THE EFFICACY OF AN ESTRADIOL-SILICONE RUBBER REMOVABLE IMPLANT IN SUCKLING, GROWING AND FINISHING STEERS[1]

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Summary

Sixty steer calves, 42 Simmental × Hereford and 18 Hereford, averaging 59 days of age and 78 kg, were assigned to six estradiol-17β implant treatments. Implants were cut from cylindrical formed tubes containing a mix of 80% nonpolymerized silicone and 20% microcrystalline estradiol-17β by weight and cut into lengths that provided 0, 8.5, 15.6, 30.7, 30.9 and 46.7 μg estradiol-17β/day over a 499-day trial period. Two types, a coated and solid implant, were tested at the 31-μg level; all others were coated with a solid placebo used for the 0-μg or control treatment. Animal performance was recorded through the suckling, growing and finishing phases of production, and carcass data were collected. Cummulative gains over the 499 days were greater (P<.05) for the steers given the 30.9- and 46.7-μg levels than for those given the 0-, 8.5- and 15.6-μg levels, with respective daily gains being .97 and .97 *vs* .90, .90 and .89 kg; steers given the implant delivering 30.7 μg daily tended to gain more (P<.10) than the controls: .95 *vs* .90 kilograms. These values represent a 6% increase in gain over the control with the 30.7-kg coated implant and an 8% increase with the 30.9-μg solid and 46.7-μg coated implants. Implants did not improve feed efficiency during a 65-day feedlot period. Neither the amount of estradiol-17β nor the type of implant significantly influenced any carcass parameters except maturity. As the dose rate increased, the degree of carcass maturity increased. Type of implant did not affect gain during any period or any of the carcass measures. Results of this study indicate that a single implant of estradiol-17β delivering approximately 30.7 μg/day will improve weight gains over a long period of time and increase carcass maturity grade of steers.

(Key Words: Beef Steers, Estradiol Implants, Rate of Gain, Suckling, Growing, Finishing.)

Introduction

Bailey *et al.* (1966) and Ellis *et al.* (1974) have demonstrated that bulls and males with short scrotums grow faster than steers. However, there are several anabolic agents available today that improve rate of gain by steers. Numerous studies have reported a positive effect of diethylstilbestrol on steer gains during the postweaning and finishing periods (Clegg and Cole, 1954; Wilson *et al.*, 1963). Steers implanted with zearalanol have shown increased gains during the suckling, growing and finishing stages of growth (Thomas and Armitage, 1970; Sharp and Dyer, 1971; Nichols and Lesperance, 1973). A progesterone-estradiol benzoate implant has also improved gains of growing and finishing steers (Goodrich and Meiske, 1973; Lofgreen, 1974). The objectives of this study were to evaluate various levels of estradiol-17β as an anabolic agent in steers during the suckling, growing and finishing phases of production under a single implant regimen and with two forms of implant.

Materials and Methods

Sixty steer calves, 42 Simmental × Hereford and 18 Hereford, averaging 59 days of age and 78 kg, were divided into two groups, based on age. The animals were then stratified by breed, age, weight, average daily gain from birth to trial initiation and age of dam within the groups and randomly assigned to six treatment groups. Calves ranged in age from 10 to 80 days. Crossbred calves were the result of artificial insemination from a single Simmental sire and straightbred calves were the result of two Hereford cleanup bulls. The older age group

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consisted entirely of crossbred steers and the other was a mix of cross- and straightbred steers. Treatments were: (1) control, 2.54 cm placebo; (2) .64 cm, coated; (3) 1.27 cm, coated; (4) 2.54 cm coated; (5) 2.54 cm, solid, and (6) 3.81 cm, coated.

The estradiol-17β ($E_2\beta$) implants[5] were cylindrical in shape (4.76 mm in diameter), cut into lengths of .64, 1.27, 2.54 or 3.81 centimeters. Solid and coated implants were used and dose levels depended on surface area. The solid implant was formulated by mixing nonpolymerized silicone rubber (80% by weight) with microcrystalline $E_2\beta$ (20% by weight), adding catalyst and molding into a long cylinder. The implant was then cut to the desired length. Coated implants were of the same outside dimensions as the solid implant, with the inner core composed of nonmedicated silicone rubber. The composition of the outer coating was the same as that of the solid implant. Implants were cut to desired lengths from this cylinder. Placebo implants were formulated from the nonmedicated silicone rubber.

