Effects of growth-promoting agents and season on yearling feedlot heifer performance[1]

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ABSTRACT: Angus × crossbred heifers (270 per trial) were used in an experiment conducted over one 105-d summer and one 104-d winter feeding period. Treatments were identical for each trial and included: 1) control, 2) estrogenic implant (E), 3) trenbolone acetate implant (TBA), 4) E + TBA (ET), 5) melengestrol acetate (MGA) in the feed, and 6) ET + MGA (ETM). Each treatment was replicated in five pens, with nine heifers per pen in each season. Initial weights (mean = 384 kg, SE = 57) were the same for each season. There were no treatment × season interactions for final BW, ADG, G:F, water intake, or carcass characteristics. Heifers receiving a growth-promoting agent were 11.6 kg (SE = 4.08) heavier and gained 0.108 kg/d (SE = 0.04) more ($P < 0.05$) than control heifers. Heifers receiving ET gained 0.09 kg/d (SE = 0.032) more ($P = 0.05$) than heifers not receiving ET. Heifers receiving ET (with and without MGA) had greater G:F ($P < 0.05$) than control, E, and TBA heifers. Carcass weights of ET-treated heifers were greater ($P < 0.05$) than carcass weights for unimplanted heifers, those fed MGA only, and heifers receiving either E or TBA implants. Marbling scores were increased ($P < 0.05$) by feeding MGA to ET-treated heifers. Water intake was greater ($P < 0.01$) in the summer (31 L/d) than in the winter (18 L/d), with no difference among implant treatments. Heifers fed in the winter had heavier carcasses, less 12th-rib fat, greater marbling scores, larger LM area, and a greater incidence of liver abscesses than heifers finished in the summer ($P < 0.01$). A treatment × season interaction ($P = 0.07$) was evident for DMI during the 35-d coldest and hottest portions of the year. Heifers fed MGA and implanted with ET tended ($P = 0.07$) to have greater DMI in the summer but lesser DMI in the winter. In general, differences among growth-promotant programs were relatively similar over the entire summer and in winter.

Key Words: Anabolic Steroids, Environment, Feedlots, Heifers, Performance, Seasons

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Introduction

Growth-promoting implants have been used for well over 30 yr to improve feed efficiency and ADG (Griffin and Mader, 1997; Mader, 1998). The majority of the implants used today have estrogenic, androgenic, or a combination of estrogenic and androgenic activity. Estrogenic implants increase thyroid gland activity and DMI (Trenkle, 1997) that would be an asset under cold environmental conditions. Hunter and Vercoe (1987) concluded that trenbolone acetate decreases maintenance energy requirements, which may be an asset under hot environmental conditions by decreasing overall metabolic heat load. Melengestrol acetate (**MGA**) is another growth-promoting agent that is fed to heifers during the finishing period. Melengestrol acetate is a progestin that enhances endogenous estrogen production and growth (Bloss et al., 1966; Hutcheson et al. 1993). A survey conducted by Busby and Loy (1996) found that feedlots that fed MGA to heifers had lower death loss (3.8 vs. 6.2%) than those that did not. These findings suggest that some growth-promoting products may be more appropriate for use in feedlot cattle in the winter, whereas others may be more effective in the summer. The objective of this study was to assess the effects and interaction of growth-promoting agents on feedlot heifers fed during summer vs. winter feeding conditions.

Materials and Methods

The experiment was conducted at the University of Nebraska Northeast Research and Extension Center with the approval of the University of Nebraska-Lincoln Institutional Animal Care and Use Committee. Facility

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design was previously reported by Mader et al. (1997). Facilities are located at lat 42°23′N and long 96°57′W, with a mean elevation of 445 m above sea level.

Winter Season

Two hundred seventy crossbred Angus, nonpregnant, yearling heifers (mean BW = 338 kg) were purchased from western South Dakota in early November. Heifers were pregnancy-checked and found to be nonpregnant before arrival at the University of Nebraska Northeast Research and Extension Center feedlot. At arrival, heifers were given ad libitum access to water and a receiving diet. Heifers were subsequently processed, which included the following: weighing; removing any existing implants; vaccinating with Bar-Vac-7/Somnus for clostridial organisms (seven-way) and *Haemophilus somnus*, and with Elite 4 for IBR, BVD, PI3, and BRSV (Boehringer Ingelheim Animal Health Inc., St. Joseph, MO); deworming and treating for external parasites (Cydectin; Fort Dodge Animal Health, Overland Park, KS).

