The Professional Animal Scientist 20 (2004):344–352

CASE STUDY: Effects of Implant Programs on Buller Incidence, Feedlot Performance, and Carcass Characteristics of Yearling Steers[1]

B. L. VOYLES*,[2], M. S. BROWN†,[3], R. S. SWINGLE*, and K. J. KARR*, PAS
*Cactus Feeders, Amarillo, TX 79106 and †Division of Agriculture, West Texas A&M University, Canyon and Texas Agricultural Experiment Station, Amarillo

Abstract

*English and English × Continental crossbred steers (272 steers per pen; 4 pens per treatment) were used in a randomized complete block design to determine the effects of terminal implant type (Revalor S® [Hoechst-Roussel Vet, Somerville, NJ] and Component TES™ [Vet Life, Overland Park, KS]; each containing 24 mg of estradiol-17β and 120 mg of trenbolone acetate) and timing of terminal implant administration (d 1 or 50) on buller incidence, feedlot performance, and carcass characteristics. Steers either received Component TES™ (**TES**) or Revalor S® (**RevS**) on d 1 or 36 mg of zeranol (Ralgro®; Schering-Plough, Omaha, NE) on d 1 and TES (**Ral/TES**) or RevS (**Ral/RevS**) on d 50. Steers receiving TES and RevS were not removed from the home pen on d 50, and all steers were harvested after 144 d. Bullers pulled during the first 50 d were returned to home pens on d 50 and were classified as a repull if removed again as a buller. The incidence of new bullers during the first 50 d did not differ (P=0.14) between steers receiving TES (2.3%), RevS (1.75%), or Ralgro® initially (1.42%; Ral/TES + Ral/RevS). There were fewer new bullers from d 50 to 144 for TES and Ral/TES than for RevS and Ral/RevS (P=0.02; 0.97% vs 1.88%, respectively) and also when steers received a terminal implant on d 1 compared with d 50 (P=0.01; 0.92% vs 1.93%, respectively); however, the overall incidence of new bullers did not differ (P>0.43) among treatments. Neither implant type nor timing influenced repull incidence from d 50 to 144 (P>0.45) or the overall incidence of total (new + repull) bullers (P>0.43). Steer DMI (implant type × timing, P=0.04) was least (P<0.02) for Ral/TES, intermediate for TES, and greatest RevS and Ral/RevS. Live and carcass-adjusted BW gain efficiencies were 2.4% greater (P<0.03) for TES or Ral/TES than for RevS or Ral/RevS. Final BW, ADG, and hot carcass weight did not differ (P>0.19) among treatments. Steers receiving Ral/TES and Ral/RevS had a greater percentage of dark cutters (P<0.01), more Yield Grade 1 carcasses (P<0.01), and fewer Yield Grade 3 carcasses (P<0.01) than TES or RevS. Administering TES on d 1 or 50 resulted in improved gain efficiency, whereas overall buller incidence was not influenced by terminal implant type or timing. Administering either TES or RevS on d 50 increased the incidence of dark carcasses, resulted in more Yield Grade 1 and fewer Yield Grade 3 carcasses, and influenced when bullers developed but did not influence carcass quality grade distribution or overall buller incidence.*

(Key Words: Buller Steer Syndrome, Anabolic Implants.)

Introduction

The buller steer syndrome observed in feedlots is an abnormal behavioral and social condition that can be considered an economic problem arising from animal injury, mortality, and management. A 15-yr summary of buller steers in Midwest feedyards consisting of 5,355,318 steers reported a buller incidence of 2.45% (Edwards, 1995). A 2-yr study by Taylor et al. (1997) at a western Canadian feedyard using 78,445 male cattle indicated a buller incidence rate ranging from 0.0 to 11.2%; average incidence was 2.7%.

[1]The authors gratefully acknowledge the technical assistance provided by Walt Garrison and the staff at Wolf Creek Feedyard. Contribution number AREC 03-48 from the Texas Agric. Exp. Stn., Texas A&M University System.
[2]Present address: Global Animal Management, 34 Canyon Rim, Canyon, TX 79015.
[3]To whom correspondence should be addressed: msbrown@mail.wtamu.edu

It is generally recognized that anabolic implants may be one of several factors involved in the buller steer syndrome. Irwin et al. (1979) reported a greater percentage of bullers in groups of steers implanted with a combination of progesterone and estradiol (2.46%) than in those implanted with zeranol (0.46%); 13,244 steers received the combination implant, and 1721 steers received the zeranol implant. Taylor et al. (1997) concluded that re-implanting with estradiol + progesterone (Synovex S®, Fort Dodge Animal Health, Fort Dodge) did not alter buller incidence compared with cattle receiving only Synovex S initially. In contrast, Turgeon and Koers (1997) analyzed data from a historical database involving 47.85 million feedlot cattle and reported that buller incidence was substantially increased for re-implanted steers (3.21% *vs* 1.65%).

Booker et al. (1997) conducted a field trial in Nebraska with 14,196 steers fed for an average of 147 d. Those researchers reported that the overall new rider incidence was increased when the initial implant contained 28 mg of estradiol benzoate and 200 mg of trenbolone acetate compared with an initial implant with 36 mg of zeranol followed by a re-implant on d 70 with either 28 mg of estradiol benzoate and 200 mg of trenbolone acetate or 24 mg of estradiol-17β and 120 mg of trenbolone acetate (9.93, 5.06, and 3.99% new riders, respectively), whereas the rider repull incidence did not differ. The objective of this study was to determine the effects of terminal anabolic implant type and timing of terminal implant administration on buller incidence, live performance, and carcass characteristics of yearling steers.

