A dose-response study of melengestrol acetate on feedlot performance and carcass characteristics of beef steers[1]

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ABSTRACT: The dose response of melengestrol acetate (MGA) on ADG (kg/d) and gain efficiency (gain/DMI, g/kg) was estimated in beef steers fed a finishing diet under commercial feedlot conditions. Melengestrol acetate is not approved for use in steers as a feed additive. The study design was five blocks of four pens (each pen was assigned a dose of MGA) with 166 to 200 steers per pen. Melengestrol acetate was fed to steers at 0 (n = 899, five pens), 0.1 (n = 900, five pens), 0.2 (n = 899, five pens), and 0.4 (n = 900, five pens) mg of MGA/steer daily. Pens within a block were slaughtered on the same day. Blocks 1 through 5 were fed MGA for 123, 122, 116, 124, and 138 d, respectively. The experimental unit was a pen of steers, and blocking was based on source of steers. The ADG was 1.81, 1.85, 1.80, and 1.83 kg/d for steers fed 0, 0.1, 0.2, and 0.4 mg MGA per day, respectively. For ADG, the dose was significant, but neither linear nor quadratic effects were significant. Compared with steers of the control group, ADG was greater for steers fed 0.1 mg MGA ($P < 0.01$). Feed efficiencies were 170, 173, 171, and 172 g/kg for steers fed 0, 0.1, 0.2, and 0.4 mg MGA/d, respectively; however, no effects of dose ($P = 0.19$) or linear ($P = 0.21$) or quadratic ($P > 0.60$) effects were observed. There was no evidence for either positive or negative effects of MGA on DMI, hot carcass weight, dressing percent, quality grade, yield grade, back fat thickness, marbling score, longissimus muscle area, and incidence of dark cutter carcasses in response to feeding MGA to steers at doses of 0.1, 0.2, and 0.4 mg daily. The incidence of buller behavior (0.43 to 1.11%) was low and did not permit an accurate test of the clinical observations that feeding MGA to steers decreases the occurrence of buller steers. Melengestrol acetate fed to finishing beef steers produced small improvements in growth performance (ADG, 2.2%) at the 0.1 mg MGA dose, but none of the doses examined produced improvement in carcass quality or yield grade measurements.

Key Words: Average Daily Gain, Gain Efficiency, Live Weight Gain, Melengestrol Acetate, Steers

 J. Anim. Sci. 2003. 81:2699–2703

Introduction

Melengestrol acetate (**MGA**) is an orally active progestogen that inhibits estrus and ovulation and increases weight gain in heifers (Bloss et al., 1966; Lauderdale, 1983). Melengestrol acetate is approved for feeding to heifers in confinement for slaughter at doses ranging from 0.25 to 0.50 mg/heifer daily for increased weight gain, improved gain efficiency, and suppression of estrus (Federal Register, 1968; Food and Drug Administration, 1968). Melengestrol acetate is not approved for use in steers as a feed additive. Research has suggested that steers fed MGA had increased daily gains (Lauderdale, 1983). Anecdotal information from commercial feedlots indicated that providing MGA to steers decreased the incidence of "bullers" (steers that allow themselves to be repeatedly ridden by herd mates); however, federal law prohibits extra-label use of this drug. Data derived from eight studies (Lauderdale, 1983) with steers and bulls suggested that daily feeding of MGA in excess of 0.35 mg depressed both ADG by 1 to 21% and gain efficiency by 0 to 7%, whereas daily feeding of 0.20 mg MGA increased ADG 10 to 25%. Limitations of these studies in applicability of the data to feedlot production are absence of within-study dose-response data, minimal data with doses below 0.35 mg MGA daily, and limited numbers of animals per treatment group (n = 4 to 9 for four studies and 12 to 20 for four studies).

