1984

Effect of Monensin, Estradiol Controlled Release Implants and Supplement on Performance in Grazing Steers

J. F. Wagner
Lilly Research Laboratories

H. Brown
Lilly Research Laboratories

N. W. Bradley
University of Kentucky

W. Dinusson
North Dakota State University

W. Dunn
Lilly Research Laboratories

See next page for additional authors

EFFECT OF MONENSIN, ESTRADIOL CONTROLLED RELEASE IMPLANTS AND SUPPLEMENT ON PERFORMANCE IN GRAZING STEERS

J. F. Wagner[1], H. Brown[1], N. W. Bradley[2], W. Dinusson[3], W. Dunn[1], N. Elliston[1], J. Miyat[1], D. Mowrey[1], J. Moreman[4], L. C. Pendlum[1], C. Parrott[1], L. Richardson[1], I. Rush[5] and H. Woody[6]

Lilly Research Laboratories, A Division of Eli Lilly and Company, Greenfield, IN 46140

Summary

Five trials in five locations in the United States involving 512 steers were conducted to evaluate the effect of monensin [200 mg/d in .9 kg of supplement (Rumensin®)] and estradiol-controlled release implants (Compudose®) administered alone and in combination on average daily gain (ADG) in steers on pasture. The effect of energy supplementation on rate of gain was also evaluated in these same trials. The initial weight of steers averaged 250 kg and the average duration of the five trials was 124 d. Estradiol-controlled release implants increased ADG by 15.6% (.095 kg/d; P<.0001) and monensin increased ADG by 8.1% (.054 kg/d; P<.05). The combination of estradiol-controlled release implant and monensin increased ADG by 27.4% (.168 kg/d). Treatment responses were additive relative to ADG response, with no interaction observed between the treatments. Nine-tenths kilogram of an energy supplement/d increased ADG by 12.4% (.073 kg/d; P<.01).

(Key Words: Estradiol, Anabolic Implants, Monensin, Pasture Cattle.)

Introduction

Monensin, a fermentation product, and estrogenic anabolic implants are both considered growth promoters in pasture cattle. However, the modes of action of these two growth promoters are quite different. Monensin affects rumen fermentation to favor increased propionate production (Perry et al., 1976; Richardson et al., 1976; Van Maanen et al., 1978), which is more efficiently produced and utilized than acetate, while estrogenic anabolics are thought to increase rate of growth by increasing pituitary size (Struempler and Burroughs, 1959) and also secretion of growth hormone (Trenkle, 1970; Wagner et al., 1978). Monensin has been used in combination with estrogens in both feedlot (Trenkle and Willham, 1977; Dinius et al., 1978) and pasture cattle (Utley et al., 1976; Corah, 1977). When energy concentration is not limiting (feedlot), the effect of monensin is primarily to improve feed conversion (Davis and Erhart, 1976; Raun et al., 1976), however, in high roughage diets (pasture) monensin increases rate of gain (Oliver, 1975; Potter et al., 1976; Rouquette et al., 1980). In one study the estrogen anabolic response was more than additive to that of monensin in pasture cattle (Utley et al., 1976), whereas, in another case the combined treatments produced a growth response somewhat less than the sum of the two separate components (Corah, 1977). The extent to which these two growth promoters are additive in stimulating rate of growth in pasture cattle is somewhat obscure. If both monensin and estrogens stimulate growth by different modes of action, then the combination of the two treatments should be at least additive.

The purpose of the studies reported in this paper was to further evaluate the responses to both monensin and an estradiol-controlled re-

[1] Lilly Research Laboratories, P.O. Box 708, Greenfield, IN 46140.

[2] Dept. of Anim. Sci., Univ. of Kentucky, Lexington.

[3] Dept. of Anim. Sci., North Dakota State Univ., Fargo, ND.

[4] Box 68, Clarendon, TX.

