increased the return above a single implant by $4 to $20. Implanting heifers once increased return from $17 to $22; reimplanting increasing return to as much as $40 above non-implanted animals. The increase in carcass weight associated with implants typically adds an additional $4.20 to the value of each animal due to a cost for slaughter and fabrication. Implants reduce beef's production cost by approximately 7 percent. If this amount of cost competitiveness were lost, beef's share of the meat market would fall from its current 31.9 percent to 29.8 percent. This would result in annual loss of roughly $1.4 billion in retail sales of beef. This reduction in sales would reduce the number of beef cows needed by about 1.2 million.

## INTRODUCTION

Implants have been used in beef cattle production since the 1960's. Implants have the potential for increasing the market weight of steers 154 by pounds. (NRC 1996) This large increase has a sizable effect on both production economics on the total supply of beef. The first part of this paper will address the effect of implants on production economics. The second part will examine the effect of implants on the supply of beef, its market share and profitability of beef production.

## PART 1

### The effects of implants on the cost of beef production in the United States.

Implants improve both the rate and efficiency of gain in beef cattle. The value of any implant program is dependent on cattle performance, cattle prices, feed prices, overhead prices, and the cost of capital. Implants also affect carcass traits other than carcass weights. These changes can alter the value of the end product. Computer models such as the Oklahoma State University feedlot calculator and the pasture calculator are capable of making cost comparisons under a given set of cost conditions.

For suckling calves the value of implants can be determined by multiplying the added gain by the value of gain minus the cost of the implant. For this paper the value of gain for calves and stocker cattle was assumed to be $55 per hundred pounds. This value has remained constant for a number of years and was determined by comparing how much more the market is willing to pay for a 500 pound steer compared to a 400 pound steer of the same quality description. For suckling calves receiving a single implant, gain is increased by 18.6 pounds (steer & heifer average). While one would assume that these calves may have eaten slightly more feed, none of the research has reported an amount. Most cattlemen thus assume that the suckling calf implant has a gross value of (18.6 * $0.55 = $10.23). Most cattlemen implant at a normal working time for the calves and consider that the only added cost is the cost of the implant, about one dollar. Thus, return is about $10 for each $1 invested in implants. Because response to calfhood implants varies with rate of gain faster gaining calves probably produce a larger dollar return than slower gaining calves. Reimplanting suckling calves increased gains about 5 pounds over a single implant. Using the same value of gain, the value of reimplanting is (5 lbs @ $.55 = $2.75) less the cost of the implant.

The value of implants in stocker cattle can be accurately evaluated using the Oklahoma State University Stocker Planner 1996 as shown in Figure 1. As in all cattle budgets, the value of an implant depends on many factors. In preparing these budgets we assumed that the value of the added live weight gain again is worth $55 per hundred. The OSU Stocker Planner (NEWPAST) CR-3026 can pinpoint the value of an implant for steers on the wheat pasture (Figure 1.) All calculations of this program are based on the assumption that an implanted steer will gain 12 percent faster than one that is not implanted. The implant value can be determined by subtracting the

Figure. 1

OKLAHOMA STATE UNIVERSITY STOCKER PLANNER (PASTURE COST GAIN OR WT. BASIS)

| | | | | |
|---|---|---|---|---|
| *** PRESS ALT D TO ENTER DATE *** | | Starting date | 11/23/96 | |
| Cattle cost per cwt | $65.00 | Pasture pricing options | | 1 |
| purchase weight (lbs) | 500 | Cost per pound of gain = 1 | | |
| cattle cost per head ($) | $325.00 | Cost in $ per cwt grazed per month=2 | | |
| Days pastured | 100 | COSTS ON A TOTAL OR DAILY BASIS | | |
| | ********* | TOTAL | DAILY | |

| | | TOTAL | DAILY |
|---|---|---|---|
| Equity in dollars per head | $0.00 | | |
| Cattle interest rate (%) | 11.00 | $9.93 | $0.10 |
| Pasture cost option: | $3.60 | $60.00 | $0.60 |
| Medical costs ($) per head | $7.00 | $7.00 | $0.07 |
| Death loss rate (%) | 2.00 | $6.64 | $0.07 |
| Pickup and equipment ($) / head | $0.00 | $0.00 | $0.00 |
| Management fee ($ per head) | $0.00 | $0.00 | $0.00 |
| Labor cost ($) per day | $0.05 | $5.00 | $0.05 |
| Beef check off ($) | $1.00 | $1.00 | $0.01 |
| Options / hedge costs ($/head) | $0.00 | $0.00 | $0.00 |
| Marketing costs ($ per head) | $0.00 | $0.00 | $0.00 |
| Freight ($) per head | $0.00 | $0.00 | $0.00 |
| Feed costs ($ per head) | $6.00 | $6.00 | $0.06 |
| opperating capital interest (%) | 11.00 | $1.31 | $0.01 |
| Dollars invested / head at end | $421.88 | TOTAL $ $96.88 | $0.97 |

| | | | | Control | Implanted |
|---|---|---|---|---|---|
| Performance options for | | SELLING DATE-->> | 03/03/97 | Control | Implanted |
| items with (*) | | PROJECTED DAILY GAIN --->>> | | 2.00 | 2.24 |
| 0=NO; 1=YES; | | TOTAL GAIN POUNDS | | 200.0 | 224.0 |
| Implant cost ($) | $0.92 | SELLING WEIGHT | | 700.0 | 724.0 |
| **Implant present *** | 1 | SELLING PRICE $ PER CWT | | $65.71 | $65.42 |
| Days fed | 0 | COST OF GAIN $ / CWT | | $48.44 | $43.67 |
| Pounds fed per day | 0.00 | FEED ONLY COST OF GAIN | | $33.00 | $29.46 |
| Feed cost per ton | $0.00 | BREAKEVEN SELLING PRICE | | $60.27 | $58.40 |
| Protein supplement * | 0 | **PROFIT PER HEAD** | | **$38.12** | **$50.80** |
| Ionophore * | 0 | TOTAL PROFIT | | 38.12 | 50.80 |

Expected value of gain ($ / cwt.) $55.00

Price structure at sale weight

| WEIGHT | $ PER CWT | CASH NEEDED |
|---|---|---|
| 400 | $73.75 | FIGURED ON |
| 450 | $71.67 | EXPECTED=0 |
| 500 | $70.00 | OPTION =1 |
| 550 | $68.64 | |
| 600 | $67.50 | 0 <SELECT |
| 650 | $66.54 | |
| 700 | $65.71 | |
| 750 | $65.00 | < Expected sales |
| 800 | $64.38 | price adjusted for |
| 850 | $63.82 | basis. |
| 900 | $63.33 | |
| 950 | $62.89 | |
| 1000 | $62.50 | |

| TOTAL COST FOR-->> | 1 HEAD |
|---|---|
| TOTAL CATTLE COST | 325.00 |
| TOTAL CATTLE INTEREST | 9.93 |
| GAIN COST (PASTURE ONLY) | 60.00 |
| MEDICAL COST | 7.00 |
| DEATH LOSS COST | 6.64 |
| PICKUP & EQUIPMENT | 0.00 |
| LABOR COST | 5.00 |
| MANAGEMENT FEE | 0.00 |
| BEEF CHECK OFF | 1.00 |
| OPTIONS /HEDGE COST | 0.00 |
| MARKETING COSTS | 0.00 |
| FREIGHT | 0.00 |
| FEED & MINERAL & IMPLANTS | 6.00 |
| OPERATING CAPITAL INTEREST | 1.31 |
| TOTAL MONEY NEEDED | 421.88 |

NOTE PASTURE PRICING OPTIONS: PERFORMANCE OPTIONS INCLUDE THE FOLLOWING INCREASES: IMPLANT 12%, IONOPHORE .2 LB GAIN, PROTEIN .31, FEED .09 LB.

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expected profit per head for control from that of implanted steers. This was $12.68 ($50.80-38.12=$12.68). The implant advantage was apparent even though the implanted cattle were assumed to sell for less per hundred weight because of their greater weight. Pricing assumptions for the winter of 1996 are apparent in the budget

The value of implants for feedlot cattle sold live is computed in Figure 2 using the OSU Program to Estimate Feedlot Cost of Gain (FLCALC Revision 2) CR-304. An abbreviated form of this program was used to calculate profitability of different implant programs under the cost structure in place in November 1996. Table 1 shows the feedlot cost structure. We assumed that corn was delivered to the feedlot for a price of $2.90 per bushel. Feed markup, typical of commercial practice, generated a gross return markup between feed and yardage of about 25 to 35 cents per day depending on feed intake. The cattle performance response used was that presented by Duckett and Owens in a separate paper in this publication. Only selected cost comparisons were made based on comparisons with the most data and interest. The value of the implant is depends on the value of gain and the input costs assigned to cattle feeding. The values generated in this paper are valid only at the price structure specified.

The cost of each implant for calculation purposes is shown in Table 2. No charge was made for the cost of extra labor involved for implanting or reimplanting; the $6.00 medical cost to cover cattle handling was assigned to all cattle in these comparisons. The cost of multiple implants by some programs becomes substantial.

**Table 1. Feedlot Cost Structure (steers and heifers).**

| | |
|---|---|
| Cattle cost $ per cwt. | $66.00 |
| Purchase weight | 713 |
| Days on feed | 140 |
| Sale price $ per cwt. | $67.00 |
| Cattle interest rate (%) | 11.00 |
| Death loss (%) | 0.75 |
| Medical cost / head $ | $6.00 |
| Beef checkoff $ / head | $1.00 |
| Yardage cost per day | $.05 |
| Operating capital interest (%) | 11.00 |

**Table 2. Implant Cost**

| Implant | Cost |
|---|---|
| Revalor S | $3.35 |
| Revalor H | $3.95 |
| Finaplex H | $3.20 |
| Finaplex S | $2.75 |
| Synovex Plus | $3.65 |
| Synovex H | $.92 |
| Synovex S | $.92 |
| Ralgro | $1.00 |
| Ralgro Magnum | $1.60 |

The complete feeding budget for control cattle is shown in Figure 2 . Similar budgets were calculated for each comparison. Implant value in each case was calculated as the difference between total profit between control and implanted cattle. This ignores any difference in carcass quality.

**Figure 2**. Control cattle for the mild estrogen comparison.

| OSU FEEDLOT PERFORMANCE PROGRAM. | | DATE PLACED ON FEED | 11/23/96 |
|---|---|---|---|
| MEDIUM-FRAME STEER CALVES. | (INPUTS) | | |
| Cattle cost $ per /cwt. | $66.00 | ***Optional inputs*** | |
| **Purchase weight lbs.** | **713** | Ration NEm | 96.00 |
| **Days fed** | **140** | Ration NEg * | 62.00 |
| Sex and body type (1-8) | 6 | (Average energy for feed period) | |
| Feed cost per ton 'as is' | $121.56 | ****************************************************** | |
| Ration dry matter (%). | 81.00 | Feed cost per /ton DM. | $150.07 |
| Selling price $ per cwt. | $67.00 | Mean feeding weight. | 904.80 |

| | (INPUTS) | Total cost($) | Cost per day($) |
|---|---|---|---|
| Equity in ($) per head. | $0.00 | | |
| Cattle interest rate (%) | 11.00 | $20.13 | $0.14 |
| Freight to feedlot $/head. | $0.00 | $0.00 | $0.00 |
| Death loss % | 0.75 | $3.57 | $0.03 |
| Medical cost / head ($). | $6.00 | $6.00 | $0.04 |
| Beef check off ($) head. | $1.00 | $1.00 | 0.01 |
| **Implant costs ($) head.** | **$0.00** | $0.00 | $0.00 |
| Yardage cost ($) per day. | $0.05 | $7.00 | $0.05 |
| **Daily feed dry matter (#)** | **19.14** | | |
| **Estimated daily gain (#).** | **2.74** | | |
| Operating interest (%). | 11.00 | $4.60 | $0.03 |
| | Non-feed total $ | $42.30 | $0.30 |
| | Feed cost / head $ | $201.07 | $1.44 |
| | Total cost $ | $243.37 | $1.74 |

| EXPECTED SALE DATE----->>>> | 04/12/97 | Calculated Values |
|---|---|---|
| **Daily gain lbs.** | | **2.74** |
| **Feed DM per pound of gain.** | | **6.99** |
| Cost of gain feedlot basis $. | | 55.81 |
| Cost of gain total $ | | 63.44 |
| Expected sale weight lbs. | | 1096.60 |
| Total dollars returned. | | 734.72 |
| Total less original cattle cost. | | 264.14 |
| Break-even selling price. | | 65.11 |
| **Profit or loss per head ($).** | | **20.77** |
| Break-even purchase price ($)/CWT. | | 68.91 |

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Tables 3 through 14 show specific comparisons for steers sold live.

**Table 3. Control vs. Mild Estrogen**

| | Control | Mild Estrogen |
|---|---|---|
| Average daily gain | 2.74 | 2.98 |
| Feed / gain | 6.99 | 6.66 |
| Feedlot cost / gain | $55.81 | $53.10 |
| Total cost / gain | $63.44 | $60.41 |
| Sale weight | 1096 | 1130 |
| Break-even price | $65.11 | $63.94 |
| Profit / head | $20.77 | $34.64 |
| **Implant advantage** | | **$13.87** |

**Table 4. Control vs Strong Estrogen**

| | Control | Strong Estrogen |
|---|---|---|
| Average daily gain | 2.68 | 3.09 |
| Feed / gain | 7.66 | 6.90 |
| Feedlot cost / gain | $60.95 | $54.75 |
| Total cost / gain | $68.84 | $61.86 |
| Sale weight | 1088 | 1145.60 |
| Break-even price | $66.98 | $64.44 |
| Profit / head | $0.23 | $29.37 |
| **Implant advantage** | | **$29.14** |

**Table 5. Control vs Androgen + Estrogen**

| | Control | And + Est |
|---|---|---|
| Average daily gain | 3.11 | 3.77 |
| Feed / gain | 6.39 | 5.65 |
| Feedlot cost / gain | $50.95 | $44.86 |
| Total cost / gain | $57.72 | $51.15 |
| Sale weight | 1148 | 1240 |
| Break-even price | $62.86 | $59.68 |
| Profit / head | $47.53 | $90.78 |
| **Implant advantage** | | **$43.25** |

**Table 6. Control vs Androgen**

| | Control | Androgen |
|---|---|---|
| Average daily gain | 2.51 | 2.92 |
| Feed / gain | 7.36 | 6.50 |
| Feedlot cost / gain | $58.95 | $51.98 |
| Total cost / gain | $67.24 | $59.83 |
| Sale weight | 1064 | 1122 |
| Break-even price | $66.41 | $63.75 |
| Profit / head | $6.28 | $36.45 |
| **Implant advantage** | | **$30.17** |

**Table 7. Strong Estrogen vs Androgen + Estrogen**

| | Strong Estrogen | And + Est |
|---|---|---|
| Average daily gain | 3.32 | 3.50 |
| Feed / gain | 6.07 | 5.87 |
| Feedlot cost / gain | $48.32 | $46.67 |
| Total cost / gain | $54.87 | $53.41 |
| Sale weight | 1178 | 1203 |
| Break-even price | $61.61 | $60.87 |
| Profit / head | $63.50 | $73.72 |
| **Implant advantage** | | **$10.22** |

**Table 8. Mild Estrogen vs Strong Estrogen**

| | Mild Estrogen | Strong Estrogen |
|---|---|---|
| Average daily gain | 3.08 | 3.13 |
| Feed / gain | 6.53 | 6.38 |
| Feedlot cost / gain | $52.91 | $50.82 |
| Total cost / gain | $59.09 | $57.76 |
| Sale weight | 1144 | 1151 |
| Break-even price | $63.40 | $62.86 |
| Profit / head | $41.23 | $47.61 |
| **Implant advantage** | | **$6.38** |

**Table 9. Mild Estrogen vs Mild Estrogen Reimplant**

| | Mild estrogen | Mild Est Reimplant |
|---|---|---|
| Average daily gain | 2.84 | 3.04 |
| Feed / gain | 7.11 | 6.61 |
| Feedlot cost / gain | 56.59 | 52.64 |
| Total cost / gain | $64.27 | $60.06 |
| Sale weight | 1111 | 1139 |
| Break-even price | $65.38 | $63.78 |
| Profit / head | $17.97 | $36.67 |
| **Implant advantage** | | **$18.70** |

**Table 10. Strong Estrogen vs. Strong Estrogen Reimplant**

| | Strong | Strong Est Reimplant |
|---|---|---|
| Average daily gain | 3.02 | 3.07 |
| Feed / gain | 7.25 | 7.13 |
| Feedlot cost / gain | $57.49 | $56.55 |
| Total cost / gain | $64.79 | $63.95 |
| Sale weight | 1136 | 1143 |
| Break-even price | $65.55 | $65.23 |
| Profit / head | $16.48 | $20.23 |
| **Implant advantage** | | **$3.75** |

**Table 11. Androgen + Estrogen vs Androgen + Estrogen Reimplant**

| | Androgen + Estrogen | Reimplant And + Est |
|---|---|---|
| Average daily gain | 3.66 | 3.89 |
| Feed / gain | 5.83 | 5.56 |
| Feedlot cost / gain | $46.31 | $44.09 |
| Total cost / gain | $52.79 | $50.83 |
| Sale weight | 1225 | 1258 |
| Break-even price | $60.48 | $59.43 |
| Profit / head | $79.93 | $95.18 |
| **Implant advantage** | | **$15.25** |

Heifer comparisons: The same cattle and feed price assumptions are made for heifers as was used for the steers.

**Table 12. Heifer Control vs Androgen + Estrogen**

| | Control | Androgen + Estrogen |
|---|---|---|
| Average daily gain | 2.74 | 3.05 |
| Feed / gain | 6.83 | 6.38 |
| Feedlot cost / gain | $54.66 | $50.92 |
| Total cost / gain | $61.98 | $58.49 |
| Sale weight | 1064 | 1107 |
| Break-even price | $64.55 | $63.10 |
| Profit / head | $26.04 | $43.14 |
| **Implant advantage** | | **$17.10** |

**Table 13. Heifer Control vs Synovex-H + TBA**

| | Control | Synovex H + TBA |
|---|---|---|
| Average daily gain | 3.34 | 3.67 |
| Feed / gain | 5.78 | 5.35 |
| Feedlot cost / gain | $46.16 | $42.71 |
| Total cost / gain | $52.20 | $49.19 |
| Sale weight | 1147 | 1193 |
| Break-even price | $60.34 | $58.76 |
| Profit / head | $75.99 | $98.32 |
| **Implant advantage** | | **$22.33** |

**Table 14. Heifer control vs Synovex H + TBA with same Reimplant**

| | Control | Syn + TBA Reimplant |
|---|---|---|
| Average daily gain | 2.97 | 3.46 |
| Feed / gain | 6.57 | 5.67 |
| Feedlot cost / gain | $52.39 | $45.23 |
| Total cost / gain | $59.20 | $52.11 |
| Sale weight | 1096 | 1164 |
| Break-even price | $63.42 | $60.22 |
| Profit / head | $39.24 | $78.94 |
| **Implant advantage** | | **$39.70** |

**Table 15. Adjustment for reduced Choice percentage for Androgen & Estrogen implants.**

| | Control | And + Est |
|---|---|---|
| Average daily gain | 3.11 | 3.77 |
| Feed / gain | 6.39 | 5.65 |
| Feedlot cost of gain | $50.95 | $44.86 |
| Total Cost of Gain | $57.72 | $51.15 |
| Sale Weight | 1148 | 1240 |
| Break-even price | $62.86 | $59.68 |
| Profit sold live | $47.53 | $90.78 |
| Live Implant advantage | | $43.25 |
| **Discount for 14.6% less choice** | | **-$7.91** |
| **Net Effect** | | **35.34** |

Profit comparisons in these tables all assumed that the selling price for control and implanted cattle was the same. Other factors altered value of the carcass. In most packing plants the costs associated with slaughter and fabrication of the carcass are calculated per animal. If these costs are $100 per head, then the heavier animal has more value. Using the OSU boxbeef calculator (NEWCUTII), a live steer producing a 800 pound carcass is worth $0.76 more per cwt live than one yielding a 700 pound carcass, all else being the same. If an implant increases carcass weight by 50 pounds, the decrease in kill-fab costs is worth about $4.20 per head ($0.38 x 1100 lb).