The objective of this study was to estimate the dose response of MGA on ADG, gain efficiency, carcass characteristics, and buller behavior of feedlot beef steers. The study was completed in a single location with suffi-

[1]The authors acknowledge D. P. Horton, S. D. Huse, M. I. Wray, and the research staff at Horton Research Center, and A. D. Grona, J. A. Scanga, and K. E. Belk at Colorado State University for their excellent assistance in completing this research.

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Received January 21, 2003.

Accepted August 5, 2003.

cient animal numbers and statistical power to detect differences on the order of 2.5% or greater.

Materials and Methods

Animal Management

English and Continental crossbred steers were purchased from two ranches in Montana, two ranches in Colorado, and one auction barn in Colorado. The steers were trucked to a feedlot in Colorado typical of the High Plains cattle feeding area. Each pen had a dirt floor, a fresh water supply, 18 to 19 cm of feed bunk space per steer, and approximately 76.3 to 91.5 m^2/steer. Animals had sufficient freedom of movement for expression of behavior, including the ability to turn around, groom themselves, lie down, get up, and stretch their limbs without difficulty. There was sufficient room for riding (bulling) behavior. The steers were managed in accordance with applicable laws and regulations governing the humane care of animals. This study was conducted under INAD 2714, which stipulated a 7-d preslaughter withdrawal period for steers fed MGA.

The study consisted of five blocks of four pens per replicate. Before processing, each steer was assessed visually and steers were removed if they had health problems, were of predominantly Holstein or Brahman breeding, or were excessively heavy or light BW. Steers were processed, consistent with the feedlot standard operating procedures, within 48 h after arrival. During processing, both ears of each steer were palpated for the presence of growth-promotion implants and detected implants were removed. Each steer was weighed, identified with ear tags, vaccinated for infectious bovine rhinotracheitis and bovine viral diarrhea (BoviShield IBR-BVD, Pfizer Animal Health, Exton, PA) and treated for internal and external parasites (Dectomax [doramectin], Pfizer Animal Health). Each steer received an ear tag with a unique number in one ear and an ear tag with a unique number that identified the steer by treatment group, replicate, and animal number in the other ear. Lost ear tags were replaced. Steers were not assigned to this study if they weighed less than 341 kg BW or more than 420 kg BW for Replicates 1 through 4 and less than 300 kg BW or more than 375 kg BW for Replicate 5. Upon release from the chute, each steer was assigned to one of four holding pens. After all steers from a source were in the holding pens, they were transported to the feedlot pens. Additional steers from other sources were added in the same manner until the feedlot pens reached maximum capacity of 166 to 200 steers per pen. A maximum of 7 d was allowed for assembling a replicate of four feedlot pens containing the maximum capacity of steers. Replicates 1 through 4 consisted of animals weighing 341 to 419 kg BW, and Replicate 5 consisted of animals weighing 301 to 374 kg BW.

Within each of the five replicates, the dose of MGA was assigned randomly to each of the four pens. The dose of MGA was fed at rates of 0, 0.1, 0.2, and 0.4 mg/steer daily. Each pen of steers was weighed before feeding on the day MGA was introduced into the feed (d 0), on d 56, and on the day MGA was removed from the ration. The accuracy of the scales was confirmed (tare = 0, 114 kg, 341 kg) before each weighing. Pen weight was obtained by weighing 20 to 25 steers as a group and summing those group weights. Termination of a replicate was based on the decision of one or two professional cattle buyers that at least one of four pens of steers within a replicate had reached market weight and condition; when that decision was made, MGA was removed from the ration of all pens within that replicate and all pens of steers of that replicate were harvested 7 d subsequently. Pen riders observed steers in each pen at least once daily. Steers were removed to the hospital pen if they appeared to have bovine respiratory disease, injury, lameness, lack of fill, bloat, or diarrhea. Steers that recovered from their diagnosed condition were returned to their feedlot pens. Steers that did not recover from disease or injury were removed from study at the discretion of the attending veterinarian, who did not have knowledge of the dose being fed to the steers. Steers observed to be bullers were pulled, allowed a 3- to 7-d stay in a hospital pen (to decrease bulling activity), and then returned to their feedlot pens. The second time a steer was identified as a buller, he was removed from the study.

