# EFFECT OF PROPIONATE ENHANCERS ON THE PERFORMANCE OF GRAZING STEERS AND THE SEXUAL DEVELOPMENT OF BEEF BULLS

by

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# TRIAL I. EFFECT OF AVOPARCIN ON THE PERFORMANCE OF GRAZING STEERS

## Introduction

Avoparcin is a glycopeptide antibiotic produced by a strain of Streptomyces candidus (Kunstmann et al., 1969) with activity against certain gram-positive bacteria but not against gram-negative bacteria (Redin and Dornbush, 1969).

Roth and Kirchgessner (1975) reported that in swine, Avoparcin increased average daily gain by 6.5%. Avoparcin fed to broiler chickens increased weight gain 3.2% and improved feed efficiency 5% (Roth-Maier and Kirchgessner, 1976).

Recent work by Johnson et al. (1979) and Embry et al. (1979) indicated that Avoparcin improved rate and efficiency of gain in feedlot cattle. In the Johnson et al. (1979) trial, feed consumption was not affected, whereas in the Embry et al. (1979) trial, Avoparcin reduced feed consumption.

Johnson et al. (1979) observed increased ruminal propionate production when Avoparcin was fed. Monensin, a biologically active compound produced by Streptomyces Cinnamonensis with activity against gram-positive organisms (Haney and Hoehn, 1967), has also increased molar proportion of ruminal propionate (Potter et al., 1976; Richardson et al., 1976). Subsequent research showed that when monensin was fed

to grazing cattle, it improved average daily gain (Oliver, 1975; Potter et al., 1976; Hill et al., 1979).

This study was conducted to determine the efficacy of Avoparcin with grazing steers and to determine the optimum drug level to feed.

## Materials and Methods

Ninety-eight yearling Hereford steers averaging 227 kg were purchased from one ranch to provide similar genetic and nutritional background. Upon arrival at the research unit, steers were ear tagged, dewormed with levamisole,[1] received prairie hay, and were self-fed the control mineral mix (table 1). At the start of the trial (Day 0), all steers were weighed after 15 hours off feed and water, treated with 2 oz. of Famphur[2], allotted, and placed on pasture. The steers were allotted by weight to four treatments (control, 200, 400, and 600 mg) with four pasture replicates per treatment.

Pastures were predominantly brome grass with the balance native grasses. Stocking rate ranged from 1.56 to 1.0 steers/acre, depending on pasture condition. Pasture replicates were rotated to minimize pasture-effect. All steers received .454 kg of a grain cube daily to assist in pasture rotation.

The mineral mix (table 1) was fed ad libitum in wind-vane mineral feeders. On day 71, additional dilution of the Avoparcin was necessary at all drug levels as weekly mineral consumption was increasing in all

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[1]Tramisol$^{R}$, levamisole phosphate injectable (18.29%), American Cyanamid Co.

[2]Warbex$^{R}$, Famphur pour-on (13.29%), American Cyanamid Co.

treatments. Mineral consumption was recorded each week with daily intake for one replicate for one week. Dust bags containing Famphur[3] were used for fly control.

The desired length of the trial was 100 days. Upon completion of the trial, the steers were weighed after 15 hours off feed and water, with rumen samples taken on approximately 18 steers per treatment 5 hours after removal from grass.

Rumen fluid pH was measured immediately after collection. Eighteen ml of rumen fluid was acidified with 2 ml of 6NHCl to stop further fermentation. Rumen ammonia (Conway, 1963) was analyzed within 6 hours of collection. Volatile fatty acids (VFAs) were separated by gas chromatography (glass column, 4 mm ID by 184.6 cm, with 100/120 mesh Chromosorb 101) at 195 C, using a flame ionization detector.

Daily gain was computed for each steer; average daily gain, rumen pH, rumen ammonia, molar percentages of VFAs, and weekly mineral consumption were subjected to analysis of variance (Steel and Torrie, 1960).

## Results and Discussion

Lack of rainfall required the replicate containing steers stocked at 1.56 steers/acre to be taken off grass on day 74 of the trial; after 93 days, the other three replicates were removed.

Average daily gain (ADG), daily mineral intake, and daily Avoparcin intake are presented in table 2. Avoparcin increased ($P<.05$) ADG over

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[3]Warbex$^{R}$, Famphur insecticide dust (1%), American Cyanamid Co.

control steers, and steers receiving 400 mg Avoparcin per day tended to gain faster (P = .11) than those on 200 or 600 mg levels. The 22% improvement in ADG at the 400 mg dosage was similar to the 17% improvement in gain with 200 mg of monensin reported by Potter et al. (1976).

One replicate had higher daily gains than the other three replicates, and in this instance the effect of Avoparcin was reduced. Pastures grazed by that particular replicate had more forage available at the end of the trial. In previous work with monensin, a propionate-increaser, Potter et al. (1976) speculated that on high-quality forage, feed intake may not be limited by gut fill but by net energy intake. In such cases, the gain response may be small, while feed efficiency or the carrying capacity may improve 10 to 15%.

As noted in table 2, average daily mineral consumption for the entire trial was higher ($P < .10$) for the control steers than for those receiving the Avoparcin treatments; however, during the first 5 weeks (table 3), average daily mineral consumption was similar for all treatments. For the balance of the trial, consumption of control mineral trended higher, but Avoparcin treatments remained at a relatively constant level, similar to intake during the first 5 weeks. Actual average daily Avoparcin consumption was 223, 401, and 594 mg per head per day for the projected 200, 400, and 600 mg treatments, respectively.

It should be pointed out, however, that weekly mineral consumption varied considerably among pastures within replicates of steers. Daily mineral intake for the four treatments within one replicate ranged from 0 to 115.3 g/head/day.