Changes in carcass traits caused by implants can alter carcass grade and value. Grade breakdown of test cattle makes it possible to adjust the sale prices for implants. However, Choice to Select spread in price is not constant. For 1995, Dolezal (1996) reported that the average discount from Choice to Select was $7.10 per cwt carcass. Owens and Duckett (1997) reported, that 67.3% receiving a single Androgen + Estrogen implant, had a choice grade compared to 81.9 percent for controls. The economic consequence of this 14.6 percent drop in percentage of Choice cattle with the 1995 average spread of $7.10 is illustrated in Table 15.

The economic advantage was decreased by $7.91 a head. Had the $22 spread was in effect on the day of this conference been considered, the loss in value would have been tripled. Most of the reported implant data does not contain sufficient detail on carcass data to make economic comparisons. The only precise way to calculate the value of cattle on a carcass basis use each individual carcass weight, its measured yield grade and its quality grade. In addition, weight discounts, discounts for Standard grade cattle and a schedule for carcass defects must be used. In many pens of cattle from mixed background, the lightest carcasses often draw a grade premium while the heavy cattle are often discounted for grade.

Implants also may effect the yield grade of cattle. From the OSU Boxbeef Cutout Calculator a 0.1 unit change in yield grade 750 pound carcass affects final cutout value by $3.75 per cwt carcass.

Limited data are available on the effects of implants on boxed beef yields. In a study at Oklahoma State, Al-Maamari et al (1995) reported no difference in box beef yields between non-implanted (CON), and steers implanted with either 28 mg estradiol benzoate and 200 mg trenbolone acetate on day 0 (ET), ET on day 0 plus reimplants on day 61 (ETET), and 20 mg estradiol benzoate and 200 mg progesterone on day 0 and a reimplant of ET on day 61 (SET). These treatments achieved quite high levels of both estradiol and trenbolone acetate in some treatments. However, other than an increased yields of lean box, yield grades were not different from the control. In this serial slaughter study, implanting did not appear to alter composition of gain (tissue percentage basis) in time constant comparisons; however, implants increased weight of sellable lean without increasing trimmable fat.

Implants have both positive and negative effects on carcass value. The two items most important economically are the cost efficiencies associated with increased carcass weight and the negative from a reduced percentages of high grading cattle. Caution should be taken when assigning value to increased carcass weight. Many cattle, because of genetics or management, are already too large in the eyes of consumers; making cattle larger has a very negative effect. Research to reduce the depressions in quality grade and in tenderness associated with implants should have a high priority.

PART 2

Implants can reduce production cost in the calf, stocker and feeder phases of beef production. Estimates of cost savings vary with the type(s) of implants used and other assumptions made. Tables 16 and 17 summarize the typical production cost savings attributable to using implants for steers and for heifers.

**Table 16. Cost Advantages of Using Implants With Steers**

| | Minimum | Maximum |
|---|---|---|
| Suckling Calves | $9.23 | $10.98 |
| Stockers | 9.10 | 9.10 |
| Feeders | 21.49 | 58.50 |
| Total | 39.82 | 58.50 |
| Animal Value | $752.00 | $831.00 |
| Percent Cost Reduction | 4.8% | 10.4% |
| Expected Percentage Cost Reduction 7.5% | | |

These costs can be expressed as a percentage of total production cost by placing a value on the animals produced assuming that total production cost equals the value of the animal, i.e., that production is occurring at break-even cost.

**Table 17. Cost Advantages of Using Implants With Heifers**

| | Minimum | Maximum |
|---|---|---|
| Suckling Calves | $9.23 | $10.98 |
| Stockers | 9.10 | 9.10 |
| Feeders | 17.10 | 30.70 |
| Total | 35.43 | 58.78 |
| Animal Value | $742.00 | $799.00 |
| Percent Cost Reduction | 4.4% | 6.8% |
| Expected Percentage Cost Reduction 5.6% | | |

This should be a fairly accurate assumption in the long-term. For this study the typical sales price for both steers heifers was assumed to be $67/cwt. Slaughter/sales weight varied with the implant system used; hence, a maximum and minimum animal value was calculated depending upon sales weight. Dividing the minimum cost by the maximum value and the maximum cost by the minimum value (e.g. in the case of steers $39.82/$831 and $78.58/$752) gives the widest feasible range of percentage reductions in cost of production attributable to implant use. The midpoint of this range likely represents typical cost savings in the industry from implant use.

As noted from Tables 16 and 17, the cost advantage for steers is about 2 percentage points greater than for heifers. Since about 20 percent of all heifers produced typically are held as replacements, the slaughter mix typically is about two-thirds steers and one-third heifers. Thus, for the average animal slaughtered, the cost savings from using implants is closer to the 7.5 percent for steers than the 5.6 percent for heifers. With this in mind, we assumed that the average cost advantage to producing beef with implants averages about 7 percent.

Several points should be noted with regard to this 7 percent advantage. This analysis ignores any reduction in the quality of the beef produced and that reduces the value of the animal. Likewise, feed costs were based on $2.90/bushel corn, this yields a costs of gain of about $.50/pound. Obviously, the cost advantages of using implants rises as the cost of feed rises. A complete sensitivity test of the impact of high feed cost (such as those seen recently) was not done here. Rather typical feed costs were used to reflect the long term impact of implant use upon the cattle industry. However one rough rule-of-thumb is that for each 10% increase in feed costs, the cost value of using implants will rise by 0.5%. Thus, a 30 to 40 percent increase in feed cost caused the advantage to using implants to be 8 to 9 percent versus the typical advantage of 7 percent assumed here.

## INDUSTRY WIDE IMPACT OF IMPLANT USE VERSUS NON-USE

Thus far this analysis has estimated the cost advantage to using implants for individual animal. If implants were to be "banned" from use, and the industry lost the cost competitiveness attributable to implant use, how would that impact sales and income? A "market share" analysis helps to answer that question. Before presenting that analysis it is necessary to examine some historical relationships between beef's market share and its price competitiveness.

### A Brief History of the Beef Market

Figure 3 shows the per capita pounds of retail weight meat disappearance in the in the United States from 1930 to 1995. Following the depression and drought years in the early 30's, and excluding several years in the mid 40's during World War II, per capita meat consumption grew steadily until about 1970. At that time meat consumption per capita stabilized. Some would argue that the industry "matured" at that point and that further growth through increased consumption per capita had ended. The 10 pound per capita increase in meat consumption from 1990 to 1995 raises some question about this mature industry hypothesis.

What has been beef's share of the growing meat market depicted in Figure 3? Figure 4 shows the meat market shares of beef, pork and chicken from 1970-1996. In 1975-76, beef's market share was close to 50 percent of the market. However, since that time beef's market share has eroded steadily while the market share of chicken has grown steadily. Pork's market share has remained reasonably constant at around 25 percent of the market. Why did beef lose market share from 1975 to 1996? What impact would eliminating the use of implants have upon beef's market share in the future?

Beef's loss of market share from 1975 to 1996 can be attributed to two factors, 1) changes in consumer preferences and 2) changes in the price competitiveness of beef versus other meats. More specifically "variations" in beef's market share can be attributed to beef's fluctuating price competitiveness, while the prolonged drop in beef's market share since 1975/76 is more attributable to a general decline in consumer's preference for beef relative to other meats over the period from 1979 to 1986.

Figure 5 shows the responsiveness of beef's market share to its price competitiveness. Beef's price competitiveness is measured by the ratio of beef price to the weighted average of chicken and pork price (referred to hereafter as B/CP). The weighted average price of chicken and pork is calculated as the total expenditures on chicken and pork divided by the total pounds of chicken and pork consumed. As can be seen in Figure 5, when beef had nearly 50 percent of the market in 1975-76, the B/CP ratio was about 1.5, or stated alternatively, beef price was only about 50 percent higher than the weighted average chicken and pork price. Beef's price competitiveness declined rapidly from 1976 to 1979. During this same period beef's market share fell from 48 percent to about 40 percent. Likewise looking at the time period from 1986 to 1993, beef's price competitiveness weakened and it lost market share. In the last two years, 1994 and 1995, beef has regained some price competitiveness and has stabilized its market share at about 32 percent of the market. However, what is disturbing is that today's B/CP ratio of 1.7 results in a market share of only 32 percent; 20 years ago during the period from 1970 to 1975, a similar B/PC ratio would have resulted in a market share of about 45 percent. This decline in beef's ability to maintain market share, despite maintaining price competitiveness, indicates a decline in consumer preference for beef -- consumers will no longer buy as much beef as they used to, even given the same relative price relationship between beef and competing meats.

Figure 6 presents an alternative view of the relationship between beef's market share and its price competitiveness as measured by the B/CP price ratio. It shows much more clearly when beef lost market share due to a change in consumer preferences versus due to price competitiveness. From 1970 to about 1980, beef's market share fluctuated between 40 to 48 percent in response to changes in the B/CP ratio between 1.5 and 2.0. The upper right line (demand curve) shows that beef lost (gained) about one percent of the market for every .06 points of increase (decrease) the B/PC ratio. However, from 1979 to 1986, the B/CP ratio fell from 2.1 to 1.5 with virtually no change in beef's market share. Starting in 1986, and continuing through 1995, a new, lower, and flatter demand curve for beef has been formed. On this curve, beef loses (gains) about 1 percent of the total meat market for each .03 units of change in the B/CP ratio.

This lower, and flatter demand curve for beef from 1986 to 1995 has two implications. First, beef has suffered a loss amounting to about 8 percent or the total meat market between 1979 to 1986 for some reason other than price competitiveness, i.e., because of adverse changes in consumer preferences for beef. Secondly, beef's market share is now twice as sensitive to beef's price competitiveness as it was during the 1970 to 1980 period, i.e. a .1 unit change in the B/CP ratio will now cause beef's share of the market to change by 3.3 percent versus only 1.6 percent during the period 1970 to 1980.

Exactly what caused the loss in preference for beef between 1979 and 1986 cannot be quantified: there is no way to measure what is in the minds of consumers. The decline, however, is generally attributed to two factors. The first is a concern over the health effects of having to much beef in one's diet. Concern over the amount of cholesterol in beef and its relationship to heart conditions were widely publicized and discussed during this period. Likewise, some contend that the high price of beef in 1979 and 1980 broke many consumers of their beef consuming habits and forced them to turn to alternative forms of meat. After learning to eat these meats as a major part of their diet (which was a new first time experience for some consumers) they never returned to the same level of beef consumption even after beef prices fell back into a normal relationship with chicken and pork.

## LINKING PRODUCTION COST CHANGES TO IMPACTS UPON MARKET SHARE

Two relationships must be established to link a production cost change to its impact upon beef's price competitiveness and hence its market share. The first of these is to establish the fact that beef cattle production is a very competitive industry and changes in cost of production are soon matched by changes in cattle prices such that profits remain very near break-even. The second relationship to be established is that a 1 percent change in the cost of beef production does not translate into a 1 percent change in retail beef prices.

*Cost Equals Revenue*. In the beef industry "we eat what we produce and we produce what is profitable." Beef is not a very storable commodity. Once an animal is born it will go to market within a fairly predictable time period (i.e., plus or minus a few months). Thus when an over-supply of animals is produced, they must be sold one way or the other. The general consequence of over supplying beef is that the price must be cut to sell the available supply. The packing industry has long stated this situation as "sell it or smell it". Price cutting inevitably leads to losses and losses inevitably lead to cut-backs in production. These cut-backs remove beef from the market and eventually alleviate the "sell it or smell it" situation and allow prices to rise, thus restoring a measure of profitability to the industry. But just as losses lead to cut-backs, profits, in a competitive industry, lead to expansion in response to high prices, good profits and shortages in the market. Eventually profits are removed through expanded production and falling prices and the cycle of expansion and contraction begins to repeat itself. In the cow/calf business, this well known cycle is about 10 years long. In the stocker and feedlot business it is shorter, i.e., about one to two years in length.

Figure 7 shows the recent ups and downs in feedlot profits. Profits and losses have ranged from a +$100/hd. to a -$100/hd. over the period from late 1992 to late 1996, but have averaged $5.61/hd. This average profit occurred over a time when slaughter cattle prices ranged from a high of about $80/cwt. to a low of less than $60/cwt., thus causing animal values to fluctuate by about $250/hd. The point here is that despite tremendous volatility in prices and cost of production, in the long-term (over this four period) production cost and revenue averaged out to be nearly the same such that only $5.61/hd of profit occurred. This relationship will be found for any phase of the beef industry considered (cow/calf, stocker, feedlot) for any extended period of time considered. This is because the beef industry is competitive. It adjusts to any change in cost of production or price of its product by expanding to take advantage of profits (and in so doing eliminating them) and contracting to avoid losses (and in so doing alleviating losses). Thus, over extended periods of time, the average price of beef is always very near its cost of production. Thus the bottom-line in this analysis is the inference that <u>if banning the use of implants causes a 7 percent increase in beef's production cost, eventually a 7 percent increase in the live animal price for beef will occur.</u> This increase in beef price, assuming the consumer's preference for beef does not change, must come from a cut-back in beef production. More specifically, in today's meat market it must come from moving to the left up the lower, and flatter demand curve in Figure 6, i.e. by losing market share through a loss of price competitiveness.

*The Live to Retail Beef Price Relationship.* Before we can use Figure 6 to determine what a 7 percent increase in the cost of live beef production, and hence in the price of live cattle, means in terms of market share and the total value of beef sales, a link must be made between live cattle prices and retail prices. The 7 percent increase in production cost estimated here from not using implants was calculated on a live animal basis. The market share analysis in Figure 6 is done in terms of retail price, the price level at which beef establishes its competitiveness to other meats.

Figure 8 plots the percentage changes in retail versus live cattle prices from 1970-1996. The percentage change in retail price from one year to the next is plotted on the vertical axis while the percentage change in live cattle prices during the same year is plotted on the horizontal axis. Hence the dot for 1973 (which appears by itself near the upper right hand corner of the graph) indicates that in 1973 retail beef prices rose by 20 percent while live cattle prices rose by about 22 percent. One of the first things to note from this graph is that live cattle prices have been more volatile than retail beef prices, i.e. retail price changes have ranged from a -5 percent to a plus 25 percent while live cattle price changes have ranged from a -12 percent to a plus 30 percent.

Two trend lines and one reference point line (Ref. Line) have been drawn through the data plotted in Figure 8. The steepest line is a Ref. Line. It is drawn at a 45 degree angle, i.e., it connects points showing equal percentage changes in retail and live cattle prices. Notice that to the right of the vertical line through a 0 percent change in live cattle prices, most of the points fall below this reference line. This implies that in most cases when live cattle prices rise, retail prices do not rise by as much in percentage terms. Likewise to the left of the vertical line through a 0 percent change in live cattle prices, most of the dots fall above the reference line, meaning that when live cattle prices fall, retail prices do not fall as much in percentage terms. This reference line, and the relationship of the points plotted to it, reiterate the point made above; retail prices do not change as much as live cattle prices. In the twenty six years of data plotted here, only three clear exceptions to this rule exist, i.e. 1982, 1989 and 1993. In those years, retail prices rose slightly more than live prices in percentage terms. The graph also shows that in five out of twenty-six cases retail prices rose when live cattle prices fell. Those years were 1974, 1980, 1981, 1991 and 1995.

The two trend lines plotted in Figure 8 depict the average relationship/ratio of percent changes in live cattle and retail price changes over the entire period considered (1970 to 1996) and over the last twelve year (1985 to 1986). The trend line over the last twelve years is flatter than that for the entire period. This indicates that retail prices have become less responsive to changes in live cattle prices over time. This is consistent with the fact that the "farmer's share" of the retail price of meat has declined over the period 1970 to 1996 from about 65 percent, to an little less than 50 percent. This implies that the raw commodity, i.e., live beef, makes up only about 50 percent of the total price of meat at the retail counter. The other 50 percent consist of value-added processing, shipping, packaging, storage, labor, etc. Thus what the two trend lines in Figure 8 display is the fact that as the farmer's share (live cattle value portion of the retail product) has declined over time, retail prices have become less sensitive to changes in live cattle prices. The bottom line in this analysis is that according to the 1985-96 trend line, a 7 percent increase in live cattle prices will translate into about a 4 percent increase in retail level beef prices

*Expected Adjustments to a 7 Percent Increase in Beef Production Cost.* Following the logic presented in the preceding section, Table 19 calculates and summarizes the impact of a 7 percent increase in beef production cost; this is assumed to be the impact of removal of implant use.

Figure 9 depicts and summarizes what is reported in line 4 of Table 19. It shows graphically that a 4.15% increase in retail beef prices (and thus a 4.15% increase in the B/CP ratio) causes a 2.12% decline in beef market share. Viewing this change graphically helps put in perspective the impact of a 7 percent rise in beef production cost relative to other changes in market share and price competitiveness that have occurred recently.

## INDUSTRY WIDE IMPLICATIONS OF NOT USING IMPLANTS

A perspective upon the industry wide implications of a 7 percent increase in beef production cost due to discontinuing the use of implants can be gained by making a few additional calculations from the results presented in Table 19. Table 20 presents these calculations.

The 2.12 percent loss in market share calculated in Table 19, as shown in Table 20, translates into a 4.48 lb. per capita drop in beef consumption, this is equates to a 6.65 percent decline. This per capita drop in beef consumption, when multiplied by the current U.S. population of 263.2 million, implies a decline in retail weight sales of 1.18 billion pounds. The revenue reduction due to this sales decline will not be as severe in percentage terms as the quantity of sales decline because prices do rise with reduced sales (e.g., enough to cover the increased production cost). Thus beef expenditures per capita are calculated to drop $5.29 per capita, or 2.76 percent. This translates into a loss of $1.39 billion of retail beef sales. The 1995 "farmer's share" of the retail value of beef was 49 percent, which implies that $0.58 billion of live cattle sales would be lost.