The number of steers assigned to the study was 3,598, and 3,552 steers completed the study. Numbers of steers per dose at the start and end of the study for the MGA doses of 0, 0.1, 0.2, and 0.4 mg/steer daily were 899 and 886, 900 and 890, 899 and 886, 900 and 890, for losses of 13, 10, 13, and 10 steers, respectively. Reasons for removal from study for the 0-, 0.1-, 0.2-, and 0.4-MGA-dose groups were as follows: repeat buller (8/13, 3/10, 3/13, and 2/10), chronic lameness (2/13, 4/10, 3/13, and 3/10), poor doer (1/13, 0/10, 2/13, and 2/10), injury (0/13, 1/10 spinal cord; 2/13 leg and spinal cord; and 1/10 broken leg), and various debilitating conditions (2/13 bloat and heart failure; 2/10 pneumonia and acute enteritis; 3/13 unknown, bloat, and liver abscesses; and 2/10 bloat and founder).

Diet and Feeding

To minimize bias, two individuals mixed and delivered feed but did not weigh either steers or feed and did not collect data at slaughter. The first day (start of study for each replicate) and last day of MGA feeding (days on study) for Replicates 1 through 5 were 9/12/97 and 1/12/98 (123 d), 9/13/97 and 1/12/98 (122 d), 9/20/97 and 1/13/98 (116 d), 9/26/97 and 1/27/98 (124 d), 9/26/97 and 2/10/98 (138 d), respectively. Steers were fed twice daily. Four step-up rations were used to adjust the steers to the final ration. Monensin (33 mg/kg; Rumensin, Elanco, Indianapolis, IN) and tylosin (11 mg/kg; Tylan, Elanco) were incorporated into the ration. Melengestrol acetate (MGA 500 Liquid Premix, Phar-

Table 1. Nutrient composition of step-up diets A, B, C, and D, plus final diet E, 100% DM basis

Item	A	B	C	D	E Oct	E Nov	E Jan	E Feb	E Mean[a]
Composition									
Steam-flaked corn[b]	43.6	50.8	57.5	71.2	—	—	—	—	83.1
Corn silage[b]	3.5	24.5	26.1	14.1	—	—	—	—	5.0
Alfalfa hay[b]	46.1	16.2	7.7	5.5	—	—	—	—	2.2
Liquid supplement[b]	6.7	8.5	8.7	9.2	—	—	—	—	9.7
Analyzed nutrient composition									
Dry matter, %	72.4	53.8	51.9	61.4	68.3	71.1	70.4	68.8	69.6
Crude protein, %	16.6	15.7	14.7	14.4	14.8	12.8	13.1	15.3	14.0
Crude fiber, %	17.8	12.9	11.9	6.0	4.7	4.3	6.6	5.1	5.2
Crude fat, %	2.6	3.1	2.6	3.3	2.5	3.5	2.8	3.0	3.0
Calcium, %	0.90	0.72	0.67	0.66	0.47	0.73	0.46	0.58	0.56
Phosphorus, %	0.34	0.35	0.35	0.38	0.36	0.43	0.27	0.34	0.35
Potassium, %	1.18	0.90	0.79	0.65	0.56	0.62	0.74	0.71	0.66
Magnesium, %	0.21	0.21	0.20	0.20	0.15	0.21	0.13	0.18	0.17
Sodium, %	0.22	0.25	0.22	0.21	0.27	0.22	0.29	0.31	0.27
Sulfur, %	0.22	0.22	0.20	0.20	0.17	0.17	0.28	0.32	0.24
Iron, ppm	286.5	238.7	281.0	341.5	141.2	194.2	153.5	167.2	164.0
Manganese, ppm	42.0	51.2	48.3	45.1	25.2	42.1	30.9	30.4	32.2
Zinc, ppm	44.2	53.4	48.3	51.1	32.3	50.1	71.1	54.7	52.1
Copper, ppm	12.9	21.8	10.7	11.0	15.1	18.0	24.7	20.3	19.5
Calculated NE_m, Mcal/kg[c]	1.62	1.86	1.93	2.13	2.22	2.22	2.22	2.22	2.22
Calculated NE_g, Mcal/kg[c]	1.04	1.24	1.29	1.42	1.53	1.57	1.53	1.57	1.53