[5] Panhandle Station, Univ. of Nebraska, Scottsbluff.

[6] Southern Illinois Univ., Carbondale.

Received March 21, 1983.

Accepted September 26, 1983.

TABLE 1. EXPERIMENTAL DESIGN

Treatment[a]			
	Main plot		
Split-plot Estradiol implants[b]	Monensin, mg/d	Supplement, kg/d	Total number of steers
–	0	0	85
–	0	.9	85
–	200	.9	86
+	0	0	86
+	0	.9	84
+	200	.9	86

[a]Number of experimental units = two/location with five locations for a total of 10 experimental units for each treatment.

[b]Silicone rubber matrix containing 20% estradiol-17β.

lease implant alone and in combination on rate of gain in pasture cattle.

Materials and Methods

A series of five trials were conducted over a wide range of geographical areas in the United States. Steers were used in all five locations and were predominantly of British breeding with an average starting weight for each trial ranging from 236 to 265 kg. Steers received no anabolics before initiation of the studies.

A split-plot design was used in these studies. The main plot treatments were: 1) supplement with monensin, 2) supplement and no monensin and 3) no supplement and no monensin. The split-plot treatments were with and without estradiol implants (table 1).

Six pastures were used at each location for a total of 30 pastures. Steers at each location were ranked by weight, the heaviest one-half were assigned to a block of three pastures and the lightweight one-half to another block of three pastures. One-third of the cattle in each block were assigned to each pasture of the three pastures in the block. The three main plot treatments were then assigned randomly to each of the three pastures of heavy cattle and each of the three pastures of lightweight cattle. The steers in each pasture were then paired by weight and an estradiol implant was assigned randomly to one steer in each pair.

Pastures at each location were of uniform size and quality. Within each three-pasture block the steers were rotated among pastures every 2 wk. Water was available in each pasture and supplements were fed in feed bunks located in the pastures. Weighing facilities were located within a short distance of all pastures.

The pastures were composed of grasses common to the particular location (table 2). Supplement, with or without monensin, was fed at the rate of .45 $kg \cdot head^{-1} \cdot d^{-1}$ for the first 5 d of the trial and then .9 $kg \cdot head^{-1} \cdot d^{-1}$ until the trial ended. The supplement in all five locations was composed of high energy ingredients locally available. Mineral supplement, either block or loose, was fed ad libitum in a mineral box in each pasture.

Monensin (Rumensin®)[7] was administered in the supplement at a desired concentration of 220 mg/kg. Samples were submitted for assay at the time of mixing. Assays averaged 92% of theoretical.

Estradiol implants (controlled release; Compudose®)[7] were cylindrical in shape (dimensions: 4.76 mm diameter, 3.0 cm in length) with the outer 500 μm containing estradiol-17β ($E_2\beta$) crystals embedded in a silicone rubber matrix (20% $E_2\beta$, 80% silicone rubber). Each implant was placed subcutaneously in the posterior median surface of the ear using an implant needle with a bore diameter sufficient to accommodate a 4.76-mm diameter implant. All implants were removed at termination of the trial with a tool designed to immobilize the implant in a groove that contains a surgical cutting edge.

[7] Elanco Products Co., A Division of Eli Lilly and Co., Indianapolis, IN.

TABLE 2. INDIVIDUAL TRIAL INFORMATION

State	Pasture composition	Supplement	Start	Duration, d	Breed	No. of steers
Texas	Lovegrass	20% protein	April	115	British X	84
Kentucky	Fescue L. clover bluegrass	Cracked corn[a]	May	139	Angus (A)	118
N. Dakota	Native mixed grasses	90% barley[b] 10% soybean meal[c]	June	112	Hereford (H)	118
Nebraska	Crested wheatgrass	Cracked corn[a]	May	113	H X A	96
Illinois	Fescue clover	Ground corn[a]	July	140	H X A	96

[a]IFN 4-02-856.

[b]IFN 4-00-549.

