# Monensin Effects On Beef Cattle Grazing Warm-Season Perennial Grasses

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## Introduction

Warm-season perennial grasses are the main forage used for beef cattle production in the southeastern USA (Ball et al. 1991). In general, forage-based cow-calf systems in tropical and subtropical regions are characterized by extensive grazing with low input levels.

Ionophores have been used to increase efficiency of ruminant production and monensin has been the most used ionophore in the US. Although the mechanisms are not completely elucidated, the main effects of monensin on ruminants are: 1) Shift in production of volatile fatty acids (**VFA**), 2) Change feed intake and digestibility, 3) Alter gas production, and 4) Increase protein use efficiency.

Monensin can be described as a cation-proton antiporter and mediates primarily $Na^+/H^+$ exchange. The affinity of Monensin for $Na^+$ is 10 times greater than that for $K^+$ (Bergen and Bates, 1984). Accepted mechanisms by which ionophores negatively affect bacteria include non-physiological ion leak caused by ionophores and consequently adenosine triphosphate (**ATP**) depletion. This effect is greater in gram-positive bacteria. Gram-negative bacteria have a cellular envelope (outer membrane) that serves as a protective barrier, excluding ionophore complexes (Russell and Strobel, 1989).

Bergen and Bates (1984) summarized the effects of monensin as follow: the ionophore acts on the flux of ions through the membranes dissipating cation and proton gradients and interfering with the update of solutes and the primary transport system in the cells. The organisms try to maintain the transport by expending metabolic energy. The gram-negative bacteria can survive better to ionophore because they are able to produce ATP through the electron transport and there is a favorable shift of gram-negative bacteria in the rumen. Although Bergen and Bates (1984) postulated that monensin would cause entry of protons into ruminal bacteria in exchange for $Na^+$, Russell (1987) showed that the direction of $Na^+$ was the opposite using *Streptococcus bovis* as a model. Monensin decreased intracellular $K^+$ concentration and influx of protons, resulting in lower intracellular pH. Once intracellular pH was acidic, monensin produced an efflux of protons in exchange for $Na^+$. The inhibition of *S. bovis* was attributed to futile cycling of ions across the cell membrane resulting in loss of intracellular K+, accumulation of intracellular Na+ and depletion of ATP.

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There have been several articles promoting the use of monensin in beef cattle on pasture with limited levels of supplementation. It is known that monensin select microorganisms in the rumen and enhance fermentation efficiency by increasing propionic acid and decreasing methane production. However, in extensive grazing systems, the animals are usually consuming limited amount of propionic acid precursors, such as starch and sugars, and therefore, it is expected that monensin may not be an efficient feed additive to be used under those conditions. Conversely, beef cattle supplemented on pasture with significant levels of concentrate may consume considerable amount of starch and sugars, which may enhance the effects of monensin and result in increased animal performance.

There are few published research studies reporting the effects of monensin on performance and forage intake of beef cattle grazing warm-season grass pastures. Feed efficiency data is rarely available because inherent difficulty in measurement of feed intake in grazing animals, therefore, there may be trials with no change in averaged daily gain (**ADG**) and decreased pasture intake; however, the forage intake was not measured or the scientific methods do not have precision to detect small variations in forage intake. In this case, the benefit of feeding an ionophore will be realized only if stocking rate is increased. Rouquette et al. (1980) compared the effects of monensin on beef calves grazing Bermudagrass and receiving 0.9 kg/d of concentrate. Calves receiving 200 mg monensin daily had greater ADG (0.54 vs. 0.40 kg/d) than calves receiving the concentrate only. It seems clear that monensin can improve the efficiency of utilization of concentrate supplements to cattle grazing warm-season grasses; however, the effect of ionophore to no supplemented animals is not consistent. Parrott et al. (1990) reported 8 trials of beef cattle grazing native warm-season grasses or Bermudagrass and observed variable responses of ADG to monensin and there was a trend for greater numerical ADG when the 8 trials were combined (0.90 vs. 0.93 kg/d). Walker et al. (1980) indicated that dry matter intake levels may be reduced by 5-10% when beef cows are supplemented with 200 to 300 mg/d of monensin. Randel and Rouquette (1976) reported that 200 mg/d monensin reduced dry matter intake of lactating beef cows by 12.4%; however, monensin did not affect milk production and composition. Clanton et al. (1981) fed 95, 90, and 90 % of the amount of forage consumed by control cows to beef cows fed 50, 200, or 300 mg/d of monensin. Cows fed 200 and 300 mg/d of monensin and 90% as much forage as control cows had similar weight gains as control cows.