In early December, heifers were assigned randomly to pens (nine heifers per pen) and six treatments based on stratification of the first of two individual weights taken. Initial individual weight was the average of two nonshrunk weights. Growth-promotant treatments were as follows: 1) control, 2) estrogenic implant (**E**, Compudose [24 mg of estradiol-17β; Vetlife, West Des Moines, IA), 3) androgenic implant (**TBA**, Finaplix-H [200 mg of trenbolone acetate]; Intervet Inc., Millsboro, DE), 4) E + TBA (**ET**), 5) no implant and fed MGA (provided by Pharmacia and Upjohn, Kalamazoo, MI), and 6) ET implant and fed MGA (**ETM**).

By the start of the experiment, heifers had been stepped up to a 1.43 NE_g (Mcal/kg; DM basis) high-energy finishing diet (Table 1). Heifers were fed Rumensin and Tylan (Elanco Animal Health, Indianapolis, IN) throughout the experimental feeding period. Diets were formulated to meet or exceed NRC (1996) nutrient requirements. Individual BW were taken on d 35, 70, and on the day of slaughter.

Water meters (model C700; ABB Water Meters Inc., Ocala, FL) were used to record daily water intake in 24 of the 30 pens. Water intake was recorded daily just before placement of fresh feed in bunks. Cattle were fed once daily at approximately 0800. Dietary ingredients were sampled monthly to determine DM, CP, Ca, P, and ash content. On the day cattle were slaughtered, ovaries were collected and hot carcass weight and liver abscesses were recorded. Ovaries were frozen and stored for future analysis to determine maturity and physiological status. If present, both ovaries were collected and inspected. Physiological status was based on the ovary that seemed to be closest to ovulation. Ovaries less than 20 mm in diameter were considered to be immature. Mature ovaries were classified as containing one large follicle, multiple follicles, or as having a corpus luteum. After a 24-h chill, USDA quality grade; marbling score; USDA yield grade; 12th-rib fat thickness; percentage of kidney, pelvic, and heart fat; LM area; and maturity score were recorded. Carcass data collection procedures were described by Mader and Lechtenberg (2000). Fill differences among treatment groups were corrected by adjusting final BW to a common dressing percent (63%).

Table 1. Composition of diets fed in winter and summer seasons

	Finishing diet			
	Winter		Summer	
Item	No MGA	MGA	No MGA	MGA
Days fed	104	104	105	105
Diet, % DM	79.36	79.35	78.46	78.46
Ingredients, % diet DM				
Alfalfa hay	5.00	5.00	5.00	5.00
Corn silage	5.00	5.00	5.00	5.00
Dry rolled corn	81.50	81.50	81.50	81.50
Soybean meal, 44%	2.00	2.00	2.00	2.00
Rumensin/Tylan supplement[a]	2.00	—	2.00	—
MGA supplement[b]	—	2.00	—	2.00
Liquid supplement[c]	4.50	4.50	4.50	4.50
Chemical composition, DM				
CP, %	12.82	12.87	13.15	13.11
NE_m, Mcal/kg	2.00	2.00	2.00	2.00
NE_g, Mcal/kg	1.43	1.43	1.43	1.43
Ca, %	0.74	0.74	0.76	0.77
P, %	0.30	0.30	0.26	0.26
K, %	0.77	0.77	0.85	0.85
Mg, %	0.14	0.15	0.14	0.14

[a]Contained on DM basis: 35.11% ground corn; 30.62% soybean hulls; 19.96% wheat midds; 4.21% molasses; 5.61% limestone; 3.10% soybean meal; 0.87% Rumensin 80 (176.4 g monensin/kg; Elanco Animal Health, Indianapolis, IN); and 0.52% Tylan 40 (89 g tylosin/kg; Elanco Animal Health).

[b]Contained on DM basis: 34.57% ground corn; 30.62% soybean hulls; 19.96% wheat midds; 4.21% molasses; 5.61% limestone; 3.10% soybean meal; 0.54% MGA 200 (melengestrol acetate, 441 mg/kg; Pharmacia and Upjohn, Kalamazoo, MI), 0.87% Rumensin 80 and 0.52% Tylan 40.