[c]IFN 5-04-604.

Ears were palpated every 28 d at time of weighing for the presence or absence of implants. Any missing implants were replaced. Implant loss during the trials ranged from 0 to 15% over the five locations. The average duration of all five trials was 124 d (range 112 to 140 d).

Steers were weighed twice at the initiation and termination of the trial and single interim weights were taken at approximate 28-d intervals.

Drug delivery was measured by implant weight loss at the end of the trial in all locations except one where individual implant identification was not recorded. Implant weight loss for each of the four trials is shown in table 3.

Data from the five trials were pooled and the variable, average daily gain (ADG), was analyzed using an analysis of variance. Main plot treatment means were compared using the Student-Newman-Keuls (Newman, 1939; Keuls, 1952) multiple comparison procedure, and variance homogeneity between trials was determined using Bartlett's (1937) test.

Routine animal health procedures employed at all trial locations included vaccination, anthelmintic treatment and external parasite treatment. A total of 10 steers were removed from the five trials for various reasons not related to the treatments.

Results and Discussion

The results from the analysis of variance (table 4) indicated a highly significant difference ($P<.0003$) in ADG among locations. The location by main plot treatment interaction was not significant ($P<.09$), indicating that the effects of the main plot treatments were the same for each location. Bartlett's (1937) test procedure was used to test for homogeneity of variance. The test was found to be nonsignificant ($P>.20$). The analysis also indicated that there was a significant difference ($P<.0001$)

TABLE 3. IMPLANT WEIGHT LOSS (ESTRADIOL ELUTION DURING TREATMENT PERIOD)

Trial[a]	Duration of trial, d	No. of implants	Implant weight loss		
			mg	SD	µg/d
Illinois	140	39	13.1	.63	94
Nebraska	113	48	10.2	.39	90
Kentucky	139	59	11.8	.45	84
Texas	115	31[b]	6.7	.34	58

[a]In one trial the implants were not weighed.

[b]Five implants not included in the average because a portion of the implant was missing.

TABLE 4. ANALYSIS OF VARIANCE[a] OF AVERAGE DAILY GAIN ($KG \cdot HEAD^{-1} \cdot D^{-1}$) FOR STEERS ON PASTURE RECEIVING MONENSIN AND ESTRADIOL IMPLANT

Source of variation	df	Sums of squares	Mean squares	F-ratio[b]	Prob F
Location	4	6.21	1.55	48.37	.0003
Pastures (locations)	5	.032	.0064		
Main plot treatments	2	.789	.394	47.26	.0001
Location X main plot treatments	8	.159	.020	2.39	.0990
Pasture X main plot treatments (location)	10	.084	.0084		
Split-plot treatments	1	.687	.687	68.12	.0001
Main plot treatments X split-plot treatments[c]	2	.025	.0125	1.59	.2231
Error	27	.215	.008		

[a]Snedecor and Cochran (1969). Analyses were performed using statistical procedures given in SAS (1979).

[b]Test for location differences used pastures (locations) as the error term to compute F-ratio. Test for main plot treatments and location X main plot treatments used pasture X main plot treatments (locations) as the error term to compute F-ratios. The other terms given used the error term to compute the F-ratios.

[c]The lack of significance for the term indicates that the split-plot treatments had the same effect independent of the main plot treatments.

among the main plot treatments, indicating that at least one pair of main plot treatment means was different. The analysis showed that: 1) there was a difference in ADG (P<.0001) among split-plot treatments (estradiol vs no estradiol) and 2) the split-plot and main plot treatments did not interact (P>.20), implying that the split-plot treatment effect was similar across main plot treatments.

These studies indicated that both monensin and estradiol increased ADG of steers on pasture as shown in the summary of estradiol and monensin main effects in table 5. Monensin or estradiol only increased ADG by 7.3 and 15.5%, respectively, over those animals receiving only supplement. The increase in ADG for those animals that received both monensin and estradiol was 27.4% greater than the supplemented control group, indicating that the responses were additive.