**Table 19. Expected Industry Level Adjustments to a 7 Percent Increase in Beef Production Cost.**

1) Percent Change in Live Cattle Production Cost .......... 7%
2) Implied Retail Price Change = (1.36 + .398x7) .......... 4.15%
3) 1995 B/CP Price Ratio and Beef Market Share

$$\text{Price ratio} = \frac{\text{Avg. Retail Beef Price}}{\text{Weight Avg. Retail Chick and Pork Price}} = \frac{\$2.84}{\$1.67} = 1.70$$

$$\text{Market Share} = \frac{\text{Lbs. of Beef Per Capita}}{\text{Weighted Avg. Retail Chicken and Pork Price}} = \frac{67.4}{211.2} = 31.9\%$$

4) New B/CP Price Ratio and Beef Market Share

a) New Retail Beef Price = $2.84 x 1.0415 = $2.96

$$\text{Price Ratio} = \frac{\text{Avg. Retail Beef Price}}{\text{Weight Avg. Retail Chicken and Pork Price}} = \frac{\$2.96}{\$1.67} = 1.77$$

b) New Market Share = (.879 - .3285 x 1.77) .......... 29.79%

One last way to look at the implications of a 7 percent increase in beef production cost due to not continuing to use implants is in terms of numbers of animals that would remain in the national beef breeding herd. Table 21 presents these calculations.

Meat production per cow would drop without the use of implants. The budgeting figures presented previously in this paper suggest that slaughter weights would decline by about 4 percent; thus, beef production per cow also would drop by about 4 percent. Retail weight beef production per cow per year was 397.4 lbs. in 1995.

**Table 20. Implications of 7 Percent Increase in the Cost of Beef Production**

| | |
|---|---|
| Consumption Changes | |
| Current Per Capita Beef Consumption is | 67.40 lbs. |
| Per Capita Beef Consumption Becomes | 62.92 lbs. |
| Change in Per Capita Beef Consumption | -4.48 lbs. |
| Change in Per Capita Beef Consumption | - 6.65% |
| Current Population (millions) | 263.2 |
| Total Retail Weight Change of | -1.18 Billion lbs. |
| Industry Revenue Changes | |
| Beef Sales Per Capita | |
| Currently 67.40 lbs. @ $2.84/lb. | $191.42/person |
| Becomes 62.92 lbs. @ $2.96/lb. | $186.13/person |
| Change in Beef Expenditures Per Capita | $-5.29/person |
| Change in Beef Expenditures Per Capita | - 2.76% |
| Total Change in Retail Beef Expenditures | $-1.39 Billion |
| Net Change in Farm Level Value (Assuming a Farmer's Share of 49%) | -$0.58 Billion |

**Table 21. Implied Changes in the National Cow Herd Size as a Result of Not Continuing to Use Implants.**

1995 Retail Weight Beef Production Per Cow ....................397.4 lbs.

Estimated Retail Weight of Beef Production per Cow Without the Use of Implants.................... 381.5 lbs.

| | Lbs. of Retail Wt. Beef (billions) | Retail Wt. Production Per Cow | Number of Cows (millions) |
|---|---|---|---|
| 1995 | 17.74 | 397.4 | 44.64 |
| Without Implants | 16.56 | 381.4 | 43.41 |
| Change | -1.18 (-6.6%) | 16.0 (-4.0%) | -1.23 (-2.7%) |

If this figure dropped by 4 percent it would become 381.5 pounds per cow. In 1995 the U.S. beef industry produced 17.64 billion lbs. of retail weight beef from 44.64 million head of cows, i.e. 397.4 lbs. per cow. The estimates made here indicate that after retail and farm level prices rise to cover a 7 percent increase in beef production cost, only 16.56 billion lbs. of beef would be sold. If productivity per cow dropped by 4 percent to only 381.4 lbs. of retail beef per cow, it would take 43.41 million cows to produce the beef consumers would continue to demand. Thus cow numbers would not drop by as much in percentage terms as retail sales of meat. However the decline in cow numbers would still be sizable at 2.7 percent, a number roughly equal to half the cows currently in Oklahoma (e.g., in 1995 Oklahoma was reported to have 2.1 million head of cows).

## SUMMARY

A beef industry without implants would be a less competitive with other industries producing meat. The use of implants is estimated to reduce live beef cattle production costs by 7 percent. If this cost competitiveness were lost due to an inability to continue to use implants, beef's share of the meat market would fall from its current 31.9 percent to 29.8 percent, a little over 2 percentage points. This would result in a loss of roughly $1.4 billion in retail sales of beef. This reduction in sales would reduce the need for beef cows about 1.2 million. Thus the U.S. beef cow inventory could be expected to shrink within a few years by 1.2 million head, a number equal to half the cows currently in Oklahoma.

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## QUESTIONS & ANSWERS

**Question:** How does the price of competing products alter the price of beef? Is there a 1:1 ratio?

**Trapp:** It doesn't matter whether price or cost of production changes; the impact is the same. If in composite, pork and chicken drop their price by 7% relative to the beef, this has the same impact as beef losing 7% in price.

**Question:** Is the ratio of the live animal to retail meat the same for beef, pork, and chicken?

**Trapp:** No. The ratio of live to meat price for beef and pork around 40%. In pork that makes a big difference. In chicken, I don't know the percentage. This depending on extent of processing and the efficiency of both production and processing. USDA recently mentioned pork as around 40% and beef near 49%. Over time, this ratio has decreased because efficiency of live animal production has increased more rapidly than efficiency of processing. So the live animal share has dropped from 50 or 55 down to 49 over the last 20 years.

**Question:** How would a grain price of $200 per ton alter your conclusions?

**Trapp:** One can calculate the percentage increase in cost of production and the fraction of total cost that is feed cost and work that into the equations. If grain cost increases by 40% and feed is one-third of total production cost, then total production cost is increased by 10 to 15%. However, pork and poultry eat grain, too, so their costs are rising also. Which does an increase in grain price hurt the worst - beef, pork or chicken? Chicken is much more efficient at using grain than beef, but beef has the flexibility to substitute forage for grain. So it is a wash after you pencil through it. Increases in grain prices cause similar increases in production cost for all species. Overall, as cost production goes up, retail prices are going rise, but it will take time for that to happen.

**Question:** How does grain price alter the value of implants?

**Gill:** The economic impact of implants are larger with higher priced corn. Had I use $5 corn in my examples, the savings from implants would have been larger.

**Trapp:** We did not use today's grain prices in these calculations because they would be misleading when grain prices drop. The impact of removing implants is quit sensitive to the cost of gain in beef. Implants are specific to beef and do not affect production cost of pork or chicken. Grain prices affect all markets to the same degree.

**Question:** Beef production per cow has been listed several times. What is this and why is it increasing?

**Trapp:** Production per cow includes two things - cows and meat from all slaughtered animals. Both beef and dairy cows are included in the formula. Productivity has been increasing not only because the beef industry itself is doing better, but because we have fewer and fewer dairy cows. Dairy cows are not good beef producers. If you decrease the proportion of the population that is dairy cows, meat production per cow will increase. Some of that spillage may explain these increases. (WHAT ABOUT WHETHER THE COW HERD IS EXPANDING OR CONTRACTING?)

**Question:** If we need to examine carcass information more closely to evaluate implants, what can Oklahoma State do to gather more information and put it on the internet for everybody to fit to their own conditions?

**Gill:** It would be relatively easy for us to put our own data on the Animal Science home page we haven't done any of that yet. We have completed two serial slaughter studies from which we have made the carcass data available. To me those are two studies are under-utilized. For example, a given pen of feed cattle fewer or more days. Total price will change each day with the market. But the relative value of feeding cattle for fewer or more days doesn't change that much. Other universities should do the same thing. We don't have carcass data from these studies on the internet yet, but we can stick it on the Animal Science home page.

**Question:** Someone needs to take the initiative to gather the complete implant data base provide it for users in some usable format.

**Morgan:** This is something that the National Beef Cattle Association tried to do with their beef carcass collection program. However, the data fed back to producers was not user friendly. The association is rethinking how it could be made more user friendly. The Ranch-to-Rail program provides feedout and carcass data, also. These are little drops in the bucket toward accumulating more carcass data. I agree that more carcass information of this type is needed.

# CONSUMER ACCEPTANCE—DOMESTICALLY AND INTERNATIONALLY—OF BEEF FROM CATTLE PRODUCED WITH USE OF GROWTH PROMOTANT IMPLANTS

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## INTRODUCTION

Consumer concern regarding the safety of the U.S. food supply ebbs and flows, depending largely upon the amount of attention being paid by the media to food-safety issues at a given point in time. In 1989, stories about alar in apples and cyanide in grapes heightened consumer awareness of potential foodborne hazards and caused front-page coverage of issues in *Time* and *NewsWeek* under the headlines "How Safe Is Our Food?" and "Is Your Food Safe?" (Smith *et al.*, 1994b). In 1993, foodborne illness caused by an outbreak of *Escherichia coli* O157:H7 in undercooked ground beef prompted *NewsWeek* to again give front-page coverage to that issue under the headline "How Safe Is Our Food?"; a provocative subtitle to that 1993 *Newsweek* story read "Contamination Causes 9,000 Deaths A Year, And New Dangers Are Emerging?" Prominently displayed in a side-bar was beef (Smith *et al.*, 1994b).

Only very rarely are U.S. consumers knowledgeable enough of the chemistry or microbiology involved in food-safety issues to make reasoned judgments of what is or is not a "clear and present danger." To force us to learn—as children—what our elders felt was necessary knowledge, the "written word" was sanctified to the degree that most of us believe—unequivocally—that "if it's written, it's gospel." That latter, incorrect analogy makes the general public highly susceptible to the misinformation which poses as journalism. And, inasmuch as the written word is most often the means by which we seek to correct the incorrect written word, on whom and in whom is one to trust? The horns of the present dilemma regarding food safety most often pit the scientist against the journalist on a playing field that is far from level because of the language barrier created when the scientist seeks to explain issues to the consuming public. Most consumers, through no fault of their own, fall easy prey to the eloquence of the fear-monger who—unfortunately—is seldom bridled by the need for proof, while disbelieving the scientist who can almost never be definite, absolute or conclusive about anything (Smith *et al.*, 1994b). According to Dr. David Meeker (personal communication, 1996) of the National Pork Producer's Council, "A 1989 study by the National Science Foundation surveyed 2,041 U.S. citizens and found that only 5.6% were 'sufficiently literate' in the sciences to make informed decisions about issues such as nuclear power and toxic wastes!" "Yet," Meeker concluded, "in spite of these findings about the level of public understanding, the fate of agriculture is being determined on the basis of public opinion....and, public opinion is framed by the news media."

### Food Selection Concerns

Each year, the Food Marketing Institute conducts a nationwide consumer survey to identify changing concerns, needs and priorities of supermarket shoppers. Results of the 1996 survey were published in "TRENDS IN THE UNITED STATES--Consumer Attitudes & The Supermarket 1996" (Food Marketing Institute, 1996). According to TRENDS--1996, the top food selection concerns and the percentages of the shopping public that considered these factors "Very Important" in food selection were as follows: (1) Taste, 88%; (2) Nutrition, 78%; (3) Product Safety, 75%; (4) Price, 66%; and (5) Storability, 43%. Interestingly, worry about product (food) safety has not changed much in the past six years; this issue ranked third in importance in food selection concerns in 1991 (72%) and fourth in importance in food selection concerns in 1992 (71%), 1993 (72%), 1994 (69%) and 1995 (69%), in TRENDS reports for these respective years (Food Marketing Institute, 1991, 1992, 1993, 1994, 1995).

### Safety of the Food Supply

When asked "How important is food safety when you shop for food?" 75% said "Very Important," 17% said "Somewhat Important," 4% said "Not Too Important," 3% said "Not At All Important" and 1% said "Not Sure" (Food Marketing Institute, 1996). When asked "How confident are you that the food in your supermarket is safe?" 20% were "Completely Confident," 64% were "Mostly Confident," 15% were "Somewhat Doubtful," 2% were "Very Doubtful" and none were "Not Sure" (Food Marketing Institute, 1996).

When asked "What, if anything, do you feel are the greatest threats to the safety of the food you eat?", the shopping public (Food Marketing Institute, 1996) identified the following *unaided-response* items (the number following each item is the percentage of supermarket shoppers who identified that item as a threat to food safety):

(1) Spoilage, 49%
(2) Freshness/long-shelflife/expiration-dates, 22%
(3) Bacteria/contamination/*E. coli*/germs, 17%
(4) Pesticides/ residues/insecticides/herbicides, 17%
(5) Quality control/improper shipping, handling/storage, 14%.

Possible food-safety concerns about beef (Smith *et al.*, 1994b) include: (a) Presence on meat of foodborne pathogens (most important would be *Salmonella, Listeria monocytogenes, Campylobacter jejuni* and *Escherichia coli* O157:H7), (b) Residues, in meat, of pesticides (of either or both of the types--chlorinated hydrocarbons and organophosphates), (c) Antibiotics (fear of residues of the antibiotics, in meat, and/or of development and presence, on meat, of antibiotic-resistant strains of human pathogens because of continued exposure of human pathogens--that have livestock vectors--to feed-grade antibiotics) and (d) Residues of livestock growth-promoting compounds in meat; concern is about the presence, in beef, of residues of naturally occurring growth-promotants (the hormones--estrogen, testosterone, progesterone) as well as of the chemically synthesized growth-promotants (the xenobiotics--trenbolone acetate, melengestrol acetate, zeranol).

When told "I'm going to read a list of food items that may or may not constitute a health hazard; for each one, please tell me if you believe it is a 'serious health hazard,' 'somewhat of a hazard,' or 'not a hazard at all" the shopping public (Food Marketing Institute, 1996) gave the following *aided-response* answers (the number following each item is the percentage of supermarket shoppers who identified that item as a "serious health hazard"): (1) Contamination by bacteria or germs, 77%; (2) Residues, such as pesticides and herbicides, 66%; (3) Product tampering, 66%; (4) Antibiotics and hormones in poultry and livestock, 42%; (e) Food handling in supermarkets, 41%.

**Consumer Acceptance—Domestically—of Meat From Livestock Produced with Use of Growth Promotant Implants**

Critics who question the safety of red meat (beef, veal, pork, lamb, mutton) do so by emphasizing concerns about residues of hormones, antibiotics and pesticides, in red meat, and about presence. in and on red meat, of bacteria--especially food-borne pathogens. Results of TRENDS --1996 (Food Marketing Institute, 1996) can be used to determine comparability of concerns of critics vs. concerns of supermarket shoppers. The critics are correct in stating that consumers are concerned about presence of bacteria on red meat; "Spoilage," "Freshness," "Bacteria/ contamination," "Quality control" and "Unsanitary store workers" are top-of-mind concerns ranked first, second, third, fifth and sixth in TRENDS--1996. "Pesticides/residues/insecticides/herbicides" are also top-of-mind food-safety threats and ranked fourth in TRENDS--1996. But, critics are not right about residues of "Antibiotics" or "Hormones" being top-of-mind concerns as food-safety threats because "Antibiotics/ Hormones" ranked 17th in *unaided-response* queries in TRENDS—1996 (Food Marketing Institute, 1996).

In the *aided-response* part of TRENDS--1996 and when forced to respond to a suggestive question, 66% (down 16 percentage points since 1989) of those questioned considered "Pesticides/ residues/ insecticides/ herbicides" a "Serious Hazard" and 42% (down 19 percentage points since 1989) of those interviewed considered "Antibiotics and hormones" a "Serious Hazard" (Food Marketing Institute, 1996). The disparity and dichotomy observed in the *aided responses* vs. *unaided responses*, above, can be likened to the situation with worms in apples. When asked to *identify* their concerns about the quality/safety of apples, unaided responses of consumers would seldom include "worms" (because that is not a top-of-mind concern of apple consumers); yet, if asked the question "Aren't you concerned about worms in your apples?", a very high percentage of consumers respond, in the affirmative, to this "aided" query. In fact, the only way you could increase the latter ("very high") percentage would be to say "Aren't you concerned when you find half a worm in your apple?"

In the Personal Safety Survey of the "General Public" by CMF&Z (1995), "Safety of Food" ranked third ("Safe Drinking Water" ranked first; "Being Safe From Crime," ranked second) with 80% of those interviewed being "personally concerned about food safety." Comparison of "general public concern" versus "editor concern" over the issue of "use of hormones in meat production" in the CMF&Z Personal Safety Survey revealed ranks of 9th for the general public and 7th for editors. So, the "use of hormones in meat production" is—when mentioned specifically—a matter of substantial concern (as an "aided response") based on results of the CMF&Z (1995) survey.

**Who to Trust About Food Safety**

In response to the question "As far as you personally are concerned, on whom do you rely most to be sure that the products you buy are safe?," the shopping public (Food Marketing Institute, 1996) responded as follows: (a) Yourself as an individual, 25%; (b) Government, 21%; (c) Manufacturers, 21%; (d) Retailers (food stores), 16%; (e) All/Everybody, 8%; (f) Consumer Organizations, 5%; (g) Farmers, 3%; and (h) Not Sure, 1%.

Results of a February 1995 poll conducted by Peter D. Hart Research (National Cattlemen's Association, 1995) revealed that 82% of the thought leaders expressed confidence in beef's safety and wholesomeness. These opinion-leaders and consumer-influences assigned cattlemen "mean scores" or "grades" of "B-" for "Providing safe beef, free of chemicals and pesticides" and of "B" for "Providing beef free of bacterial contamination." National Cattlemen's Association (1995) further reported that confidence in the safety of U.S. beef is one reason why beef exports have increased. The International Beef Quality Audit, conducted by Colorado State University, surveyed beef purchasers in five regions of the world and revealed that U.S. beef is the safest in the world; it has the world's highest microbiological quality and the world's lowest incidence of violative levels of chemical residues (Morgan *et al.*, 1995).

**Consumer Acceptance—Internationally—of Beef from Cattle Produced with Use of Growth Promotant Implants**

The 1994 International Beef Quality Audit (Morgan *et al.*, 1995) was conducted via personal Face-To-Face Interviews with traders/wholesalers, retail operators, hotel and restaurant managers/chefs, and personnel from trade/promotion organizations in selected foreign markets. These interviews, conducted in 20 countries with people from 288 businesses and organizations, were completed during the time-period of March 1994 through October 1994. Countries were categorized by geographical region: North America, Asia, UK plus Europe, ASEAN (Association of South East Asian Nations) and the Middle East. These regions had been identified by the U.S. Meat Export Federation (USMEF) as "high-growth" markets for U.S. beef (Morgan *et al.*, 1995).

The International Beef Quality Audit (IBQA) was conducted to quantify the components of quality for which changes can be made to enhance the desirability of U.S. beef in the global marketplace (Morgan *et al.*, 1995). Intense competition to supply the world with beef causes foreign buyers and users of U.S. beef to compare and contrast U.S. products with those of their own country's domestic production and with products from other beef-exporting countries. "Quality" can be defined in many ways and can include many variables. To understand the needs and wants of its export customers, the U.S. beef industry must be able to identify accurately the parameters used in evaluating "quality" attributes that customers consider when comparing U.S. beef to competitive sources of beef (Morgan *et al.*, 1995).