Materials and Methods

The present study was conducted at a 60,000-animal capacity commercial feedlot near Perryton, Texas. Research pens were constructed of wood and cable fences, were soil-surfaced (approximately 2% slope), contained automatic water tanks, and contained concrete fenceline feed bunks allowing 22 cm of bunk space per animal. Pen space per animal ranged from 13.10 to 13.33 m^2. Mounds were situated perpendicular to the feed bunk in each pen, and pens did not contain shade or shelter. Blocks of study pens were located in a single line with feed bunks oriented east and west. Animal housing conditions and animal care and handling procedures followed recommendations by FASS (1999).

English and English × Continental crossbred steers (n = 4352; mean initial BW = 351 kg) of Southwestern US origin (three states and seven sources) were used in a randomized complete block design to evaluate the effect of terminal anabolic implant type and timing of terminal implant administration on buller incidence, live performance, and carcass characteristics of steers. The first block of steers was received on January 29, the second block was received on February 16, the third block was received on February 23, and the fourth block was received on March 7, 2000. Cattle within a block (1088 steers) were randomized to pens in groups of 10 using random number sequences of the four sorting pens; four contiguous study pens (272 steers per pen) within a block were randomized to treatment. Each replicate was stratified by source and was randomized within 1 to 7 d after arrival. Treatments of terminal implants were 1) TES, an estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Component TES™; Vet Life, Overland Park, KS) on d 1 only; 2) RevS, an estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Revalor S®; Hoechst-Roussel Vet, Somerville, NJ) on d 1 only; 3) Ral/TES, a zeranol (36 mg) implant (Ralgro®; Schering-Plough, Omaha, NE) on d 1 and Component TES™ on d 50; and 4) Ral/RevS, Ralgro® on d 1 and Revalor S® on d 50.

Each pen of steers was processed using a hydraulic squeeze chute for restraint. Processing included administering the appropriate implant, vaccination against viral antigens (Bovishield® IBR-BVD; Pfizer, Exton, PA), administering a clostridial bacterin-toxoid (Vision 7 with Spur®; Bayer, Shawnee Mission, KS), and treatment for internal and external parasites (Dectomax®; Pfizer). Cattle were weighed as a pen after randomizing. The processing crew administered implants in a procedure in which the ear was scraped and washed as needed (chlorhexidine solution); however, any previous implants were not excised.

Steers were adapted to a high concentrate diet over 24 d by altering the ratio of the adaptation diet to the finishing diet. The adaptation diet (as-fed basis) consisted of 49.2% steam-flaked corn, 15.0% chopped alfalfa hay, 18.0% cottonseed hulls, 8.0% molasses, 8.0% starter supplement, and 1.8% vitamin-mineral premix. Calculated DM composition of the diet was 1.07 Mcal of NE_g/kg and 14.0% CP (NRC, 1996). The finishing diet (as-fed basis) consisted of 78.9% steam-flaked corn, 9.5% chopped alfalfa hay, 2.0% molasses, 2.2% fat, 6.4% finisher supplement, and 1.0% vitamin-mineral premix; calculated DM composition of the finishing diet was 1.52 Mcal of NE_g/kg and 13.57% CP (NRC, 1996).

Feed deliveries were recorded daily, and diet DM was determined daily to calculate DMI. Health data were recorded for each animal that entered the hospital pen. Buller steers pulled from the home pen were individually identified with a numbered ear tag and placed in a common buller pen until d 50, at which time all bullers were returned to their home pens. The buller pen housed both bullers from the study as well as bullers from other pens at this feedlot. Home pen feed intake data were adjusted to add DMI by bullers and animals residing in the hospital pen and by deducting DMI by animals that died or were harvested before the end of the study (i.e., railed). These adjustments were made at the end of the study to overall individual DMI for each pen based

on the assumptions that 1) DMI by animals in the hospital pen was 50% of overall individual DMI by steers remaining in the home pen for the appropriate number of days and 2) DMI by other cattle removed from the home pen (bullers, railers, cattle that died in the home pen) was 100% of overall individual DMI by steers remaining in home pen for the appropriate number of days. Thus, performance data are presented with deceased and railed animals removed.

The first block of steers was shipped for slaughter on June 28, the second block was shipped for slaughter on July 6, the third block was shipped for slaughter on July 13, and the fourth block was shipped for slaughter on July 27, 2000. On the day of shipment, each pen was weighed in multiple groups, and animals from a pen were maintained separately during transport and harvest. The order of weighing and shipping of each pen within block at the feedlot was the same order in which each pen was harvested. Any buller steers that were pulled after d 50 remained segregated in the buller pen until shipment for slaughter. Buller steers corresponding to each study pen were shipped for harvest on the same day as the study pen, but buller steers were weighed and remained segregated through the harvest process. Individual carcass data determined by USDA graders were obtained from the customer sheet provided by the harvest facility (IBP, Amarillo, TX) and included hot carcass weight, quality grade, and yield grade. Adjusted final BW was calculated by dividing hot carcass weight by the overall mean dressing percentage.

Live performance, hot carcass weight, and dressing percentage data were analyzed using the mixed model procedures (SAS Inst., Inc., Cary, NC). Models included the fixed effects of terminal implant type, terminal implant timing, implant type × timing, and the random effect of block using pen as the experimental unit. Means were separated by least significant difference following a protected ($P<0.05$) *F*-test. The incidence of dark cutters and bullers and quality and yield grade distributions were evaluated using nonparametric procedures (Catmod; SAS Inst., Inc.); Fisher's exact test was used to accommodate low cell frequencies.