The effects of monensin and an energy supplement on gain are summarized in table 6. Monensin increased ADG by an additional 8.1% (P<.01) for a total response of 21.5% (P<.01) increase in ADG in the monensin supplement treatment over that of the negative controls.

TABLE 5. SEPARATE AND COMBINED EFFECTS OF MONENSIN AND ESTRADIOL IMPLANTS ON AVERAGE DAILY GAIN ($KG \cdot HEAD^{-1} \cdot D^{-1}$) IN STEERS ON PASTURE[a]

Estradiol implants	Monensin 0	Monensin 200 mg/d	Implant effect
No	.61	.66 (7.3)[b]	.64
Yes	.71 (15.5)	.78 (27.4)	.74 (17.1)
Monensin effect	.66	.72 (8.1)	

[a]Average duration of the combined five trials = 124 d (range 112 to 140 d). Values within each subgroup are the means of 10 observations (two observations/trial; 7 to 10 steers/observation). Steers not receiving supplement are not included in this table.

[b]Values within parentheses are the percentage response above that of the negative controls (no monensin, no estradiol implants).

TABLE 6. EFFECTS OF AN ENERGY SUPPLEMENT AND MONENSIN ON AVERAGE DAILY GAIN OF STEERS ON PASTURE

Main plot treatment	Mean ADG[a], $kg \cdot head^{-1} \cdot d^{-1}$	% Response as compared with control	% Response as compared with supplement
Control	.59[b]		
Supplement	.66[c]	12.4	
Supplement + monensin	.72[d]	21.5	8.1

[a]Means are calculated by averaging those animals that did and did not receive estradiol implant for a given treatment. Thus, each mean consists of 20 observations that included two pastures for each main plot treatment in each of five trials (10) times the two split-plot treatments in each pasture.

[b,c,d]Means with different superscripts are different from one another; b–d, c–d at the .01 level and b–c at the .05 level, using Student-Newman-Keuls multiple comparison procedure.

Supplementation (.9 kg/d) increased ADG 12.4%.

The main effect of estradiol on ADG, along with the estradiol effect within each main plot treatment (control, supplement, monensin supplement), is given in table 7. Overall, estradiol increased ADG 15.6%. Within main plot treatments, increases in ADG of 14.1, 15.5 and 18.7%, respectively, were observed when animals receiving estradiol were compared with those not receiving estradiol. The estradiol responses were similar across the main plot treatments. However, the percentage response as well as absolute gain increases tended to be greater as rate of gain was increased by supplement or monensin. This positive relationship between rate of gain and response to estrogenic implants has been observed in other studies (Davis et al., 1977).

In summary, results of these five trials demonstrate that the effects of monensin and anabolic levels of estradiol on performance in beef cattle are additive. The gain response produced by monensin in pasture cattle is the result of more energy being available to the animal through changes in ratios of volatile fatty acids, specifically, more propionic acid in relation to acetic and butyric acids. The greater production of propionic acid results in more efficient conversion of feed energy to energy that is usable by the animal. Anabolic levels of estradiol effect increased rates of gain, presumably by increasing secretion of growth hormone, which also affects efficiency and rate of growth. Because these two mechanisms affecting growth are different it would be expected that these two drugs would be additive relative to their effect on rate of growth.

TABLE 7. EFFECT OF ESTRADIOL IMPLANTS ON AVERAGE DAILY GAIN OF STEERS ON PASTURE

Main plot treatments	No estradiol implants, $kg \cdot head^{-1} \cdot d^{-1}$	Estradiol implants, $kg \cdot head^{-1} \cdot d^{-1}$	% Response to estradiol implants
Control	.55	.63	14.1
Supplement	.61	.71	15.5
Supplement + monensin	.66	.78	18.7
Overall	.61[ab]	.71[a]	15.6

[a]Thirty observations for overall mean (total number of split-plot pasture groups).

