Project Title: **Effects of long-acting Estrogen-base Growth Promotant on Growth and Performance and Carcass Characteristics in Holstein Steers**

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Project Summary

The objective of the proposed research was to test the efficacy of a long-lasting, sustained-release estrogen implant, singularly, and in combination with other growth promotants. Specifically, the following responses will be measured: (1) effect on growth and efficiency characteristics, (2) influence on quality grade, yield grade, dressing percent and ribeye area, and (3) effect of season on implant regimen. The working hypotheses of the proposed research are (1) A long-acting estrogen implant can be used in a growth promoting strategy (which limits the number of times the cattle must be handled) maintains the rapid growth and high efficiency of other implants regimens, yet minimizes the detrimental effects of implants on carcass quality. (2) Different strategies are appropriate depending on the season of placement into the feedyard. Two hundred thirty-six Holstein steers (141 kg) randomly assigned to one of four treatment groups (A, B, C, D; n = 59) were used to investigate the effects of a long-acting estrogen implant with and without a trenbolone acetate/estradiol terminal implant on growth, performance and carcass characteristics. Implants contained zeranol (Z), progesterone (P_4), estradiol benzoate (EB) or trenbolone acetate (TBA) and estradiol (E_2). Animals were treated as described (tables) and weight gain, average daily gain (ADG), and feed efficiency were calculated on 30-d intervals. Steers were harvested after 276d on feed and carcass measurements were collected. All implanted groups had heavier ($P<0.05$) average final live weights and carcass weights, and improved ADG ($P<0.05$) compared with non-implanted controls. Cattle receiving the TBA/E_2 terminal implant produced heavier carcasses than implanted cattle not receiving the terminal implant ($P<0.05$). Average REA were significantly greater ($P<0.05$) for all groups receiving the terminal implant than either E_2 only or non-implanted groups. The percentage of carcasses with USDA quality grade of Choice or better was significantly lower ($P<0.05$) for treatment A (66.7%) than treatment B (83.9%) and non-implanted controls (85.2%), but treatment C (72.9%) was not different from any other treatment group. In a second phase of the study, cattle were 960 steers were fed in a commercial feedyard in Southern California. The cattle were placed in Spring or Fall, and implanted with similar protocols as described above. Relative differences in carcass data were similar to those in Phase I. Encore does not significantly reduce quality grade compared with control cattle, particularly when calves are exposed to heat stress during the early growth phases. Based on these data, a long-acting estrogen implant is effective in increasing growth and efficiency compared with non-implanted controls. A TBA/E_2 terminal implant 180 d after the initial estrogen implant significantly improved growth and efficiency, yet did not significantly suppress quality grades compared with non-implanted controls.

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Brief Statement of the Problem

Currently, approximately 95% of all the fed cattle in the United States are provided supplemental growth stimulation through the use of growth-promoting implants. The vast majority of the research identifying the optimal combinations and times of implant presentation was conducted on traditional beef cattle (*Bos taurus*). However, a large number of steers from the dairy industry are fed in feedlots. The United States currently has over 9 million dairy cows in production (USDA, 1997). Specifically, California has approximately 1.3 million dairy cows. A major byproduct of the dairy industry is the large number of male calves (approximately 4.5 million head annually), of which the majority will be fed in feedlots and harvested as retail beef products. Holstein steers have genetic differences compared with typical beef steers. Knapp and coworkers (1989) found Holsteins had higher frame and lower conformational scores than beef counterparts. Differences in dairy-influenced steers and beef-bred steers is further emphasized by overall body conformation. Holstein steers have longer rumps, and longer deeper bodies than Hereford cattle. In comparison Hereford cattle were wider with greater round circumferences (Garcia-de-Siles et al, 1977). Furthermore, dairy-influenced steers had a higher percentage of bone along with lower fat trim than other beef-bred types leading to a decrease in yield when compared with traditional beef breeds harvested at the same weight. Nour and coworkers (1983a) described weight to mature size as a major factor of meat animal yield and value. Meat yield from Holstein steer carcasses is lower than from beef carcasses. Garcia-de-Siles (1977) and coworkers found that Holstein steers reached slaughter weight an average of 83.3 days before Hereford cattle. The large mature size of Holstein steers results in cattle with excess weight at slaughter if fed to reach a desired internal muscular fat deposition (marbling) endpoint. Ziegler and coworkers (1971), reported that non-implanted Holstein steers had reduced marbling scores, quality grades and overall acceptability when compared with non-implanted Angus, Hereford and Shorthorn breeds harvested at approximately the same weight. These differences are also consistent when administering growth implants. Nour and coworkers (1983b) reported that implanted Angus steers had higher marbling scores and quality grades than implanted Holstein steers at various chilled weights. Additionally, Garrett (1971) reported that Hereford steers, given an estrogen-like anabolic implant, have improved feed to gain ratios with a larger yield and higher grade compared with identically implanted Holstein steers. These genetic differences put Holstein steers, fed and managed in traditional feedlot settings, at an economic disadvantage when compared with their beef breed counterparts. ***Holstein steers have grossly different energy partitioning criteria, coupled with a distinctive growth curve.***