Avoparcin increased ($P<.05$) the molar percentages of propionate and isobutyrate (table 4) and decreased ($P<.05$) the acetate:propionate ratio and the molar percentages of acetate and butyrate. The increase in the molar percentage of propionate agreed with the findings of Johnson et al. (1979) in feeding Avoparcin to feedlot cattle. The molar percentage of acetate tended to be less ($P<.06$) when comparing the 600 mg to the 400 mg levels, and the molar percentages of propionate were higher ($P<.10$) for the 600 mg as compared to the 200 mg level.

Avoparcin increased the molar percentages of isobutyrate, valerate, and isovalerate, although differences were not always significant ($P<.05$).

The shift in the acetate:propionate ratio should result in a theoretical energy savings because propionic acid fermentation is energetically more efficient than either acetic or butyric acid (Wolin, 1960; Hungate, 1966). Apparently Avoparcin improves the conversion of feed to body weight gain in cattle by altering the ruminal fermentation process. The shift in VFA production agreed with the findings of Johnson et al. (1979) in feeding Avoparcin to feedlot cattle and were consistent with those observed by Potter et al. (1976) and Boling et al. (1977) when monensin was fed to grazing cattle.

Avoparcin increased rumen pH ($P<.05$) at 400 and 600 mg and at the 200 mg level ($P<.06$) when compared to the controls.

Rumen ammonia values were less ($P<.10$) for the 400 mg Avoparcin steers than for those fed the control mineral. Slyter et al. (1979) concluded that a concentration of 2 to 5 mg $NH_3$-N/100 ml of rumen fluid is sufficient to allow maximum growth of rumen microbes in

rumen-fistulated steers. Monensin also reduces ruminal ammonia levels (Dinius et al., 1976).

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Table 1. Composition of mineral treatments.

| | Avoparcin treatment levels | | | |
|---|---|---|---|---|
| | 0 | 200 mg | 400 mg | 600 mg |
| | Day 0-70 | | | |
| Avoparcin, % | 0 | 5.5 | 10.4 | 14.8 |
| Control mix, %[1] | 100 | 94.5 | 89.6 | 85.2 |
| | Day 71-93 | | | |
| Avoparcin, % | 0 | 3.7 | 7.2 | 10.4 |
| Control mix, % | 100 | 96.3 | 92.8 | 89.6 |

[1]Composition of control mineral mix, %: Dicalcium phosphate, 50; salt, 25; monosodium phosphate, 10; limestone, 7; Z-10 trace mineral, 2; magnesium oxide, 1; wet molasses, 5.

Table 2. Effect of Avoparcin on steer performance and mineral intake.

| Item | Avoparcin treatment levels | | | |
|---|---|---|---|---|
| | 0 | 200 mg | 400 mg | 600 mg |
| No. of pastures | 4 | 4 | 4 | 4 |
| No. of steers | 25 | 25 | 24 | 24 |
| Initial weight, kg | 230.4 | 225.3 | 224.5 | 227.9 |
| Final weight, kg | 298.4 | 302.4 | 306.2 | 304.9 |
| Daily gain, kg | .76[a] | .86[b] | .93[b] | .87[b] |
| Daily mineral consumption (g/head/day) | 81.48[c] | 63.41[d] | 60.45[d] | 62.91[d] |
| Daily Avoparcin consumption (mg/head/day) | 0 | 223 | 401 | 594 |

[a,b]Means on the same line with different superscripts are significantly different ($P<.05$).

[c,d]Means on the same line with different superscripts are significantly different ($P<.10$).

Table 3. Weekly mineral consumption (grams/head/day).

| Week | Avoparcin treatment levels | | | | Std. dev. |
|---|---|---|---|---|---|
| | 0 | 200 mg | 400 mg | 600 mg | |
| 1st | 58.9 | 45.2 | 43.9 | 56.6 | 16.9 |
| 2nd | 50.0 | 33.7 | 50.8 | 53.4 | 19.2 |
| 3rd | 51.6 | 56.1 | 39.2 | 52.7 | 16.0 |
| 4th | 56.6 | 62.7 | 63.9 | 69.6 | 12.5 |
| 5th | 80.4 | 61.8 | 58.3 | 64.4 | 23.8 |
| 6th | $111.5^{a}$ | $61.6^{b}$ | $67.9^{b}$ | $61.6^{b}$ | 15.8 |
| 7th | 103.8 | 79.0 | 75.0 | 90.0 | 26.0 |
| 8th | 90.0 | 81.8 | 64.5 | 84.8 | 28.1 |
| 9th | 88.2 | 75.7 | 64.6 | 64.6 | 17.7 |
| 10th | $96.5^{a}$ | $74.8^{b}$ | $62.8^{b}$ | $62.3^{b}$ | 13.7 |
| 11th[1] | $116.2^{a}$ | $65.5^{b}$ | $72.6^{b}$ | $57.6^{b}$ | 21.9 |
| 12th | $75.2^{a}$ | $53.4^{a,b}$ | $64.6^{a,b}$ | $36.6^{b}$ | 15.6 |
| 13th | 88.6 | 73.5 | 62.2 | 69.1 | 19.0 |
| 14th[2] | $66.4^{a}$ | $56.4^{a,b}$ | $65.2^{a}$ | $19.2^{b}$ | 20.2 |
| Average | $81.48^{c}$ | $63.41^{d}$ | $60.45^{d}$ | $62.91^{d}$ | 13.8 |

$^{a,b}$Means in the same row with different superscripts are significantly different ($P < .05$).

$^{c,d}$Means in the same row with different superscripts are significantly different ($P < .10$).

[1]One rep had 4 days' consumption.

[2]Two days' consumption.