Results and Discussion

Buller Incidence. The design of the present study was such that three treatments rather than four existed before reimplanting (d 1 to 49). Thus, data were pooled for steers receiving Ral/TES and Ral/RevS before analyzing data for the incidence of new bullers before d 50. The number of steers pulled as new bullers during the first 49 d (Figure 1a) did not differ ($P=0.14$) among steers receiving TES, RevS, or Ralgro® initially (Ral/TES + Ral/RevS). Fewer new bullers were pulled from d 50 to slaughter (Figure 1b) for TES and Ral/TES (implant type, $P=0.02$) compared with Rev S and Ral/RevS or when steers received an initial terminal implant (TES and RevS; timing, $P=0.01$) compared with those receiving the terminal implant on d 50 (Ral/TES and Ral/RevS); the effects of implant type and timing were independent ($P=0.89$). However, overall (d 1 to slaughter) new buller incidence (Figure 1c) did not differ ($P>0.43$) among treatments.

No interactions ($P>0.34$) were evident between terminal implant type and timing of implant administration for the incidence of bullers repulled after d 50 or total bullers (new + repulls; Table 1). The incidence of repulled bullers, either as a percentage of the pen or as a percentage of new bullers, was not influenced by terminal implant type or timing ($P>0.45$). There was a terminal implant type effect ($P=0.04$) and a timing effect ($P=0.05$) for total bullers from d 50 to 144 (implant type × timing, $P=0.89$); there were fewer total bullers after d 50 for TES and Ral/TES compared with RevS and Ral/RevS (1.65% *vs* 2.58%, respectively) or when the terminal implant was given on d 1 compared with d 50 (1.66% *vs* 2.57%, respectively). However, total bullers over the entire study (d 1 to 144) did not differ ($P>0.93$) among treatments.

Although the overall (d 1 to 144) incidence of new, repulled, or total (new + repulls) bullers was not influenced by either terminal implant type or timing, the greater new buller incidence from d 50 to 144 by Ral/TES and Ral/RevS steers in the present study was reflected in the greater total buller incidence from d 50 to 144 by Ral/TES and Ral/RevS. An explanation for the increased total buller incidence after d 50 for Revalor (RevS + Ral/RevS) compared with TES (TES + Ral/TES) is not readily apparent. In the present study, animals receiving the terminal implant initially were not removed from their home pen and handled on d 50 in a manner similar to the re-implanted cattle. Thus, the relative contribution of handling independent of administering an implant cannot be discerned from the present study.

Taylor et al. (1997) concluded from their 2-yr epidemiological study using 78,445 male cattle entering a feedlot in western Canada that re-implanting with estradiol + progesterone (Synovex S®) did not alter buller incidence compared with cattle receiving Synovex S® on d 1 only. In contrast, Turgeon and Koers (1997) reported that buller incidence in their historical data on 47.85 million feedlot cattle was substantially increased for re-implanted steers (3.21% *vs* 1.65%). A 30-pen field trial conducted under commercial feedlot conditions in Nebraska involving 14,196 steers fed for an average 147 d was conducted by Booker et al. (1997). They found that the overall new rider incidence was greater when the initial implant contained 28 mg of estradiol benzoate and 200 mg of trenbolone acetate compared with an initial implant with 36 mg of zeranol followed by a re-implant on d 70 with either 28 mg of estradiol benzoate and 200 mg of trenbolone acetate or 24 mg of estradiol-17β and 120 mg of trenbolone acetate (9.93, 5.06, and 3.99% new riders, respectively), whereas the rider