Therefore, the effects of monensin on beef cattle receiving warm-season perennial grasses with limited supplementation is inconsistent. Research has been conducted at the University of Florida IFAS Range Cattle Research and Education Center to develop management practices to increase the efficiency of using monensin under those conditions.

## Recent Research Conducted in Florida

Recent studies conducted at the IFAS Range Cattle Research and Education Center tested the effects of monensin (200 mg/d) to beef heifers grazing Bahiagrass (*Paspalum notatum*) pastures at two stocking rates, 1.6 or 2.5 heifers/ha for 2 yr in Florida

(Vendramini et al. 2015). Heifers received 0.4 kg of a concentrate supplement daily. The objective of the study was to verify the effectiveness of monensin in grazing animals with limited supplementation and forage quantity. Due to the seasonality of forage production in tropical areas, beef cattle are subject to limited forage allowance during some months of the year. Pastures grazed with greater stocking rates had lesser herbage mass (2,300 vs. 2,800 kg/hectare [ha]) and herbage allowance (**HA**, 1.0 vs. 1.8 kg DM/kg live weight, **LW**); however, there was no effect of stocking rates on forage crude protein (**CP**, 8.5%) and *in vitro* digestible organic matter (**IVDOM**, 49.7%). Pastures grazed by heifers receiving monensin or control had similar herbage mass, allowance, and nutritive value. There was a month by stocking rate interaction response on heifer ADG (Table 1); however, there was no effect of monensin supplementation on ADG (mean = 0.44 kg/d). According to Inyang et al. (2010), forage allowance below 1.4 kg DM/kg LW would limit performance of beef heifers grazing Bahiagrass pastures. The combinations of environmental factors and forage characteristics may have limited the potential positive effects of the monensin. The same authors quantified the effects of monensin (200 mg/d) on forage intake of heifers receiving Stargrass (*Cynodon nlemfuensis*) hay (11% CP, 51% IVDOM) and observed that there was no difference in total DM intake (2.1% body weight, **BW**) or forage DM intake (2.0% BW) between treatments.

Vendramini et al. (2015) evaluated the effects of increasing levels of monensin on rumen and blood metabolites of steers receiving Bermudagrass hay with limited supplementation. Treatments were 4 levels of monensin (0, 125, 250, or 375 mg monensin/d) added to a daily concentrate supplement fed at 0.2% BW. Considering a voluntary DM intake of 2.2% BW, these monensin levels were designed to supply the equivalent of 0, 10, 20, and 30 mg/kg/animal/d and create a wide range of doses, including the minimum and maximum doses recommended for grazing beef cattle, 50 and 200 mg/d, respectively. There was an increase in propionic acid concentration acid in the rumen and a tendency to decrease acetic acid. Rumen pH, ammonia, isobutyric, and butyric acid concentrations were not affected by treatments (Table 2). In addition, there was no effect on dry matter intake, 2.1 % BW. The slight increase in propionic acid was not sufficient to increase blood glucose, insulin-like growth factor-1 (**IGF-1**), and insulin concentrations. The increasing levels of monensin may have caused a change in microbial populations and the fermentation profile in the rumen, thus optimizing propionate formation. However, the magnitude of increase was insufficient to increase blood metabolites.