Table 4. Effect of Avoparcin on rumen pH, volatile fatty acid, and ammonia concentrations.

| Item | Avoparcin treatment levels | | | |
|---|---|---|---|---|
| | 0 | 200 mg | 400 mg | 600 mg |
| No. of steers sampled | 18 | 18 | 18 | 17 |
| Acetate, molar % | 63.07[a] | 60.79[b] | 61.16[b] | 59.40[b] |
| Propionate, molar % | 17.67[a] | 20.81[b] | 21.13[b] | 22.77[b] |
| Butyrate, molar % | 15.78[a] | 14.23[b] | 13.82[b] | 13.55[b] |
| Isobutyrate, molar % | 1.22[a] | 1.57[b] | 1.57[b] | 1.61[b] |
| Isovalerate, molar % | 1.18[a] | 1.38[a,b] | 1.20[a] | 1.42[b] |
| Valerate, molar % | .76[a] | .87[b,c] | .84[a,c] | .96[b] |
| Acetate:propionate ratio | 3.57[a] | 2.92[b] | 2.89[b] | 2.61[b] |
| pH | 7.02[a] | 7.19[a,b] | 7.25[b] | 7.33[b] |
| No. of samples analyzed for ammonia | 13 | 13 | 13 | 12 |
| Ammonia-N, ppm | 60.53 | 57.25 | 45.31 | 47.74 |

[a,b,c]Means on the same line with different superscripts are significantly different ($P < .05$).

## TRIAL II. EFFECT OF MONENSIN ON THE SEXUAL DEVELOPMENT OF BEEF BULLS

### Introduction

Monensin, a biologically active compound produced by Streptomyces Cinnamonensis with activity against gram-positive organisms (Haney and Hoehn, 1967), improves feed efficiency in the ruminant by increasing the concentration of propionic acid and reducing acetic and butyric, with total volatile fatty acids remaining the same (Raun et al., 1976; Dinius et al., 1976). Monensin increases gains in grazing cattle (Potter et al., 1976; Oliver, 1975), improves feed efficiency in grain fed cattle (Perry et al., 1976; Raun et al., 1976) and improves feed efficiency in gravid cows with no reduction in production or reproductive performance (Turner et al., 1980).

The age at which bulls reach puberty depends upon both genetic (Foote, 1969; Lunstra et al., 1978) and nutritional factors (Bratton et al., 1959; Abdel-Raouf, 1960). The level of nutrition influenced the age at puberty in Holstein bulls (Bratton et al., 1959); average age at onset of sperm production (50 x $10^7$ sperm/ml with 50% motility) was 37, 43 and 51 weeks for bulls receiving high, medium, or low levels of nutrition, respectively. Van Demark and Mauger (1964) reported that bulls fed only 60% of their calculated needs in total digestible nutrients from 8 weeks of age through 44 months, and tested for semen

production by partial exhaustive collections every 4 months, never equalled control bulls in sperm production; however, no differences in sexual interest were shown by the two groups of bulls. Abdel-Raouf (1960) found that low nutrition retarded puberty in bulls by 8 weeks.

It is apparent that the nutritional levels affect reproductive capabilities in bulls. If monensin can provide a nutritional advantage for growing bulls then it is important to determine if monensin affects the reproductive capabilities of bulls.

The objective of this study was to determine the effect of monensin on the growth rate and sexual development of beef bulls as measured by average daily gain, testicular size, blood concentrations of luteinizing hormone and testosterone, sexual aggressiveness and sperm production.

## Materials and Methods

Fifty percentage Simmental bulls from the Kansas State University breeding-research herd, born from February 21 to May 11, 1979, were allotted by weight, age and percentage Simmental to either the control or monensin treatment group.

The trial consisted of 2 periods, early weaned (114 days) and growing (149 days). During the early weaned period, 37 bulls (control = 19 head, monensin = 18 head) were weaned at 52 (R = 26-78) days of age and utilized in a factorial experiment comparing control versus monensin for early weaned calves. A portion of the bulls (n = 13) grazed hybrid pearl millet for 76 days, with the other bulls (n = 24) maintained under drylot conditions. All the bull calves were fed ad libitum during the early weaned period with the monensin group ration containing 10 g

monensin/ton the first 28 days and 20 g monensin/ton until the conclusion of the early weaned period. Rations for the early weaned and growing periods are shown in table 1.

All the bull calves in the monensin group during the early weaned period received monensin during the growing period. At the start of the growing period, 13 bulls (control = 6 head, monensin = 7 head) suckled first-calf heifers until they were weaned at 190 (R = 159-222) days of age. After a 23-day post weaning adjustment period, the bulls were allotted to either the control or monensin treatment group. Within the monensin group, 18 head and 7 head received monensin for 270 days and 125 days, respectively.

Bulls were group-fed with each group receiving an equal amount/head/day of their respective growing concentrate mix (table 1) and 2.2 kg of prairie grass hay/head/day. The prairie grass hay had a crude protein and dry matter content of 5.60% and 92.91%, respectively. The growing mix had a crude protein and dry matter content of 12.26% and 89.66%, respectively. The monensin group received an average of 96.5 mg and 236.8 mg of monensin/head/day throughout the early weaned and growing periods, respectively.

Initial and final weights were taken after bulls were off feed and water 15 hours. Interim weights were taken at 28-day intervals. Scrotal circumference was measured at each weighing. Height at the shoulder and hip were measured at the start and completion of the trial.

Five libido tests were conducted when the bulls' average age was 231, 258, 287, 318, and 352 days. Bulls were pre-stimulated prior to

their test by watching mating activity in an adjacent pen. Bulls were exposed in random order within their treatment group in groups of 4 bulls/3 ovariectomized, estrus induced, restrained heifers for a 10 minute test period. Each bull's reactions and movements were recorded and his libido was scored according to Chenoweth et al. (1977) as follows:

0 = bull showed no sexual interest.

1 = sexual interest showed only once.

2 = positive sexual interest in female on more than one occasion.

3 = active pursuit of female with persistent sexual interest.

4 = one mount or mounting attempt. No service.

5 = two mounts, or mounting attempts. No service.

6 = more than two mounts or mounting attempts. No service.

7 = one service followed by no further sexual interest.

8 = one service followed by sexual interest, including mounts or mounting attempts.

9 = two services followed by no further sexual interest.

10 = two services followed by sexual interest, including mounts, mounting attempts or further services.