[a]Mean of four monthly samples.
[b]Based on 100% DM ingredient composition.
[c]Based on tabular values for individual ingredients (NRC, 1996).

macia Corp., Kalamazoo, MI) was incorporated into both the four step-up rations and the final ration with a Microingredient machine (Lextron, Inc., Greeley, CO). Each pen of steers was fed to appetite to prevent build-up of excessive feed in the feed bunk.

The four step-up diets (A, B, C, and D) and the final diet (E) were each composed of corn silage, alfalfa hay, steam-flaked corn, and liquid supplement. Based on 100% dry matter, the respective percentages for the four step-up diets and the final diet are shown in Table 1. Nutrient assays were conducted by Olsen's Agricultural Laboratory, Inc., McCook, NE, on each of the four step-up rations as they were used and on a monthly basis for the final ration (Table 1). The quantity of feed placed in the feed bunk of each pen was recorded daily. Feed weigh-backs were recorded for each pen as needed throughout the study, on d 56, and on the day the performance test was completed for each pen. Weigh-backs were measured on an as-is basis and then multiplied by percentage of dietary dry matter to compute 100% DM. Moisture contents were obtained for corn silage, alfalfa hay, and steam-flaked corn for each pen on each weigh-back sample. Average daily feed intake and gain efficiency were computed for the interval from initial weighing until final weighing. The DMI was calculated for each pen on a DM basis as the amount of feed offered minus the weigh-back divided by the number of animal-days. An animal-day was contributed for each animal and each day that animal resided in the pen. Animals that were removed from a pen did not contribute to the DMI for those days outside the pen. To calculate ADG, the initial pen weight was divided by the number of steers in the pen, which was subtracted from the final pen weight divided by the number of steers in the pen. This difference was then divided by the number of days on trial.

Slaughter

On the day of slaughter, pen weights were obtained by weighing an empty truck, weighing the truck when loaded, and continuing this process until all steers from a pen were loaded and weighed; if there were insufficient steers to complete a truckload, the truck was weighed with the incomplete load and additional steers from the next pen were added to the truck and the truck reweighed. Pen weights were the summation of weights of the steers from that pen. The steers were trucked to a commercial beef packing facility. Individually identified steers were followed through slaughter. The carcasses were chilled for 36 h. Trained personnel from Colorado State University, using the USDA-AMS 1997 Official Grade Standards for Beef Carcasses (USDA, 1997), determined all USDA Quality and Yield Grade factors, including hot carcass weight, adjusted backfat thickness, longissimus muscle area, kidney, pelvic and heart fat, skeletal and lean maturity and marbling. Dressing percentage was calculated by summing the hot carcass weights of all steers in a pen and dividing that sum by the final pen weight.

Statistical Analysis

The data for each variable were pen averages and were analyzed using the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC) with models that included block (random) and dose (fixed). The experimental unit was pen of steers. The error term was the block × dose interaction (12 df). This error term was used to test for statistical significance of dose (3 df) and linear (1 df) and quadratic (1 df) components of dose. Additionally, if the main effect of dose was significant ($P < 0.05$), each dose group was compared to the control group using one-sided contrasts. If the assumptions of the ANOVA were severely violated, as in a significant ($P \leq 0.01$) test for homogeneity of variance and visual inspection of the residual plots indicating a nonrandom pattern (such as an outlier), then nonparametric tests were used (longissimus muscle area data only). With 20 pens (five blocks of four pens per block) of 166 to 200 steers per pen, this study was designed to have 80% power to detect about a 2.5% improvement in ADG and gain efficiency at a significance of $P = 0.05$.