Reports on the effects of implants in Holstein cattle are also limited. Apple and coworkers (1991) report that a combination of TBA and E_2 result in a synergistic effect on gain in Holstein steers. Specifically, in Holstein steers an implant protocol combining TBA and E_2 improved ADG when compared with TBA implants, zeranol, or no implant (Apple et al., 1991). TBA and E_2 implants also increased longissimus muscle area by $10cm^2$ over the control group, and marbling score was unaffected. Previous results at Cal Poly indicate that with proper implant management, it is possible to achieve an acceptable quality and yield grade in implanted Holstein steers (**Figure 1**). Steaks from Holstein steers could not be distinguished from Angus x Simmental steers by visual or sensory evaluation (Thonney et al., 1991). The challenge for feedlot operators who manage Holstein steers is to optimize performance, carcass conformation, and quality grade without sacrificing discounts for heavy carcasses. ***Proper regimens regarding repeated implanting of Holstein steers have not been developed and properly validated, particularly regarding the onset of implant exposure.***

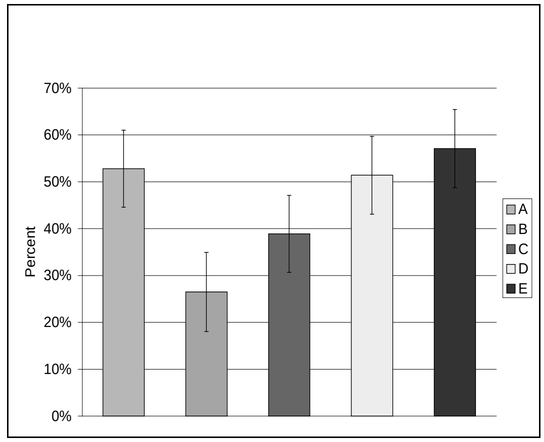

Figure 1. Percent of steers grading USDA Choice or better. Treatments A-D included various implant regimens; treatment E was nonimplanted control (Fowler et el., 1999, unpublished data).

Recently, an estradiol-based implant has been developed that dispenses the active ingredient over a period of 400 days. This sustained release is being used primarily in cattle grazing on forage prior to entry into the feedyard. Although the Encore® product is approved for use in feedlot cattle, steers of traditional beef genetics generally do not spend more than 130 days in the feedyard. Therefore, the long-lasting implant is not well-suited for that application. However, most Holstein steers on feed in California spend approximately 300 days on feed. Presumably, the Encore® implant would dispense the active ingredient in sufficient quantities throughout the growing phase of these cattle. However, it is unknown whether the dose of Estradiol presented to the animals immediately after implantation would be too high for the small calves. Additionally, it is unclear whether the implant would have sufficient growth stimulation capabilities remaining during the final 100 days of feeding in these cattle. The use of a terminal implant containing either trenbolone acetate alone or in combination with estradiol may be necessary to complete the growing process efficiently. Finally, even if the implant is effective in promoting growth and performance, the effect of the implant on carcass quality has not been investigated in the Holstein steer. ***The working hypotheses of the proposed research are (1) A long-acting estrogen implant can be used in a growth promoting strategy (which limits the number of times the cattle must be handled) maintains the rapid growth and high efficiency of other implants regimens, yet minimizes the detrimental effects of implants on carcass quality. (2) Different strategies are appropriate depending on the season of placement into the feedyard.***

Statement of Methodology

The hypotheses were tested in two phases. Phase I was conducted at the Beef Cattle Evaluation Center on the Cal Poly campus in San Luis Obispo. The primary interest in Phase 1 was to determine the effects of the proposed implant strategies on growth and performance of feedlot cattle. Phase II was conducted as a field trial at the El Toro Feedyard in Heber, CA. The primary objective of Phase II was to determine the effects of implant strategy on carcass quality.