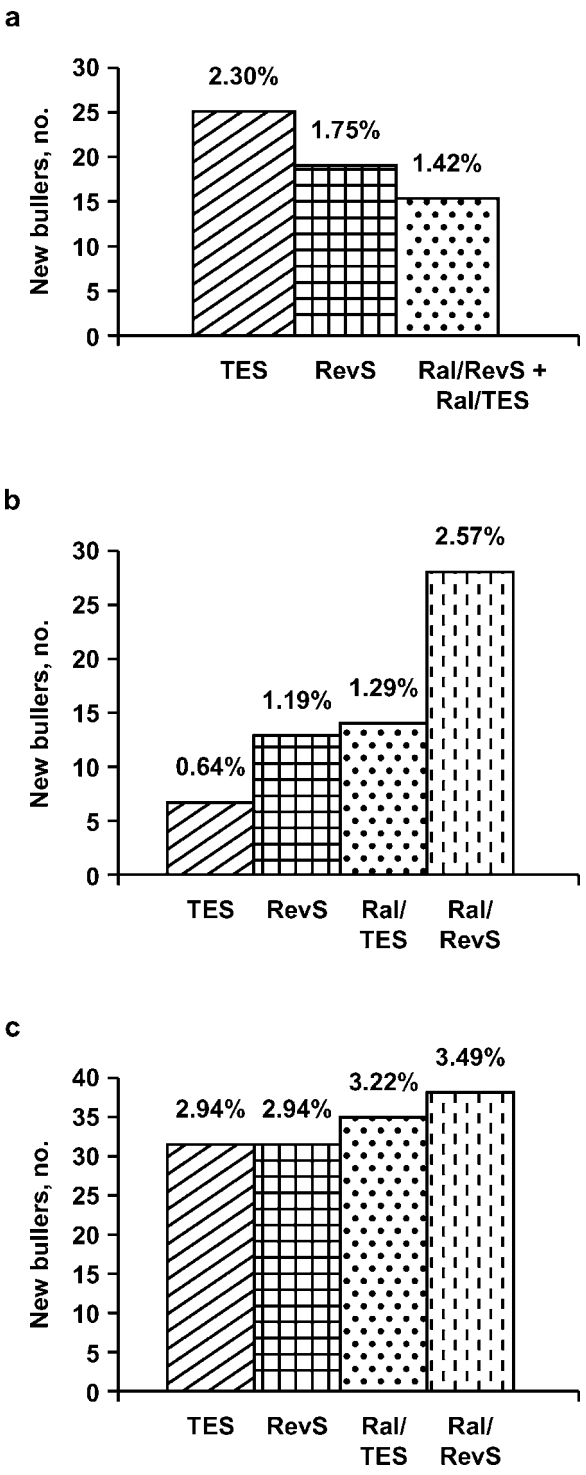


Figure 1. Effect of terminal anabolic implant type and timing of administration on new buller incidence a) from d 1 to 49, b) from d 50 to slaughter, and c) from d 1 to slaughter. Treatments were TES = estradiol (24 mg) + trenbolone acetate (120 mg) implant (Component TES™; Vet Life, Overland Park, KS) on d 1; RevS = estradiol (24 mg) + trenbolone acetate (120 mg) implant (Revalor S®; Hoechst-Roussel Vet, Somerville, NJ) on d 1; Ral/TES = zeranol (36 mg) implant (Ralgro®; Schering-Plough, Omaha, NE) on d 1 and TES on d 50; and Ral/RevS = Ralgro® on d 1 and RevS on d 50. New buller incidence from d 1 to 49 reflects the three treatments that existed before re-implanting on d 50. The initial implant did not influence (χ^2 statistic, P=0.14) new buller incidence from d 1 to 49 (a). New buller incidence from d 50 to slaughter (b) was less for steers receiving TES and Ral/TES than for steers receiving RevS and Ral/RevS (implant type, P=0.02) and for steers receiving the terminal combination implant on d 1 compared with d 50 (timing, P=0.01). These effects did not interact (P=0.89). New buller incidence from d 1 to slaughter (c) was not influenced by either terminal implant type or timing of administration (P>0.43).

TABLE 1. Effect of terminal anabolic implant type and timing of administration on buller incidence by steers[a].

	Treatment[b]			
Item	TES	RevS	Ral/TES	Ral/RevS
Repulls[c]				
d 50 to 144, % of pen[d]	0.64	0.83	0.74	0.55
d 50 to 144, % of new bullers[e]	21.9	28.1	22.9	15.8
Total bullers				
d 50 to 144, % of pen[f,g]	1.29	2.02	2.00	3.13
d 1 to 144, % of pen[h]	3.58	3.77	3.95	4.04

[a]Implant type × timing interaction for all response variables ($P>0.34$).

[b]TES = Estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Component TES™; Vet Life, Overland Park, KS) on d 1; RevS = estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Revalor S®; Hoechst-Roussel Vet, Somerville, NJ) on d 1; Ral/TES = zeranol (36 mg) implant (Ralgro®; Schering-Plough, Omaha, NE) on d 1 and TES on d 50; and Ral/RevS = Ralgro® on d 1 and RevS on d 50.

[c]Repulls only occurred from d 50 to 144 because previously pulled bullers (d 1 to 49) from all treatments were not reintroduced into the respective home pen until d 50.

[d]Number of repulled bullers from d 50 to 144 divided by the total number of animals in the home pen.

[e]Number of repulled bullers from d 50 to 144 divided by the number of new bullers from d 1 to 144.

[f]Number of total bullers (new bullers + repulled bullers) from d 50 to 144 divided by total number of animals in the home pen.

[g]Chi-square statistic for implant type effect ($P=0.04$), timing effect ($P=0.05$), implant type × timing ($P=0.89$).

[h]Number of total bullers pulled from d 1 to 144 divided by the total number of animals in the home pen.

repull incidence did not differ. Those researchers further reported that implant type within re-implant treatments did not influence the overall new rider rate. However, the extent to which the rider incidence of Booker et al. (1997) equates to buller incidence in the present study (similar between an initial Ralgro®, RevS, or TES) is not clear.

Irwin et al. (1979) evaluated buller incidence over a 1-yr period in a feedlot near Bushland, Texas (20,428 steers) and reported a greater percentage of bullers in groups of steers implanted initially only with a combination of progesterone and estradiol (2.46%) than in those implanted with zeranol (0.46%). It should be noted that 13,244 steers received the combination implant, and 1721 steers received the zeranol implant, thus making the study design unbalanced. Although Herrick (1980) proposed that the implanting technique is a more likely cause for bullers than implant type, data supporting this contention are not available. Collectively, data may suggest that a tendency exists for greater buller incidence during the early part of the feeding period when an estrogen + progesterone or estrogen + trenbolone acetate implant is given on arrival than when implants with zeranol (36 mg) are given on arrival, but that buller incidence during the latter part of the feeding period is likely to be greater for steers re-implanted with an estrogen + trenbolone acetate implant than for steers receiving a single estrogen + trenbolone acetate implant on arrival only. Data from the current study suggest that these interim influences (d 1 to re-implant, re-implant to slaughter) on buller incidence are offset by the end of the finishing period, such that buller incidence over the entire feeding period is similar.