In a similar study, Moriel et al. (2018) tested the effects of adding 200 mg/d of monensin to molasses supplementation of beef heifers grazing Bahiagrass pastures during the summer and autumn in Florida. Heifers were offered 14 kg of sugarcane molasses and 3.5 kg of cottonseed meal weekly from day 0 to 84. Weekly supplement amount was divided and offered 3 times weekly on Monday, Wednesday, and Friday at 0800 h. Supplement DM disappearance (% of initial supplement DM offered) was determined every other week at 4, 10, 24, 28, and 34 h after morning supplementation. On d 85, heifers allocated to individual drylot pens, provided free choice access to Bermudagrass hay, and remained on their respective treatment for 10 d of adaptation and 11 d of data collection. The addition of monensin to the supplement did not impact

heifer BW, BCS, overall ADG, Bahiagrass IVDOM, CP, herbage mass, and herbage allowance from day 0 to 84 (Table 3). Supplement disappearance after 10 and 34 hours of supplementation was greater for control vs. monensin heifers and tended to be greater for control vs. monensin heifers 24 hours after supplementation (Table 4). Plasma concentrations of glucose, IGF-1, and BUN did not differ between treatments. During the drylot phase, forage DM intake, total DM intake, heifer BW and ADG did not differ between treatments. In summary, the addition of monensin into sugarcane molasses-based supplements decreased the rate of consumption of the supplement but did not impact ADG and blood parameters of heifers grazing warm-season grasses with limited nutritive value.

Early weaning is an effective management practice to increase the likelihood of rebreeding of first-calf beef heifers in the southeast USA. Arthington and Kalmbacher (2003) verified greater pregnancy rates in first-calf heifers whose calves were weaned at 3 months of age (94%) than those whose calves were weaned at normal age (65%). However, the practice of early weaning calves is still a challenge for beef cattle producers, in part because of few management options for the weaned calves. Mild winters in the southern USA allow producers to raise early-weaned calves on pastures of cool- or warm-season grasses with at least 1% BW supplementation (Vendramini et al., 2006; 2007). With greater levels of concentrate, it is likely that monensin would be an effective additive to add to supplementation of early-weaned calves.

Vendramini et al. (2018) conducted two experiments to evaluate the effects of concentrate amount and monensin inclusion on growth and physiological parameters of early-weaned beef calves consuming warm-season grasses in drylot and pastures. In both experiments, treatments consisted of two concentrate DM amount (1 or 2% BW) and two inclusion rates of monensin (0 or 20 mg of monensin/kg of total DM intake). In the drylot, early-weaned beef calves (initial age = 90 ± 13 d; initial BW = 83 ± 12 kg) were distributed in 12 drylot pens (4 calves/pen; 3 pens/treatment) and provided Stargrass hay (9% CP and 52% IVDOM) at amounts to ensure 10% DM refusals for 56 d. On pasture, early-weaned heifer calves (initial BW = 171 ± 15 kg) were allocated into Bahiagrass pastures on a continuous and fixed stocking rate (1 ha and 3 heifers/pasture; 3 pastures/treatment). In both experiments, effects of monensin inclusion × concentrate amount were not detected for any variable (Tables 5 and 6), but overall ADG and plasma IGF-1 concentrations were greater whereas fecal coccidia egg counts tended or were less for calves offered concentrate with vs. without monensin inclusion (Tables 5 and 6). Calves offered concentrate at 2% of BW had greater overall ADG. Herbage mass, *in vivo* apparent digestibility, total DMI and plasma concentrations of glucose and IGF-1, less forage DM intake, and no effects on fecal coccidia egg counts compared to calves offered concentrate at 1% of BW (Tables 5 and 6).