[c]Contained on a DM basis: 61.54% CP; 12.30% Ca; 5.39% salt; 3.85% K; 0.71% P; 0.43% Mg; 0.148% Zn; 0.037% Fe; 0.050% Mn; 0.021% Cu; 0.002% I; 0.001% Co; 6.6×10^4 IU/kg vitamin A; 1.3×10^4 IU/kg vitamin D; and 44 IU/kg vitamin E.

Summer Season

In early spring, 270 crossbred Angus nonpregnant yearling heifers (mean BW = 338 kg), similar in breed composition, body condition, and body type to those used in the winter season-were received from western South Dakota and were managed similarly to heifers fed in the winter. In early June, heifers were randomly allotted to 30 pens (five pens per treatment; nine heifers per pen) using methods similar to those described for winter-fed heifers. Initial BW were the average of consecutive BW taken over a 2-d period. Individual unshrunk weights were taken on d 34, 68, and on the day before slaughter. Diets fed, dietary ingredient sampling intervals, and analyses performed were similar to those used in the winter.

Table 2. Mean daily (±SD) climatic conditions during the winter and summer seasons[a]

Item	Period 1 (d 0 to 35)	Period 2 (d 36 to 69)	Period 3 (d 70 to end)[b]
Winter			
Ambient temperature, °C			
Average	–3.2 ± 5.04	–4.4 ± 4.61	4.4 ± 6.18
Maximum	3.3 ± 7.04	2.0 ± 6.11	11.1 ± 7.18
Minimum	–10.0 ± 5.01	–11.7 ± 4.64	–3.3 ± 6.09
Relative humidity, %	75.9 ± 12.29	74.9 ± 11.18	74.1 ± 15.63
Wind speed, m/s	2.2 ± 1.00	2.3 ± 0.92	2.8 ± 1.68
THI[cd]	29.7 ± 8.86	28.1 ± 8.00	41.7 ± 9.79
Black globe temperature, °C	–2.4 ± 5.00	–2.9 ± 7.96	5.4 ± 5.74
Black globe index[de]	30.8 ± 8.68	30.3 ± 7.92	43.0 ± 9.01
Wind chill index[df]	27.0 ± 8.81	24.0 ± 8.59	38.2 ± 9.07
Summer			
Ambient temperature, °C			
Average	22.5 ± 3.34	23.6 ± 3.85	20.6 ± 3.09
Maximum	28.6 ± 3.86	29.3 ± 4.13	27.2 ± 3.81
Minimum	16.2 ± 3.44	18.0 ± 4.53	14.5 ± 3.45
Relative humidity, %	72.2 ± 11.67	80.7 ± 6.75	78.2 ± 7.40
Wind speed, m/s	2.9 ± 1.30	2.9 ± 0.88	2.8 ± 0.72
THI[cd]	69.7 ± 5.21	72.3 ± 6.29	67.3 ± 5.01
Black globe temperature, °C	25.4 ± 3.93	26.7 ± 4.33	24.9 ± 3.59
Black globe index[de]	73.5 ± 6.02	76.7 ± 6.98	73.7 ± 6.03

[a]Collected using a weather station located in the feedlot facility.
[b]End of trial = 104 and 105 d for winter and summer, respectively.
[c]THI = temperature humidity index = (0.8 × temperature) + [(relative humidity/100) × (temperature – 14.4)] + 46.4 (Thom, 1959; NOAA, 1976).
[d]Indices contain no units but depict temperatures that are more closely related to the Fahrenheit rather than to the Celsius temperature scale.
[e]Black globe index = temperature humidity index using black globe temperature (Buffington et al., 1981).
[f]Wind chill index = 91.4 – {[0.475 – (0.0457 × wind speed) + (0.450 × wind speed$^{0.5}$)] × [59.4 – (1.8 × temperature)]}; National Weather Service, 1992.

During the summer season, one heifer died on d 74 and was not included in statistical analysis. At slaughter, ovary and carcass data collection procedures were the same as those described for the winter experiment. During the experiments, climatic data were obtained near the research site as described by Mader et al. (2002).