The IBQA determined that the principle reasons U.S. beef is purchased by global customers (Morgan *et al.*, 1995) are as follows: (1) High Ability To Supply Individual Items; (2) Excellent Tenderness And Flavor; (3) High Perception Of Value; (4) Excellent Overall Product Quality; (5 tie) High Perception/Image Of The U.S. And The U.S. Quality Grading System; and (5 tie) Confidence In Product Safety. Relative to item (5 tie), *Confidence In Product Safety* was an important factor in explaining why foreign customers purchase U.S. beef. Both the USDA and the National Cattlemen's Association (NCA) oversee and promote beef safety throughout the beef production chain. Recognized worldwide, the Food Safety and Inspection Service (FSIS) of USDA and its Residue Monitoring Program give customers in other countries, as well as those in the U.S., an assurance and a feeling of safety about U.S beef. Foreign beef customers appreciate, and understand the importance of, the controls that the U.S. applies to the processing and handling of the live cattle, carcasses and beef produced in the U.S. A partner with FSIS/USDA has been the Beef Quality Assurance (BQA) program activities of U.S. cattlemen; state and national BQA programs also function to assure that U.S. beef is safe.

Among the 288 people interviewed in the International Beef Quality Audit, 147 were traders/wholesalers, 44 were retail operators, 85 were hotel and restaurant managers/chefs and 12 were personnel from trade or promotion organizations. "Use of hormones in growing/finishing cattle" was not identified among the "Top Ten Concerns About Quality" by traders/wholesalers or of personnel of trade/promotion organizations (no such categorization was done for the latter group), but was the number 3 concern of retail operators and the number 5 concern of managers/chefs (Morgan *et al.*, 1995).

Within Regions, "Use of hormones in growing/finishing cattle" was the number 8 concern (8.1% of those interviewed were "dissatisfied" about this) in Region 1 (North America), but it was not included in the "Top Ten Concerns About Quality" in Regions 2, 3, 4 or 5. In Region 1, more than 1 of every 12 interviewees felt that use of hormones for promoting growth and leanness of slaughter cattle was not acceptable. Although U.S. use of hormones, for growth promotion, has not influenced purchasing decisions of Canadian or Mexican beef buyers nor has it created any regulatory problems, the customers of the businesses operated by some of the interviewees do not understand the use of hormones and consider this practice "unnatural" (Morgan *et al.*, 1995). Although "Use of hormones in growing/finishing cattle" did not make the list of "Top Ten Concerns About Quality" in Region 3 (UK plus Europe) concerns about that issue did surface in the listing made of "We Would Buy More U.S. Beef If..." where four of the six highlighted comments dealt with that issue. The latter comments were: (a) From the Netherlands, "We would buy more U.S. beef if we could buy hormone-free beef that wasn't low in quality (cow) and tasteless (young bull) and so poor in shelf-life (cow, young bull), which is what we get now." (b) From Austria, "We would buy more U.S. beef if the U.S. government convinced the Austrian government to decrease the import tax and that the hormone issue is political (not scientific)." (c) From Belgium, "We would buy more U.S. beef if we could purchase it 100% clean (hormone-free); quality of beef is better with use of hormones but the customer will accept it, only if it is hormone-free." And (d) From The Netherlands, "We would buy more U.S. beef if it was accepted as hormone-safe, supply was constant and prices were competitive" (Morgan *et al.*, 1995).

Although it is well-known, and agreed-upon by all who understand the issue, that the "Hormone Ban" of the EEC (now EU) is a non-tariff trade barrier, it is now also widely believed that if the U.S. wins its court case, with the World Trade Organization, to force the EU to abandon its "Hormone Ban," enough consumers in the EU have now been sensitized to the issue that U.S. beef produced with use of hormones in growing/finishing may not find a ready market among present EU consumers. The U.S. may find that its only hope for selling beef in the EU—in the future—is to sell beef produced without use of the growth promotants.

**Anabolic Steroids/Hormones and the Red-Meat Supply**

There are consumers, but not many, who are concerned about use of growth promotants in the feeding of cattle. The rationale usually given by those in the beef industry for use of these chemical compounds is as follows: Beef animals of different genotypes differ quite markedly in size/height/weight at a given point in chronological age. Differences in genetic size are caused by differences in the amount (and/or timing) of release of *Growth Releasing Factor* (GRF) from the *hypothalamus*. GRF causes the *pituitary gland* to release differing amounts of *Growth Hormone* (depending upon the amount of GRF signal received by the pituitary). Increases in Growth Hormone (GH) cause (a) *stature to increase*, (b) *muscle growth to be enhanced*, and (c) *fat deposition to be lessened* (delayed, chronologically). Research, conducted beginning nearly 40 years ago, revealed that minute doses of natural hormones (e.g., *estrogen*, *progesterone* and *testosterone*) and of artificially synthesized growth promotants--called xenobiotics (e.g., *zeranol*, *trenbolone acetate* and *melengestrol acetate*) caused growth and composition changes in cattle that were remarkably similar to those attributed to Growth Hormone (Smith, 1995). In the 1980s, Dr. Bill Tanner and Dr. Tom Welsh of Texas A&M University discovered that administration of estrogen *"tricked"* (in much the same way that a vaccine tricks the animal into developing immunity to a disease) *the animal's pituitary*-- making it believe it was receiving more GRF signal--*into releasing more Growth Hormone* (Smith, 1995). Other growth promotants act in another way that is not related to Growth Hormone; trenbolone acetate, for example, is believed to act by decreasing protein turnover so that more muscle accretion per unit of time takes place (Smith, 1995). *"Implanting"*--introduction into the animal's ear of a tiny rubber silastic cylinder that contains about 36 milligrams of estrogen, for example--causes the animal (during the 90 or so days it takes for the estrogen to be absorbed and to enter the animal's bloodstream) to *repartition* its use of what it eats. It has now been amply demonstrated that implanted animals produce more muscle and less fat (all other things being equal) than do non-implanted animals.

Concern is registered by a few people who have observed that there is *58% more estrogen* in a serving of beef steak, for example, from an animal implanted with estrogen than in a steak of equal size from an animal that was not implanted (3-ounce portions contain 1.9 nanograms of estrogen if from an implanted animal and 1.2 nanograms of estrogen if from a non-implanted animal). Such concerns disappear when it is realized that the normal daily *in vivo* (within the person's body) production of estrogen by an average male is *136,000 nanograms* and by a normal non-pregnant female is *480,000 nanograms*. Experts conclude that there would be *no physiological effect* on humans caused by the difference (1.9 billionths of a gram) between 480,001.9 and 480,001.2 or 480,000.0 nanograms in daily estrogen supply (Smith, 1995).

Much of the present consumer concern regarding use of growth promotants in beef production arose when the European Economic Community (EEC) banned importation of beef from the U.S. on grounds of our use of anabolic steroid hormones. In truth, the EEC -- drowning at the time in excess beef -- *used the hormone issue to create a non-tariff trade barrier* to preclude importation of U. S. beef into those 12 countries. According to Smith (1995), since imposition of the "EEC Hormone Ban," (a) a committee of scientists appointed by the EEC (and chaired by Dr. Eric Lamming of the United Kingdom), (b) Codex Alimentarius, and (c) the Food and Agriculture Organization of the World Health Organization, all have gone on record as stating *"there is no risk to the public health or well-being as a result of properly administered growth-promoting, anabolic steroid hormones to beef cattle."*

Smith (1992), in a position paper prepared for the U.S. Meat Export Federation, stated *"If the EEC agrees to accept the Joint FAO/WHO Expert Committee Report of 1988 and the EEC Scientific Advisory Committee Report by Lamming in 1987 confirming no risk to human health from proper use of anabolic and xenobiotic agents and if the EEC will change the wording in EEC Council Directives from "residues" to "violative residues"* (as delineated by FDA, FSIS or the JECFA of FAO/WHO)....*then, the U.S.A. will request of FSIS/USDA that it test beef for presence of residues of diethylstilbestrol, estradiol-17B, estradiol benzoate, testosterone propionate, progesterone, zeranol, melengestrol acetate and trenbolone acetate, on a continual, annual basis."* According to Smith (1995), Dr. H. Russell Cross, then Administrator of FSIS-USDA, agreed to implement the latter process--as a part of the National Residue Program; EEC officials agreed on July 7, 1992 to consider the proposal presented in the position paper, and there is still hope (in 1996) that the EEC (now called the European Union) will rescind its ban on importation of beef and beef products from cattle that were administered natural or artificial growth-promotants.

An article in KRF/Global News (1996) said that a German federal health institute had advised the Health Ministry that meat imports from Australia and Uruguay should increasingly be tested for the carcinogens diethylstilbestrol (DES) and ethinyloestradiol (EE2). These growth enhancers are banned in the European Union (EU) but have increasingly been detected in Australian and Uruguayan meat. In 1995, seven cases of animals for slaughter containing the hormone DES were found in Uruguay (KRF/Global News, 1996). So, a black market for growth enhancers in other countries makes reasonable the concerns of people in the EU about use of growth promotants in beef production.

U.S. beef producers are trying very hard to produce leaner beef. As they proceed from producing flagrantly fat, to sensibly slim, beef, attempting to reduce the amounts of external and seam fat, on and in beef cuts, use of growth promotants that repartition consumed nutrients--toward muscle and away from fat--is a vital tool for accomplishing desired modifications in body composition. *To lose the use of these immensely valuable chemical compounds, especially based on trumped-up charges and greatly exaggerated consequences, would be a setback to recent success in "the leaning of the U.S. beef supply."*

## Chemical Residues in "Conventional," "Natural" and "Organic" Beef

Some marketers have tried to position "natural" or "organic" beef as superior to "conventional" beef in terms of safety (National Live Stock and Meat Board, 1995). The wording of the advertisements for beef of the "other kind"—nonconventionally produced product—is clearly designed to frighten, to alarm, to provoke, or—at the least—to concern, consumers. "What would beef be....WITHOUT HORMONES, STEROIDS OR ANTIBIOTICS? ...It would be Coleman Natural Meats, Inc....Raised At The Head Of The Creek... Man Hasn't Messed With It," reads one ad. "Honest To Goodness Beef...No Added Hormones or Chemicals...ALL BEEF, NO BULL...Raised on Natural Grains at the Harris Ranch"...reads another ad. "The Beef Behind the U.S. Olympic Athletes...NaturaLite BEEF...Maverick Ranch" reads yet another advertisement. Point-of-purchase materials from Coleman Natural Meats, Inc. that are distributed at retail stores say "Every box of Coleman Natural Beef shipped to your butcher carries the USDA definition of "natural," plus our own, much stronger statement of purity "Our animals never receive any antibiotics or growth hormones from the time they are born. Any animal requiring therapeutic treatment is treated and removed from the herd. No antibiotics were ever added to the feed."

Confusion exists in the marketplace as to what the terms "natural" and "organic" mean when applied to red meat; both terms imply a difference from "conventional" beef. Following implementation of a USDA National Organic Program (which is supposed to occur anytime — perhaps in 1997) the "organic" meat label will have an official meaning (as opposed to the present definitions applied by those who market beef as "organic") and--according to knowledgeable sources--will indicate those products that are derived from animals raised on certified organic farms and processed by certified handlers in ways that minimally impact the environment (Kinsman, 1994). In efforts, though, to position "natural" beef uniquely in the marketplace, some marketers have argued that the term connotes beef from cattle raised in specific geographic locations on uncontaminated land, never treated for disease or illness, containing no additives, with a unique taste, and produced differently during finishing.

In March 1991, one producer of "natural" beef launched a 12-week advertising campaign in the Boston Globe (1991) promoting the idea that "natural" beef is "pure" as opposed to the "adulterated kind" raised by cattlemen who use antibiotics or hormones, and that cattle which have been exposed to antibiotics and hormones should be labeled as "chemical cattle." The primary problem with such ads is that they may raise questions in consumers' minds regarding the safety and wholesomeness of the generic beef supply (Wilkinson, 1991). In 1982, the USDA approved use of the term "natural" for beef that is minimally processed and that contains no additives—a definition that allows *all* conventionally prepared fresh beef to bear the "natural" label (USDA, 1982).

In efforts, to position "natural" beef uniquely in the marketplace, overzealous marketers have argued that the term "natural" connotes beef from cattle raised in specific geographic locations (e.g., "up high in the mountains, way up at the head of the creek, where the water is clean and pure," *Boston Globe*, 1991), on uncontaminated land (e.g., "on rangeland untainted by pesticides or fertilizers," *Boston Globe,* 1991), never treated for disease or illness (e.g., "kept off drugs," *Boston Globe*, 1991), containing no additives (e.g., "totally free of chemical additives," *Boston Globe*, 1991), with a unique taste (e.g., "it tastes clean, like all beef would taste if man hadn't come along and messed with it," *Boston Globe*, 1991) and produced differently during finishing (e.g., not given "growth hormones, not unlike the steroids employed by athletes"; not given "antibiotics to prevent illness or to treat it"; "chemical cattle" gain faster but "a large proportion of that is just fat, which you don't want anyway," *Boston Globe*, 1991).

FSIS/USDA (USDA, 1993, 1994, 1996) does not report separately the residue monitoring results for samples from cattle raised under different management systems (i.e., "conventional," "natural," "organic"). The Cattlemen's Beef Promotion and Research Board provided funds for determining the incidence of chemical residues in beef tissues to the National Live Stock and Meat Board, who awarded funding to conduct two such studies to the Center For Red Meat Safety at Colorado State University. Results of the two studies conducted by the Center For Red Meat Safety (Heaton *et al.*, 1993a; Smith *et al.*, 1994c) confirm that beef is safe based on an exceptionally low incidence of violative chemical residues. One of those studies (Smith *et al.*, 1992, 1994a) involving 80 samples of muscle, fat, liver and kidney from "conventional," "natural," "organic" and "realizer" (chronically ill) steers and heifers as well as "cull (beef/dairy) cows," detected no violative residues of the five anabolic steroids, the two heavy metals, the three stress reducers, the six thyrostats/sulfa-drugs and the 25 chlorinated hydrocarbon and organophosphate pesticides being assayed. A second study (Smith *et al.*, 1997) of muscle, fat, liver and kidney samples from "conventional," "natural" and "organic" steers and heifers detected zero violative residues in 558 tests for three anabolic steroids, zero violative residues in 558 tests for three xenobiotics, zero violative residues in 1,860 tests of 10 sulfa-drugs/antibiotics and 15 violative residues (three in "conventional" beef; six in "natural" beef; six in "organic" beef; all residues were in liver samples and none in muscle, fat or kidney samples) in 4,650 tests for the 25 chlorinated hydrocarbon and organophosphate pesticides.

Data from the two studies conducted by the Center For Red Meat Safety revealed an exceptionally low incidence of violative chemical residues in U.S. beef produced under "conventional" production/management conditions (Smith *et al.*, 1992; 1994a; 1994c; 1997). There were no violative residues of anabolic steroids (estrus suppressants; growth promotants), xenobiotics (growth promotants), heavy metals (environmental contaminants), stress reducers (tranquilizers), thyrostats/sulfa-drugs (growth promotants; health aids), beta-lactams (health aids), or tetracyclines (health aids). In one of the CSU studies in which violative residues occurred, the residues were of pesticides, and the highest incidence was in livers from beef cattle produced under "natural" (six of 1,575 tests; 0.38%) and "organic" (six of 1,575 tests; 0.38%) management conditions. The only violative residues of any chemical found in these two studies were in livers and not in meat *per se* (Smith *et al.*, 1997).

Results of the two studies conducted by the Center For Red Meat Safety reveal that it is highly unlikely that there is any difference in presence of harmful chemical residues of vaccines, pesticides, drugs, antibiotics and/or growth promotants between "conventional," "natural" and "organic" beef (National Live Stock and Meat Board, 1995). Beef companies that attempt to position a "natural" or "organic" product as safer or less dangerous to personal or public health by claiming that "conventional" beef contains violative chemical residues must be held accountable for conducting research studies of the type conducted by the Center For Red Meat Safety, to document their claims. To the best of our knowledge they have never done so (National Live Stock and Meat Board, 1995).

**Tests of Chemical Residues in Red Meat for (in order to Sell to) Other Countries**

A memorandum (ECD No. 90-22-EEC), sent by FSIS/USDA on March 29, 1990 to slaughter plants in the U.S. that were approved for export by the European Economic Community (EEC), detailed guidelines involved with the 1990 EEC Residue Testing Program for meat, and described "an expanded Residue Testing Program" consisting of five requirements; requirement number four identified 10 "residue compounds" (compounds/compound classes/elements) for which residue levels must be determined for meat to be exported to EEC countries (Fetzner, 1990). For dairy/beef breeding cows, these "residue compounds" were listed as (a) diethylstilbestrol, (b) zeranol, (c) thyrostat(s), (d) trenbolone acetate, (e) melengestrol acetate, (f) tranquilizer(s), (g) beta-blocker(s), (h) lead, (i) cadmium and (j) clenbuterol; for "nontreated beef" (presumably feedlot steers and heifers that had not been given growth-promotants or heat-suppressants), no analyses were required for items a, b, d, or e, above (Fetzner, 1990). For swine, USDA-FSIS-ECD No. 90-22-EEC Residue Testing Requirements for 1990 also are a barrier to exports of U.S. pork to Europe. The latter directive describes a residue testing program consisting of five requirements; requirement number four lists 10 compounds/compound classes/elements (later reduced to six—eliminating thyrostats, lead, cadmium and melengestrol acetate) for which residue levels must be determined. Residue compounds to be assayed in pork products and variety meats include: (a) diethylstilbestrol, (b) zeranol, (c) trenbolone acetate, (d) tranquilizers, (e) beta-blocker and (f) clenbuterol.

The Center For Red Meat Safety, in the Department of Animal Sciences at Colorado State University, has conducted several studies to determine the safety of U.S. beef and pork relative to presence/absence of violative chemical residues (as defined by EPA, FDA or USDA).

The first study involved Canadian bacon, chorizo sausage, ham, bacon, beef trim and pork fat; these products were produced by two packing/processing plants in Colorado and the investigation was funded by the Federal Agricultural Extension Service (USDA-ES). Results of that study (Sofos *et al.*, 1992; Kukay *et al.*, 1996) revealed no violative residues of anabolic steroids (zeranol, melengestrol acetate), heavy metals, tetracycline, sulfa drugs, chlorinated hydrocarbons or organophosphate pesticides. The second study involved muscle, fat, kidney and liver samples from steers, heifers and cows and included "organic," "natural," "conventional," "realizer" (chronically ill) and "cull cow" cattle. Analyses revealed no violative residues of anabolic steroids/xenobiotics (diethylstilbestrol, zeranol, trenbolone acetate, melengestrol acetate, clenbuterol), heavy metals, stress reducers, thyrostats/sulfa-drugs, chlorinated hydrocarbons or organophosphate pesticides (Smith *et al.*, 1994).

The third study involved muscle, fat, kidney and liver samples from steers and heifers and included "organic," "natural" and "conventional" beef. Analyses revealed no violative residues in muscle or fat, of anabolic steroids (estradiol, testosterone, progesterone), xenobiotics (zeranol, melengestrol acetate, trenbolone acetate), beta-lactam antibiotics, sulfa drugs, tetracycline antibiotics, chlorinated hydrocarbons or organophosphate pesticides (Smith *et al.*, 1997). The fourth study involved pork carcass fat, ham and fresh pork sausage collected from pork carcasses and from supermarkets or retail meat markets in the eastern, central and western portions of the United States. Analyses revealed no violative residues of chlorinated hydrocarbons or organophosphate pesticides (Smith *et al.*, 1993; Heaton *at al.*, 1993b; Heaton *et al.*, 1996). The fifth study involved muscle, fat, liver and kidney tissues from slaughter hogs and were used to assay levels of the six compounds/compound-classes specified for testing by the European Community. Analyses revealed no violative residues of anabolic steroids/xenobiotics (diethylstilbestrol, trenbolone acetate, zeranol, clenbuterol) or stress reducers (Smith *et al.*, 1993; Heaton *et al.*, 1993b; Heaton *et al.*, 1996).