It is hypothesized that hormonal changes may be involved in buller development, and it is possible that even subtle differences in release rate of active ingredients may contribute to buller incidence, even if the type and dose of active ingredients is identical (e.g., RevS and TES). Brower and Kiracofe (1974) reported that buller and normal steers excreted a similar amount of total estrogens in urine using total urine collections. Brower and Kiracofe (1978) discovered that bullers had both a greater total urine and plasma estrogen concentration in spot samples collected every 6 h for 24 h than did normal steers. However, Irwin et al. (1979) provided evidence that the expression of a gonadal hormone may not be responsible for buller behavior. In a group of steers implanted with estradiol + progesterone, total serum estradiol and testosterone concentrations were less in buller steers when they were first observed bulling than in either normal steers or in the buller steers 3 d after being isolated from pen mates. Wettemann and Lehman (1997), in two pilot studies in different feedlots and during different seasons, reported that the concentrations of estradiol in plasma were numerically less in bullers.

Serum concentrations of estradiol and trenbolone acetate were dramatically greater for steers given RevS (Lee et al., 1990) and heifers given Revalor H® (Hoechst-Roussel Vet) (Henricks et al., 1997); however, comparative data between RevS and TES are not available. Epp et al. (2003) collected blood samples from steers at feedlot arrival and at the onset of bulling behavior to assess circulating hormone concentrations. Those researchers reported a lesser progesterone concentration (0.36 *vs* 0.22 ng/mL) and greater testosterone concentration by bullers (4.2 *vs* 16 pg/mL) at the time of bull-

ing behavior compared with serum concentrations at feedlot arrival. In vitro data (Youdim et al., 1989) using bovine adrenal endothelial cells suggest that testosterone does not influence, progesterone mildly stimulates, and 17α-estradiol potently inhibits monoamine oxidase type A activity. Bachman et al. (1992) hypothesized that estrogenic implants might inhibit monoamine oxidase activity in ruminants and increase the biological half-life of epinephrine. Lambs challenged with epinephrine after 21 d of exposure to an estradiol-17β implant had increased serum glucose, similar serum insulin, and decreased nonesterified fatty acid concentrations at 10 min after the challenge compared with non-implanted lambs, which may be consistent with decreased monoamine oxidase activity. Brain tissue collected by Epp et al. (2003) from bullers at the packing plant contained more monoamine oxidase A mRNA than tissue from non-bullers. The lesser estradiol concentrations previously reported for bullers tend to support the monoamine oxidase data of Epp et al. (2003; reduced inhibition), although the functionality of the greater enzyme quantity found in bullers has not been tested. Perhaps a component of the etiology of the buller steer syndrome and the influence of re-implanting on buller incidence relates differences in estrogen metabolism [e.g., testosterone conversion to estradiol via aromatase (Zubay, 1993), estrogen degradation] and/or modifications in dopamine availability (Zubay, 1993), but further research is needed.

TABLE 2. Effect of terminal anabolic implant type and timing of administration on overall feedlot performance by steers (deceased and railed animals removed).

	Treatment[a]				
Item	TES	RevS	Ral/TES	Ral/RevS	SE[b]
Pens, no.	4	4	4	4	—
Animals, no.	1076	1084	1076	1071	—
Initial BW, kg	350.6	349.5	349.7	350.5	7.4
Final BW, kg	574.6	571.8	570.2	574.7	4.4
ADG, kg/d (live basis)	1.56	1.55	1.54	1.56	0.03
ADG, kg/d (carcass adjusted[c])	1.55	1.54	1.55	1.56	0.03
DMI, kg/d[d]	8.91[e,f]	8.98[e]	8.73[f]	9.11[e]	0.1
Feed efficiency, DMI:ADG					
Live basis[g]	5.73	5.80	5.69	5.85	0.09
Carcass-adjusted[c,g]	5.75	5.82	5.65	5.82	0.04
Observed/expected diet NE_g	97.4	96.0	98.7	94.7	—

[a]TES = estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Component TES™; Vet Life, Overland Park, KS) on d 1; RevS = estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Revalor S®; Hoechst-Roussel Vet, Somerville, NJ) on d 1; Ral/TES = zeranol (36 mg) implant (Ralgro®; Schering-Plough, Omaha, NE) on d 1 and TES on d 50; and Ral/RevS = Ralgro® on d 1 and RevS on d 50.

[b]Standard error of the least square mean; n = 4 pens per treatment.

[c]Calculated using adjusted final BW (observed hot carcass weight/[overall observed dressing percentage/100]).

[d]Implant type × timing interaction (P=0.04); implant type effect (P=0.01).

[e,f]Means with different superscripts differ (P<0.02).

[g]Implant type effect (P<0.03).

Feedlot Performance. Data from animals that did not complete the study were excluded (27 died, 18 railed, 2 condemned) from analysis. In the overall mixed model, there was an interaction between terminal implant type and timing (P=0.04) for DMI (Table 2). Dry matter intake was least (P<0.02) for steers receiving Ral/TES, intermediate for steers receiving TES, and greatest for steers receiving RevS and Ral/RevS; DMI tended (P=0.06) to be greater for steers receiving Ral/RevS than for steers receiving TES. As a result, DMI by steers receiving RevS and Ral/RevS was greater (implant type, P=0.01) than that by steers receiving TES or Ral/TES. Live DMI:ADG and carcass-adjusted DMI:ADG showed no interaction between implant type and timing (P>0.10). Live (5.83 and 5.71 ± 0.08) and carcass-adjusted DMI:ADG ratios (5.82 and 5.70 ± 0.03) were greater (implant type, P<0.03) for steers receiving TES and Ral/TES than for those receiving RevS and Ral/RevS, respectively. Neither implant type nor timing (P>0.19) influenced final BW, live ADG, or carcass-adjusted ADG.