[b]Split-plot treatments differ ($P<.0001$).

Literature Cited

Bartlett, M. S. 1937. Some examples of statistical methods of research in agriculture and applied biology. J. Royal Statist. Soc. Suppl. 4:137.

Corah, L. R. 1977. Additives and implants for growing cattle. Proc. 10th Res. Ind. Conf., Columbia, MO. p 105.

Davis, G. V. and A. B. Erhart. 1976. Effects of monensin and urea in finishing steer rations. J. Anim. Sci. 43:1.

Davis, D. I., J. E. Huston, C. S. Menzies, S. Lindsey, J. D. DeBord and D. B. Herd. 1977. Response of nursing calves to zeranol implants. J. Anim. Sci. 45(Suppl. 1):382.

Dinius, D. A., H. G. Goering, R. R. Oltjen and H. R. Cross. 1978. Finishing beef steers on forage diets with additives and supplemental lipid. J. Anim. Sci. 46:761.

Keuls, M. 1952. The use of the studentized range in connection with the analysis of variance. Euphytica 1:112.

Newman, D. 1939. The distribution of the range in samples from a normal population in terms of an independent estimate of standard deviation. Biometrika 31:20.

Oliver, W. N. 1975. Effect of monensin on gains of steers grazed on Coastal Bermudagrass. J. Anim. Sci. 41:999.

Perry, T. W., W. M. Beeson and M. T. Mohler. 1976. Effect of monensin on beef cattle performance. J. Anim. Sci. 42:761.

Potter, E. L., C. O. Cooley, L. F. Richardson, A. P. Raun and R. P. Rathmacher. 1976. Effect of monensin on performance of cattle fed forage. J. Anim. Sci. 43:665.

Raun, A. P., C. O. Cooley, E. L. Potter, R. P. Rathmacher and L. F. Richardson. 1976. Effect of monensin on feed efficiency of feedlot cattle. J. Anim. Sci. 43:67.

Richardson, L. F., A. P. Raun, E. L. Potter, C. O. Cooley and R. P. Rathmacher. 1976. Effect of monensin on rumen fermentation *in vitro* and *in vivo*. J. Anim. Sci. 43:657.

Rouquette, F. M., Jr., J. L. Griffin, R. D. Randel and L. H. Carroll. 1980. Effect of monensin on gain and forage utilization by calves grazing Bermuda grass. J. Anim. Sci. 51:521.

SAS. 1979. SAS User's Guide. Statistical Analysis System Institute, Inc., Cary, NC.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods (6th Ed.). Iowa State Univ. Press, Ames. pp 369–375.

Struempler, A. W. and W. Burroughs. 1959. Stilbestrol feeding and growth hormone stimulation in immature ruminants. J. Anim. Sci. 18:427.

Trenkle, A. 1970. Plasma levels of growth hormone, insulin and plasma protein bound iodine in finishing cattle. J. Anim. Sci. 31:389.

Trenkle, A. and R. L. Willham. 1977. Beef production efficiency. Science 198:1009.

Utley, P. R., G. L. Newton, R. J. Ritter III and W. C. McCormick. 1976. Effects of feeding monensin in combination with zeranol and testosterone-estradiol implants for growing and finishing heifers. J. Anim. Sci. 42:754.

Van Maanen, R. W., J. H. Herbein, A. D. McGilliard and J. W. Young. 1978. Effects of monensin on *in vivo* rumen propionate production and blood glucose kinetics in cattle. J. Nutr. 108:1002.

Wagner, J. F., E. L. Veenhuizen and R. Basson. 1978. Anabolics in ruminants: Mode of action, efficacy and safety. In: D. Hudd (Ed.) Beef Prod: European Congress for Improved Beef Productivity. Erl Wood Manor, Windlesham, Surrey, U.K.