Semen collection was attempted twice on all bulls by electro-ejaculation when the bulls averaged 263 and 351 days of age. Sperm motility was rated by visual appraisal. Sperm cell concentration was measured by microscopic counting with a hemacytometer (Sorenson, 1971). Live-dead and normal-abnormal counts were taken as described by Sorenson (1971).

Blood was collected by jugular puncture within 2 minutes after restraint of bulls in a squeeze chute. One 15 ml blood sample was collected from each bull at an average age of 231 and 339 days. Blood was allowed to coagulate under refrigeration, centrifugated and serum stored at -20C until assayed for luteinizing hormone (LH) and testosterone.

Ten bulls (average age of 341 days) from each treatment group were randomly selected on day 148 of the growing period to receive 3 hourly intramuscular injections of 100 µg of gonadotropin releasing hormone (GnRH). Blood samples were collected every 30 minutes starting just prior to the first GnRH injection and ending 3.5 hours later. Blood samples were collected and handled the same as above. All serum samples were assayed for LH. Serum samples taken at 0, 150, and 210 minutes were also assayed for testosterone.

Testosterone was measured in extracts of duplicate 20-µl aliquots of serum by radioimmunoassay using antiserum and procedures described by Sitarz et al. (1977). Serum luteinizing hormone concentrations were determined by use of a double antibody radioimmunoassay similar to that reported by Lunstra et al. (1978).

At the conclusion of the early weaned and growing periods, rumen samples were taken 4 hours after bulls were fed. Twenty-five ml of rumen fluid was acidified to stop further fermentation and volatile fatty acids were separated by gas chromatography.

Least squares means were obtained and analyzed by split-plot analysis of variance for data with unequal subclasses numbers using

the methods of Snedecor and Cochran (1978). Mean differences were tested using Duncan's multiple range test.

## Results and Discussion

Performance and volatile fatty acid values during the early weaned period are shown in table 2. Monensin and control fed bulls gained similarly during the early weaned period. The molar % of acetate tended ($P = .07$) to be lower for the monensin group as compared to the control group. A shift ($P = .13$) was noted in the A:P ratio due to monensin feeding 1.75 and 1.46 for control and monensin groups, respectively. During the 76 day pasture versus drylot trial of the early weaned period, the drylot group outgained ($P<.05$) the pasture group 97.3 to 71.0 kg.

Two bulls in the control group were removed during the growing period of the trial. One bull sustained a stifle injury and the other bull developed lamentitis. They were removed from the trial 25 days early, but their data were used up until they were withdrawn.

Bull gain data and height changes during the growing period are presented in table 3. Average daily gain was improved ($P<.05$) by ingestion of monensin and since both groups received the same amounts of feed/head/day, feed efficiency was improved in the monensin fed cattle. Our 9.2% improvement in feed efficiency is similar to that reported by Riley et al. (1976) and Perry et al. (1976) in feedlot steers. Monensin had no effect on the increase in height at the hip or shoulder.

Monensin had no effect on scrotal circumference or the increase in scrotal circumference (figure 1). Sire-of-bull had the greatest

influence on scrotal circumference. Sire had no significant effect on the increase in scrotal circumference during the post weaning period. Coulter and Keller (1979b) have reported a heritability estimate for scrotal circumference in yearling beef bulls of 0.69 ± 0.15.

Scrotal circumference was positively correlated to initial sperm motility ($r = .39$; $P<.01$) and initial sperm concentration ($r = .25$; $P = .10$) at an average age of 263 days. No correlations were found at the final semen evaluation. Martin et al. (1979) found correlations between scrotal circumference and sperm motility ($r = .33$; $P<.01$) and sperm concentration ($r = .25$; $P<.01$). Scrotal circumference was highly correlated ($r = .77$; $P<.01$) with body weight. Lunstra et al. (1978) reported a positive ($r = .80$; $P<.01$) correlation between scrotal circumference and body weight in young beef bulls.

Monensin had no effect on libido or sexual aggressiveness as measured by the number of mounts and completed matings during the five 10-minute test periods (figure 1 and table 4).

Relatively high correlations ($r = .44$ to $.82$; $P<.01$) were obtained between the 5 libido scores (table 5) indicating that each test was approximately equal in reliability in assessing the sexual drive of yearling bulls within their group. Chenoweth et al. (1977) reported correlations of .49 between their first and second libido score in yearling beef bulls.

Weight at the time of the libido test was positively correlated ($r = .29$ to $.45$; $P<.05$) to the libido score. Age at the time of the libido test was positively correlated ($r = .31$ to $.40$; $P<.05$) to the second, third and fourth libido scores.

Libido was not highly correlated to scrotal circumference, measures of seminal quality or a single blood sample assayed for LH or testosterone. Chenoweth et al. (1977) had similar conclusions with yearling beef bulls.

Monensin had no effect on semen parameters as shown in table 6. Initial sperm cell concentration and serum testosterone levels taken 32 days earlier had a correlation of $r = 0.32$ ($P<.04$). The final sperm cell concentration taken when the bulls were an average age of 351 days showed a correlation of 0.44 ($P<.01$) with a testosterone level measured 11 days earlier.

The most widely accepted definition of puberty is the age at which the first ejaculate contains a minimum of $50 \times 10^6$ total spermatozoa with at least 10% progressive motility is collected (Barber and Almquist, 1975; Killian and Amann, 1972; Wolf et al., 1965).

The monensin and control groups both had 56% of the bulls reaching puberty by 351 days of age by this definition. The number of bulls copulating at least once during the 5 libido tests was 17 and 14 bulls for the control and monensin groups, respectively.

According to Foote (1969), puberty, in its fullest sense, occurs when bulls attain the ability to produce viable spermatozoa, exhibit sexual aggressiveness and penile development permits intromission and ejaculation. Bulls having both copulated and had a viable sperm concentration (at least $50 \times 10^6$ spermatozoa with 10% motility) were 11 and 6 bulls for the control and monensin groups, respectively.

