

## The effect of monensin on milk production, milk urea nitrogen and body condition score of grazing dairy cows

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### Abstract

Twenty Holstein-Friesian cows, two to four months postpartum, were randomly assigned to two groups. The control group received no monensin, whereas the treatment group received 300 mg monensin per cow per day. Cows grazed kikuyu pasture and received maize-based concentrates (2% of body weight) in two equal feeds after the morning and afternoon milkings. Monensin was supplemented with the concentrates for six weeks. Monensin supplementation reduced the numbers ( $\times 10^5/\text{cm}^3$ ) of small protozoa (9.1 vs. 13.0) and large protozoa (0.37 vs. 1.09) in the rumen. No significant difference was recorded between control and treatment groups for average milk yield ( $21.6 \pm 0.7$  vs.  $22.1 \pm 0.7$  kg/day), milk protein ( $2.91 \pm 0.05$  vs.  $2.84 \pm 0.04$  %) or milk fat ( $2.75 \pm 0.13$  vs.  $2.69 \pm 0.12$  %). The combined morning and afternoon milk urea nitrogen concentrations of the monensin supplemented cows ( $19.9 \pm 1.37$  mg/dl) were lower than those of the control group ( $24.1 \pm 1.43$  mg/dl). The average daily gain of the treatment group ( $471.4 \pm 87.5$  g/day) was higher than that of the control group ( $193.9 \pm 52.8$  g/day). No significant difference was observed between the average condition score of the control ( $1.4 \pm 0.1$ ) and treatment ( $1.7 \pm 0.1$ ) groups after six weeks. Although monensin supplementation reduced milk urea nitrogen concentrations, these were still in the critical zone ( $> 18$  mg/dl) which could negatively affect fertility. Monensin can play an important part in ensuring that cows are in a stable or improving condition (i.e. gaining weight) at service time, this being an important prerequisite for improved reproductive efficiency.

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**Keywords:** Monensin, milk production, milk composition, blood urea nitrogen, milk urea nitrogen, cow

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### Introduction

Ionophores are antibiotic rumen manipulators, one of their major documented benefits being reduced proteolytic activity (Poos *et al.*, 1979; Bergen & Bates, 1984). Monensin is used in Australia for bloat control (Lowe *et al.*, 1991; Cameron & Malmo, 1993), where it effectively reduces soluble protein breakdown in the rumen. Dugmore (1992) postulated that monensin could reduce the excessive breakdown of pasture protein in the rumen and consequently reduce blood urea nitrogen. The first hypothesis of this study was that monensin supplementation to cows grazing pasture with a high crude protein content ( $> 200$  g CP/kg DM), which is also highly degradable ( $> 0.7$  degradable; van der Merwe, 1998), would decrease blood urea and milk urea concentrations as a result of a decreased rumen ammonia concentration. Monensin has also been shown to increase propionate formation in the rumen (Richardson *et al.*, 1976; Sauer & Teacher, 1987; Kone *et al.*, 1989). The second hypothesis was that monensin supplementation would increase the rate at which body weight and body condition is regained after calving.

### Material and methods

Twenty Holstein-Friesian cows (c. 482 kg; 1.45 body condition score), two to four months postpartum, were blocked into two groups. A randomized block design was used to reduce the variation between the two groups, and animals were blocked for body weight, body condition score, milk production, stage of lactation and lactation number. The control group received no monensin whereas the treatment group received 300 mg monensin per cow per day. Cows grazed a mixed kikuyu (*Pennisetum clandestinum*)/clover pasture (200-250 g CP/kg DM) and received a maize-based concentrate (c. 85% maize; 120 g CP/kg, 11.5 MJ ME/kg) at a rate equivalent to 2% of body weight per day (c. 10 kg/cow) in two equal feeds after morning and afternoon milkings. A premix containing 132 mg monensin per gram was used, of which 1.136 g was mixed with 40 g of molasses meal and fed twice a day with the concentrates for a period of six weeks. Milk yields were recorded daily and milk samples were taken on a weekly basis for protein and

butterfat analysis. Cows were weighed and body condition scored on a scale of 0 to 5 (Mulvany, 1977; MAFF, 1986) at the start of the experimental period and thereafter at two weekly intervals.