Vendramini and Arthington (2008) evaluated the supplementation of different levels of concentrate to early-weaned calves grazing dormant warm-season perennial grass pastures during the winter and concluded that it was necessary 2% BW supplementation for calves to have a similar performance to the contemporaneous calves that were not early-weaned. The coccidiostat effect of monensin was an attractive

characteristic to potentially increase the performance of these early-weaned calves during the winter. Vendramini et al. (data not published) tested the effects of adding 20 ppm of monensin to the supplement of early weaned calves grazing dormant Bahiagrass in the winter and receiving 2% BW supplementation. The addition of monensin in the supplement resulted in significant increase in ADG from 0.8 to 0.9 kg/d. In addition, calves receiving monensin had 76% reduction in the incidence of coccidia. There was no difference in forage mass, implying that forage intake was similar among treatments. The calves were moved to a drylot and maintained in the same treatment for 30 d to evaluate the effect of monensin on DM intake. There was no effect of monensin on forage DM intake (0.7% BW) or total DM intake (2.6% BW).

## Conclusions

It was concluded that the positive effects of monensin on rumen fermentation and VFA proportion may be minimized due to the lack of substrate for propionate production in cattle receiving predominantly warm-season forages with limited concentrate supplementation. However, the addition of monensin may decrease supplement intake rate and be desirable in systems with infrequent supplementation on pasture.

Monensin should be supplied to early-weaned calves grazing warm-season pastures and receiving concentrate at 1% of BW or above because of the benefits in controlling coccidia and additional average daily gain.

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**Table 1.** Herbage mass and allowance, and average daily gain of heifers grazed on Bahiagrass pastures at different stocking rates (1.2 vs. 1.7 AU/ha)[1]

| | Month | | | | |
|---|---|---|---|---|---|
| Response variable / stocking rate | June | July | August | September | SE[2] |
| Herbage mass, kg/ha | | | | | |
| 1.2 AU/ha | 1,600[b] | 1,700[b] | 2,600[a] | 2,700[a] | |
| 1.7 AU/ha | 1,490[b] | 1,530[b] | 2,080[a] | 2,090[a] | 300 |
| *P* value[3] | 0.20 | 0.18 | < 0.01 | < 0.01 | |
| SE | | | 450 | | |
| Herbage allowance, kg DM/kg BW | | | | | |
| 1.2 AU/ha | 1.1[b] | 1.3[b] | 2.3[a] | 2.3[a] | |
| 1.7 AU/ha | 0.9[b] | 1.0[b] | 1.3[a] | 1.4[a] | 0.1 |
| *P* value[3] | 0.26 | 0.02 | < 0.01 | < 0.01 | |
| SE | | | 0.1 | | |
| Average daily gain (kg/d) | | | | | |
| 1.2 AU/ha | | 0.3[b] | 0.6[a] | 0.6[a] | |
| 1.7 AU/ha | | 0.1[b] | 0.3[b] | 0.6[a] | 0.1 |
| *P* value[3] | | 0.15 | < 0.01 | 0.85 | |
| SE | | | 0.1 | | |

[a,b] Within a row, means without a common superscript differ ($P \leq 0.05$).

[1] AU/ha = animal units per hectare.

[2] SE = standard error.

[3] *P* value for the comparison of means between stocking rate treatments within month.

Data from Vendramini et al. (2015).

**Table 2.** Effects of supplemental levels of monensin on ruminal fermentation parameters of steers receiving Stargrass (*Cynodon nlemfuensis*) hay and supplemented with 0.2% body weight of concentrate

| | Monensin (mg/kg) | | | | Orthogonal contrast | | | |
|---|---|---|---|---|---|---|---|---|
| Item | 0 | 10 | 20 | 30 | L | Q | C | SE[1] |
| Ruminal pH | 6.6 | 6.6 | 6.7 | 6.5 | 0.41 | 0.19 | 0.33 | 0.07 |
| Propionate, mol/100 mol | 16.9 | 17.9 | 19.1 | 19.4 | 0.004 | 0.56 | 0.64 | 0.5 |
| Acetate, mol/100mol | 74.0 | 73.1 | 71.3 | 71.1 | 0.09 | 0.91 | 0.82 | 1.0 |
| Butyrate, mol/100 mol | 8.7 | 8.4 | 8.3 | 8.5 | 0.82 | 0.72 | 0.98 | 0.7 |
| Acetate:Propionate | 4.3 | 4.0 | 3.7 | 3.6 | 0.001 | 0.19 | 0.65 | 0.2 |
| Ammonia-N, mg/100 ml | 7.3 | 6.1 | 6.4 | 7.3 | 0.86 | 0.17 | 0.79 | 0.7 |

[1] SE = standard error.