Testosterone and LH concentrations in blood serum are shown in table 7. Single samples were taken from the bulls twice, when the average age of the bulls was 231 and 339 days. Bulls receiving monensin had similar testosterone and LH levels when the initial sample was taken. However, the second sample indicated a higher ($P<.05$) testosterone level for the monensin group as compared to the control group. LH was similar for both groups for the second sample. The correlation between daily gain and the second testosterone level was 0.28 ($P<.06$). Martin et al. (1979) reported a positive correlation ($r = .23$; $P<.05$) between plasma testosterone and daily gain. Our correlation between the first testosterone and second testosterone was 0.37 ($P = .01$). Scrotal circumference at the time of the second sample was positively correlated ($r = .15$; $P = .30$) to the second testosterone level. Chenoweth et al. (1977) and Lunstra et al. (1978) reported a correlation of .23 and .22, respectively, between testosterone and scrotal circumference. Martin et al. (1979) found a value of $r = .14$ and .079 ($P>.05$) between the plasma testosterone and scrotal circumference.

Testosterone values increased 2 to 3 fold during the 108 days between the first and second blood samples. Lunstra et al. (1978) reported a linear increase in testosterone and LH from 7 through 13 months of age in beef bulls. Our data (table 7) indicate there was no increase in LH; however, this may be due to taking only one sample/bull under the stress of restraint even though blood samples were taken as quickly as possible after restraint.

The GnRH-mediated LH and testosterone release are shown in figure 2. Three hourly injections of 100 μg of GnRH resulted in an increase in LH with the peak occurring 30 minutes after the third injection of GnRH. Schanbacher and Echternkamp (1978) reported a 30-fold and a 7-fold increase in LH and testosterone in mature Hereford bulls after an intravenous injection of 500 μg of GnRH. Testosterone peaked 3 hours after GnRH or approximately 1 hour after the LH peak. Monensin had no effect on the LH release or the subsequent testosterone release, indicating that monensin had no effect on the pituitary's ability to release LH.

The final rumen samples (table 8) taken indicate monensin decreased ($P<.05$) the A:P ratio and total VFA concentration. The molar percentage of propionic acid tended to be higher ($P<.12$) for the monensin fed bulls as compared to the control bulls. The molar percentage of acetic acid tended to be less ($P<.18$) for the monensin.

Monensin improved daily gain probably by decreasing ruminal A:P ratio while having no detrimental effects on scrotal circumference, libido, semen parameters or the ability of the anterior pituitary to release luteinizing hormone. It would appear that monensin can be fed to increase gains in young beef bulls without affecting their reproductive ability.

Monensin had no effect on scrotal circumference which, according to Coulter and Foote (1979a), is an accurate predictor of both testicular weight and sperm output in growing bulls. Libido was not affected by monensin. Libido in yearling bulls can be evaluated effectively and bulls exhibiting low libido produce decreased pregnancy

rates under pen- and hand-mating conditions (Lunstra et al., 1979). The semen parameters measured in this trial were not affected by monensin; as reported by Lindley et al., 1967, the production of viable sperm is necessary for high conception rates. Monensin had no effect on the release of LH. Assay of frequently collected serial blood samples from bulls (Katongole et al., 1971; Haynes et al., 1976) indicates that an important relationship exists between serum concentrations of LH and the secretion of testosterone.

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Table 1. Rations for early weaned and growing periods.

| Ingredient | Early weaned period | | Growing period (%) |
|---|---|---|---|
| | Starter[1] (%) | Standard creep[2] (%) | |
| Rolled oats | 21.85 | 65.30 | 50.68 |
| Rolled corn | 36.74 | 18.30 | 39.62 |
| Soybean oil meal | 21.85 | 4.62 | 4.06 |
| Calf Manna[3] | 14.90 | -- | -- |
| Fat | 1.49 | 1.52 | 1.45 |
| Dry molasses | -- | 5.08 | -- |
| Dehydrated alfalfa | -- | 4.57 | -- |
| Wheat bran | -- | -- | 3.62 |
| Salt | -- | -- | .48 |
| K-State Swine Vitamin Premix[4] | 4.99 | -- | -- |
| Dicalcium phosphate | .60 | -- | -- |
| Limestone | .60 | -- | -- |
| Z-10 trace mineral[5] | -- | .05 | .05 |
| Vitamin A (30,000 IU/lb) | -- | .04 | .03 |

[1]Fed day 0 to 56 of early weaned period.

[2]Fed from day 57 to end of early weaned period.

[3]Calf Manna is made by Albers Milling Company.

[4]Premix contains: Vitamin A, vitamin D, riboflavin, d-calcium pantothenate, choline chloride, niacin, vitamin E and vitamin $B_{12}$.

[5]Z-10 trace mineral is made by Calcium Carbonate Company.

Table 2. Effect of monensin on performance and volatile fatty acids of early weaned bulls.

| Item | Treatment | |
|---|---|---|
| | Control | Monensin |
| No. of head | 19 | 18 |
| No. of days on trial | 114 | 114 |
| Average birth date | March 26 | March 26 |
| Initial weight, kg | 103.3 | 102.9 |
| Final weight, kg | 237.7 | 240.4 |
| Daily gain, kg | 1.18 | 1.21 |
| Rumen Samples Taken on Day 114 of Early Weaned Period | | |
| No. of bulls sampled | 13 | 11 |
| Acetate, molar % | 59.0 | 54.6 |
| Propionate, molar % | 33.8 | 37.5 |
| Butyrate, molar % | 7.2 | 7.9 |
| A:P ratio | 1.75 | 1.46 |
| Total VFA conc., (mM/liter) | 45.2 | 48.1 |

Table 3. Effect of monensin on bull performance and height at hip and shoulder during the growing period.

| Item | Treatment | |
|---|---|---|
| | Control | Monensin |
| No. of bulls | 25 | 25 |
| Average birth date | March 26 | March 26 |
| Initial weight, kg | 237.5 | 238.1 |
| Final weight, kg | 410.4 | 425.4 |
| Daily gain, kg | 1.17[a] | 1.27[b] |
| Feed/gain ratio[1] | 6.89 | 6.31 |
| Initial hip height, cm | 106.4 | 106.2 |
| Final hip height, cm | 125.1 | 125.7 |
| Increase in hip height, cm | 18.7 | 19.5 |
| Initial shoulder height, cm | 100.7 | 101.1 |
| Final shoulder height, cm | 119.8 | 120.3 |
| Increase in shoulder height, cm | 19.1 | 19.2 |

[a,b]Means on the same line with different superscripts are significantly different ($P < .05$).