A recent study by Schnell *et al.* (1995) revealed that there were no significant pesticide residues in beef carcass tissues or organs from cattle fed fruits, vegetables or fruit/vegetable byproducts during feedlot finishing.

**Test of Chemical Residues in Red Meat in Other Countries.**

Usborne (1994) compared "natural" and "conventional" beef, purchased as such in retail supermarkets in Canada, and reported no violative residues of sulfa-drugs, antibiotics, heavy metals, polychlorinated biphenyls, growth promotants, parasiticides, pentachlorophenol (a wood fungicide) or pesticides, in either kind of beef. Potthast (1993), of the German Meat Research Institute in Kulmbach, concluded--based upon studies of beef and pork from the European Union--that: (a) environmental residue contaminants (i.e., lead, mercury, cadmium) were hardly ever found, (b) pesticides had concentrations considerably below established limits such that complaints about pesticide contamination are becoming rare, (c) toxic dioxins, which arise mostly from combustion processes have not--so far--been detected in meat, and (d) random sampling and residue testing for antibiotics, drugs, anabolics and thyrostats effectively protect the consumer and assure that chemical residues in meat will not be harmful to the public health.

**Present Status of Meat and Poultry Safety in the U. S.**

Each year, the National Residue Program of the Food Safety and Inspection Service of the U.S. Department of Agriculture releases results of its nationwide residue monitoring efforts in U.S. meat and poultry (Carnevale, 1991). The National Residue Program for 1994 (USDA, 1996) tested for 42 chemicals in 12 classes of animal drug and pesticide compounds. FSIS/USDA, in announcing results for FY-1994 (in August, 1996), said, *"Only 0.18% of the 38,894 samples of livestock and poultry meats tested in 1994 by FSIS/USDA during our domestic routine residue-monitoring program showed illegal levels (violative concentrations) of pesticide, hormone, antibiotic, drug and other chemical residues, down from 0.26% in the 1991 samples, 0.29% in the 1992 samples and 0.26% in the 1993 samples"* (USDA, 1996). Nevertheless, producers, processors, wholesalers, retailers, scientists and agents of Federal/State governments must be constantly vigilant and do all that is possible to maintain and improve the safety of our food supply (Smith, 1995).

Sofos *et al.* (1992) conducted a study of residues of heavy metals (lead; cadmium), hormones (zeranol; melengestrol acetate), antibiotic (tetracycline), sulfa drugs (six specific sulfonamides) and pesticides (15 chlorinated hydrocarbons and 10 organophosphates) and did not find a single violative residue in Canadian bacon, Chorizo sausage, ham, bacon, beef trim or pork trim. The latter study, "National Extension Service--HACCP for Small- and Medium-Size Meat Plants," concluded that there were *no problematic or violative residues of heavy metals, hormones, antibiotics or pesticides in samples of six kinds of meat products (Sofos et al., 1992).*

Another study (Smith et al., 1994a) determined that *"tests prescribed by European Economic Community import-statutes confirm that U.S. beef does not contain violative or problematic residues of anabolic steroids, thyrostat, tranquilizers, beta-blocker, beta-agonist, heavy metals, sulfa-drugs, chlorinated hydrocarbons, or organophosphate pesticides."*

Finally, in summarizing results of all of the studies conducted between 1990 and 1995 by the Center For Red Meat Safety at Colorado State University, Smith et al. (1994b) at the Reciprocal Meat Conference of the American Meat Science Association said, "Data of these five studies reveal that the incidence of violative chemical residues in U.S. beef and pork produced under 'conventional' production/management conditions is exceptionally low; beef and pork are 'safe' based on absence of violative chemical residues."

## CONCLUSIONS

Why do we continue to use all these chemicals? Smith (1995) reported that Dr. Lowell Schake (of the University of Connecticut) said in September 1990, "Had humankind remained hunters and gatherers, the maximum human population that could have been sustained on planet Earth would be 30 million. As of this date, we have 5 billion people on Earth, and, we expect to have another 5 billion here in the early part of the 21st century. *We can and will feed all of those people because we have developed and used science and technology for food production"* (Smith, 1995).

The United States of America has the most abundant, the cheapest, and the safest food supply in the world. According to Smith (1995), Dr. Dixie Lee Ray (then, a scientist at the University of Washington and former Governor of Washington, said, in Priorities magazine in 1989, *"Despite all the evidence of our physical well-being, beyond the dreams of all previous generations, we seem to have become a nation of easily frightened people--the healthiest hypochondriacs in the world."*

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## QUESTIONS & ANSWERS

**Eng:** We have focused on the implant issue in Europe which represents one fear. But hasn't there been a structural change in Europe in the last several years toward over-civilization and against biotechnology?

**A:** Yes. Among the countries I've visited, European countries are the most radical in terms of animal welfare, handling issues, and proper animal treatment. Australia is growing that way; certainly, Australians are far more concerned about such things than we are. We are on our way toward greater concern about those issues; I think we do a pretty good job of explaining those issues - but it is coming. A time will come when we will have to identify for others, all the production systems that we use to make sure that we treat animals fairly. I have a class of twenty-three students from all over campus. We have just spent a week they know that discussing the Oprah Winfrey show. You can not imagine what people who do not know of Gary Weber say about Gary Weber. "I thought that man looked stupid." Intruth, he looked like he didn't know anything about the issue because of the way the tape was edited. They could not believe that we feed cow parts (from rendering) back to cows! They agree with Oprah. These issues will grow larger and larger in time. We must handle each one as we go and try to do the best we can to avoid criticism. I do not tell a dietitian that something is safe. I show them tables of data. Show them the data to make the point. Then, we're safe from criticism. I have had a very revealing experience working with the young people who will physicians for the next generation lack of general knowledge of anything practical! These people know anatomy, disease, and health, but most don't know anything about agriculture, where meat comes from, or what farmers and ranchers do. They think that food appears at the back of the grocery store. We must do whatever is necessary to teach them. It is hard to get entree into this group - very difficult to get your spokesmen to speak to them. But the young people that I have spoken to have lots of interest and questions. Usually, I spend an extra hour or hour and a half discussing agriculture with them after the seminar has ended. They don't know anything about such subjects, yet they want to be able to inform their patients correctly. If we keep fighting for such audiences we can present the facts that support our case.

## USDA RESIDUE TRACKING PROGRAM FOR GROWTH PROMOTANTS

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### ABSTRACT

Over 130 million head of livestock and 7 billion birds are slaughtered each year. The vast majority of those slaughtered in federally inspected facilities are free of violative residues. Prevention of chemical residues in the U.S. meat supply is economically important to the meat and poultry industry, not only because contaminated products are destroyed, but also because the market price drops in response to an increased consumer concern about the safety of the meat supply. The U.S. Department of Agriculture, the U.S. Environmental Protection Agency, and the U.S. Food and Drug Administration, are responsible for setting guidelines and residue tolerance levels to ensure the safety and wholesomeness of the U.S. meat supply. In conjunction with regulatory actions, the industry can contribute to the residue avoidance programs by implementing a Hazard Analysis Critical Control Point (HACCP) system approach to preventing violative levels of residues in meat and poultry products.

### INTRODUCTION

Over 130 million head of livestock and 7 billion birds are slaughtered each year. According to the U.S. Department of Agriculture (USDA), the vast majority that are slaughtered in federally inspected facilities are free of violative residues. This can be attributed to the education efforts by livestock trade associations in the area of residue control and the monitoring efforts of the USDA's National Residue Program. Prevention of chemical residues and the perception of residues in the U.S. meat supply is important economically to the meat and poultry industry, not only because contaminated products are destroyed, but also because the market price drops in response to an increased consumer concern about the perceived safety of the meat supply. Several federal government agencies are responsible for setting guidelines and residue tolerance levels to ensure to safety and wholesomeness of the U.S. meat supply.

### USDA's National Residue Program

The National Residue Program (NRP) is conducted by the USDA's Food Safety and Inspection Service (FSIS) as part of this agency's responsibility to ensure that all USDA inspected meat and poultry products are safe, wholesome, free of adulterating residues and accurately labeled. The goal of USDA's National Residue Program is to help prevent the marketing of animals containing unacceptable or violative residues from pesticides, animal drugs or potentially hazardous chemicals. Residue testing in the United States is divided into two areas: population sampling programs (monitoring, exploratory and surveillance testing) and enforcement testing. Each year, the National Residue Program collects over 400,000 meat and poultry product samples at FSIS and state inspected slaughter facilities. These samples are analyzed for violative residue concentrations; violations are determined by reference to residue limits for pesticides set by the Environmental Protection Agency (EPA) and for animal drugs and environmental contaminants set by the Food and Drug Administration (FDA). In-plant tests are an important part of the National Residue Program because they provide a rapid screening method to detect residues at the plant level.

#### *Monitoring Testing*

USDA's National Residue Program monitors specific animal populations to provide yearly information on the occurrence of residues nationally. The compounds considered in the monitoring program have established residue limits and are selected based on the potential hazard and availability of laboratory methods suitable for regulatory purposes. The results are used to identify producers or marketing entities that have animals with violative residue concentrations. In 1994, a total of 38,894 samples were analyzed from all classes of food-producing animals as part of NRP's monitoring activities. The NRP monitoring program sampled and tested for 12 classes of animal drugs and pesticide compounds comprising approximately 42 residues. Of the 38,894 monitoring samples, 70 showed violative residue concentrations. Violations included 23 sulfonamides, 19 antibiotics, 10 chlorinated hydrocarbons and chlorinated organophosphates, seven ivermectin, six levamisole, five arsenic and one morantel tartrate. In most cases, these are not safety hazards but simply residues within the typical tolerance range but for a species with no allowable usage of the test compound. (FSIS, 1994)

*Exploratory Testing*

Through the NRP exploratory programs, FSIS studies the occurrence of residues for which no residue limits have been set or for which a laboratory testing method has not been validated. The exploratory testing program evaluates chemicals such as trace metals, industrial chemicals and mycotoxins that do not have residue limits and are inadvertently present in animals. FSIS conducts exploratory studies to obtain information on the frequency and concentration of such residues. With this information, FSIS can better evaluate the need for residue limits to protect public health.

*Surveillance Testing*

Surveillance testing is designed to identify areas of the livestock and poultry populations where residue problems exist and to measure the extent of the problem. Once a residue problem has been identified, the impact of various actions taken to reduce the occurrence of residues in the populations are evaluated. Through this program, carcasses and organs may be retained pending test results. An example of this program is the surveillance for clenbuterol.

*Enforcement Testing*

As part of its enforcement testing activities, the NRP analyzes specimens obtained from individual animals or lots based on clinical signs or herd history. In 1994, a total of 364,728 enforcement samples were analyzed. According to the 1994 USDA Domestic Residue Data Book, the great majority of the 131.6 million head of livestock and 7.5 billion birds slaughtered in federally inspected plants are free of violative residues.

The National Residue Program's annual plan is developed during the preceding year through discussions among the residue planning staff, the FSIS Science and Technology Program, other FSIS programs and divisions and involved federal agencies. The plan is based on a "compound/slaughter class pair" design concept. The slaughter or production-classes are grouped with compounds that are determined by common production practices for particular animals because these factors impact the animal's exposure and the probability that residues may be present at slaughter. For example, market hogs have an exposure potential profile that differ from profiles for boars and sows. The NRP annual plan is dynamic and can be modified during the year as additional information becomes available or sampling and analytical capabilities change. (Franco, 1990)

*Compound Evaluation System*

In order to develop and manage the National Residue Plan, residues are given precedence using the Compound Evaluation System (CES). The CES has three elements: residue, hazard and exposure. (FSIS, 1995)

*Residue Evaluation*

FSIS is able to predict the likely presence of the first element, residue, by knowing the tolerances established by the FDA and EPA for specific compounds and assessing the pharmacokinetic properties of a compound including the rates of absorption, excretion and tissue distribution. Each compound is evaluated for its potential to produce residues in meat or poultry following the criteria that there is a zero-day withdrawal period established by FDA or EPA; the compound is biodegraded rapidly to non-toxic products; the compound is not absorbed; or if absorbed, is excreted rapidly; and the specific compound and its metabolites are physically unstable in the environment.

*Hazard Evaluation*

Hazard, refers to the inherent toxicity of a compound. Residues producing life-threatening, irreversible or severely debilitating toxic effects are emphasized through the hazard element. Toxicological profiles are based on findings from both clinical and laboratory studies and developed to evaluate the individual critical toxic effects of specific compounds. Once an overall conclusion is reached on the toxic effect of a specific compound, then the compound is assigned to one of five hazard categories:

(A) high health hazard potential, (B) moderate health hazard potential (C) low health hazard potential, (D) negligible health hazard potential, and (Z) insufficient information available.

### *Exposure Evaluation*

Exposure characterization (EC) is the third element of the Compound Evaluation System. Exposure characterization assesses the factors that influence the likelihood of human exposure to chemical residues of pesticides, animal drugs and other contaminant concentrations occurring in meat and poultry that may affect human health. An exposure characterization checklist is used by FSIS to provide uniformity and standardization in the evaluation of many variables known to affect the probability of a chemical residue occurring in meat and poultry. Based on the information in the EC checklist, the compound under consideration is assigned to one of five exposure categories ranging from (1) high probability of exposure, (2) moderate probability of exposure to (3) low probability of exposure and (4) negligible probability of exposure and (Z) designates a substance with insufficient information available.

### USDA's Residue Program for Growth Promoting Hormones

Although FSIS has received letters of concern from consumers about hormones in the meat supply, scientific data do not substantiate any cause for concern. USDA does not currently monitor growth promoting hormones because they do not pose a public health risk. Hormones are used by livestock producers to increase lean meat production and improve conversion of feed energy to lean meat products. The majority of cattle entering feedlots in the United States are given hormone implants. Five hormones are approved for use in the United States: estradiol, progesterone and testosterone, three natural hormones, and two synthetic hormones, zeranol and trenbolone acetate. Studies indicate that any increase above the normal level of these hormones in implanted livestock is so minute that it is insignificant. FDA toxicologists have concluded that any increase in the hormone level is insignificant if it does not exceed one percent of the daily production rate of natural hormones in prepubertal children. Furthermore, residues from naturally occurring hormones such as implants cannot be distinguished from naturally present hormone levels in livestock. Residues of natural or synthetic hormones always are well below tolerance levels. Thus, in 1992, hormones were taken out of the National Residue Program plan.

Because synthetic hormones are not produced by humans, zeranol and trenbolone underwent extensive toxicological testing to determine safe levels in meat before they were approved for use in livestock. The tissue residue tolerance levels for beef are 20 parts per billion for zeranol and 50 parts per billion for trenbolone acetate. Zeranol is approved for use in cattle, suckling calves and sheep. Zeranol is ranked as a C-2, which means it has a low health hazard potential with a moderate probability of exposure. Trenbolone, the other approved synthetic hormone, is classified as D, which means it has a negligible health hazard potential. In 1987, the Codex Committee on Residues of Veterinary Drugs in Foods met to evaluate the safety of hormone use for growth promotion and concluded that all five previously named hormones were unlikely to pose a human health hazard. (FSIS, 1993)

The only growth promotant that is currently being studied by the NRP is clenbuterol. Clenbuterol is a beta agonist used in some countries to treat respiratory conditions in livestock and to prevent premature uterine contractions in pregnant cattle. Although FDA has not approved clenbuterol for use in the United States, it has been used illegally in some livestock show circles to increase the muscle mass of animals. As part of its special study, the NRP is taking samples from meat-type show animals and testing them for clenbuterol residues. (FSIS, 1995)

### Should Industry or USDA be Monitoring for Current Growth Promotants?

Neither the U.S. meat industry nor the U.S. Department of Agriculture should test for growth promotants. First, there is overwhelming scientific evidence that meat from approved hormone-implanted cattle is completely safe. Second, because livestock producers have access to five approved hormone ear implants, there is no incentive for producers to use illegal growth promotants such as DES. Third, there is no practical way to test animals for the three natural hormones because they naturally occur in all cattle at levels that vary among cattle dependent upon their physiological state. Furthermore, extensive testing has been conducted on the two synthetic hormones to determine that residues always were well below a safe concentration level; thus, no residue tolerance level was required. Initiating test for hormone residues would not only be a waste of economic resources, but also it would send a negative signal to the European Union that we are not confident in the safety of our meat supply. (Brady, 1992)

**What are the Issues and Problems?**

On January 1, 1989, the European Union (EU) implemented a ban on red meat imports from animals treated with growth-promoting hormones; this cut off U.S. beef exports to the EU. This ban has cost the United States alone a projected $450 million in reduced red meat exports over the past seven years. Worldwide, this has caused even greater losses as countries have eliminated implants; this has increased costs of producing all beef - for local, as well as export markets. The United States then implemented unilateral retaliation measures. In 1987, the USDA (G.E. McEvoy and G.A. Pastoria) and Texas A&M (F.M.Byers), in a comprehensive assessment study, concluded that the U.S. impact of eliminating these growth regulators would range from $2.4 to 4.1 billion annually, and for the 26 beef producing nations, a 6% reduction in the 60 billion pounds of carcass beef produced; this represents $10 billion less in carcass beef produced alone. Scientific expert panels including the CODEX Committee on Residues of Veterinary Drugs and Foods along with an EEC committee of European scientists and even the EU's Conference on Growth Promotants all have concluded that the use of hormones as growth promotants in cattle are safe for consumers. With the formation of the World Trade Organization (WTO), the EU is now responsible for proving that the ban on U.S. red meat imports is based on sound scientific principles or else the EU must lift the ban. (FSIS, 1987)

In January 1996, the United States requested consultations of the WTO regarding the EU's hormone ban. Consultations were held on March 27, 1996, with Australia, Canada and New Zealand joining the United States in its complaint. However, the consultations were not successful in resolving the trade dispute. At the May meeting of the WTO's Dispute Settlement Body, the United States requested to have a panel examine the EU's ban on U.S. beef, but the EU blocked the request under WTO dispute settlement rules. On May 20, the United States made a second request for a WTO panel examination of the ban on U.S. beef. The United States' main objective is to reopen the EU market for U.S. beef exports.

**What Role Can HACCP Play?**

As a process approach to identifying, monitoring and controlling chemical, physical and microbial hazards, a Hazard Analysis Critical Control Point (HACCP) system would be the first step in preventing violative levels of residues in beef products. Using the seven HACCP principles, the following illustrates the first steps for chemical residue prevention:

1. Conduct a hazard analysis to identify potential hazards that could occur in the food production process. A chemical residue, potentially from an implant growth regulator, especially on an unapproved compound (i.e., clenbutenol), is a potential hazard in beef cattle operations.

2. Identify critical control points (CCPs), which are points in the process where potential hazards could occur and can be prevented and(or) controlled. An example CCP could be a cattle processing facility or an implant program.

3. Establish critical limits for preventive measures associated with each CCP. The critical limits could be the published and government-approved tissue residue tolerance levels for implants.

4. Monitor each CCP to ensure that it stays within the limits. This can be accomplished by maintaining records documenting proper implant administration of each animal during cattle processing.