Statistical Analysis

Performance, intake, and carcass characteristics were analyzed using the mixed models procedure of SAS (SAS Inst. Inc., Cary, NC) for a factorial arrangement of treatments. Data were analyzed for main effects (growth-promotant treatment and season) and the treatment × season interaction. Pen was the experimental unit. Residual (pen within growth-promotant treatment and season) was used as the error term. Means were separated using Fisher's least significant difference. Quality grade and liver abscess scores were analyzed by χ^2 analysis using PROC FREQ of SAS.

Results

Mean climatic conditions for every period in each season are shown in Table 2. In the winter, ambient temperatures averaged approximately –1°C and slightly above the normal of –6°C (Mader, et al., 1997). In the summer, ambient temperatures averaged 22.2°C, which are very close to normal (22.9°C). Recorded wind speeds were approximately half the normal speeds in both seasons owing to shelter and shelter belts located near the feedlot facilities. In general, environmental conditions during these studies were within normal ranges, with no particularly adverse weather occurring during the course of either experiment.

The average BW (338 kg) of heifers at purchase were the same for both the winter and summer seasons. Average initial heifer BW (384 ± 57 kg) were equal ($P > 0.20$) between winter and summer seasons and averaged between 383.8 and 385.2 among growth-promotant treatments (Table 3). There were no season × growth promotant interactions for BW, ADG, or G:F. Over the entire experiment, ADG were greater ($P < 0.05$) for heifers receiving a combination (ET and ETM) of growth-promoting products compared with control heifers or heifers receiving only one growth-promoting product (E, TBA, or MGA). Also, heifers fed in the winter had overall greater ADG ($P < 0.01$) (1.42 vs. 1.28 kg; SE = 0.02), but lower ($P < 0.01$) G:F (0.132 vs. 0.138; SE = 0.001) than heifers fed in the summer (means not shown in tables). Season × growth-promotant treatment interactions ($P = 0.07$) were evident for DMI for the d-35 to -69 feeding period, which allowed the same interaction to be prevalent from d 0 to 69 ($P = 0.09$). During the period of d 35 to 69, winter conditions were the coldest

Table 3. Effect of growth-promoting treatment on feedlot heifer performance and DMI

	Growth-promoting treatment[a]						
Item	C	E	TBA	ET	MGA	ETM	SE
BW, kg[b]							
Initial	384.0	384.4	385.2	383.8	384.3	384.2	1.00
Final	513.5[c]	522.6[d]	521.6[cd]	532.5[f]	523.1[de]	531.3[ef]	3.10
ADG, kg							
0 to 35 d	1.49[c]	1.56[c]	1.66[cd]	1.77[d]	1.59[cd]	1.85[e]	0.07
0 to 69 d	1.45[c]	1.51[c]	1.57[cd]	1.64[d]	1.54[cd]	1.65[d]	0.04
0 to end	1.25[c]	1.33[d]	1.31[cd]	1.43[e]	1.38[d]	1.42[e]	0.03
DMI, kg/d							
0 to 35 d							
Winter	11.06	10.97	10.87	10.74	10.40	10.53	0.19
Summer	8.82	8.90	8.72	8.95	8.77	9.17	0.19
Mean	9.94	9.93	9.79	9.84	9.59	9.85	0.14
36 to 69 d[g]							
Winter	11.13[j]	11.02[ij]	10.91[hij]	11.21[j]	10.65[hi]	10.54[h]	0.19
Summer	8.56[h]	8.69[hi]	8.56[h]	8.85[hi]	8.62[h]	9.09[i]	0.19
Mean	9.85	9.85	9.74	10.03	9.63	9.81	0.14
0 to 69 d[k]							
Winter	11.09[i]	11.00[i]	10.89[hi]	10.98[i]	10.53[h]	10.54[h]	0.18
Summer	8.68[h]	8.78[hi]	8.64[h]	8.89[hi]	8.68[h]	9.12[i]	0.18
Mean	9.89	9.90	9.76	9.94	9.60	9.83	0.12
70 to end							
Winter	10.16	10.50	10.48	10.73	10.13	10.35	0.18
Summer	9.91	10.03	10.06	10.30	9.97	10.61	0.18
Mean	10.04[c]	10.27[cd]	10.27[cd]	10.51[d]	10.05 [c]	10.48[d]	0.13
0 to end							
Winter	10.81	10.86	10.78	10.92	10.42	10.50	0.17
Summer	9.11	9.23	9.15	9.39	9.14	9.65	0.17
Mean	9.96	10.04	9.96	10.15	9.78	10.07	0.12
G:F							
0 to 35 d	0.149[c]	0.156[cd]	0.169[de]	0.180[ef]	0.165[cde]	0.187[f]	0.006
0 to 69 d	0.146[c]	0.152[cd]	0.160[de]	0.165[e]	0.160[de]	0.168[e]	0.003
0 end	0.125[c]	0.133[d]	0.132[cd]	0.142[e]	0.137[de]	0.141[e]	0.002