Data from Vendramini et al. (2015)

**Table 3.** Overall herbage mass (HM), herbage allowance (HA), in vitro organic matter digestibility (IVOMD) and crude protein (CP) of Bahiagrass pastures, and growth performance of heifers offered 14 kg of sugarcane molasses + 3.5 kg of cottonseed meal per heifer weekly (DM basis) from day 0 to 84

| | Treatment (TRT) | | | *P*-value | | |
|---|---|---|---|---|---|---|
| Item | Control | Monensin | SEM[1] | TRT | TRT x day | Day |
| HM, kg DM/ha | 3,061 | 3,128 | 28.9 | 0.13 | 0.19 | <0.0001 |
| HA, kg DM/kg BW | 4.37 | 4.19 | 0.273 | 0.65 | 0.36 | <0.0001 |
| IVOMD, % | 40.3 | 41.2 | 0.75 | 0.46 | 0.80 | 0.0007 |
| CP, % of DM | 7.64 | 7.98 | 0.239 | 0.34 | 0.78 | 0.24 |
| Body weight, kg | | | | | | |
| d 28 | 363 | 360 | 3.6 | 0.63 | 0.66 | <0.0001 |
| d 56 | 368 | 363 | 5.4 | --- | --- | --- |
| d 84 | 388 | 386 | 6.0 | --- | --- | --- |
| Body condition day 84 | 6.34 | 6.37 | 0.152 | 0.89 | --- | --- |
| ADG 0 to 84 d, kg/day | -0.04 | -0.05 | 0.060 | 0.94 | --- | --- |
| Body condition change | 0.14 | 0.23 | 0.129 | 0.66 | --- | --- |

[1] SEM = standard error of the mean.
Data from Moriel et al. (2018).

**Table 4.** Supplement DM disappearance (% of initial DM offer) pattern of heifers offered 14 kg of sugarcane molasses + 3.5 kg of cottonseed meal per heifer weekly (DM basis) from day 0 to 84

| | Treatment | | | |
|---|---|---|---|---|
| Item | Control | Monensin | SEM[1] | *P*-value |
| Supplement DM disappearance, % of initial offer | | | | |
| 4 hours | 25.4 | 20.9 | 0.02 | 0.13 |
| 10 hours | 81.8 | 75.5 | | 0.04 |
| 24 hours | 92.6 | 87.3 | | 0.07 |
| 28 hours | 96.7 | 92.5 | | 0.16 |
| 34 hours | 99.3 | 93.0 | | 0.04 |

[1] SEM = standard error of the mean.

Data from Moriel et al. (2018).

**Table 5.** Responses of early-weaned calves offered free choice access to long-stem Stargrass hay in drylot and provided, in a 2 x 2 factorial arrangement, two amounts of concentrate DM (1 and 2% of body weight, BW) with or without monensin (20 mg/kg of total DM intake) for 56 d