Implants were given once, at the initiation of the study, and were weighed individually before implantation. Implants were placed subcutaneously on the posterior median surface of the ear; an implant needle with a bore diameter sufficient to accommodate the implant was used. Implants were removed with a tool designed to immobilize the implant in a groove equipped with a surgical cutting edge. After removal, the implants were washed in tap water, dried in an incubator at 37 C for 2 hr and allowed to equilibrate at room temperature for at least 2 hr before the final weighing. Implant weights were taken to determine average daily dose rates. No implants were lost during the study.

Calves were born in March and April. They were castrated, dehorned and injected with Se and vitamin E before the start of the study on May 5, at which time they were weighed and implanted. All animals were placed together for 5 days, and, during this period, calves were vaccinated against *Clostridium chauvoei* and *Clostridium septicum* and the cows against *Clostridium haemolyticum*. Cow-calf pairs were then grazed on wet meadow pastures as one group until June 17 to facilitate artificial insemination of the cows. Pasture composition was 50% rushes and sedges and 50% grasses, with the dominant species being Idaho Fescue *(Festuca idahoensis)* and Timothy *(Phleum pratense)*. For the rest of the trial, each of the previously described age groups was maintained separately but under the same management procedures throughout the suckling and growing phases. During the finishing period, each treatment was group-fed, with the two age groups fed at two different locations. Location effects could not be tested separately because of confounding with age, which was confounded by breed and weight. However, all treatment × location effects were nonsignificant. One group of animals was trucked 380 km, which temporarily depressed feed intake and delayed the animals' reaching full feed.

[5] Estradiol implants and financial assistance were provided by Eli Lilly and Co., Vancouver, WA.

TABLE 1. AMOUNT OF ESTRADIOL-17β DELIVERED PER DAY

Treat-ment	Implant		Estradiol-17β dosage per day, μg^a
	Length, cm	Prep-aration	
1	2.54	Placebo	$-.04^b \pm <.1$
2	.64	Coated	$8.5^c \pm .3$
3	1.27	Coated	$15.6^d \pm .2$
4	2.54	Coated	$30.7^e \pm .2$
5	2.54	Solid	$30.9^e \pm .7$
6	3.81	Coated	$46.7^f \pm .7$

[a] Dosage was determined by difference in weight of the implant at the initiation of the trial and termination divided by the number of days between implantation and removal (499).

[b,c,d,e,f] Means in the same row bearing different superscripts differ (P<.05).

From June 17 to September 17, the calves and their dams grazed a mixed-conifer forest range. Calves were weaned on this date (135 days after implantation), vaccinated against *Clostridium haemolyticum*, given an injection of *Clostridium, novyi-sordelli-perfringens* type C and D bacterin-toxoid and placed on alfalfa-grass hay aftermath pastures for a period of 61 days. During the 173-day wintering period, each age group was fed .91 kg barley (IFN 4-07-939)/head/day an an appropriate amount of alfalfa hay (IFN 1-00-068), based on body weight, to maintain approximately .68 kg daily gain. The following spring, steers from both age groups grazed improved irrigated pasture and received .68 kg barley/head/day for the first 37 days. For the last 28 days, barley intake was increased to 3.18 kg/head/day at the rate of .11 kg/day.

During the 65-day finishing period, steers were fed an initial diet that contained 57% concentrate, which was gradually increased to 89% by the end of the finishing phase. The concentrate consisted entirely of barley, except during the final 25 days, when .9 kg of corn (IFN 4-02-931) replaced .9 kg of barley. Native meadow hay (IFN 1-03-181) provided the roughage portion of the diet. Feed supplied was weighed daily and fed *ad libitum,* with orts recorded each weigh day. On September 20, final steer weights were taken and implants removed (499 days from implantation). Steers were fed for an additional 28 days before slaughter, and this was designated the withdrawal period. Steers were slaughtered on October 18, and carcass data were obtained from the USDA carcass data service.