Morning and afternoon milk samples were taken at the end of the experimental period (following 42 days adaptation) and assayed for milk urea using a method adapted from that of Chaney & Marbach (1962). Blood samples were also taken from the caudal vein after the morning milking, centrifuged and the serum frozen until analysed for blood urea concentration (Chaney & Marbach, 1962). The urea content of morning milk samples were also estimated using a commercially available test strip (Azotest, Compangie Chimique d'Aquitaine, Lalade de Pomerol, France). Rumen samples were taken from rumen fistulated cows at the end of the experimental period to assess the impact of monensin supplementation on the rumen protozoa population. Protozoa counts were conducted under microscopic observation using a haemocytometer (Coleman *et al.*, 1976).

Statistical analyses were conducted using Statgraphics 6 (Manugistics Inc., Rockville, Maryland, USA). Analysis of variance was used to test for treatment differences. Average daily gains were estimated from linear regressions fitted to data taken over the experimental period for each individual cow.

## Results

The effect of monensin on blood urea nitrogen (BUN) and milk urea nitrogen (MUN) concentrations is presented in Table 1. The BUN concentrations of supplemented cows were lower ( $P < 0.05$ ) than those of the control group. The combined morning and afternoon MUN concentrations of the monensin supplemented cows ( $19.9 \pm 1.37$  mg/dl) were lower ( $P < 0.05$ ) than those of the control group ( $24.1 \pm 1.43$  mg/dl). Milk urea nitrogen concentrations for samples taken on the morning of the last day using the Azotest strips were compared with concentrations obtained by laboratory analysis (Table 1). Both methods indicated that monensin supplementation reduced MUN concentrations but this effect was only statistically significant ( $P < 0.01$ ) for concentrations determined by laboratory analysis.

The milk production response and milk composition response to monensin supplementation is presented in Table 1. There was no difference between control and treatment groups for average milk yield, milk protein or milk fat.

**Table 1** The effect of monensin supplementation on milk yield, milk composition, milk urea nitrogen and blood urea nitrogen of dairy cows

	Control	Monensin	SEM	P
Milk yield (kg/cow/day)	21.6	22.1	0.51	0.6915
FCM (kg/cow/day)	17.3	18.2	0.59	0.4752
Milk protein (%)	2.91	2.84	0.04	0.3216
Milk fat (%)	2.75	2.69	0.09	0.7115
Blood urea nitrogen (mg/dl)	206.8	186.6	4.3	0.0299
Milk urea nitrogen (mg/dl)				
Test strip (morning milking)	21.2	20.3	0.46	0.3505
Wet chemistry (morning milking)	24.7	18.9	0.89	0.0041
Pooled milk (morning and afternoon milkings)	24.1	19.9	0.97	0.0498

The effect of monensin supplementation on the average daily gain (ADG) of cows over the experimental period is shown in Table 2. The ADG of the monensin-supplemented treatment was greater ( $P < 0.05$ ) than that of the control treatment. Both groups had a similar average condition score (CS) ( $P = 0.35$ ) at the start of the experimental period (Table 2). After six weeks, the average CS of the control cows had not improved whereas that of the monensin-supplemented cows had improved slightly (1.6 to 1.7). At the end of the trial period, the average CS of the monensin supplemented cows was greater ( $P = 0.101$ ) than that of the control cows.

The effect of monensin supplementation on the concentrations of three groups of rumen protozoa is presented in Table 3. Monensin reduced ( $P < 0.01$ ) the numbers of *Holotrichs*, small *Entodinia* and large *Entodinia* by 100, 30 and 60%, respectively.

**Table 2** The effect of monensin on the average daily gain (ADG) and condition score of dairy cows

	Control	Monensin	SEM	P
ADG (g/day)	193.9	471.4	51.1	0.0187
Condition score (0-5)				
Start	1.4	1.6	0.09	0.3466
End	1.4	1.7	0.08	0.1012

**Table 3** The effect of monensin supplementation on rumen protozoa concentrations in dairy cows

Protozoa	Control	Monensin	SEM	P
	(10 <sup>5</sup> /ml)			
<i>Holotrichs</i>	0.28	0.00	0.06	0.0034
Small <i>Entodinia</i>	13.03	9.12	0.81	0.0011
Large <i>Entodinia</i>	1.09	0.37	0.14	0.0005

## Discussion

The results of this study indicate that monensin has a toxic effect on rumen protozoa. The magnitude of this defaunating effect varied, depending on species, and reduced protozoa concentrations from 30-100%. This suggests that monensin has a selective toxicity.