[a]C = Control (no growth promotant); E = estrogenic implant; TBA = trenbolone acetate implant; ET = estrogenic + TBA; MGA = melengestrol acetate in the feed; ETM = E + TBA + MGA.
[b]Final BW was taken on 104 and 105 d in winter and summer, respectively, and was based on hot carcass weight and a dressing percent of 63.
[c,d,e,f]Means within a row that do not have common superscripts differ ($P < 0.05$).
[g]Season × growth-promoting treatment interaction ($P = 0.07$).
[h,i,j]Means within a row that do not have common superscripts differ ($P < 0.10$).
[k]Season × growth-promoting treatment interaction ($P = 0.09$).

and summer conditions were the hottest. The season × growth-promotant interaction, during the d-36 to –69 period, seemed to be most closely associated with heifers fed MGA and, more specifically, with heifers that were implanted with ET and fed MGA. In the winter, DMI tended ($P = 0.07$) to be lower for heifers assigned to the ETM treatment compared with control, E, and ET treatment groups, whereas in the summer, DMI of heifers assigned to the ETM treatment tended ($P < 0.07$) to be greater than DMI of control, TBA, and MGA treatment groups. Also, relative to control heifers, a decrease in winter DMI was observed in the MGA-treated heifers, whereas summer DMI for these heifers averaged the same as control heifers. From d 0 to 69, heifers receiving TBA or MGA had greater ($P < 0.05$) G:F than control heifers; however, overall, heifers receiving either MGA or E had greater G:F than control heifers.

Overall, winter DMI averaged 1.44 kg (10.72 vs. 9.28 kg) or 15.5% greater ($P < 0.05$) than summer DMI (Table 4). However, during the coldest and hottest periods of the experiment (d 36 to 69), winter DMI was 25% greater ($P < 0.05$) than summer DMI. During the last 35 d on feed, DMI numerically decreased by approximately 5% in the winter and numerically increased by nearly 16% in the summer, primarily due to moderating climatic conditions. Water intake (average range = 23.38 to 25.88 L/kg) and water intake per unit of DMI (average range = 2.40 to 2.68 L/kg) did not vary among growth-promotant treatment groups. However, water intake in summer averaged 74% greater ($P < 0.05$) than in the winter. Per unit of DMI, water intake was more than doubled ($P < 0.05$) in the summer compared with the winter. Water intake per unit of DMI was 2.3 times greater ($P < 0.05$) in the hottest portion (d 36 to 69) of

Table 4. Effect of season on feedlot heifer DMI and water intake

Item	Season		SE
	Winter	Summer	
DMI, kg/d			
0 to 35 d	10.76[c]	8.89[b]	0.08
36 to 69 d	10.91[c]	8.73[b]	0.08
70 to end[a]	10.39[c]	10.15[b]	0.08
0 to end	10.72[c]	9.28[b]	0.07
Water intake, L/d			
0 to 35 d	18.97[b]	32.10[c]	0.91
36 to 69 d	17.04[b]	30.98[c]	1.21
70 to end	17.80[b]	30.52[c]	1.34
0 to end	17.93[b]	31.19[c]	1.01
Water intake: DMI, L/kg			
0 to 35 d	1.76[b]	3.62[c]	0.09
36 to 69 d	1.56[b]	3.59[c]	0.12
70 to end	1.72[b]	3.01[c]	0.13
0 to end	1.67[b]	3.38[c]	0.10

[a]Trials concluded on d 104 and 105 in winter and summer, respectively.
[b,c]Means within a row that do not have common superscripts differ ($P < 0.05$).