The lesser feed intake by steers receiving Ral/TES and tendency for higher DMI by steers receiving Ral/RevS was unexpected, and reasons for this response are not clear. It is expected that a small influence on performance would be exerted by the observed increase in new buller incidence after d 50 by steers receiving Revalor (RevS, Ral/RevS) compared with those receiving TES (TES, Ral/TES). It is not clear whether ADG and DMI by bullers are comparable with non-bullers residing in the home pen. In addition, some estimation error is anticipated in determining buller DMI using the assumption mentioned previously. Although total buller incidence did not differ among treatments, the total number of buller days (number of bullers in buller pen × days of residence) was 1817, 2116, 1806, and 2292 for TES, RevS, Ral/TES, and Ral/RevS, respectively. Thus, treatment DMI would change approximately 0.09 to 0.1 kg/d if buller DMI for a treatment was truly over- or underestimated by 10%.

The potential influence of implant defects on treatment response cannot be excluded in the present study be-

cause implant integrity after administration was not assessed. Berry et al. (2000) reported that steers missing the terminal implant (administered at 60 d on feed) at the time of post-slaughter ear evaluation had lesser ADG than steers having normal implants at slaughter. However, the similar ADG between treatments in the present study argues against differences in implant retention or other abnormalities (Anderson and Botts, 2002), and the clear changes in carcass yield grade and dark cutter incidence caused by terminal implant timing (discussed subsequently), but not implant type, seem to further suggest similar arrival implant status of study cattle.

A comprehensive review (Duckett et al., 1997) concluded that the greatest increase in DMI seems to occur when steers are implanted twice with a strong estrogen implant compared with steers re-implanted with a strong estrogen + androgen implant. The terminal implants used in the present study contained similar concentrations of the same active ingredients; thus, differences between implant types should reflect potential differences in release rate of active ingredients and/or other unique aspects associated with manufacturing. Bartle et al. (1992) reported that lactose-based and cholesterol-based carriers in combination implants (estrogen + trenbolone acetate) supported similar animal performance. Moreover, the terminal combination implants used in the present study both contain a cholesterol-based carrier (J. Hutcheson, Intervet, Inc., personal communication, Marcy 18, 2003; P. Anderson, Vet Life Inc., personal communication, March 10, 2003).

Duckett et al. (1997) indicated that ADG by implanted steers tended to increase with DMI. Regression analyses by those researchers indicated that an estrogen + androgen implant increased ADG by over 0.18 kg (0.4 lb)/d, even when feed intake was not increased, suggesting that this response may be the result of increased lean *vs* lipid deposition (Montgomery et al., 2001) and/or improved energetic efficiency (Hutcheson et al., 1997; Guiroy et al., 2002). Even though steers receiving Ral/RevS tended to have the greatest DMI in the present study, steers receiving TES and Ral/TES had improved feed efficiency. The similar feed efficiency between steers receiving TES or Ral/TES is similar to the response reported by Pritchard (2000) for 327-kg steers given Revalor S initially or as a re-implant after 56 d of exposure to zeranol and fed for 138 d.

TABLE 3. Effect of terminal anabolic implant type and timing of administration on carcass characteristics of steers.

	Treatment[a]				
Item	TES	RevS	Ral/TES	Ral/RevS	SE[b]
Pens, no.	4	4	4	4	—
Animals, no.	1075	1084	1076	1070	—
Hot carcass weight, lb[c]	817	813	815	820	7.5
Hot carcass weight, kg[c]	370.8	368.9	369.5	372.1	3.4
Dressing percentage[d]	64.53	64.52	64.79	64.73	0.28
Quality grade[d]					
Prime, %	0.7	0.6	0.7	0.5	—
Choice, %	52.1	51.1	49.9	53.0	—
Prime + Choice, %	52.8	51.7	50.6	53.5	—
Select, %	42.0	43.4	43.8	41.3	—
Standard, %	5.1	4.7	4.8	4.4	—
Dark cutter, %[e,f]	0.1	0.2	0.8	0.8	—
Yield grade[d]					
1, %[f]	18.5	18.0	26.0	26.6	—
2, %	39.8	41.0	40.5	37.4	—
3, %[f]	39.6	39.1	31.9	34.4	—
4 and 5, %	2.1	1.9	1.6	1.6	—

[a]TES = estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Component TES™; Vet Life, Overland Park, KS) on d 1; RevS = estradiol (24 mg) plus trenbolone acetate (120 mg) implant (Revalor S®; Hoechst-Roussel Vet, Somerville, NJ) on d 1; Ral/TES = zeranol (36 mg) implant (Ralgro®; Schering-Plough, Omaha, NE) on d 1 and TES on d 50; and Ral/RevS = Ralgro® on d 1 and RevS on d 50.

[b]Standard error of the least square mean; n = 4 pens per treatment.

[c]Implant type × timing interaction (P=0.06), implant type effect (P=0.73), and timing effect (P=0.38).

[d]Implant type × timing interaction (P>0.14).

[e]Only includes full dark carcasses (e.g., 3/3).

[f]Timing effect (P<0.01).

Carcass Characteristics. There was a tendency for an interaction between terminal implant type and timing (P=0.06) for hot carcass weight (Table 3), but neither implant type (P=0.73) nor timing (P=0.38) influenced hot carcass weight. There were no main effect interactions for carcass quality measures, yield grade, or dressing percentage (P>0.14). However, administering the terminal implant on d 50 (Ral/TES, Ral/RevS) resulted in a higher percentage of dark cutters (P<0.01) than TES or Rev S (on d 1 only). Timing of implant administration was also a factor in the proportion of Yield Grade 1 and 3 carcasses (P<0.01); steers receiving the terminal implant on d 50 (Ral/TES, Ral/RevS) had more Yield Grade 1 carcasses but fewer Yield Grade 3 carcasses than steers receiving the terminal implant on d 1 only (TES, RevS). As mentioned previously, all bullers pulled

after d 50 were maintained separately from pen mates through harvest, and these data (Table 3) include the contribution from buller steers for each treatment. Hot carcass weight of bullers pulled after d 50 (92 animals) was 350.0, 368.2, 361.6, and 356.8 ± 8.6 kg for RevS, TES, Ral/RevS, and Ral/TES, respectively.