Defaunation of the rumen has been reported to increase the molar proportions of propionate in the rumen (Huntington, 1996). The greater ADG of monensin-supplemented cows may be partially attributed to this shift in volatile fatty acid production. Grazing dairy cows normally lose 30-60 kg of body weight during early lactation, representing a drop of 1-1.5 points in condition score. The condition score technique, being a subjective measurement, was not sensitive enough to reflect the magnitude of the live weight gain in either the control group (8.1 kg over 6 weeks) or treatment group (19.8 kg over 6 weeks). Phipps *et al.* (1995) found that an increasing dose rate of monensin was associated with increased body weight gain for cows after the lactation peak in milk yield. The present study was conducted over the period 60-150 days post-calving, a phase when the management emphasis is on early reconception to reduce the intercalving period. In order to reconceive at an early stage, the cow should be in a stable or improving condition and should be gaining weight at the time of service. It is well-documented (Butler *et al.*, 1981; Butler & Smith, 1989) that a negative energy balance during early lactation is associated with reduced fertility. The present results indicate that monensin could play a significant role in improving the fertility of grazing dairy cows by increasing the rate at which live weight and condition is regained during the breeding period. This positive effect of monensin supplementation on live weight gain and improvement of cow condition has also been observed in practice on pasture based dairy systems in the KwaZulu-Natal midlands (J.A.H Evans, 1997, personal communication).

The absence of a milk production response to monensin supplementation to tropical pasture (kikuyu) is consistent with the results of others. Walker (1996b) found that monensin had no effect on the milk yield of cows grazing guinea grass and glycine pastures in summer, whereas they recorded an increase in milk yields of cows grazing fertilised ryegrass oversown into kikuyu in winter.

Lower rumen ammonia concentrations are often observed in animals with reduced rumen concentrations of protozoa. Increased rumen ammonia in the presence of protozoa results from protozoal action on dietary and bacterial protein and possibly protozoal protein. Bacteria have also been associated with ammonia production in the rumen (Chen & Russel, 1989; Chen & Russel, 1991). The concentration of rumen ammonia was reduced by 50% when non-lactating cattle were supplemented with monensin, and numbers of certain species of bacteria dropped ten-fold. The urea content of milk is closely correlated blood urea content and rumen ammonia concentration (Refsdal *et al.*, 1985; Baker *et al.*, 1992; Roseler *et al.*, 1993). MUN values considered to be optimum for milk production and reproduction vary significantly (Westwood *et al.*, 1998a). Cited optimum concentrations for MUN include: 12.8 mg/dl (Refsdal *et al.*, 1985), 8.4-10.7 mg/dl (Kirchgessner *et al.*, 1988), 11.2-19.6 mg/dl (Pehrson *et al.*, 1992), 12-17 mg/dl (Hutjens & Barmore, 1995) and 19.0 mg /dl (Butler *et al.*, 1996) for Northern Hemisphere data. Moller *et al.* (1993) reported that blood urea nitrogen concentrations approached 280 mg/dl in some New Zealand herds grazing immature spring pastures and that there was an apparent association between high blood/milk urea