[1]100% dry matter basis.

Table 4. Effect of monensin on libido score and number of mounts/10-minute test period.

| Item | Treatment | |
|---|---|---|
| Libido Test No. | Control | Monensin |
| I | | |
| Libido score | 4.68 | 3.96 |
| No. of mounts/bull | 6.48 | 4.04 |
| II | | |
| Libido score | 5.12 | 5.64 |
| No. of mounts/bull | 6.36 | 7.84 |
| III | | |
| Libido score | 7.16 | 6.36 |
| No. of mounts/bull | 7.20 | 9.00 |
| IV | | |
| Libido score | 6.36 | 5.72 |
| No. of mounts/bull | 5.96 | 5.56 |
| V | | |
| Libido score | 6.26 | 6.20 |
| No. of mounts/bull | 5.50 | 5.52 |

Table 5. Correlation between libido scores and weight, age and scrotal circumference at time of libido test.

| | Libido test | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | V |
| 1. Libido Score I | | | | | |
| 2. Libido Score II | .66** | | | | |
| 3. Libido Score III | .55** | .57** | | | |
| 4. Libido Score IV | .44** | .53** | .82** | | |
| 5. Libido Score V | .45** | .52** | .75** | .68** | |
| Weight at time of libido test | .30* | .43** | .45** | .44** | .29* |
| Age at time of libido test | .20 | .31* | .40** | .36* | .17 |
| Scrotal circumference at time of libido test | .24 | .41** | .32* | .29* | .04 |

**(P <.01).

*(P <.05).

Table 6. Effect of monensin on semen parameters of beef bulls at an average age of 263 and 351 days.

| Item | Treatment | |
|---|---|---|
| | Control | Monensin |
| Initial Collection (Average age 263 days) | | |
| No. of samples collected[a] | 9 | 11 |
| Motility, % | 8.3 | 5.0 |
| Sperm conc., no./ml | $1.1 \times 10^7$ | $2.1 \times 10^7$ |
| No. of slides prepared[b] | 6 | 5 |
| Live sperm cells, % | 37.4 | 43.2 |
| Normal sperm cells, % | 81.5 | 82.3 |
| Final Collection (Average age 351 days) | | |
| No. of samples collected[a] | 23 | 25 |
| Motility, % | 12.6 | 12.0 |
| Sperm conc., no./ml | $7.5 \times 10^7$ | $7.9 \times 10^7$ |
| No. of slides prepared[b] | 19 | 22 |
| Live sperm cells, % | 47.0 | 54.6 |
| Normal sperm cells, % | 86.3 | 85.4 |
| No. of bulls with sperm conc. of $50 \times 10^6$ and 10% motility | 13 | 13 |
| No. of bulls copulating | 17 | 14 |

[a]Remainder of bulls did not have enough sperm for evaluation from electroejaculation.

[b]Remainder of bulls did not have enough sperm for accurate determination.

Table 7. Effect of monensin on serum LH and testosterone levels of beef bulls at an average age of 231 and 339 days.

| Item | Treatment | |
|---|---|---|
| | Control | Monensin |
| Initial Sample (Average age 231 days) | | |
| Number of bulls | 25 | 25 |
| Testosterone, ng/ml | 3.25 | 3.19 |
| LH, ng/ml | 1.49 | 2.58 |
| Final Sample (Average age 339 days) | | |
| Number of bulls | 23 | 25 |
| Testosterone, ng/ml | 6.71[a] | 10.04[b] |
| LH, ng/ml | 1.30 | 1.22 |

[a,b]Means on the same line with different superscripts are significantly different ($P<.05$).

Table 8. Effect of monensin on volatile fatty acids at the conclusion of the growing period.

| Item | Treatment | |
|---|---|---|
| | Control | Monensin |
| Number of samples | 23 | 25 |
| Acetate, molar % | 67.0 | 65.2 |
| Propionate, molar % | 24.9 | 27.2 |
| Butyrate, molar % | 8.1 | 7.6 |
| A:P ratio | 2.69[a] | 2.40[b] |
| Total VFA conc., (μM/1) | 60.4[a] | 53.2[b] |

[a,b]Means on the same line with different superscripts are significantly different ($P<.05$).

Fiqure 1. Effect of Monensin on Scrotal Circumference and % of Bulls Copulating.