Table 6. Effect of season on carcass characteristics

Item	Season		SE	*P*-value[a]
	Winter	Summer		
Hot carcass wt, kg	333.7[c]	325.3[b]	1.10	—
Dressing percent	63.0	63.2	0.19	—
Fat thickness, cm	1.17[b]	1.29[c]	0.02	—
Kidney, pelvic, heart, %	2.31	2.34	0.02	—
LM area, cm^2	82.6[c]	69.6[b]	0.60	—
Marbling score[d]	588[c]	561[b]	5.28	—
Yield grade	2.30[e]	2.42[f]	0.04	—
Liver abscesses, %	12.27[c]	4.09[b]	—	0.001
USDA quality grade, %				
Prime (Pr)	11.90[c]	5.58[b]	—	0.01
Choice	73.98	75.84	—	0.62
Select	14.13	18.59	—	0.16
Choice + Pr	85.87	81.41	—	0.16

[a]*P*-values based on χ^2 analysis.
[b,c]Means within a row that do not have common superscripts differ ($P < 0.01$).
[d]400 = slight; 500 = small; 600 = modest.
[e,f]Means within a row that do not have common superscripts differ ($P < 0.05$).

the summer when compared with the coldest portion of the winter.

Heifers receiving ET and ETM treatments had greater ($P < 0.05$) carcass weights than heifers assigned to control, E, TBA, and MGA treatment groups (Table 5). With the exception of marbling, other carcass characteristics did not vary among growth-promotant treatments. Heifers receiving the ET implant treatment had a lower ($P < 0.05$) marbling score than control, E, ET, MGA, or ETM treatment groups. Chi-squared analysis revealed differences ($P = 0.05$) in USDA grade among growth-promotant treatment groups. The ET group had the greatest percentage of carcasses grading USDA select (27.78%), whereas the MGA treatment group had the least (12.22%). The remaining growth-promotant treatment groups had between 12.5 and 16.7% USDA select carcasses. Seasonal effects on carcass characteristics were more evident than growth-promotant effects (Table 6). Fat thickness was greater ($P < 0.01$) in the summer, whereas LM area and marbling scores were greater ($P < 0.01$) in the winter. The greater marbling score resulted in a greater ($P = 0.01$) percentage of the carcasses grading USDA prime in the winter. The lower fat thickness and greater LM area of the winter-fed heifers resulted in average USDA yield grade being lower ($P < 0.05$) in the winter. Winter-fed heifers did have three times ($P = 0.001$) more abscessed livers than summer-fed heifers, possibly owing to the greater DMI.

Table 5. Analysis of effects of growth-promotant regimen on carcass characteristics[a]

Item	C	E	TBA	ET	MGA	ETM	SE	Treatment[b]
Hot carcass weight, kg	322.8[d]	328.5[e]	328.1[de]	334.7[f]	328.7[e]	334.1[f]	1.9	—
Dressing percent	63.0	63.0	63.0	63.8	63.0	63.0	0.3	—
Fat thickness, cm	1.24	1.24	1.21	1.25	1.22	1.22	0.04	—
Kidney, pelvic, heart, %	2.32	2.34	2.31	2.34	2.38	2.25	0.04	—
LM area, cm^2	75.2	75.6	76.6	78.0	74.9	76.4	1.1	—
Marbling score[c]	579[e]	580[e]	594[e]	535[d]	581[e]	578[e]	9.0	—
Yield grade	2.36	2.39	2.29	2.30	2.46	2.39	0.07	—
Liver abscesses, %[b]	5.56	10.00	8.89	12.22	3.33	9.09	—	0.29
USDA quality grade, %[b]								
Prime (Pr)	11.11	6.67	12.22	4.44	6.67	11.36	—	0.32
Choice	72.72	80.00	72.22	67.78	81.11	76.14	—	0.28
Select	16.67	13.33	15.56	27.78	12.22	12.50	—	0.05
Choice + Pr	83.3	86.67	84.44	72.22	87.78	87.50	—	0.05

[a]C = Control (no growth promotant); E = estrogenic implant; TBA = trenbolone acetate implant; ET = estrogenic + TBA; MGA = melengestrol acetate in the feed; ETM = E + TBA + MGA.
[b]*P*-values based on χ^2 analysis.
[c]450 = select average; 550 = small average; 650 = modest average.
[d,e,f]Means within a row that do not have common superscripts differ ($P < 0.05$).