Consistent with the ADG data, hot carcass weight was not influenced by the terminal implant types used or the timing of administration of the terminal implant. Previous data (Duckett et al., 1997) suggest that the greatest effect on hot carcass weight would be expected for steers re-implanted with strong estrogen + androgen compared with a non-implanted control, but present data agree with those reported by Pritchard (2000) for steers receiving RevS initially or as a re-implant after zeranol. However, an important mode of action of anabolic implants is to potentiate lean deposition (Montgomery et al., 2001).

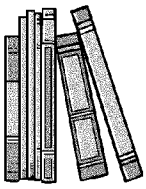
Findings regarding dark cutters and yield grade distribution suggest that timing of terminal implant administration is a factor of importance. Present data indicate that re-implanting steers, in this case with a combination implant, resulted in a greater percentage of dark cutters. The present data reported include only full dark carcasses; grading standards (USDA, 1997) dictate that carcasses displaying less than full dark color (e.g., one-third or two-thirds) are accommodated by decreasing final quality grade of the carcass, and carcass data for the present study were obtained by USDA graders. The NBQA (2000) survey reported that the frequency of one-third, one-half, two-thirds, and full dark carcasses was 1.0, 0.6, 0.4, and 0.3%, respectively, of 9396 carcasses evaluated in 30 packing plants. Thus, the incidence of full dark carcasses in the present study for re-implanted steers was considerably greater than suggested by survey data.

Present data are in contrast to those of Morgan (1997), who indicated that data reviewed at that time did not support a direct relationship between administration of trenbolone-containing implants and the incidence of dark cutters. Although the potential exists that the observed increase in dark cutters may be related to the observed increase in new (and total) buller incidence after d 50 for re-implanted steers, no bullers were classified as dark cutters in the present study. Indeed, other preslaughter stressors such as transportation and handling conditions, emotional excitement, or acute changes in environment are also important for the depletion of muscle glycogen stores before slaughter. A recent report by Waylan et al. (2003) suggests that RevS exposure for 28 d did not alter the presence of mRNA for glycogenin, a core protein in glycogen synthesis. However, data regarding the stability of the glycogenin message are not available.

Administering the terminal implant on d 50 resulted in a greater proportion of carcasses achieving Yield Grade 1 and fewer Yield Grade 3 carcasses, but did not influence the number of Prime + Choice carcasses. Duckett et al. (1997) reported that final average yield grade was not consistently changed by implants and concluded that the greatest effects on longissmus area were for steers re-implanted with a strong estrogen + androgen. Distinct differences in the method of yield grade data acquisition between the present study and many of the studies reviewed by Duckett et al. (1997) may explain this disparity. Yield grade data for each carcass in the present study was obtained as a whole number assigned by the USDA grader, whereas yield grade for each carcass in many of the studies reviewed by Duckett et al. (1997) was calculated from actual carcass measurements (except internal fat percentage). Carcass quality grade distribution, other than the number of dark carcasses, was not altered by either terminal implant type or timing, and present data are in contrast to the findings of Pritchard (2000); steers receiving RevS initially tended to produce fewer Choice + Prime carcasses than steers given RevS as a re-implant after Ralgro® (51% *vs* 60%).

Implications

An initial implant or a re-implant (following zeranol) of TES resulted in improved gain efficiency compared with an initial implant or a re-implant (following zeranol) of RevS. Administering a terminal combination implant on d 50 following an initial Ralgro® implant increased the incidence of full dark carcasses and resulted in more Yield Grade 1 and fewer Yield Grade 3 carcasses than providing the terminal implant on d 1 only. More new bullers were produced after d 50 (re-implanting) when steers received a terminal combination implant on d 50 following an initial Ralgro® implant than when steers received a terminal combination implant on d 1 only and when RevS was used as the terminal implant compared with TES, but buller incidence over the entire feeding period (new, repulls, or total) did not differ among treatments.



Literature Cited

Anderson, P. T., and R. L. Botts. 2002. Evaluation of the ability of implants containing a pellet of tylosin tartate (Component® with Tylan®) to prevent implant site abscesses under field conditions. Prof. Anim. Sci. 18:262.

Bachman, S. E., M. L. Galyean, D. M. Hallford, C. E. Heird, and G. C. Duff. 1992. A note on the influence of oestradiol-17β implants on serum hormone and metabolite concentrations in response to an epinephrine challenge in lambs. Anim. Prod. 55:295.

Bartle, S. J., R. L. Preston, R. E. Brown, and R. J. Grant. 1992. Trenbolone acetate/estradiol combinations in feedlot steers: Dose-response and implant carrier effects. J. Anim. Sci. 70:1326.

Berry, B. A., L. J. Perino, M. L. Galyean, T. H. Montgomery, and S. Bachman. 2000. Association of implanting abnormalities with growth performance of feedlot steers. Prof. Anim. Sci. 16:128.