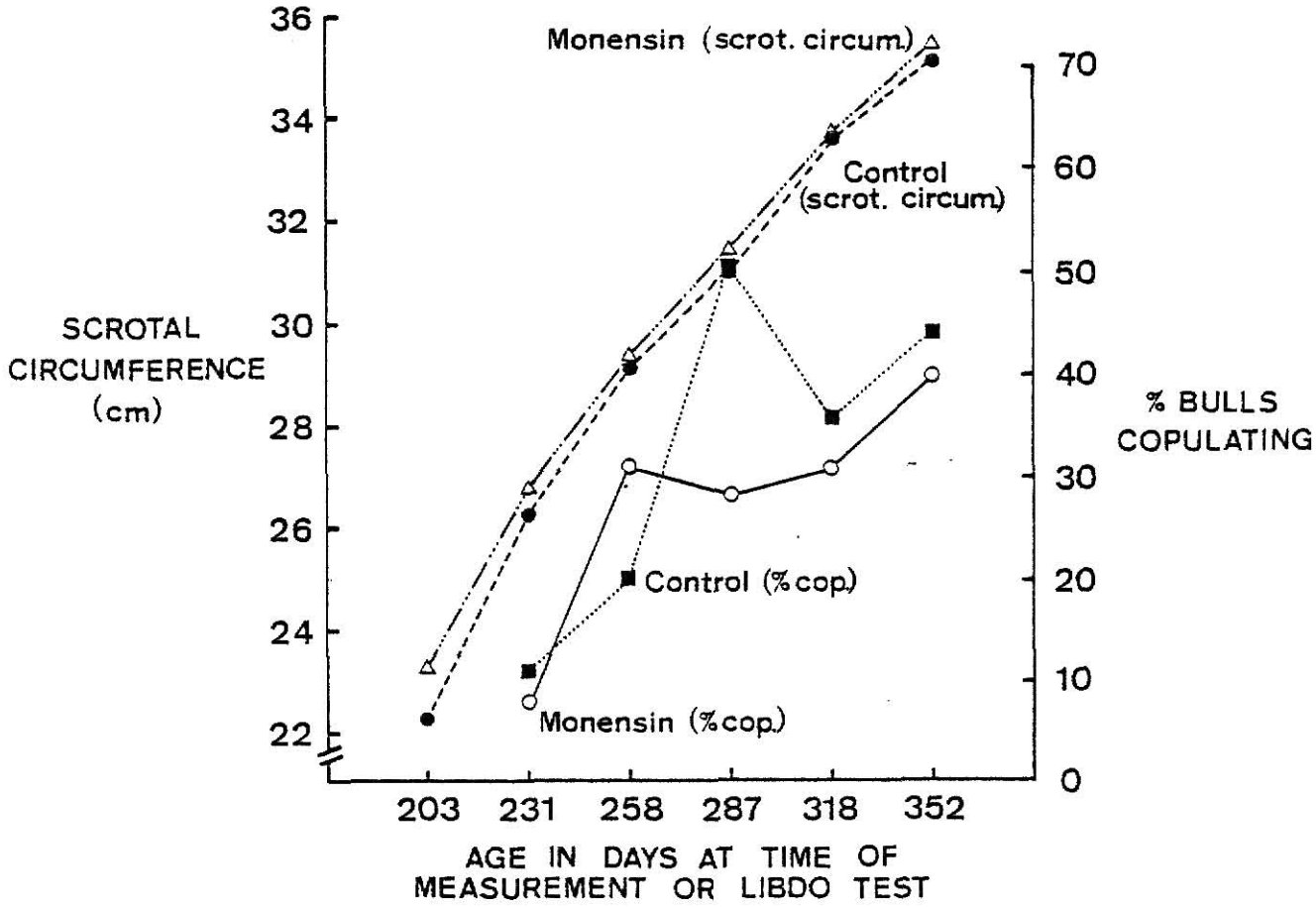
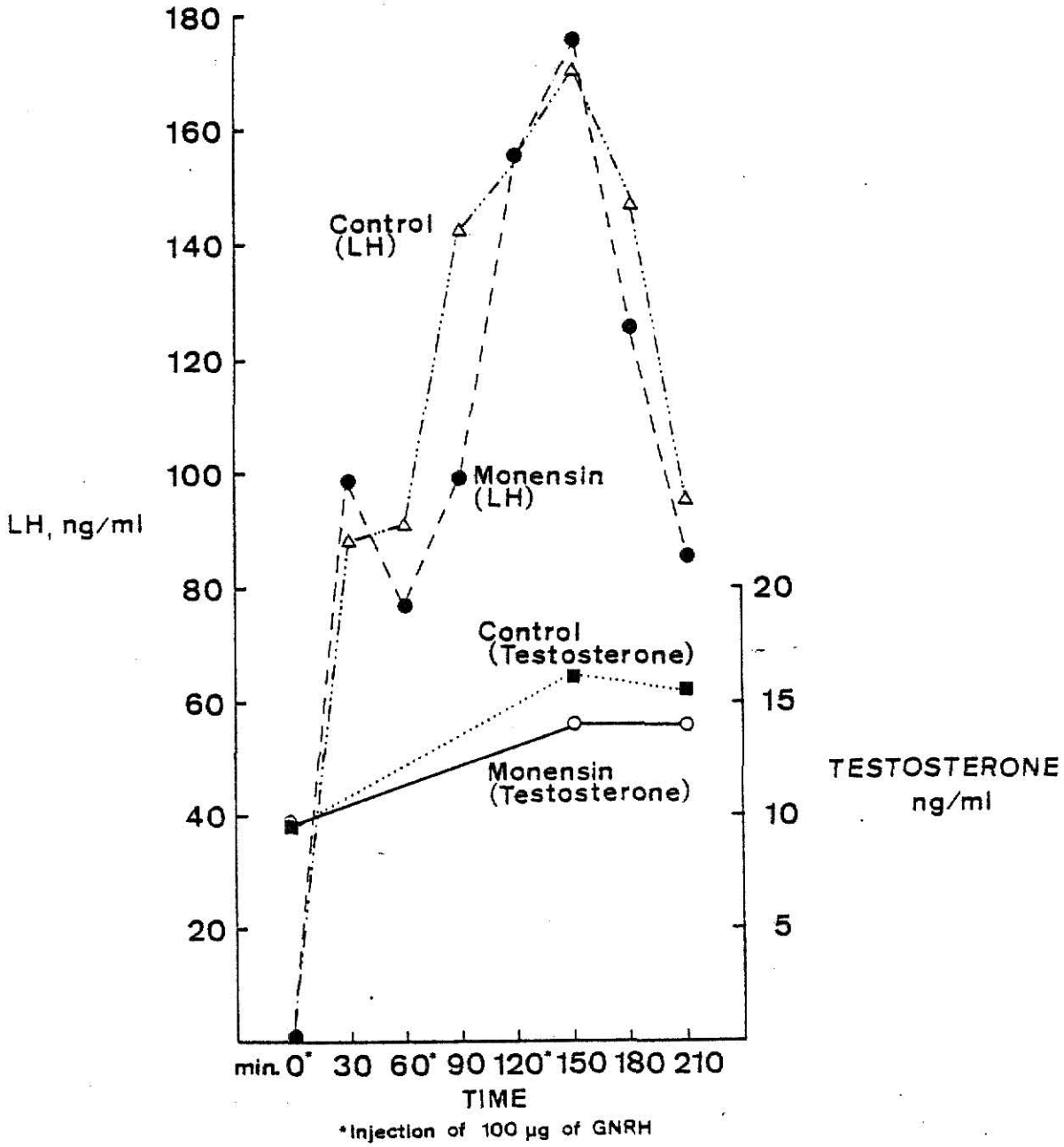


Figure 2. Effect of monensin on serum LH and testosterone levels in yearling bulls injected with 100 µg of GNRH at hourly intervals for 3 hours.