5. Take corrective actions when monitoring determines a CCP is not within the established limits. Establish a process to manage animals when records indicate that the implant was not delivered properly and determine an acceptable procedure to follow to neutralize to remove an incorrectly placed implant.

6. Keep records that document that the HACCP system is monitored and working correctly. A HACCP plan might include electronic animal identification tags with appropriate information on implant administration, inventory of implant products and other administrative records.

7. Verify that the HACCP system is working properly through tests and other measures. This can be accomplished by reviewing data from liver and plasma samples to verify the absence residues. If a residue is detected, it could be traced back

through the electronic animal identification system and determined where in the process the problem occurred.

## CONCLUSIONS

Although U.S. regulatory agencies and several scientific panels have determined that growth promoting hormones are safe and pose no health risks for consumers, the EU's ban on U.S. beef still stands. Fortunately, the United States has an effective residue tracking program that is scientifically based and not only ensures that the meat supply is free of residues, but also aids in maintaining consumer confidence.

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## QUESTIONS & ANSWERS

**Question:** Shouldn't beef be tested routinely for residues from hormone implants?

**A:** I don't think hormone testing is necessary because of the low risk to public health. Residue testing for high risk compounds, I fully support. But there is no reason to test for hormone residues in the US because according to the FDA compound evaluation system, implants are safe and the risk is very low. We should not test for hormones simply because the Europeans think we should.

**Owens:** Wasn't there a problem in Puerto Rico some years back with hormone residues in meat? How was that resolved?

**A:** Basically what happened in Puerto Rico was connected to advanced puberty in young girls. Beef was blamed initially, but the culprit turned out to be birth control pills.

**Question:** How should the industry respond to the BSE problem that has plagued England?

**A:** The FDA has been considering the options and we have expected a response for the last two months. Basically, there are multiple options. One is a total ban on feeding ruminant protein to ruminants. This includes muscle tissue. Other variations including banning use of nervous tissue, spinal cord, brain, etc. I don't know what is delaying the decision. Perhaps the election. We expect a ruling any day. You can argue on either side of a ban. I have serious concerns about the public response to the BSE issue. We eventually will find BSE in the US if we search long enough. Some people are convinced that BSE is linked to the human disease CJD. We need to decide as an industry what we will tell the public in advance of a BSE detection. The first step is to stop feeding ruminant protein back to ruminants. I realize that this has serious ramifications for the rest of the animal industry including pet food. But as far as beef is concerned, we all should stand behind a ban. We also should eradicate scrapies (the sheep disease) in this country. Competitors like New Zealand, Argentina, and

Australia that can make the claim that they don't have scrapie; but we can't make that claim. The most important issue and the highest priority is for dealing with the perception of BSE. Number two is to find a rapid method for detecting the prion that works.

**Question:** How difficult would it be to eradicate scrapie?

**A:** It would be expensive and difficult. You need the proper education and commitment from state, federal and private sector groups. This is perhaps the very highest priority for the US sheep industry. The time for action is now. I can't give a dollar figure; we tried once before and it was stopped in the agency, but I think it has to be done.

**Question:** Is HACCP well perceived by the general public?

**A:** Are you talking about the consuming public? I think it is not well perceived. It probably shouldn't be. I doubt if we are going to educate the public what HACCP stands for. But we can educate them in a different way. We can educate them on the prevention method of being adapted by the industry. We can educate them on their role in food safety. I am more interested in making sure they are all aware of our industry's initiatives and understand what practicing HACCP can do.

**Question:** We talked about what we do as far as hormonal implants are concerned. I've heard some horror stories about the use of clenbuterol and other drugs being used in Europe. Can you comment on their drug control programs?

**A:** Let me answer with an illustration from several years ago. I was doing research with one of the largest retailers in Europe. They showed me the data on abscesses in their carcasses. More than 25% of the carcasses had injection site abscesses. Over 75% of the tissues from those abscesses had violations in use of up to ten different compounds; violations are 2 to 15 times larger than in the United States. This was fairly routine for this company. Universities were having difficulty buying animals for research that didn't have high residue levels. Problems with residues were rampant. Drug testing is Europe is mixed and not that sophisticated.

# RATIONALE FOR THE SAFETY OF IMPLANTS

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## INTRODUCTION

Hormonal stimulants have been used to improve growth and efficiency of beef cattle since 1954 (Preston, 1975 and 1987; Hancock et al. 1991). After feeding a nutritionally adequate diet, hormone implants are "the best technology that the cattle industry has for improved efficiency and decreased carcass fat" (Preston, 1993), or, more correctly, increased lean. Safety of implants, both for cattle and for people consuming beef, is assured by U. S. Food and Drug administration (FDA) approval prior to implant use in commercial practice. The compounds used in implants are classified as natural or synthetic, even though all are synthesized chemically. "Natural" compounds are those found in normal body metabolism; "synthetic" compounds have actions similar to the natural compounds but are not found in normal body metabolism. Freedom of Information Summaries, prepared by the manufacturer and available from the FDA, provide information on efficacy, dosage, investigators, animal safety, pharmacology, residue, human safety, and indications for use of all approved implant products. Estrogens and androgens are the primary compounds used in implants, although progestins also are found in some products.

### Estrogens

Diethylstilbestrol (DES) was the first hormonal growth stimulant used for cattle. It is a synthetic estrogen. Because it has activity when fed orally, it was either fed or implanted. Approval of DES was based on a residue bioassay sensitive to 3 ppb (Preston et al, 1956) that utilized its hormonal activity to increase the uterine weight of immature female mice. Potential intake from beef containing residues less than this amount were considered infinitesimal compared to human doses of DES used at that time for the prevention of miscarriage (later shown to be ineffective) and as a contraceptive (Marcus, 1994). Thus, in a sense, a "no hormonal effect level" (3 ppb) was used as the basis for the approval of DES for cattle production. Use of DES in cattle production was discontinued in 1979, after 25 years of use, not because of any safety problems associated with its use in cattle.

Estradiol (17-beta, E2) is a natural estrogen found in many implant products. The rationale for its safety was similar to that used for DES. This can be illustrated by comparing potential estrogen intake from various foods (Table 1); hormonal activity is present "naturally" in many human foods. Table 2 shows relative estrogen levels secreted by humans in various physiological stages and the daily payout of estrogen from an estrogen implant in a steer averaged over 120d, and the potential estrogen intake in beef from implanted cattle. Considering that the oral effectiveness of natural estrogens is low (approximately 10%), it is readily apparent that estradiol implants pose no human safety risk.

Zeranol also is used as an estrogenic implant compound. Classified as a synthetic estrogen, it was discovered as a fungally produced contaminant in moldy corn. Like estradiol, the potential intake of zeranol in beef from cattle implanted with this product is infinitesimally small (Stob et al, 1954).

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Table 1. Estrogenic activity of several common foods.

| Food | Estrogenic activity[1] |
|---|---|
| Soybean oil | 1,000,000 |
| Cabbage | 12,000 |
| Wheat germ | 2,000 |
| Peas | 2,000 |
| Eggs | 17,500 |
| Ice cream | 3,000 |
| Milk | 65 |
| Beef from pregnant female | 700 |
| Beef from implanted cattle | 11 |
| Beef from non-implanted cattle | 8 |

[1]ng/500 g of food.

Table 2. Estrogen production in humans, estrogen payout from a typical estrogen implant, and potential estrogen intake in beef from implanted cattle.

| Item | Estrogen amount |
|---|---|
| Estrogen production in humans: | |
| Pregnant woman | 90,000,000 ng/d |
| Non-pregnant woman | 5,000,000 ng/d |
| Adult man | 100,000 ng/d |
| Pre-puberal children | 40,000 ng/d |
| Synovex-S implant (120 d) | 120,000 ng/d |
| 500 g beef from implanted cattle | 11 ng |

**Androgens**

The primary androgen used in implant products is trenbolone acetate (TBA). Testosterone propionate is used in some implant products based on a no "hormonal effect level" for testosterone of .64 ppb; observed residue levels in beef from heifers 30 days after implantation were .101, .339, .034 and .450 ppb, respectively, for muscle, fat, liver and kidney, indicating a wide margin of safety for implant products containing testosterone propionate.

Activity of androgens can be partitioned into androgenic (male characteristics) and anabolic (muscle stimulation) effects. Compared to testosterone, the anabolic activity of TBA is much greater (8 to 10 fold) whereas its androgenic activity is relatively less (3 to 5 fold; Neuman, 1975). This is a major reason for TBA use in the newer implant products. During metabolism, the acetate group is hydrolyzed leaving the active compound, 17-beta trenbolone (17-beta TBOH), the primary form found in muscle. Via epimerization, 17-beta TBOH is converted to a less active metabolite, 17-alpha trenbolone (17-alpha TBOH), the primary form found in the liver, bile and feces (Heitzman and Harwood, 1977).

Based on radioimmunoassay procedures, residues of trenbolone 63 days after implantation are shown in Table 3 (Heitzman and Harwood, 1977); the difference in residue level between these two treatments probably is due to the difference in TBA dosage between the two implants rather than an effect of estradiol. Table 4 shows residues of 17-beta TBOH and 17-alpha TBOH 60 days after implantation with TBA (Dixon and Heitzman, 1983). The residue from 17-beta TBOH was much higher than from 17-alpha TBOH in muscle and fat, whereas the opposite was true for liver and kidney.

Table 3. Trenbolone residues (ppb) in steers implanted[1] with TBA[2] or TBA+E2[3].

| Tissue | Control | TBA | TBA+E2 |
|---|---|---|---|
| Muscle | 0.05 | 0.30 | 0.25 |
| Fat | 0 | 0.24 | 0.18 |
| Liver | 0.02 | 0.39 | 0.21 |
| Kidney | 0 | 0.11 | 0.06 |

[1]63 d prior to slaughter
[2]300 mg TBA
[3]140 mg TBA + 20 mg estradiol

Table 4. TBA residue forms and concentrations (ppb) from a cow implanted[1] with TBA[2].

| Tissue | 17B-TBOH[3] | 17A-TBOH[4] |
|---|---|---|
| Muscle | 0.27 | 0.04 |
| Fat | 0.25 | 0.15 |
| Liver | 0.28 | 1.42 |
| Kidney | 0.16 | 0.41 |

[1]60 d prior to slaughter
[2]300 mg TBA
[3]17beta-trenbolone
[4]17alpha-trenbolone

Do these residue levels of TBA pose a human safety problem? Part of any approval requirement is the determination of a "no hormonal effect level" (NHEL) in several animal species (Table 5). For the more active metabolite (17-beta TBOH), the pig is the most sensitive animal because it gives the lowest NHEL. Using the NHEL for both metabolites in the pig and a safety factor of 100, an acceptable daily intake (ADI) for a 60 kg human is calculated to be 6 and 216 ug/day (Table 6). Using an assumed consumption value for beef muscle, fat, liver and kidney (Table 7), consumption of both metabolites can be calculated as a maximum of .129 and .181 mg/day. These potential consumption amounts are then compared to ADI amounts for both metabolites (Table 8). As can be seen, both metabolites have very large safety factors. These results gave rise to a joint FAO/WHO conclusion that "the low residue levels of TBA and its metabolites in meat products would result in exposures far below levels at which hormonal activity was observed in animal models" (FAO/WHO, 1983).

Table 5. No hormonal effect level (NHEL) in several animals.

| Animal | Sex | Compound | NEHL[1] |
|---|---|---|---|
| Rat | Male/Female | TBA | 25 |
| Mouse | Male/Female | TBA | 50 |
| Pig | Barrow | 17B-TBOH | 10 |
| | Barrow | 17A-TBOH | >360 |
| Monkey | Castrate male | 17B-TBOH | >40 |
| | Female | TBA | >240 |

[1]No hormonal effect level; ug/kg body weight.

Table 6. Acceptable daily intake (ADI)[1] for humans[2].

| Metabolite | NHEL[3](pig) | ADI |
|---|---|---|
| 17B-TBOH | 10 | 6 ug/d |
| 17A-TBOH | 360 | 216 ug/d |

[1][(NHEL)(BW)] / (safety factor = 100).
[2]60 kg body weight (BW).
[3]No hormonal effect level.

Table 7. Potential human consumption of TBA metabolites.

| Tissue | Consumption[1] | 17B-TBOH[2] | 17A-TBOH[2] |
|---|---|---|---|
| Muscle | 300 | .081 | .012 |
| Fat | 50 | .012 | .007 |
| Liver | 100 | .028 | .142 |
| Kidney | 50 | .008 | .020 |
| Totals | 500 | .129 | .181 |

[1]Assumed consumption, g/d
[2]ug/d.

Table 8. Potential human consumption of TBA metabolites relative to ADI.

| Item | 17B-TBOH | 17A-TBOH |
|---|---|---|
| PDI[1] | .129 | .181 |
| ADI[2] | 6 | 216 |
| Safety factor[3] | 4,650x | 119,300x |

[1]Potential daily intake, ug/d.
[2]Acceptable daily intake, ug/d.
[3]Including the 100x safety factor used in calculating ADI.

**Implications**

The safety of properly administered hormonal implants in beef production is assured when FDA approves their use; such approval is highly important in national and international deliberations. Implant safety also is implied by the fact that historical (over 40 years) usage in cattle production has resulted in no observed safety problem. Furthermore, the following agencies and committees have concluded that the use of hormonal implant technology in cattle production poses no safety risk to humans consuming beef:

U. S. Food and Drug Administration
World Health Organization (WHO)
Food and Agriculture Organization (FAO)
Codex Alimentarius
European Economic Community (EEC) Scientific Working Group on Anabolic Agents (1981)
European Community (EC) Scientific Conference on Growth Promotion in Meat Production (1995)

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## QUESTIONS & ANSWERS

**Question:** It is common knowledge that athletes and sports enthusiasts use various steroids. Are implants being used by humans and what side effects are apparent?

**A:** I'm not aware of any abuse, but abuse may occur. Health defects may not show up for many years as was the case for DES used for pregnant women and effects on uterine cancer in their daughters. So effects of estrogen or steroid abuse may be very delayed.

# IMPLANT PRACTICES BY NUTRITIONAL CONSULTANTS: SURVEY RESULTS

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## ABSTRACT

Eight nutritional consultants (four independent and four corporate) were surveyed to determine implant practices. These consultants serviced feedlots in all the major cattle feeding states. An estrogen plus trenbolone acetate (**E + TBA**) combination implant was used as the terminal implant for steers by all eight consultants, with days targeted on the terminal implant ranging from 80 to 140. For heifers, a TBA implant was the primary terminal implant when melengesterol acetate (**MGA**) was fed, with days on the terminal TBA implant ranging from 80 to 140. When MGA was not fed, E + TBA was the choice for the terminal implant (range in days of 80 to 140). When steers received more than one implant, the range in days on the initial implant was 40 to 70 for zeranol, and 50 to 110 for estradiol benzoate. Initial implant practices generally were similar for steers and heifers. Research questions resulting from this survey include: 1) how many days does a given implant last?; 2) what differences in performance, carcass quality grade, incidence of dark cutters, and incidence of bullers exist between aggressive (i.e., fewer days targeted on a given implant) and conservative (i.e., more days targeted on a given implant) programs?

## INTRODUCTION

Consulting nutritionists typically are responsible for designing implant practices used in the commercial beef cattle feeding industry. To gain an appreciation for the nature of implant practices in use by consultants, a telephone survey of eight consulting nutritionists was conducted. The major focus of this survey was to determine the types of implants in use and the length of time targeted for use of particular implants.

### Procedures

A telephone survey of eight consulting nutritionists was conducted during the period of September 16 to 27, 1996. Live cattle prices averaged $71.99/cwt for steers and $71.95/cwt for heifers during this period; the carcass price difference between Choice and Select grades was approximately $5.00 (TCFA, 1996). Four of the eight consultants were independent, working for various feedlots on a fee basis; the remaining four consultants worked for cattle feeding corporations. Feedlots serviced by these eight consultants were located in all the major cattle feeding states (AZ, CA, ID, KS, NE, NM, OK, and TX) in the Western U.S. and Great Plains.

Each consultant was asked a series of questions regarding their implant practices. Specific questions included:

1. What is your terminal implant (the last implant before slaughter) program for steers?
2. What is your terminal implant program for heifers? How does this program vary with the feeding of MGA?
3. How many days are targeted on the terminal implant for steers and heifers?
4. What is your initial implant program for steers and heifers that will receive more than one implant before slaughter?
5. How many days are targeted on the initial implant for steers and heifers, and how does this vary with the type of initial implant?

Each consultant was assigned a letter designation to protect anonymity; results were tabulated for specific implants types in terms of the range in days targeted for use of various implants.

### Results and Discussion

Survey results for terminal implant use with steers are shown in Table 1. An E + TBA implant was used by all eight consultants as the terminal implant program for steers; however, the number of days targeted on the terminal implant varied from 80 to 140. For virtually all these consultants, cattle fed for short periods (100 d) would receive only one E + TBA implant during the feeding period. The wide range in days targeted for a terminal implant among these eight consultants presumably differentiates between "aggressive" and "conservative" implant strategies. A conservative strategy would involve only one implant with E + TBA for cattle on feed for 140 d, whereas an aggressive strategy would likely involve an initial implant (targeted for 60 d) with either zeranol or estradiol benzoate, followed by a terminal implant of E + TBA targeted for 80 d. The variable use of E + TBA by Consultant C depending on how cattle were marketed suggests that choice of aggressive or conservative strategies might vary with real or perceived differences in carcass quality.

Implant practices for heifers were impacted by the feeding of MGA; hence, results are presented for programs with or without MGA in Table 2. Typically, a TBA implant was the preferred terminal implant program for heifers fed MGA; however, two of the consultants used E + TBA implants in combination with MGA feeding. For non-MGA programs, an E + TBA implant was the preferred strategy. The range in days targeted for a particular implant was similar to the range observed for steers, as was the distribution of aggressive and conservative strategies.

Table 1. Implant practices survey: Terminal implant use with steers.

| Consultant | Terminal implant[a] | Days on terminal implant[b] |
|---|---|---|
| A | E + TBA | 80 to 130 |
| B | E + TBA | 100 to 140 |
| C | E + TBA | 80 to 85 (cash)<br>105 (formula) |
| D | E + TBA | ≥ 100 |
| E | E + TBA | 80 |
| F | E + TBA | 80 |
| G | E + TBA | 80 |
| H | E + TBA | 100 to 140 |

[a]E + TBA = estrogen plus trenbolone acetate combination implant.
[b]For Consultant C, (cash) = days on terminal implant for cattle sold on a cash market, whereas (formula) = days on terminal implant for cattle sold on formula pricing arrangements.

Table 2. Implant practice survey: Terminal implant use with heifers

| | With MGA | | Without MGA | |
|---|---|---|---|---|
| Consultant | Terminal implant[a] | Days on terminal implant[b] | Terminal implant[a] | Days on terminal implant |
| A | TBA | 80 to 110 | E + TBA | 80 to 130 |
| | E + TBA | 130 | | - |
| B | TBA | 100 to 140 | NA | - |
| C | TBA | 80 to 85 (cash) | E + TBA | ≤ 140 |
| | | 105 (formula) | | - |
| D | E + TBA | ≥ 100 | E + TBA | ≥ 100 |
| E | TBA | 80 | E + TBA | ≤ 110 |
| F | TBA | 80 | E + TBA | 80 |
| G | TBA | 85 | NA | - |
| H | TBA | 100 to 130 | E + TBA | 100 to 130 |

[a]TBA = trenbolone acetate implant; E + TBA = estrogen plus trenbolone acetate combination implant; NA = not applicable.
[b]For Consultant C, (cash) = days on terminal implant for cattle sold on a cash market, whereas (formula) = days on terminal implant for cattle sold on formula pricing arrangements.