Phase I

Experiment Two hundred thirty-four single source Holstein steers calves (126 kg) were purchased from a reputable calf grower in California's central valley. Upon arrival, steers were weighed and processed, including vaccination against IBR, BVD, PI_3 and seven clostridial pathogens. Steers were acclimated for approximately 12 days. Steers receive a booster (IBR-BVD-PI_3) and dewormed with Moxidectin (Cydectin®, Fort Dodge Animal Health, Overland Park, KS) at this time.

Steers will receive a starter ration from d-25 to d 14 fed 3x daily at 0600, 1200, and 1700, containing 17.5% roughage and 60% concentrate. Steers received a finishing ration from d 15 to d 300 containing 12% roughage and 68% concentrate 2X daily, 0600 and 1700. Steers had *ad libitum* access to salt blocks and fresh water. Individual steer weights were recorded every 30 d. Steers were harvested at an average final weight of 560 kg.

	AMOUNT	
INGREDIENT	**STARTER**	**FINISHER**
Alfalfa Hay	330.0	240.0
Corn, steam flaked	1,238.6	1,251.2
Holstein starter supplement	231.4	-
Vegetable oil	40.0	80.0
Molasses, bull test	160.0	124.0
Almond hulls	-	140.0
Holstein finishing supplement	-	153.0
Urea	-	11.8
Total:	2,000.0	2,000.0

ITEM	SUPPLEMENT (%) STARTER	FINISHER
Salt	4.75	3.92
Vitamin A, 5 mil IU/lb	1.38	0.85
Vitamin E, 54,000 IU/lb	0.56	0
Mill run carrier	0	32.68
Distillers grains	69.14	0
Ca Carb, Limestone	9.67	13.45
Kruse Calf TM	0.43	0.65
Rumensin 80	0	0.24
Chlortet .50gm/lb	1.08	0
Yeast, Diamond-V-XP	5.19	0
Urea 46N	6.39	4.58
SBM, 47 CP	0	36.6
BioPhos, 18.5CA/21P	0.14	3.55
Magnesium Oxide	1.27	2.17
Fat, An/Veg Blend	0	1.31
Total	100	100

The cattle were weighed on day minus one (-1). Cattle obviously outside of the desired weight range, or those with visible health concerns were eliminated from the study prior to assignment to treatment. Cattle acceptable for the study were blocked by body weight. The first block contained the sixteen heaviest steers, the second contained the next heaviest steers and so on until approximately 15 blocks were created. One animal within each block was randomly assigned (using a random-number generator on a spreadsheet) to each of the sixteen treatment pens, thereby forming sixteen pens with approximately 14 head per pen. Pens were randomly assigned to treatments (4 pens per treatment). Initial weights from the day –1 weighing were statistically tested for differences between treatments using PROC GLM of SAS (1985). Average initial weights (141 kg) did not differ by treatment ($p<0.05$). Treatments are described in Table 1. Implants were administered according to manufacturers' directions.

Table 1.

	Days					
Treatment period	1	2	3	4	5	6
Interval (days)	0 - 60	61 – 120	121 – 180	181 – 210	211 - 276	Slaughter
1	Ralgro	Comp E-S →	→	→	Comp TE-S	→
2	Encore	→	→	→	→	→
3	Encore →	→	→	→	Comp TE-S	→
4	Non Implanted Control	→	→	→	→	→

Drug Formulations		
Generic Name	**Trade Name**	**Company**
Estradiol (43.7 mg)	Encore®	VetLife
Zeranol (36 mg)	Ralgro®	Schering-Plough
Trenbolone Acetate (120 mg) Estradiol (24 mg)	Component TE-S®	VetLife
Estradiol Benzoate (20 mg) Progesterone (200 mg)	Component E-S	VetLife

Carcass Data Steers were transported to a mutually agreed upon packing plant (Harris Meat Company, Selma, CA) and harvested within 2 h of arrival. Dressing percentages were calculated as the ratio of hot carcass weight to live weight. Marbling score, quality grade (QG), adjusted yield grade (YG), percent kidney, and pelvic and heart fat (%KPH) were estimated by USDA graders. Measurements of longissimus muscle area, and 12th-13th rib backfat thickness were obtained by trained personnel following a 24-h chill using REA grids.