Table 7. Effects of growth-promoting treatment on heifer ovary development

Item	Growth-promoting treatment[a]						*P*-value[b]
	C	E	TBA	ET	MGA	ETM	
Ovarian stages, %							
Missing	3.95	6.45	1.52	4.05	2.74	4.62	NS
Immature	1.32	3.23	3.03	2.70	2.74	1.54	NS
Mature (LSFP)[c]	17.11	8.06	16.67	22.97	30.14	21.54	0.04
Mature (MFP)[c]	34.21	25.81	21.21	31.08	61.64	67.69	0.001
Mature (CLP)[c]	43.42	56.45	57.58	39.19	2.74	4.62	0.001

[a]C = Control (no growth promotant); E = estrogenic implant; TBA = trenbolone acetate implant; ET = estrogenic + TBA; MGA = melengestrol acetate in the feed; ETM = E + TBA + MGA.
[b]*P*-values based on χ^2 analysis.
[c]LSFP = large single follicle present; MFP = multiple follicles present; CLP = corpus luteum present.

In regard to heifer ovarian development, no season × growth promotant interactions were evident. Among growth-promotant treatments, heifers fed MGA (MGA and ETM) had approximately two to three times (P = 0.01) more mature ovaries with multiple follicles (>60%) with fewer than 5% of the ovaries with a corpus luteum (Table 7) compared with non-MGA-fed groups. Non-MGA-fed groups had between 39 and 58% of the ovaries containing a corpus luteum. Immature and missing ovaries were found only in the winter (Table 8). Missing ovaries were probably a result of not being found at the slaughter facility as opposed to heifers not having ovaries because all heifers were palpated and found to be not pregnant but having a palpable reproductive tract. However, fewer (P = 0.01) mature ovaries with a large single follicle were found in the winter. The greater number of mature ovaries, which were found in the summer, would possibly suggest that the summer-fed heifers were older than the winter-fed heifers; however, the greater LM areas found in winter-fed heifers would suggest they were older than the summer-fed heifers. Nonetheless, no grade discounts due to heifer age were assigned by USDA graders at the time carcasses were graded. This and weight agreement at purchase and start of the studies would suggest heifers in both experiments were very similar in age.

Table 8. Effect of season on heifer ovary development

Item	Season		*P*-value[a]
	Winter	Summer	
Ovarian stages, %			
Missing	7.78	—	0.01
Immature	4.86	—	0.01
Mature (LSFP)	9.15	29.11	0.01
Mature (MFP)	39.66	40.93	0.79
Mature (CLP)	38.55	29.96	0.07

[a]*P*-values based on χ^2 analysis.
[b]LSFP = large single follicle present; MFP = multiple follicles present; CLP = corpus luteum present.

Discussion

Climatic conditions during the course of this experiment were considered to be very close to normal for the region. Although average winter temperatures were slightly above normal, warmer winters, especially those in which ambient temperatures average close to freezing, do not necessarily ensure better feeding conditions owing to the freezing and thawing of feedlot surfaces and a greater percentage of precipitation coming in liquid rather than solid form.

Over both seasons, heifer groups implanted with ET had greater ADG and G:F compared with control heifers and heifer groups receiving only E or TBA implants. Feeding MGA enhanced performance compared with control heifers, but only slight numerical improvements in performance were observed when compared with single implant groups. These data agree with those reported by Mader and Lechtenberg (2000). For heifers fed MGA, little additional performance benefit would appear to be derived from an estrogen implant. Only if heifers are sexually immature or ovarian abnormalities are present would the estrogenic implants elicit a significant growth response when heifers are fed MGA (Mader and Lechtenberg, 2000). However, Macken et al. (2003), in three experiments, found economic benefits of using high-dose TBA (200 mg)-estrogen (20 mg) combination implants in heifers fed MGA compared with heifers implanted with 200 mg of TBA and fed MGA.