For cattle that received more than one implant during the feeding period, days targeted on the initial implant are shown in Table 3. Because results were very similar for steers and heifers, only steer data are presented. Two types of implants typically were used by these eight consultants for initial implants: zeranol or estradiol benzoate. Clearly, zeranol (up to 70 d) was targeted for fewer days of use than estradiol benzoate (up to 110 d). As with terminal implant programs, the range in days targeted for a particular implant varied considerably among consultants, again presumably reflecting aggressive vs conservative strategies.

Table 3. Implant practices survey: Days on initial implant with steers[a]

| Consultant | Zeranol implant[b] | Estradiol benzoate implant[c] |
|---|---|---|
| A | ≤ 60 | ≤ 80 |
| B | ≤ 70 | ≤ 100 |
| C | ≤ 60 | ≤ 90 |
| D | NA | ≥ 50 |
| E | ≤ 70 | ≤ 110 |
| F | ≤ 40 | ≤ 70 |
| G | ≤ 60 | ≤ 90 |
| H | ≤ 60 | ≥ 50 |

[a]Steer data are generally applicable to heifers.
[b]NA = not applicable.
[c]Includes 72-mg zeranol implant for Consultant C.

Generally, these results suggest that the implants currently available for use in feedlot beef cattle production offer a wide range of possibilities of application in practice. A clearer understanding of how long a given implant should last (i.e., how long an implant provides an efficacious response in performance) seems needed. Moreover, more information is needed to determine the effects of aggressive and conservative implant programs on performance, carcass quality, meat tenderness, incidence of bullers, and so on. Answers to such questions should provide practicing nutritionists with the tools needed to design implant strategies that will meet a variety of production and marketing goals.

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## QUESTIONS & ANSWERS

**Horn:** Did you ask consultants about their current feed costs and the choice-select price spread?

**A:** No, I didn't. I surveyed consultants about two months ago, but I didn't ask that question.

# RESEARCH NEEDS IN ANIMAL PRODUCTION

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## ABSTRACT

Growth-promoting implants are a safe, efficacious, and economically important tool for use in beef cattle production. Despite decades of use, however, the mode of action of implants is not understood. Further research designed to delineate the modes of action of implants on both protein and lipid metabolism of ruminants is needed. In addition, data are needed to define threshold levels of growth-promoting compounds in the blood, particularly as related to the length of time that a particular type of implant will provide an efficacious performance and(or) metabolic response. Effects of implant type on maintenance requirements need to be determined, as do the potential effects of various implants on efficiency of conversion of metabolizable protein to net protein deposited in tissues. Relationships between response to various types of implants and feed intake also need further study. Development of research models that will allow critical study of the factors associated with dark-cutting beef and "bullers" would further our understanding of how implants impact these conditions.

## INTRODUCTION

This Oklahoma State University/Plains Nutrition Council Implant Conference provided a forum for experts to review virtually all aspects of the use of growth-promoting implants in the beef cattle industry. My charge was to assess the information presented to determine potential gaps in our research knowledge on implant use and to suggest areas of needed research. In the subsequent section, general areas of research are noted in italics; more specific topics are listed under each general area. The research areas I have suggested should not be viewed as either all-inclusive or top-priority; they clearly are affected by my own biases and research interests. Readers no doubt will glean additional ideas for needed research by reading individual papers on the various topics presented at the conference.

### Summary of Research Needs

*Understanding the mode of action of implants*: Although the beef cattle industry has been using growth-promoting implants since the mid-1950's, their mode of action is not completely understood. Initial hypotheses regarding effects of estrogenic implants being mediated directly through growth hormone have been largely discarded. Further research on the effects of various types of implants on IGF-1 concentrations, IGF-1 binding proteins, and IGF-1 receptor activity in liver and muscle tissue is needed. Moreover, data on the effects of implants on other hormonal systems (e.g., catecholamines, serotonin, dopamine, melatonin) are needed. Although increased protein accretion is the touchstone of implant activity, efforts to understand the mode of action of implants should include studies on both protein and lipid metabolism because effects of implants on lipid metabolism (e.g., changes in intramuscular fat deposition) are economically important.

*Determining the threshold level for activity and the optimum release pattern*: Research to determine the level of growth-promoting compound in the blood that provides for an efficacious production response should lead to more effective application of implants in practical beef cattle feeding. To determine this "threshold" level, research may be needed to first establish the appropriate response criteria (e.g., nitrogen balance, protein synthesis and degradation) for determining efficacy. Threshold levels for various implant types would be useful for deciding how many days a given implant should be used in multiple implant programs. Pattern of release of implants into the bloodstream might be related to the threshold level. Is an exponential decrease in release optimal, or is a steady release over time at or near the threshold level more desirable? Do spikes in growth-promoting compounds that are well above the threshold level have positive or negative effects on production responses to implants? How might previous implants impact the threshold level and efficacy of subsequent implants?

*Determining effects of implants on nutrient requirements and feed intake*: Limited data suggest that estrogenic implants tend to increase maintenance requirements; in contrast, trenbolone implants may have little effect, or even decrease the maintenance energy requirement. Further research in this area is needed, particularly with animals fed high-concentrate diets. Effects of estrogen-trenbolone combination implants need to be considered, as well as effects of the ratio of estrogen to trenbolone in combination implants. Data were presented at the conference to suggest that estrogen plus trenbolone implants may have a marked effect on the efficiency of conversion of metabolizable protein to net protein deposited in tissues. To accurately apply metabolizable protein systems (e.g., NRC, 1996), we will need more research designed to evaluate efficiency of net protein deposition by cattle of various body weights as affected by different implant programs. Might effects on maintenance or efficiency of nutrient use be related to changes in feed intake that occur with implants? Data are needed to determine the role of feed intake changes in responses to growth-promoting implants, as are data to determine optimum implant strategies for cattle that a limit- or program-fed at lower rates of gain.

*Effects of implants on carcass quality and animal behavior*: In addition to concerns about decreased quality grade with aggressive implant programs, research is needed to determine the effects of various implant types on meat tenderness and on the incidence of dark-cutting beef. For the dark-cutting beef issue, it may be necessary to develop a model system that will allow detailed studies of the factors related to this condition. Similarly, model systems might be useful to determine effects of implants on animal behavior, particularly "buller" animals that exhibit submissive behavior and "rider" animals that exhibit overly aggressive behavior. These conditions typically occur at very low rates in the feedlot cattle population; however, even these low rates of occurrence have a sizable economic and management impact.

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# RESEARCH NEEDS IN MEAT QUALITY

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## INTRODUCTION

Significant improvements in average daily gain and feed conversion make the economic incentive for using growth promotants irresistible for most cattle feeders. Although live performance is enhanced by growth promotants, carcass characteristics are either unaffected or, in some cases, negatively affected. I will outline research needs concerning possible effects of implants on the beef carcass.

### USDA Yield Grade and composition

Fat measures. Neither measure of fat in the carcass — fat thickness and kidney, pelvic, and heart fat — are influenced by the use of implants. Typically, cattle are being finished to the same endpoint with or without the use of growth promoting implants.

Carcass weight. Weights are impacted by growth promoting implants, and it appears that what really happens is that the growth curve of the animal is altered slightly so that it is heavier without necessarily being fatter. Weight is added until the desired degree of finish is achieved.

Ribeye area. Ribeye area is increased, but only in proportion to the increase in carcass weight. No evidence has been found that use of growth promoting implants increases muscling.

Carcass composition. Relative carcass composition — proportions of muscle, fat and bone — are not impacted by growth promoting implants. More volume of all of these are produced because of the increased carcass weights, but the relative percentages are not changed.

Research need: To find a way to obtain added weight with less fat as external, seam and kidney fat.

### USDA Quality Grade and palatability

Marbling. Without question, the most negative effect of using some classes of growth promotants is the reduction in marbling that in turn reduces USDA quality grade. This is coming at a time in history when the overall ability of cattle to grade U.S. Choice and Prime is at an all-time low. The economic penalty for not grading U.S. Choice (the Choice/Select price spread) seems to increase every year.

The research literature is full of comparisons of carcass characteristics of bulls versus steers. In almost all cases, bulls have substantially lower marbling scores and USDA quality grades than steers. Some growth promoting implants cause similar effects. What is needed is a clearer understanding of the mechanisms by which implants reduce marbling. Most research has shown what happens rather than why it happens.

Maturity. Lean and skeletal maturity are used to determine the approximate age of the animal at the time of slaughter. In theory, meat from an older animal is less tender than that from a younger animal. There is some indication that growth promotants may cause these maturity indicators to be more advanced than control animals that are not implanted. This issue will become more important in 1997 as the USDA implements a grading change that will result in those carcasses that have "B" maturity and have marbling scores of Slight or Small to be graded U.S. Standard. With this change in grade standards, even a few carcasses that would fall into this category could eliminate financial gains from enhanced live performance with implants.

Palatability. Research has shown either no change or a slight increase in Warner-Bratzler Shear force (tougher lean) with some classes of compounds. This slight reduction in tenderness as measured by shear force could translate into reduced customer satisfaction for beef products. Whether this increase in shear force is correlated with the reduction in marbling or some other mechanism is not clear.

Dark cutters. Today, some in the packing industry believe that some growth promotants, especially those that contain trenbolone acetate, cause an increased incidence of dark cutters in cattle. This thought was a more common in the early 1990s; it surfaced during the surveys of packers taken during the National Beef Quality Audit -- 1991 (Smith et al., 1992). During the 1995 repeat of the audit (Smith et al., 1995), this purported relationship was mentioned less often.

Dark cutting is a phenomenon whereby muscle glycogen, which is converted to lactic acid in postmortem muscle resulting in the development of the bright cherry red color of beef, is depleted in the living animal due to long-term stress. Because there is less glycogen present at the time of death, less lactic acid is generated postmortem resulting in darker colored lean. Stress can be induced by many factors or a combination of factors such as sudden temperature fluctuations (especially cold fronts), excitement, mixing of cattle and other events where the animal, through the release of adrenaline, must draw on its glycogen reserves for energy.

No research has found that the use of growth promotants causes dark cutters directly. It is believed, however, that if use of a growth promotant is correlated with an increase in dark cutting, other stress factors may be at work; any additional aggressiveness caused by the implant would contribute to this condition.

*Research need:* To better understand why carcass quality traits and tenderness are negatively impacted by the use of certain classes of growth promoting implants.

**Where do we go from here?**

*Future direction of research.* To date, most research has focused on the results of using growth promoting implants, not on their mechanisms of action. Although many theories exist for how implants accomplish their positive effects, few studies have been reported that support these theories. Without question, more mechanistic research is need to better reflect how and why growth promoting implants make animals grow more rapidly.

*New endpoints of concern.* Some compounds should be developed that improve the quality — marbling and tenderness — of beef. With a move to more formula-based selling where carcass characteristics determine the value and the price paid for carcasses, and to more branded beef products, the focus on carcass traits will increase over time. We should begin now to find compounds that could be used to improve carcass and palatability traits of cattle. The financial incentive for doing so will become more evident in the future.

*Growth promotants in a total integrated system of beef production.* For too long, the use of growth promotants has been an activity of interest to only the cattle feeding segment of beef production. Because of this, compounds were created that addressed the most important aspects for that segment of the industry: average daily gain and feed efficiency. Unfortunately, some compounds that may maximize these important components of the cattle feeding segment of the industry may result in a final product that is less desirable for the consumer. In the future, a systems approach should be used when evaluating growth promotants. Compounds should be developed and used that enhance feedlot performance without causing negative effects on the carcass or meat quality.

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## QUESTIONS AND ANSWERS

**Q:** You talked about tenderness and said that it has been documented that consumers are willing to pay more for tender meat. Just quickly talk about that because I think that it is important for people to know.

**A:** One of the challenges you face as a researcher in the meat science area is that when someone asks you about measuring or sorting carcasses on their tenderness level by some instrument, you must answer by saying how much is it worth for tender beef? In the marketplace, brisket and tenderloin have the same yields from the carcass yet their values range from $.79 for brisket to $6.79 for tenderloin. Obviously, people are willing to pay more for tender cuts than for tougher cuts. What we do not know is within cuts, how much more are they willing to pay. Take the top sirloin butt for instance. Twenty years ago, it sold for about $2.00 per pound. Today, it sells for less than that because it does not deliver the customer satisfaction of the other middle meats — ribeye, strip loin, and tenderloin — which have all gone up in value in the same time period.

We conducted a study that sorted beef based on its shear force value and color-coded it for in-home consumer use. After that phase of the study, we invited consumers into a simulated retail store to asked them to purchase the product at the same price per pound. They purchased more of the product from the lower shear force category. We invited them back at a later time and then priced the product where the "tender" group was $.50 per pound more than the "average" and the "average" was $.50 more than the "tough" group. Consumers still purchased more of the "tender" group than either of the remaining two groups.

These kinds of studies are important to see what the price/value threshold is for beef. Our other alternative is for diminishing quality and eating satisfaction which will eventually result in reduced prices and market share for beef. We need to find ways of improving the quality of the product and the demand will take care of itself.

**Q:** Would you speak more on what you meant by finding compounds that really increase carcass characteristics?

**A:** What I meant was what would be the opportunity for a growth promoting implant that instead of diminishing quality, increased it. It is very easy to determine what a compound is worth if you can increase average daily gain and feed efficiency, but it is more difficult to determine what a compound would be worth if it increased USDA quality grade. The only way to be rewarded for this is to sell cattle "on the rail" on some sort of grid-based system.

As I mentioned earlier, cattle are losing their ability to grade U.S. Choice. This is very important because of where the growth in beef consumption is coming from the high-end restaurant trade. Programs such as Certified Angus Beef demonstrate the value there is for even slight increases in marbling in the marketplace. If we are genetically losing marbling ability, and with the further loss in marbling due to the use of very aggressive growth promotants, the beef industry stands to lose more market share because it does not have the product that the market is demanding.

**Q:** What do you think realistically would have some objective grading system in place to do electronically or mechanical or ultrasonic assessment of marbling or maturity in the feedlot?

**A:** There is simply not enough effort in this area to be making any headway into developing an instrument to use on live animals. Several years ago, the University of Illinois was awarded a grant to study this, but it was terminated because of a lack of progress. This area is very expensive to investigate and will take both time and money to accomplish. Under the present system we have in the U.S., we are not making enough progress in this area for this to be a viable approach to the evaluation of live animals.

## PANEL DISCUSSION

Including Wally Koers, Steve Hays, Ken Eng and Mike Hubbert

**Koers:** Serious challenges face our industry. This isn't anything new, but considering how segmented the profit centers of the beef industry are, and we have touched on most segments today, one thing is very striking: We have to hunt back to 1978 to find complete life cycle information, and that data barely considers carcass quality. We better get that corrected in our research! Each of those segments focuses on total pounds per day with little or no concern for the final overall quality. We are centered on our little profit segment. I am not saying that's wrong or bad, but that may not be best for the final overall product we are trying to produce. I would like to make a very strong statement that we in different companies in the industry, need to support large scale lifetime research on cattle. Some large companies control thousands and thousands of cattle on grass. It just takes effort to follow cattle through. We better get into gear on this or we are not going to improve our market share.

We have talked all day about implanting and reimplanting with the assumption that we have to implant. We don't have to reimplant. Reimplanting does sell more products. I refuse to believe that we cannot create or evolve the technology to do away with reimplanting for at least two hundred days. What we may give up must be balanced against total product and profitability risks. Compudose was on the right track. Technologically, the direction was absolutely correct.

It is one thing to reimplant two or three hundred head of cattle and quite another to implant pens that contain four, five, or six hundred head. There is a labor, time, and talent conflict here that is major for feedyards of the 21st century.

I've been a big pusher of reimplanting at various times, but we have some products where we probably don't have to reimplant as much as we think we do. Do we give up a little something? Maybe so, but it is time to quit being an industry of extremes. Go for the whole "productive banana" and we may mess up a good product.

Live animal average daily gain and dry matter conversions are important, but we need to focus more on carcass quality and gain. If our industry can pull through some of these knots and change a few of those things, we could make some true progress.

The focus of this panel is formula selling versus live selling. You can take the short term view say, "Well, if I sell live, I'm not responsible for the final quality" and ignore the select choice spread. If you are selling on the formula, this $20 or $22 good spread choice really hits you. If you take the short term view and say, "Hey, I'm selling live, I'm not really that concerned about the spread so I'm going to do everything I can to maximize pounds" you are disregarding quality.

Another statement I hear is "Well, in the region where I have my feedlot, 95% of the cattle going through are all sold live so the quality grade is low on all the cattle and it really doesn't make any difference." In the short term, that may be true, but do you know who that ignores? The consumer! If we believe everything we hear particularly about the international demand for our beef and the international demand for the choice beef, the one that pays the price is the consumer. Later, we pay a price because the consumer says, "No thank you."

**Hays:** Prior to moving to Cimarron, I managed Colorado Beef in Lamar, Colorado. There, we marketed cattle on formula. When I first came to Cimarron, we marketed on formula basis. Since then we have gone back to a cash basis, so I have some experience on both sides, but I'm about as far from an expert as you can get. Several things that Wally touched on that are extremely tough in our industry today. We have got a live cattle futures contract that could not be more broken than it is today. With exception of last month, it has had a cash premium every day since it started out in June. There is absolutely no way we can manage risk in that situation. Our cash market has gotten hysterical. It is exemplified this week by about three hours; in which the industry gave up $2 on a smaller show list at a time when beef demand is high, although we do have a wide spread. Obviously, with the price of our cut out product there is good demand for our product today. So we have some problems. On the other hand, we keep trying to point fingers at captive supplies. Captive supply has not changed in the last 10 years. The number of cattle reported on a cash basis to the USDA in the last ten years it has been flat at 40%. I would not have believed that until a couple of weeks ago when I saw that data and recently the Texas Cattle Feeders Association confirmed their survey. So although we hear a lot and talk a lot about captive supply, it has been relatively stable the last few years.

One of our problems in the industry, is that we are segmented. As the years pass pork and poultry may have to grab us by the hand and pull us along. We can't lose sight of why we are in business: to feed the world, as good and efficiently as we possibly can. We see performance results consistently from implants and get favorable performance through reimplants. It is our responsibility to produce a high quality product as cheaply and efficiently as we can. Basically, that's our business. When we formulate our implant strategies, there is one major factor and that is cost of gain. I hope that some of the things that we talk about will relate to guys who think they can control percentage choice. As a feeder, have some influence on yield, but every time I have tried to feed cattle a little longer to try to make choice, I have been very disappointed regardless of the type of implant program or feeding program that I have used. Whether sold by a grid or a formula, for us to be a long term rising industry, we have got to change they way we implant. We have got to get closer to consumers. I wish I knew how. I don't think it is going to come from me or anybody else in this room. Probably graduate students and someone with a fresh mind. I hope that we will be able to touch on some of those things.