| | Concentrate | | Monensin | | | *P*-value | | |
|---|---|---|---|---|---|---|---|---|
| Item | 1% BW | 2% BW | 0 mg/kg | 20 mg/kg | SEM[1] | Concentrate | Monensin | Concentrate × Monensin |
| Average daily gain, kg/d | | | | | | | | |
| d 0 to 28 | 0.33 | 0.56 | 0.33 | 0.56 | 0.023 | <0.01 | 0.04 | 0.18 |
| d 28 to 56 | 0.18 | 0.54 | 0.32 | 0.40 | 0.021 | <0.01 | <0.01 | 0.43 |
| d 0 to 56 | 0.26 | 0.55 | 0.36 | 0.44 | 0.016 | <0.01 | <0.01 | 0.15 |
| Plasma urea N, mg/dL | 12.5 | 13.0 | 13.3 | 12.2 | 0.46 | 0.44 | 0.11 | 0.80 |
| Plasma glucose, mg/dL | 73.5 | 81.7 | 76.6 | 78.6 | 2.8 | 0.05 | 0.62 | 0.86 |
| Plasma IGF-1,[2] ng/mL | 39.7 | 59.7 | 46.2 | 53.0 | 2.4 | <0.01 | 0.06 | 0.83 |
| Coccidia egg count on d 56[3] | 1.16 | 1.06 | 1.39 | 0.82 | 0.21 | 0.74 | 0.09 | 0.61 |
| Forage DM intake, % body weight | 1.5 | 0.9 | 1.2 | 1.2 | 0.09 | <0.01 | 0.50 | 0.40 |
| Total DMI, % of body weight | 2.3 | 2.6 | 2.5 | 2.5 | 0.09 | <0.01 | 0.43 | 0.26 |
| In vivo apparent digestibility, % | 56 | 62 | 58 | 60 | 0.8 | <0.01 | 0.19 | 0.28 |

[1] SEM = standard error of the mean.

[2] Insulin-like growth factor-1.

[3] $Log_{10}$ egg count/g of feces.

Data from Vendramini et al. (2018).

**Table 6.** Responses of early-weaned heifers grazing Bahiagrass pastures (3 heifers/pasture) and provided, in a 2 x 2 factorial arrangement, two concentrate DM amounts (1 and 2% of body weight, BW) with or without monensin (20 mg/kg of total DM intake) for 84 d

| | Concentrate | | Monensin | | | *P*-value | | |
|---|---|---|---|---|---|---|---|---|
| Item | 1% BW | 2% BW | 0 mg/kg | 20 mg/kg | SEM[1] | Concentrate | Monensin | Concentrate x Monensin |
| Average daily gain, kg/d | | | | | | | | |
| d 0 to 28 | 0.99 | 1.04 | 0.93 | 1.10 | 0.045 | 0.46 | 0.03 | 0.46 |
| d 28 to 56 | 0.85 | 1.21 | 0.95 | 1.12 | 0.080 | 0.01 | 0.16 | 0.72 |
| d 56 to 84 | 0.69 | 0.92 | 0.73 | 0.88 | 0.047 | <0.01 | 0.05 | 0.14 |
| d 0 to 84 | 0.85 | 1.06 | 0.87 | 1.03 | 0.042 | <0.01 | 0.02 | 0.52 |
| Plasma urea N, mg/dL | 20.8 | 21.3 | 21.5 | 20.6 | 0.71 | 0.57 | 0.42 | 0.66 |
| Plasma glucose, mg/dL | 71.9 | 75.8 | 72.3 | 75.3 | 1.80 | 0.19 | 0.31 | 0.43 |
| Plasma insulin, μIU/mL | 2.02 | 2.81 | 2.25 | 2.58 | 0.519 | 0.31 | 0.67 | 0.60 |
| Plasma IGF-1,[2] ng/mL | 155 | 171 | 149 | 176 | 6.7 | 0.14 | <0.01 | 0.30 |
| Coccidia egg count on d 84[3] | 0.45 | 0.39 | 0.70 | 0.14 | 0.192 | 0.83 | 0.05 | 0.22 |
| Herbage mass, kg/ha | 3,700 | 4,400 | 4,100 | 4,100 | 200 | 0.09 | 0.75 | 0.71 |
| Herbage allowance, kg DM/kg BW | 8.0 | 10.0 | 9.4 | 9.6 | 0.4 | 0.06 | 0.69 | 0.90 |
| CP, % | 14.0 | 14.0 | 14.7 | 13.9 | 0.3 | 0.25 | 0.17 | 0.65 |
| In vitro OM digestibility, % | 48.5 | 48.8 | 48.5 | 48.9 | 0.52 | 0.64 | 0.59 | 0.78 |

[1] SEM = standard error of the mean.

[2] Insulin-like growth factor 1.

[3] $Log_{10}$ egg count/g of feces.

Data from Vendramini et al. (2018).

# SESSION NOTES