Mader and Lechtenberg (2000) found that implanting with TBA alone and feeding MGA decreased the number of mature ovaries with no follicle and increased the number of mature ovaries with large single (assumed to be Graafian) follicles. Present data suggest that MGA is largely responsible for the increase in the number of mature ovaries with these types of follicles. Also, feeding MGA increased the number of heifers with ovaries containing multiple follicles and almost completely suppressed the number of heifers with ovaries containing a corpus luteum. Increasing the number of multiple follicles likely increases the amount of endogenous es-

trogen production by the heifer and perhaps enhances growth-promoting activity. Regardless of the effects of growth-promotant treatment, no interactions between promotant treatment and season were found for ovarian status and physiological growth. However, feeding MGA seemed to have different effects on summer vs. winter DMI, depending on what other type of growth promotant was used with it.

In the summer, heifers receiving E (E, ET, and ETM) had numerically the greatest DMI during the d-36 to -69 period. In the winter, no pattern was evident with the exception that the TBA group tended to have a lower DMI than the control, E, and ET groups. In the winter and summer feeding periods, MGA by itself tended to lower or maintain DMI, respectively. However, the ETM combination seemed to override the DMI enhancement associated with cold, resulting in lowering DMI, similar to the DMI found in the MGA group. In the summer, estrogen effects on DMI seemed to be enhanced in the ETM treatment group, resulting in an increase in DMI in the ETM group.

In summaries by Duckett et al. (1996, 1997), steers implanted with an estrogenic implant and/or estrogenic/androgenic combination had greater DMI than unimplanted steers. There was no response in DMI when steers were implanted with a single androgenic implant (Duckett et al., 1997). Also, this summary of steers closely follows the response of implants to thyroid gland activity reported by Trenkle (1997), who indicated that estrogenic implants increase thyroid gland activity whereas androgens decrease thyroxin concentrations. Increased thyroid activity, which depends on severity of cold, generally increases DMI as well (Yousef and Johnson, 1985). In the present experiment, no significant differences were found in DMI between E and TBA treatment groups. Over the entire experiment, DMI was numerically lower by less than 1% for the TBA treatment group compared with the E treatment group. However, winter DMI were found to be greater than summer DMI, indicating that climate has a greater effect on DMI than growth promotant.

Exposure to mild-to-moderate cold stress has been shown to also enhance intramuscular fat deposition (Mader et al., 1997). A similar phenomenon is apparent in this experiment, with the winter-fed heifers having greater marbling than summer-fed heifers. However, fat thickness was less in the winter-fed heifers, which is opposite to results reported by Mader et al. (1997). Clearly, the level of cold stress needed to stimulate fat deposition vs. the level of cold stress associated with depleting fat stores is not known. The nature and extent to which various fat stores are affected also are unknown.

Ray et al. (1969) evaluated the influence of season, sex, and hormonal growth stimulant on feedlot cattle in four trials conducted in Yuma, AZ. In that experiment, gains in the winter were 14 and 24% greater than during the summer, whereas feed conversions (feed:gain) were decreased 7 and 14% during the winter months. Ray et al. (1969) also reported that none of the growth promotants tested (including MGA, diethylstilbestrol [24 mg], and Synovex-H [200 mg of testosterone propionate and 20 mg of estradiol benzoate]) were effective in improving feedlot performance during the summer months, whereas significant improvements in performance were observed during the winter months by using growth stimulants. The extremely high summer temperatures were attributed to the lack of a summer response. In the present experiment, similar gain relationships were found between summer and winter as was reported by Ray et al. (1969); however, improved G:F was found in our Nebraska summer experiment, particularly with the use of growth promotants. Better efficiencies are attributed to maintenance requirements being less in northern climates in the summer than in the winter.

Ray et al. (1969) did not report DMI. Based on our experiments, it would seem that growth promotant × season interactions are evident during periods of time when climate extremes exist. Because these occurred predominantly in the treatment receiving three different growth promotants (ETM; decreased DMI in winter and increased DMI in summer), it is very difficult to determine which chemical components interacted and how they interacted to have possibly altered normal physiological function, thereby contributing to the differential response between seasons. In addition, relative to control cattle, MGA significantly decreased DMI in the winter but only slightly influenced DMI in the summer. The lower DMI, observed in the ETM group in the winter, seems to have resulted from feeding MGA, whereas the increased DMI for the ETM group in the summer seems to have resulted from implanting with ET. Increased DMI in the summer would be useful, provided the increase did not contribute to excessive heat load. Diminished DMI in the winter would not be beneficial when extra energy is needed by animals for coping with cold challenges.

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