Booker, C. W., G. K. Jim, P. T. Guichon, O. C. Schunicht, and R. L. Sibbel. 1997. Compari-

son of zeranol (Ralgro)/trenbolone acetate (Revalor-S or Synovex Plus) implant programs to an estradiol benzoate/trenbolone acetate (Synovex Plus) implant program in feedlot steers. Beef Production Leadership Summit, Breckenridge, CO. Schering-Plough Animal Health, Omaha, NE.

Brower, G. R., and G. H. Kiracofe. 1974. Urinary and plasma estrogens in buller and normal steers. J. Anim. Sci. 39:135. (Abs.)

Brower, G. R., and G. H. Kiracofe. 1978. Factors associated with the buller-steer syndrome. J. Anim. Sci. 46:26.

Duckett, S. K., F. N. Owens, and J. G. Andrae. 1997. Effects of implants on performance and carcass traits of feedlot steers and heifers. In Symposium: Impact of Implants on Performance and Carcass Value of Beef Cattle. Oklahoma Agric. Exp. Stn. P-957:63. Stillwater, OK.

Edwards, T. A. 1995. Buller syndrome: What's behind this abnormal sexual behavior? Large Anim. Vet. 50:6.

Epp, M. P., D. A. Blasi, B. J. Johnson, and J. P. Kayser. 2003. Steroid hormone profiles and brain monoamine oxidase type A (MAO-A) activity of buller steers. In Proceedings of the Plains Nutrition Council. p 107 (Abstr.). Publication No. AREC 03-13, Texas A&M University Research and Extension Center, Amarillo.

FASS. 1999. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. (1st Rev. Ed.). Federation of Animal Science Societies, Savoy, IL.

Guiroy, P. J., L. O. Tedeschi, D. G. Fox, and J. P. Hutcheson. 2002. The effects of implant strategy on finished body weight of beef cattle. J. Anim. Sci. 80:1791.

Henricks, D. M., R. T. Brandt, Jr., E. C. Titgemeyer, and C. T. Milton. 1997. Serum concentrations of trenbolone-17β and estradiol-17β and performance of heifers treated with trenbolone acetate, melegesterol acetate, or estradiol-17β. J. Anim. Sci. 75:2627.

Herrick, J. B. 1980. Bullers in the feedlot. California Vet. 34:29.

Hutcheson, J. P., D. E. Johnson, C. L. Gerken, J. B. Morgan, and J. D. Tatum. 1997. Anabolic implant effects on visceral organ mass, chemical body composition, and estimated energetic efficiency in cloned (genetically identical) beef steers. J. Anim. Sci. 75:2620.

Irwin, M. R., D. R. Melendy, M. S. Amoss, and D. P. Hutcheson. 1979. Roles of predisposing factors and gonadal hormones in the buller syndrome of feedlot steers. J. AVMA 174:367.

Lee, C. Y., D. M. Henricks, G. C. Skelley, and L. W. Grimes. 1990. Growth and hormonal response of intact and castrate male cattle to trenbolone acetate and estradiol. J. Anim. Sci. 68:2682.

Montgomery, T. H., P. F. Dew, and M. S. Brown. 2001. Optimizing carcass value and the use of anabolic implants in beef cattle. J. Anim. Sci. 79(Suppl.):E296.

Morgan, J. B. 1997. Implant program effects on USDA beef carcass quality grade traits and meat tenderness. In Symposium: Impact of Implants on Performance and Carcass Value of Beef Cattle. Oklahoma Agric. Exp. Stn. P-957:147. Stillwater, OK.

NBQA. 2000. National Beef Quality Audit. [Online.] Available at http://www.ansc.purdue.edu/beef/Hendrix/NBQA2000/. Accessed April 21, 2003.

NRC. 1996. Nutritional Requirements of Beef Cattle. (7th Ed.). National Academy Press, Washington, DC.

Pritchard, R. H. 2000. Comparison of estradiol-trenbolone acetate implant programs for yearling steers of two genotypes. SD Beef Report 00-10, South Dakota Agric. Exp. Stn., South Dakota State Univ., Brookings.

Taylor, L. F., C. W. Booker, G. K. Jim, and P. T. Guichon. 1997. Epidemiology investigation of the buller steer syndrome (riding behaviour) in a western Canadian feedlot. Aust. Vet. J. 75:45.

Turgeon, A., and W. Koers. 1997. Effects of pen size on the implant response offeedlot cattle. In Symposium: Impact of Implants on Performance and Carcass Value of Beef Cattle. Oklahoma Agric. Exp. Stn. P-957:105. Stillwater, OK.

USDA. 1997. Official US Standards for Grades of Carcass Beef. Agriculture Marketing Service, USDA, Washington, DC.

Waylan, A. T., J. P. Kayser, J. D. Dunn, E. K. Sissom, and B. J. Johnson. 2003. Effect of flax supplementation and growth promotants on steady-state lipoprotein lipase and glycogenin mRNA concentrations in finishing cattle. In Proceedings of the Plains Nutrition Council. p 119 (Abstr.). Publication No. AREC 03-13. Texas A&M Research and Extension Center, Amarillo.

Wettemann, R. P., and F. Lehman. 1997. Buller steers—Causes and control. In Symposium: Impact of Implants on Performance and Carcass Value of Beef Cattle. Oklahoma Agric. Exp. Stn. P-957:123. Stillwater, OK.

Youdim, M. B., D. K. Banerjee, K. Kelner, L. Offutt, and H. B. Pollard. 1989. Steroid regulation of monoamine oxidase activity in the adrenal medulla. FASEB J. 3:1753.

Zubay, G. 1993. Biochemistry. (3rd Ed.). K. Kane (Ed.). Wm. C. Brown Communications, Inc., Dubuque, IA.