# EFFECT OF PROPIONATE ENHANCERS ON THE PERFORMANCE OF GRAZING STEERS AND THE SEXUAL DEVELOPMENT OF BEEF BULLS

by

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Avoparcin and monensin are both propionate enhancers in the ruminal fermentation process. Avoparcin is a glycopeptide antibiotic produced by a strain of Streptomyces candidus, whereas monensin is a polyether antibiotic produced by a strain of Streptomyces Cinnamonensis with both antibiotics having activity against certain gram-positive bacteria. Both enhancers improve feed efficiency in feedlot cattle; however, no reports are available on the effect of Avoparcin on the performance of grazing steers or the effect of monensin on the sexual development of beef bulls.

Ninety-eight yearling Hereford steers averaging 227 kg were allotted by weight to a grazing trial designed to evaluate the efficacy of Avoparcin, when fed ad libitum in a loose mineral, to provide daily levels of 0, 200, 400 and 600 mg per head. There were 4 pasture replicates per treatment. Pastures were predominantly brome grass with the balance native grasses. Stocking rates ranged from 1.0 to 1.56 steers/acre. Pasture replicates were rotated to minimize pasture effect. Initial and final weights were taken after 15 hours off feed and water. Rumen samples were taken on approximately 18 steers/treatment, 5 hours post removal from grass. Average daily gain (kg/day), average daily mineral intake (gms/head/day), and average daily intake of Avoparcin for the 0, 200, 400 and 600 mg treatments were: .76, 81.48, 0 mg; .86, 63.41, 223 mg; .93, 60.45, 401 mg; and .87, 62.91, 594 mg, respectively.

Molar percent acetate, propionate, butyrate, rumen pH and rumen ammonia (ppm) for the 0, 200, 400 and 600 mg treatments were: 63.07, 17.67, 15.78, 7.02, 60.53; 60.79, 20.81, 14.23, 7.19, 57.25; 61.16,

21.13, 13.82, 7.25, 45.31; and 59.40, 22.77, 13.55, 7.33, 47.74, respectively. Avoparcin ingestion increased ($P<.05$) average daily gain, ruminal propionate and pH, but decreased ruminal acetate, butyrate and the acetate-propionate ratio.

In another trial, 50 percentage Simmental bulls were allotted by weight, age and percent Simmental to either a control or monensin treatment group to determine the effect of monensin on the sexual development of beef bulls. The trial consisted of 2 periods, early weaned (114 days) and growing (149 days). During the early weaned period, 37 bulls (control = 19 head, monensin = 18 head) were weaned at 52 (R = 26-78) days of age and fed ad libitum. The monensin group ration contained 10 g monensin/ton the first 28 days and 20 g monensin/ton until the conclusion of the early weaned period. All bulls in the monensin group during the early weaned period received monensin during the growing period. At the start of the growing period, 13 bulls (control = 6 head, monensin = 7 head) that suckled first-calf heifers until they were weaned at 190 (R = 159-222) days of age were allotted to either the control or the monensin group. Within the monensin group, 18 head and 7 head received monensin for 270 and 125 days, respectively. The monensin group received an average of 96.5 mg and 236.8 mg of monensin/head/day for the early weaned and growing periods, respectively.

Criteria used to evaluate sexual development were body weight, testicular development, hormone concentrations, sexual aggressiveness and sperm production. Initial and final weights were taken after 15 hours off feed and water. Initial and final heights at the hip and

shoulder were recorded. Rumen samples were taken 4 hours after bulls were fed. Scrotal circumference was measured approximately every 28 days. Five libido tests were conducted when the bulls were 231, 258, 287, 318 and 352 days of age. Semen collection by electroejaculation was taken when the bulls' average age was 263 and 351 days. Semen was evaluated for motility, sperm cell concentration, percent live and percent normal. Blood was collected at an average age of 231 and 339 days and assayed for testosterone and luteinizing hormone (LH). Ten bulls (341 days of age) from each treatment were randomly selected to receive 3 hourly injections of 100 μg of gonadotropin releasing hormone (GnRH). Blood samples were collected every 30 minutes for 3.5 hours after the first injection.

Monensin improved feed efficiency and also improved ($P<.05$) average daily gain by 9.2%. Monensin had no significant effect on change in height, scrotal circumference, libido, semen parameters, luteinizing hormone or the initial testosterone level. The final serum testosterone level was higher ($P<.05$) for the monensin (10.04 ng/ml) fed bulls than the controls (6.71 ng/ml).

Final serum testosterone was positively correlated with daily gain ($r = .28$; $P<.06$), initial testosterone ($r = .37$; $P<.01$) and final sperm cell concentration ($r = .44$; $P<.01$). Initial serum testosterone was positively ($r = .32$; $P<.04$) correlated with the initial sperm cell concentration. Scrotal circumference was positively ($r = .39$; $P<.01$) correlated with sperm motility at an average of 263 days and relatively high positive ($r = .44$ to $.82$; $P<.01$) correlations were found between the five libido tests. The GnRH-mediated luteinizing hormone and

testosterone release showed no significant difference between monensin fed and control bulls.

Monensin improved daily gain probably by decreasing ruminal A:P ratio while having no detrimental effects on scrotal circumference, libido, semen parameters or the ability of the anterior pituitary to release luteinizing hormone.