concentrations and reduced milk production and reproductive performance. A survey of Australian dairy herds reported MUN concentrations that ranged from 8.5 to 37.2 mg/dl for bulk tank readings (Tresvakis, 1995). Westwood *et al.* (1998b) stated that Australasian dairy cows should theoretically have poor fertility considering the high MUN values. However, Australasian herds are generally fertile and Westwood *et al.* (1998b) have questioned the validity of the association between MUN values and fertility. They are of the opinion that poor fertility among Northern hemisphere herds may involve energy balance in addition to increased concentrations of rumen ammonia nitrogen and MUN. Tresvakis & Fulkerson (1999) also found no evidence to suggest that high MUN concentrations are associated with poor reproductive performance in dairy cows grazing pasture. However, Tresvakis & Fulkerson (1999) concluded that urea concentrations in milk taken from bulk tanks are useful for assessing the dietary ratio of N to water soluble carbohydrates (WSC). In the present study, milk urea concentrations for both control and monensin supplemented cows were above 18 mg/dl. These high concentrations are indicative of excessively high rumen ammonia concentrations. High rumen ammonia concentrations are caused by the intake of dietary proteins that are rapidly degraded in the rumen, and are exacerbated by pastures that contain high concentrations of protein (> 200 gCP/kg DM). The rate of rumen protein degradation usually exceeds the rate of microbial protein synthesis, and excess ammonia is absorbed across the rumen wall into the bloodstream (Satter & Roffler, 1975; Fenderson & Bergen, 1976; Claypool *et al.*, 1980; Roseler *et al.*, 1993). The liver converts ammonia to urea, which is excreted in urine and milk, secreted into uterine fluid, and is also recycled to the rumen via saliva. Although MUN concentrations from both were high (>18 mg/dl), monensin supplementation improved the utilization of pasture protein. Blood urea concentrations were reduced by 9.8% and MUN was reduced by 23.7% in samples taken at the morning milking. MUN concentrations were reduced by 17.1% in the combined morning and afternoon milk samples. Thomas *et al.* (1988) recorded a similar reduction in blood urea nitrogen concentrations for sheep supplemented with lasalocid. Erasmus *et al.* (1999) recorded a similar decrease in the MUN concentrations for lactating cows consuming total mixed rations supplemented with lasalocid.

Others have reported a positive effect of monensin on milk production (Lynch *et al.*, 1990; Moate *et al.*, 1990; Lowe *et al.*, 1991; Phipps *et al.*, 1995; Walker *et al.*, 1996). The positive response on body weight gain, rather than on milk production, probably reflects differences in the partitioning of nutrients, as the cows in this study were in mid-lactation. The magnitude of the increased growth rates (143%) exceeds that recorded for monensin responses in feedlot trials. Goodrich *et al.* (1984) summarized data from 228 feedlot trials and concluded that cattle fed monensin-containing diets gained weight 1.6-8.5 % faster than cattle fed control diets, while Stock *et al.* (1995) reported that growth rate was increased by 2.8 % by monensin in four feedlot trials. Goodrich *et al.* (1984) also summarised the results of 24 trials for pasture-fed cattle and concluded that monensin increased the growth rates of cattle on pasture by an average of 13.5% (82 g/day). The positive growth response of 277.5 g/day may be attributed to the improved protein economy of the monensin-supplemented cows. Twigge and Van Gills (1984) reasoned that more energy is available for milk production, as less energy is required to metabolise excess ammonia. Danfaer *et al.* (1980) recorded a decrease in milk production for cows fed increasing amounts of crude protein. A 250 g CP/kg DM diet depressed milk production by 2 l/day and a 300 g CP/kg DM pasture decreased production by a further 2-3 l/day. Lean *et al.* (1996) suggested that the energetic cost of converting ammonia to urea, combined with the negative effect of low carbohydrate availability associated with high CP-containing pastures, could potentially decrease the milk yield by up to 11 litres per day when ryegrass protein content was increased from 200-350 g CP/kg DM.

There are indications that excessive CP intake in early lactation may affect reproduction and depress fertility (Ferguson *et al.*, 1988; Elrod *et al.*, 1993; Ferguson *et al.*, 1993), especially when the protein is highly degradable. The most likely mechanism for this effect is via alteration of the uterine environment (Ferguson & Chalupa, 1989), and impairment of sperm, ova or early embryo survival. The present results suggest that monensin supplementation may improve fertility by ameliorating the negative effects of high blood urea concentrations. This, together with improved live weight gain, and a positive energy balance, indicates that monensin could play a major role in improving the fertility of cows grazing young, heavily fertilized grass pastures.

The use of test strips did not prove to be very successful. The milk urea concentrations obtained with the strips did not correspond well with those obtained by laboratory analysis. The strips should be regarded as being of more use for qualitative than quantitative purposes. Butler *et al.* (1996) concluded that Azotest strips could prove useful as indicators of MUN status if chemical tests were unavailable and would indicate

when further, more precise chemical tests were required.

## Conclusion

Dairy cows grazing highly-fertilized pastures have an excessive intake of rumen degradable protein. Improved pasture protein utilization would therefore not only reduce the considerable loss of expensive protein, but should also improve cow fertility. The results of this study suggests that monensin supplementation can play an important role in improving pasture protein utilization and reproductive efficiency of grazing dairy cows.

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