**Eng:** As I look back over my experiences in industry and the university, we have had two or three different segments in the university and the industry that have had their share of fame. When I started in school, breeders and geneticists were getting most of the attention. Then, for better or for worse the nutrition area gathered a lot of attention for developments in the nutrition area. Some good work was done and still may be. In the last few years, suddenly we have a rising group of meat stars that have come out of the closet. This started with Gary Smith and now we have Glen Dolezal, Brad Morgan, and Jeff Savell, Montgomery and others, people that have a very high profile, are very talented; they present a very good case and are dedicated. Basically, this is good, but one thing that bothers me is that I hear too much bashing of our product. I am tired of hearing that 25% of beef is no good. That is not my eating experience, and I eat as much beef as anybody. In our organization, we share at least three steers a year with our employees and we never butcher the best one. Over the last ten years, that totals thirty cattle. We should have had at least seven bad eating experiences out of that thirty, but I don't recall one. I don't know what is wrong with that picture, but I don't see one lousy piece of meat for every four cuts that we talked about. I know that people that talk about poor beef quality are serious and want to see our product improve; that is fine. But, I think we are too critical about our product. A lot of this starts with meats people and I want them to be a little more positive. I get tired of the bad mouthing every time we have problem with tenderness or anything else, not necessarily from meats people but from the meat industry, as well. I would like to see us strive to improve our product. We are all for tender beef: we are all for good flavored beef; but we should approach things in a more positive manner and quit seeing all of our dirty laundry in public. Let's stay home and do our work.

The second thing is that we may have created a monster with this B-maturity thing. At best it will not bother us too much. But, frankly, it already has. I don't care about the economic analysis that they have done. The rancher has already taken a $100/head hickey on every open heifer and heiferette they have sold because people are afraid to buy them. They don't know how they've been raised, so that hickey already has been taken. Whether or not it is correct for the consumers that buy our product, a lot of reviews indicate that we have a loose cannon and lots of problems coming up January 31. To anybody that is surprised at that happening and says that it is not justified, I would say, "Wake up and smell the coffee." This is a predicament we should have thought through. Brad did a very nice job in presenting this today and several people alluded to Wyoming data on virgin, spayed and one-calf heifers that did differ in maturity. One thing that was left out is that in terms of the meat eating quality, there was no difference despite the fact that it might make a $20, $30, or $40 difference in carcass value. We need to think about this. Perhaps implants may have an impact on maturity. There must be some enormous genetic differences. We have an incredible difference on the age that heifers reach puberty, and anybody that has handled, bought, fed and grazed a lot of young heifers knows that some can be bred at an incredibly young age. If pregnancy impacts mature which I suspect it does, we could potentially have 15 month old heifers falling into the B maturity category. I find it interesting, but discouraging that approximately two weeks ago we started a study on the impact of B maturity in the market place. Here we have a new regulation which is going in to effect on January 31 and we have waited until three months prior to that to do a study. Again, it remains to be seen how large the problem will be for the feedlot industry, but the rancher has already "taken a big hit". I also find it disappointing that some viewed this regulation as a way to penalize or get even with those who feed Mexican cattle. This would be funny were it not so sad because this year, feeding Mexican cattle is a "non-event" because very few have crossed into the United State. Furthermore, Mexico should be considered a friend rather than a foe of our industry because among other things, they are one of our best beef customers.

**Hubbert:** My background is feeding Mexican cattle in Arizona. We receive a hundred thousand head, mostly 3 to 450 weight cattle. We feed to a specific target and deal with 700 to 1100 pound carcass yielding 64 with a yield grade of 2.6, I work with a lot with different implant regimans, feeding programs and limit feeding programs.

## QUESTIONS AND ANSWERS

**Question:** What is the possibility of a delay in the grading change for discounting cattle over 30 months of age?

**Dolezal:** The only possibility now is an injunction. The change already is in the federal register.

**Van Koevering:** Cattle are implanted 100 to 180 days prior to being marketed. How do you know this far ahead what the choice/select spread will be so that you can select the proper implant to use? You can follow yearly trends, but the choice/select spread can change by $10 in just two weeks.

**Koers:** We have used historical information over the past 4 to 10 years to check seasonal trends to get some idea. If you take a 10 year average, you get a different picture from the last 4 years. We try to advise our clients with our best judgement based on historic information and current trends in the industry. We then recommend a specific program to assess the risk relative to percent choice. Results will vary with the kind of cattle. There is not enough information to be specific about the risk. The other factor that makes a huge difference is ration cost. With a $2 choice spread and $250 a ton dry matter ration price, you go for pounds and profitability comes with it. But with a $20 spread and ration dry matter from $60 to $100 a ton cheaper, the decision is not hard. It is hard to be directly responsible for causing a 10 to 15% drop in the percentage of choice carcasses. From the consultant's point of view, we try to identify risk for the feedlot and assist with the most profitable decision.

**Hayes:** Presumably, steers with a yield grade of 1 or 2 are worth about $8 more per hundred that those with a yield grade of 3.

**Hubbert:** We have a set marketing plan. We are marketing approximately 20 to 22 hundred a week every week in the year. Basically we are a packing company that owns our own cattle. Our executives look at the yearly spread averages and use an implant program for maximum profit per head in the box that works year round. You don't mess with management in a 50,000 head feedyard or 100,000 head feedyard. We try not to make things too complicated or we can get ourselves in a wreck. So we just try to keep our implant system as clean as possible. We have used spread from time to time, but we have guessed wrong. So we have opted to use a crude implant program with the highest returns per head on a yearly average since we sell cattle each week.

**Hayes:** How do you view the future of live versus formula selling if fewer cattle are being sold live? What kind of mechanism is available to put a price on the formula if live prices are not reliable? Can something like Dolezal formula for value based marketing be used to establish the value of beef? Is that a direction we can or will go?

**Eng:** I think that we will continue to have both formula and live selling of cattle. The ratio will depend on competition. We have distinctly more competition in some regional areas than others; there are more alternatives in areas with more competition.

**Koers:** Does anybody here know what percentage of the hogs today are sold live? Somewhere between

60 to 70%. How many here believe that figure? When I first heard that number, I challenged it. I didn't believe that it was true but now I understand that it is true. To answer the first part of the question about whether someday we will sell no cattle live? No. But the people that will not sell live are those that are oriented to specific niche markets. They are aiming for a specific quality product. The beef industry today is a discount industry, not a premium industry. We discount everything we buy. That holds true all through our industry; that has to change.

The only way to become a premium industry is to pass premiums down through the system. I have never seen a cattle buyer come to a feedlot yet and brag about what they have; usually, they're evaluated on the 2:2 account. Cattle are either 2 tall, 2 short, 2 fat, 2 thin, 2 short fed, 2 long fed, 2 black and white, not black and white enough, or whatever. This is a discount system. In terms of what the price discovery should be, it must be just creative with lots of opportunity for those working that direction. That method or some other specific method will get away from a lot of inequities of live selling. I've used both live and formula selling. I think a lot of people perceive that all cattle will sell by a formula in the future, but that hasn't happened in the hog industry.

**Strong (Feedlot Magazine):** One big issue here and that is the consumer really doesn't know the difference between select, choice, and other grades.

**Dolezal:** I agree. Kenny Eng says that he never gets bad meat - that is because Caroline is an excellent cook. In meat preparation, much of this changed in the late '80s with Jeff (Savell) playing a big part when extension beef specialists began training young couples on how to prepare meat correctly. Today, everything goes microwave. We don't cook like we did in the past. Traditions were lost. Everything is fine when cooked medium rare. A lot of the difference between select and choice is chewiness; less fat insulates it from the heat. At the opposite extreme, many people today don't like the rare, bloody flavor that many of us grew up understanding and appreciating. Now, they like it well done. This is a double edged sword. If you stop at medium rare, customers leave beef because they don't like the bloody flavor. If you cook it well done, it gets too tough. Nothing works. One of the most frustrating things is that our industry has remained a dinosaur on many fronts. It hasn't adopted technology to improve eating satisfaction. We retain marbling as an index rather than turning to blade tenderization and aging. Packers sell a commodity as choice or select, and do not adopt technologies that would improve beef quality and consistency. This is very frustrating.

**Q:** Will the beef industry adapt the ISO-9000 standards and would that be good or bad?

**Hayes:** Can someone explain the ISO-9000 standards?

**Morgan:** Most of us are familiar with HAACP in which by inspecting and upgrading a process greater quality assurance into our product. In food safety, we inspect the system to find flaws and correct them. ISO-9000 is an international program and many European companies are ISO 9000 approved. In ISO 9000, 9000 is just a series number. For example, management is 9002. The ISO standards are sets of regulations to assure that production, rigid controls and minimums are met. These regulations make our passive inspection programs look like Ned's first grade reader. Some of the foreign countries have supermarkets called Iso where everything in the store has been produced under this ISO-9000 production system. Using these check points, quality assurance, safety, and, through uniformity, consumer satisfaction should be built into the product.

The United States has an international standards order, too. Many of the chemicals and engineered and manufactured products of the United States are ISO-9000 in order to market them in Europe.

**Hubbert:** In contrast to Dr. Koers' earlier comment, the last thing I want is only 200 day implants One is needed for 50 days, one for 70 days, and one for 200 days because cattle are not all 200 day cattle. Payout rates of implants need to differ for different breeds and growth rates. With a large number of the implants, we now can mix and match implants for specific purposes with specific types of cattle fed specific feeds and meet a specific market. A variable implant team has advantages over a single implant that lasts 200 days.

**Q:** For poultry, we have many branded name products on the store shelves. What impact would branded products have? Is our industry ready to move that direction? Can we use specific brand labels to designate types and qualities in the meat showcase and bypass many of the problems that we keep discussing such as the grading system we have today. Is that a viable option and can it happen in the beef industry?

**Dolezal:** In the late '80s, several companies tried to incorporate retail ready packaging and brand labels. The last approach was the "Double Diamond" and that has been discontinued. Now one line is being called "lean sensibles." This is being offered not only in beef but also pork and veal. You're exactly right. This is one of the technologies, one of the options, that gives packers an opportunity to marinate cuts, to blade tenderize cuts, to get an impressive package that keeps out oxygen to extend shelf life. We see more expansion in pork than in beef. Since there is little if any price competition in brand name products so, price is not a big driver to force all three packers to do it. At the start of the '90s, many of us dreamed that this would lead the way and open the door to start selling beef with guaranteed eating satisfaction through mechanical means or post mortem technology after it came to slaughter. But brand labels just haven't taken off.

**A:** The beef quality grading system is only an option. Some economist think we ought to discard the beef quality grading system. But right now, packers they don't have to use it. What difference does it make if you want to box it or not? If packers would produce branded products following their own quality standards today; they could brand them all either with or without a government grade. But most packers I've talked to don't have any better index of quality than marbling at this point. If they were to set their own grading system, they probably would incorporate the current quality grading system into their branding program.

**Smith:** Most clients that I work have all entertained the branded product idea. It's not a bad idea. There could be some real successes and there are some success stories. But I don't think branding is going to bypass grade and I don't think the grading system should be thrown out. We had better stay alert to the international demand for our meat products where the prime/choice/select grading system means something. It means something to a lot of our consumers, too. I think improvements can be made, but we better be careful before we throw out our current system without a good replacement.

**Van Koevering:** We've learned a lot from our corporate division and branded products program. We have had a lot of success launching our beef product right now. We see branded product as something that will grow in the future and we're working to set up alliances so that we track an animal from birth all the way into the packing plant and control production along the way. In this way, we will know where injection sights are located, which implants are used, and everything that makes a quality product. Whether we stop using USDA grades is a wholly different issue. We will see producers in the future maintaining control over animals so they can make a branded product, something that they can guarantee to not have returned.

**Hayes:** Products made by every other industry are sold with a label. This branded beef idea makes life complicated and people have had a hard time making it work. We have over looked something really simple. We could incorporate both accountability and feedback into the system if we simply required that every meat package in the retail counter carried the packers name prominently displayed. If it's a good product, it will sell. If not, the consumer will know who to notify. If it is good, they will continue to buy it. With the current system, the packer is not identified. Of course we know that we are an industry that really trusts our packers.

**Eng:** I like that idea. One of my pet peeves is that many things could be done by the packer to improve the tenderness of our product. They find excuses not to use technology and would rather complain about implants or something. If packers were required to label their products, that might entice them to do provide added value. I think that's a great idea.

**Owens:** My wife, a human nutritionist., says that current methods for meat display and sales are obsolete. The major change in the last 50 years is that now the meat sits on a diaper that absorbs some of the juices that previously spilled over everything else in the grocery cart. Compare that unlabelled pile of hamburger to a box of Hamburger Helper. The Hamburger Helper has complete preparation instructions including illustrations of the cups to be used. The beef industry could do a lot to improve packaging, labeling, and marketing our product to improve consumer satisfaction.

## PANEL DISCUSSION

Including Wally Koers, Steve Hays, Ken Eng and Mike Hubbert

**Koers:** One of my pet peeves relates to consumer acceptance. In everything that I have read about the consumer acceptance and panels, the number one barometer is tenderness. You can have a tender piece of juicy meat which is great but you can have a tough but juicy piece of meat and it is not. I refuse to accept the idea that we cannot come up with some technology to determine tenderness at a rapid chain speed in the packing plant. I've listened to all the excuses and I reject them all. We need to take our head out of the sand and do it. If we don't have the resources, let's get together a bunch of people and twist some arms. Mike Engler has an Engler tenderness award for any system that will work. Koers-Turgeon Consulting will pledge $1,000,000 or more right here tonight if that is what is needed to break the barriers in this area. It is absolutely ridiculous that we do not have the technology to measure and improve tenderness.

**Dolezal:** Often, people say that they aren't interested in this technology because that's not what sells right now.

**Smith:** Regarding acceptance of our product in the marketplace, during the last two years I have entered been studying human nutrition from an animal scientist's viewpoint. I do a lot of human nutrition seminars and I work with human nutritionists and dietitians. The first questions I get after a seminar for a public group not related to the animal industry is: "Is it safe to eat beef? Why should I eat beef?" At first, the prominence of these questions shocked me. When I would explain the virtues of beef versus other food items that they consume, some people thank me profusely for telling them that it is OK to eat beef. They are deadly serious and excited as can be because someone said it was OK to eat beef. But the other side of the picture is a challenge we face. All human nutrition books today, especially those related to the herbal world, in the section on meat makes the same statement. It is an accepted fact, as repeated in these books, that you beef producers are selling a product laced with hormones and they will get cancer if they eat beef. If spread of this concept continues, we will not have to worry about grading standards. We need greater education, not only for our producers, but for the consumers regarding meat safety, why they eat it, its value, and what it can do for them. Consumer and nutrition education is one of our more serious problems right now. Pick up and read any nutrition book, especially related to hormones, if you doubt my word. It is in every one of them.

**A:** I agree with you whole heartedly. Many times in the last 6 months I have read an article that says exactly that. Some of those articles, like one on "Beef is too Fat" cites or has been written by a member one of the associations who gets their dues or salary support from the beef industry. We need to stop criticizing our product and start promoting beef on its merits.

**Q:** Back on this formula versus live selling of cattle. Is there any advantage selling formula unless you can beat the plant average?

**Hayes:** If your feedlot is located in a tight spot like Lamar, Colorado or the Arkansas Valley, you have only one packer buyer in the area. Lacking competitors, formula selling offers a different opportunity. In addition, formula selling has an advantage in a weak market. On a down market, you trade on a formula basis and are being paid this week on last week's market, so you trail a down market. But the reverse happens when the market turns and begins to rise.

**Hubbert:** That's a good question. We can find quite different scenarios and simulations depending on cattle type and whether we work from the Texas Market or some combination of markets from Nebraska and Kansas, whichever you use as a live market base. If your going to go to a formula the higher the price, the better. If you are using a yield basis with an Amarillo average of 63.75 and I'm feeding calves that yield 64½ to 65, I can beat the live market on yield alone. This depends on the quality of the cattle. If I have a bunch of big yearlings that are going to yield 62½, it may not be desirable to sell on the formula. That brings up a bunch of difficult alliances, the Hereford alliance, the red angus alliance or others, and the different kinds of formulas they put out. They have specific targets that you can learn to hit providing you understand what it take to hit a target grade and carcass weight. You can't start with yearlings and hit a lot of these targets that deduct for heavy weight carcasses. You need to start with a 550 pound calves with a weight distribution of only 10% so that out weights will be about the same. We've tried several different sorting programs; we've used visual sorting and weight for age at different ages in the feeding program to try to hit specific targets. Formulas provides an opportunity to take a subaverage product and create an average product out of it, and then thereby be smart producer.

**A:** One of the real surprises I got from formula selling was that cattle that were being discounted were 2, 4, and $5 hundred weights when being sold live, suddenly went to having a $1 premium because they graded. These were ugly, thin Mexican cattle. They graded because of more maturity. The formula took those cattle into an interesting market, but now a lot of that's changed. They didn't produce the greatest box product, but that was very clearly one of major spin offs that made lots of money for some people.

**Q:** Mike Van Koevering made a good point a while ago about using specific hormone implant program from start to finish to control gain and quality grade. Has anyone tried to use different implant programs for cattle in a pen that differ in size or mature weight in order to reduce the variation among cattle in a pen at slaughter?

**A:** We have not used implants in this manner due to management problems. We try to keep implant programs simple to avoid errors.

**A:** That's an interesting thought but it would be difficult to implement. One concern is that if animals in a pen differ in implant status, the probability of bullers may be increased.

**A:** We gather 350 pound crossbred steers and feed them to around 650 pounds before sorting. In a pen averaging 650 pounds, the top 25% average around 725 pounds while the bottom 25% are around 580 pounds. These are sorted and go onto new feeding and implant programs. We sort on the basis of weight alone with some visual corrections. We've been very pleased with the results. Our discounts for carcass weights are at 550 and 850 pounds, a closer range than most. But with this sorting system, less than 2% are discounted for being off weight. Weight range may have more price impact than implants. When you're dealing with yearling, the story is different.

**A:** I envy your ability to sort cattle and use different feeding and implant programs.

**Koers:** We've tried using different implants, but Abe got tired of standing next to the chute to determine which one should be given which implant. We called Jerry Rains and asked which ones should get which implant and found out that he didn't know either! We haven't been able to make it work. We also agree that Koers-Turgeon Consulting is the best.

**A:** I would suspect that some of you were wondering why Mike and I feed these cattle of questionable genetic potential. If you analyze the bottom line, well over 50% if it relates to the original price involved. That doesn't diminish the role of other segments the industry, but buying that right animal correctly, buying the bargains if you will (that doesn't mean poor cattle but bargains from different sized cattle, different breeds and sexes, many different things) is where the majority of your profit comes from. Performance is not the major factor in terms of profit or loss of cattle. In fact, performance may be negatively related to profit because we are pretty clever in being able to identify good performance cattle and we pay dearly for them. The scale of the art is in identifying substandard animals that can perform and buying them at a discount.

**Koers:** We can't leave an implant conference with everybody believing that TBA implants are the ideal terminal implant. We strongly believe that TBA should be given up front. We understand that there is a learning curve involved here; we're doing the best to climb it, but we think that the endpoint is a moving target. There are too many indicators that product tenderness and quality are compromised with terminal use. We must focus on consumer satisfaction and market share as well as short term profitability.

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