Analysis of variance methods described by Steel and Torrie (1960) were used to evaluate data, and, where treatment significance was indicated, the differences between treatment means were tested by the Hartley modification of the Newman-Keuls Least Significance Difference procedure (Snedecor and Cochran, 1967).

Results and Discussion

Implant treatments and average daily dosage of $E_2\beta$ are presented in table 1. The drug delivery rate averaged 12 μg/cm of implant/day for the 1.27-, 2.54- and 3.81-cm implants and 13 μg for the .64-cm implant. There was no difference between the 2.54-cm solid and 2.54-cm coated implants, indicating that either form of the implant would be satisfactory.

TABLE 2. AVERAGE DAILY GAIN (± STANDARD ERRORS) IN KILOGRAMS FOR STEERS IMPLANTED WITH ESTRADIOL-17β DURING THE SUCKLING, POSTWEANING, WINTERING, PASTURE, FINISHING AND WITHDRAWAL PERIODS

Treatments[a]	Suckling	Post-weaning	Wintering	Pasture	Finishing	Withdrawal
1	1.01^{b} ± .05	.58^{b} ± .05	.65^{b} ± .02	1.08^{b} ± .06	1.48^{bc} ± .20	.94^{b} ± .12
2	1.08^{bcd} ± .05	.67^{b} ± .04	.61^{b} ± .02	1.04^{b} ± .03	1.35^{b} ± .18	.96 ± .15
3	1.05^{bc} ± .05	.63^{b} ± .02	.65^{b} ± .03	.93^{b} ± .06	1.45^{bc} ± .25	1.20^{cd} ± .11
4	1.11^{cd} ± .05	.68^{b} ± .04	.68^{bc} ± .03	1.09^{b} ± .09	1.52^{bc} ± .25	1.08^{b} ± .09
5	1.14^{d} ± .05	.63^{b} ± .05	.65^{b} ± .02	1.11^{b} ± .06	1.62^{c} ± .20	1.32^{d} ± .13
6	1.07^{bcd} ± .05	.60^{b} ± .04	.74^{c} ± .03	1.10^{b} ± .07	1.54^{bc} ± .21	1.17^{cd} ± .15

[a]See table 1 for treatment description.

[b,c,d]Means in the same row bearing different superscripts differ (P<.05).

Average daily gains for the suckling, postweaning, wintering, pasture, finishing and withdrawal periods are presented in table 2. During the suckling period, steers on treatments 4 and 5 gained faster ($P<.05$) than the controls on treatment 1 (1.11 and 1.14 *vs* 1.01 kg/day, respectively). All $E_2\beta$-implanted steers outgained the controls during the postweaning period, but differences were not significant. During the wintering period, steers on treatment 6 gained .74, compared to .65 kg for the controls ($P<.05$). No significant differences in weight gain were noted during the short pasture period. Through the suckling and growing phases (434 days after implantation), steers on treatments 4 and 5 had gained 7% faster than the controls in treatment 1, and steers on treatment 6 were gaining 8% faster.

None of the $E_2\beta$-implanted steers had gains different ($P>.05$) from those of the controls during the finishing period. However, the trend was for gains obtained with treatments 4, 5 and 6 to be higher than the control gains, and treatment 2 and 3 gains to be lower. A difference, ($P<.05$) in gain was found between age groups fed at different locations. However, there were no significant interactions between location and treatment, with treatment rank and magnitude of differences between treatments virtually identical. Differences in gain between the groups were attributed to transporting and handling of one group of animals, which depressed feed consumption for a while and delayed their reaching full feed long enough to produce a significant effect on gain over the short finishing period. During the 28-day withdrawal period, animals on treatments 3, 5 and 6 continued to outgain controls ($P<.05$), and increased gains with treatment 4 approached significance ($P<.10$). In all cases, $E_2\beta$-treated animals continued to gain as well as or better than the controls after implant removal. This finding suggests that if implant removal is required before slaughter, the animals on $E_2\beta$ will at least maintain their weight advantage over the controls and probably will increase it.