The primary decision variables, ADG and gain efficiency, were established in the study design before initiation of the study. Secondary variables of interest, established before initiation of the study, were DMI, hot carcass weight, dressing percentage, quality grade (Choice + Prime), yield grade, back fat thickness, marbling score, longissimus muscle area, incidence of dark cutter carcasses, and percentage of buller steers. Every steer assigned to study contributed data to ADG, DMI, gain efficiency, and percentage of buller steers. Only slaughtered steers contributed data to hot carcass weight, dressing percentage, quality grade, yield grade, back fat thickness, marbling score, longissimus muscle area, and incidence of dark cutter carcasses.

Results

For ADG, the dose was significant but neither linear nor quadratic effects were significant (Table 2). Compared with steers in the control group, ADG was 2.2% greater ($P < 0.01$) for steers receiving 0.1 mg of MGA. However, no differences ($P > 0.10$) were observed for steers receiving 0.2 and 0.4 mg of MGA compared with controls (Table 2). No differences ($P > 0.05$) were detected in DMI or gain efficiency for dose, linear, or quadratic effects. Means for DMI and gain efficiency are presented in Table 2.

Means for all carcass characteristics are presented in Table 2. Dose, linear, and quadratic effects were not different ($P > 0.05$) for hot carcass weight, dressing percentage, longissimus muscle area, back fat thickness, marbling score, and USDA yield grade. For USDA quality grade, there was a linear effect ($P = 0.04$), but dose and quadratic effects were not significant. The percentages of dark cutter carcasses and buller steers (Table 2) were not analyzed statistically due to the low incidences of both conditions.

Discussion

The scientific literature on mechanism of action of MGA to increase ADG and gain/DMI in heifers supports an interpretation that MGA blocks ovulation but ovarian follicles produce sufficient estrogen to elicit growth responses in heifers fed MGA at doses of 0.25 through 0.5 mg/d (Bloss et al., 1966; Zimbelman, 1966; Lauderdale, 1983). Specifically, MGA prevents ovulation in cattle by inhibiting the preovulatory surge of LH (Imwalle et al., 2002). Bloss et al. (1966) reported that ovariectomized heifers fed 0.42 mg of MGA daily did not express an increase in ADG or gain efficiency. Purchas et al. (1971) reported significant negative correlations between ADG and both plasma cortisol (–0.64, $R^2 = 0.42$) and plasma corticosterone (–0.68, $R^2 = 0.46$) in heifers fed 0.45 mg of MGA daily, data suggesting that MGA may stimulate growth by suppressing adrenal corticoids. If MGA elicits an increase in ADG other than through the ovary, MGA might be effective in increasing ADG and gain efficiency in steers.