Statistical Analysis Average body weights, weight gains, feed intake and feed efficiency were analyzed by ANOVA using PROC GLM of SAS (1985) using pen as the experimental unit. Carcass data including ADG, ribeye area, marbling, yield grade, backfat, and %KPH were analyzed by ANOVA using PROC GLM of SAS (1985) with animal as the experimental unit. Mean comparisons were made using Duncan's multiple range test (Gill, 1978). Differences in the percentage of USDA Choice or better and percentage of USDA yield grade 1 or 2 were analyzed by χ^2 analysis using PROC FREQ and quality and yield grade data was fit to log-linear models using PROC CATMOD (SAS, 1985).

The ANOVA model for all responses was as follows:

$$Y_{ijk} = \mu + T_i + P(T_i)_j + \varepsilon_{ijk}$$

where Y_{ijk} was the observation for the k-th animal receiving the i-th treatment in the j-th pen, where i = 1, 2, 3, 4; j = 1, 2, 3, 4; k = 1, 2, …, 14; T_i was the i-th treatment effect (a fixed effect), P_j was the j-th pen effect (a fixed effect), and ε_{ijk} was the residual error due to the (i, j, k)-th observation assumed to be randomly normally distributed with mean 0 and variance σ^2, where σ^2 was estimated by the ANOVA mean square error.

Phase II

Experiment Due to the extreme differences in season in the Imperial Valley, the second phase of the trial was conducted with summer placement cattle, and repeated with winter placement cattle. For each season (July – summer placement, January – winter placement), approximately 480 Holstein steers calves (144 kg), already delivered to the feedyard in Heber (El Toro Cattle Company) were weighed and processed according to the protocol of the commercial feedyard. At the initiation of the study, initial weights of steers were obtained as fed weights. Steers were fed and sick animals were treated according to the protocols in place at El Toro Land and Cattle. Steers were harvested at an approximate final weight of 600 kg at Brawley Beef Company (Brawley, CA).

During the first treatment, calves were assigned to one of 6 pens by gate cut. Two pens were randomly assigned to each of 3 treatments (Table 2), and identified with eartags colored to correspond to the treatment group. Implants were administered according to manufacturers' directions. Steers with chronic illness were removed from the trial at the discretion of the principal investigator and feedlot manager.

Table 2.

	Days					
Treatment period	1	2	3	4	5	6
Interval (days)	0 - 60	61 – 120	121 – 180	181 – 210	211 - 300	Slaughter
1	Ralgro	Comp E-S	→	→	Comp TE-S	→
2	Encore	→	→	→	→	→
3	Encore	→	→	→	Comp TE-S	→

Carcass Data Carcass data were collected and statistically analyzed as described in Phase I by season.

Results

Tmt period	1	2	3	4	5	6
Interval (days)	0 - 60	61 - 120	121 - 180	181 - 210	211 - 276	Slaughter
A	Ralgro	Comp ES →		Comp TE-S →	→	→
B	Encore →	→	→	→	→	→
C	Encore →	→	→	Comp TE-S →	→	→
D	Nonimplanted control →	→	→	→	→	→

Phase I (San Luis Obispo)