Table 3 presents feed efficiency data for the finishing period. Since animals were group fed, data were not analyzed statistically. However, implants did not appear to improve average feed efficiency. Increased gains of steers on treatments 4, 5 and 6 were accompanied by increased average pen feed intake. Average feed efficiency was almost identical between treatments. Steers on treatments 4, 5 and 6 were 23 kg heavier at the start of the finishing period than those on the other treatments and were 32 kg heavier at the end of the study, so increased feed intake would be expected. Increased maintenance requirements of the heavier animals throughout the finishing period may be the reason average feed efficiency was not improved by treatments 4, 5 and 6. Slaughtering animals at the same end weight would have removed the size difference and might have changed feed efficiency results somewhat.

The effect of $E_2\beta$ implants on gains of steers over the entire 499-day active period are shown in table 4. Gains by steers on treatments 5 and 6 (.97 kg) were greater ($P<.05$) than those by

TABLE 3. AVERAGE DAILY GAIN (ADG), AVERAGE DAILY FEED (ADF) AND FEED TO GAIN RATIO (F:G) FOR STEERS IMPLANTED WITH ESTRADIOL-17β DURING THE FINISHING PERIOD

Treatment[a]	Finishing period[b]		
	ADG	ADF[e]	F:G
1	1.48[cd] ± .20	10.6	7.3
2	1.35[c] ± .18	10.5	7.8
3	1.45[cd] ± .25	10.6	7.4
4	1.52[cd] ± .25	11.0	7.3
5	1.62[d] ± .20	11.6	7.2
6	1.54[cd] ± .21	11.2	7.3

[a]See table 1 for treatment description.

[b]ADG and F:G values are presented on a dry matter basis.

[c,d]Means in the same row bearing different superscripts differ ($P<.05$).

[e]ADF and F:G values are pen averages and data were not statistically analyzed.

TABLE 4. EFFECT OF ESTRADIOL-17β ON GAINS OF STEERS OVER THE ENTIRE 499 DAYS

Treat-ment[a]	No. of steers	Dosage	Avg initial weight	Avg total gain	Avg daily gain	Increase over control
		μg/day	kg	kg	kg ± SE	%
1	10	0	76	449	.90[b] ± .04	. . .
2	10	8.5	78	449	.90[b] ± .03	0
3	10	15.6	80	445	.89[b] ± .04	−1
4	10	30.7	80	475	.95[bc] ± .04	6
5	10	30.9	78	482	.97[c] ± .04	8
6	10	46.7	76	482	.97[c] ± .04	8

[a]See table 1 for treatment description.

[b,c]Means in the same row bearing different superscripts differ ($P<.05$).

steers on treatments 1, 2 and 3 (.90 kg), and treatment 4 gains (.95 kg) tended to be higher ($P<.10$). Dosage levels of $E_2\beta$ above 30.7 μg/day increased gains over those observed with the control; dosage levels below 30.7 μg did not improve gain. The 46.7-μg level did not improve steer gains over those obtained with the 30.9-μg level. Steers on treatments 4, 5 and 6 gained 475, 482 and 482 kg, respectively, as compared to 449, 449 and 445 kg for steers on treatments 1, 2 and 3. This represents a 6% increase in gain over the control value with treatment 4 and an 8% increase with treatments 5 and 6.

These results are similar to those of Parrott *et al.* (1979), who found the 2.54-cm implant provided the minimal dose for maximal anabolic response. Their results were obtained over a 456-day implant period. They also found that, during the finishing phase, $E_2\beta$ increased feed consumption with no effect on feed conversion.

There were no significant gain differences between animals given the 2.54-cm coated implant and those given the 2.54-cm solid implant during any of the periods examined or over the entire active period. These results indicate that either form of implant would provide similar results.