The study reported herein is the first with sufficient power and appropriate experimental design to accurately detect differences in ADG and gain efficiency in steers fed MGA. This study was completed at a single location, which precludes extrapolation to the population of commercial feedlots in the United States. The conclusion is justified that MGA fed at 0.1 mg/steer daily increased ADG, but this effect was not detected in a dose-dependent manner over the dose range of 0.1 to 0.4 mg of MGA/steer daily. The data reported by Lauderdale (1983) and the data herein are in agreement that there is an increase in ADG from feeding MGA to steers at "low" doses of MGA; however, the data are not in agreement on dose (0.2 mg in the Lauderdale paper vs. 0.1 mg in the current study) or magnitude of response (10 to 25% in the Lauderdale paper vs. 2.2% in the current study). The data of this study support an interpretation that MGA can elicit an increase in ADG via a mechanism or mechanisms of action other than through the gonad. Data reported previously suggested that MGA doses greater than 0.35 mg/d fed to steers or bulls resulted in a 1 to 21% lower ADG and up to a 7% lower gain efficiency (Lauderdale, 1983). The current study did not provide evidence of a detrimental effect on ADG, DMI, gain efficiency, and carcass characteristics (hot carcass weight, dressing percentage, longissimus muscle area, backfat thickness, USDA quality grade, marbling score, USDA yield grade, dark cutter carcasses) in response to feeding MGA to beef steers at doses of 0.1, 0.2, and 0.4 mg MGA/d. The incidence of buller behavior (0.44 to 1.11%) was low and did not permit an accurate test of the hypothesis that feeding MGA to steers reduces the occurrence of buller steers, even though this study was conducted in the fall of the year and steers from multiple sources were commingled into pens of 166 to 200 animals, conditions expected to increase the incidence of buller steer activity (Turgeon and Koers, 1997).

Table 2. Feedlot performance and carcass characteristics of beef steers fed melengestrol acetate (MGA)

	Treatments					Contrasts		
Item	Control, 0 mg MGA	0.1 mg MGA	0.2 mg MGA	0.4 mg MGA	SE	D[a]	L[b]	Q[c]
Number of steers assigned	899	900	899	900				
Number of steers completing	886	890	886	890				
Number of observations, pens	5	5	5	5				
Weighted mean pen weight, kg[d]								
Initial	67,504	67,456	67,804	67,450	3,014			
Final	106,383	107,772	106,586	107,054	3,254			
Backfat thickness, cm	1.28	1.33	1.30	1.34	0.04	0.19	0.14	0.75
ADG, kg/d	1.81	1.85*	1.80	1.83	0.03	0.04	0.78	0.73
DMI, kg/d	10.7	10.7	10.6	10.6	0.2	0.15	0.18	0.83
Gain efficiency, gain/DMI, g/kg	170	173	171	172	2	0.19	0.21	0.60
Hot carcass weight, kg	366	368	365	366	6	0.37	0.46	0.75
Dressing percentage, %	61.5	61.3	61.1	61.3	0.2	0.46	0.37	0.22
Longissimus muscle area, sq. cm[e]	83.68	84.49	85.06	85.46	1.4	0.34	0.71	
Marbling score[f]	418	425	420	424	12	0.86	0.70	0.86
USDA quality grade, % Choice/Prime	76	75	75	80	5	0.09	0.04	0.12
USDA yield grade	2.29	2.29	2.31	2.38	0.07	0.32	0.09	0.47
Dark cutter carcasses, %[g]	0.35	0.61	0.34	0.35	0.30			
Buller steers, %[g]	1.11	0.78	0.44	0.56	0.27			

[a]Dose main effect *P*-value.
[b]Linear effect *P*-value.
[c]Quadratic effect *P*-value.
[d]Average gross pen weights weighted on number of steers per pen.
[e]Failed to meet ANOVA assumptions; Page's test used for linear effect and wilcoxon sign rank test used for comparisons to control.
[f]300 = slight; 400 = small; 500 = modest.
[g]Too few observations for valid statistical testing.
*$P < 0.01$ for comparison to control.

In conclusion, no definitive dose response was detected, under the conditions of this study, from feeding MGA at 0, 0.1, 0.2, and 0.4 mg/steer daily for at least 116 d in a commercial feedlot. Melengestrol acetate fed to finishing beef steers produced small improvements in growth performance at the 0.1-mg level, but none of the doses examined produced improvement in carcass quality or yield grade measurements. Melengestrol acetate is not approved for use in steers as a feed additive.

Implications

The 2.2% improvement in average daily gain makes suspect the economical use of melengestrol acetate in feeding beef steers. The incidence of buller steers was too low to detect an effect of melengestrol acetate; therefore, additional research is required to estimate the effect of melengestrol acetate on reduction of buller steer behavior.

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