	Treatment				
	A	***B***	***C***	***D***	***Average***
Average Daily Gain (kg/d)	1.58^{a}	1.48^{b}	1.56^{a}	1.37^{c}	1.50
Feed intake (kg dm/d)	8.1^{a}	7.8^{ab}	7.9^{a}	7.4^{b}	7.8
Feed effic. (kg feed/kg gain)	5.15^{ab}	5.24^{ab}	5.09^{a}	5.36^{b}	5.2
Live Weight (kg)	580.9^{a}	557.0^{b}	577.2^{a}	525.8^{c}	560.2
Hot Carcass Weight (kg)	350.8^{a}	330.7^{b}	344.7^{a}	314.5^{c}	335.2
Dressing Percent	60.4^{a}	59.3^{b}	59.8^{ab}	59.8^{b}	59.8
Fat Thickness (cm)	0.79	0.76	0.69	0.69	0.73
Marbling Code	7.89^{b}	9.65^{a}	8.49^{b}	8.98^{ab}	8.75
Ribeye Area (cm^2)	77.4	71.6	76.8	70.6	74.1
Quality Grade	4.49^{b}	5.04^{a}	4.63^{b}	4.83^{ab}	4.75
KPH	2.45	2.28	2.28	2.45	2.37
Final Yield Grade	2.90^{ab}	2.96^{a}	2.72^{b}	2.82^{ab}	2.85
Choice or Better (%)	66.7^{b}	83.9^{a}	72.9^{ab}	85.2^{a}	77.2

Phase II (El Toro Cattle Company)

Tmt period	1	2	3	4	5	6
Interval (days)	0 - 60	61 - 120	121 - 180	181 - 210	211 - 291	Slaughter
Treatment						
A	Ralgro	Comp ES ⟶		Comp TE-S ⟶		
B	Encore ⟶					
C	Encore ⟶			Comp TE-S ⟶		

	Fall Placement			Spring Placement			
TMT	A	B	C	A	B	C	Avg
Hot Carcass Wt (kg)	370.7^{a}	362.1^{b}	374.4^{a}	370.1^{a}	358.7^{b}	373.5^{a}	368.2
Ribeye Area (cm^2)	75.3^{b}	69.8^{c}	73.9^{b}	78.8^{a}	74.7^{b}	78.3^{a}	75.1
Fat Thickness (cm)	0.6^{c}	0.8^{a}	0.7^{c}	0.7^{c}	0.7^{ab}	0.7^{bc}	0.7
Quality grade code	5.4	5.9	6.2	4.2	4.9	4.2	5.1
Yield Grade	2.0^{d}	2.4^{c}	1.9^{d}	2.9^{b}	3.1^{a}	3.0^{ab}	2.6
% Choice or better	51.4^{c}	72.2^{a}	61.4^{bc}	34.4^{d}	67.6^{ab}	33.5^{d}	53.4

Conclusion

Encore appears to be very effective in sustaining growth and performance for approximately 180 days. However, the implant does not appear to have sufficient payout to sustain growth and feed efficiency for an entire growing season in calf-fed Holstein steers. Indeed, the terminal implant containing TBA and E_2 dramatically improved gain in the cattle previously treated with Encore. Apparently, the Encore implant early in the growth phase primed the animals to respond to the TBA/E_2 terminal implant, such that the terminal implant provided an additional boost in growth and feed efficiency. Therefore, it is clear that the Encore-treated calves need a terminal implant for maximal gains.

The Encore implant does not appear to significantly suppress quality grade. Either the E_2 implant is mild enough during the early growth period that fat deposition is allowed to proceed unaltered, or the E_2 does not increase the growth curve as extensively as a more aggressive implant. If the latter is true, the cattle would be harvested at a physiological endpoint that is more similar to the natural, nonimplanted steer. However, the terminal implants tend to suppress quality grades in cattle previously treated with Encore. This was expected, and the degree of suppression was not severe. Indeed, the current pricing structure of cattle in Imperial Valley (Smithfield and Brawley Beef) limits the premium for Choice cattle to 35-50%. Therefore, any cattle grading Choice over the maximum payout are sold at Select prices. Increasing growth and efficiency at the expense of a marginal decrease in quality grade certainly can be more profitable than pursuing more marbling.

Encore does not significantly reduce quality grade compared with control cattle, particularly when calves are exposed to heat stress during the early growth phases. The greatest value with Encore will be in calves placed during the spring or early summer in hot climates. This strategy will enable producers to make it through the summer without processing the animals an additional time, thereby minimize heat stress in spring placement cattle.

Finally, fewer times through chute means less potential injury, lower labor costs and fewer wasted growth days. The sustained release implants should yield fewer carcass defects that are associated with working the animals.

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