Neither the amount of $E_2\beta$ nor the type of implant significantly influenced (table 5) any carcass parameters, except for causing a detrimental effect on maturity. Wallentine *et al.* (1961) reported similar results when steers were given diethylstilbestrol. In this study, control animals had significantly more carcasses with A− maturity grades than did animals on treatments 4, 5 and 6. As the dose rate of $E_2\beta$ increased, the degree of carcass maturity increased. Type of implant used did not influence maturity score. Ralston *et al.* (1973) obtained similar results with calves given diethylstilbestrol implants for 210 days; the authors determined carcass maturity by ashing the cartilaginous tip of the spinal process of the first thoracic vertebra and found significantly more ash in the implanted calves than in the controls.

In summary, this study indicates that a single implant of estradiol-17β delivering approximately 30.7 μg/day will improve weight gains over a long period of time (499 days) and increase carcass maturity grade of steers. Stimulatory activity from a single implant over a long period and the ability to remove the implant are important considerations. Numerous studies have pointed out the necessity of reimplanting every 65 to 100 days when using current commercial products containing zearalanol, progesterone-estradiol benzoate or diethylstilbestrol (Thompson and Kercher, 1959; Melton and Riggs, 1965; Lofgreen, 1974). In many cases, producers cannot or will not gather their steers for reimplantation and hence, will lose a portion of the potential benefit. With a long-lasting implant like the $E_2\beta$ implant, this expensive and time-consuming task of gathering and handling steers for reimplantation is eliminated. Also, with the capabilities of physically removing the implant, problems associated with withdrawal times before slaughter and residue of the drug in the carcass can be minimized.

TABLE 5. CARCASS DATA FOR STEERS IMPLANTED WITH DIFFERENT LEVELS OF ESTRADIOL-17β

Treatment[a]	Maturity[b]	Marbling[c] score	Quality[d] grade	Adjusted fat thickness, cm	Ribeye area, cm^2	Kidney, pelvic and heart fat, %	Yield grade
1	$1.6^{e} \pm .2$	$19.7^{e} \pm .7$	$7.7^{e} \pm .6$	$.53^{e} \pm .05$	$32.5^{e} \pm 1.5$	$2.2^{e} \pm .2$	$2.1^{e} \pm .1$
2	$1.4^{ef} \pm .1$	$18.9^{e} \pm .9$	$7.3^{e} \pm .6$	$.66^{e} \pm .06$	$34.8^{e} \pm 1.5$	$2.5^{e} \pm .1$	$2.1^{e} \pm .1$
3	$1.3^{efg} \pm .2$	$19.1^{e} \pm .6$	$7.3^{e} \pm .5$	$.64^{e} \pm .08$	$29.7^{e} \pm 1.0$	$2.2^{e} \pm .2$	$2.4^{e} \pm .2$
4	$1.2^{fg} \pm .1$	$19.9^{e} \pm 1.4$	$8.2^{e} \pm .8$	$.43^{e} \pm .05$	$34.0^{e} \pm 1.4$	$2.4^{e} \pm .2$	$1.8^{e} \pm .1$
5	$1.2^{fg} \pm .1$	$21.1^{e} \pm .8$	$8.9^{e} \pm .6$	$.46^{e} \pm .02$	$33.3^{e} \pm 1.3$	$1.9^{e} \pm .2$	$1.8^{e} \pm .1$
6	$1.1^{g} \pm .1$	$19.8^{e} \pm .1$	$7.3^{e} \pm .5$	$.66^{e} \pm .10$	$32.8^{e} \pm 1.5$	$2.5^{e} \pm .2$	$2.3^{e} \pm .2$

[a]See table 1 for treatment descriptions.

[b]Maturity: 1 = A, 2 = A –.

[c]Marbling scores assigned on a scale of 1 to 26, where 2 = abundant, 17 = small, 26 = devoid.

[d]Quality grade assigned on a scale of 1 to 12, where 2 = Prime, 5 = Choice, 8 = Good, and 11 = Standard.

[e,f,g]Means in the same row bearing different superscripts differ (P<.05).

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