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Effect of monensin inclusion in supplements for cattle consuming low quality tropical forage

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Abstract. A pen feeding study was carried out over 70 days to determine the effects of monensin (M) inclusion in two commercial supplements designed to provide different planes of nutrition to recently weaned steers. Thirty *Bos indicus* crossbred steers (191.4 ± s.d. 7.1 kg) were individually fed a low quality pangola grass hay (57 g crude protein/kg DM; 497 g/kg DM digestibility) *ad libitum* (Control) with either a urea/molasses-based supplement of Rumevite Maxi-graze 60 Block (B), fed at 100 g/day, or grain-based Rumevite Weaner Pellets (WP), fed at 7.5 g/kg liveweight (W).day, both with and without M, *viz.* B, B+M, WP and WP+M, respectively. There were no significant interactions between supplement type and M inclusion for any measurement. Growth rates (main effects) averaged 0.17, 0.35 and 0.58 kg/day for the Control, B and WP supplements, respectively, with all means different ($P < 0.05$), while the response ($P < 0.05$) to M across supplement type was 0.11 kg/day. Hay DM intake was similar for the Control and B treatments (18.6 and 19.6 g/kg W.day) but was reduced ($P < 0.05$) with the WP supplement (16.8 g/kg W.day) while corresponding total DM intakes increased from 18.6 to 20.0 to 23.5 g/kg W.day (all differences $P < 0.05$), respectively. Monensin inclusion in the supplements did not affect supplement, hay or total DM intake. Inclusion of M in supplements for grazing weaners in northern Australia may increase survival rates although the effect of M with cattle at liveweight maintenance or below requires further investigation.

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Introduction

Monensin (M) is an ionophore compound which in recent times has been routinely added to supplements fed to weaned calves grazing pastures during the dry season in northern Australia. This inclusion is based upon the widely recognised application of M as an aid in the prevention of coccidiosis, a protozoal disease of cattle often manifested in young cattle undergoing some form of stress (Holroyd *et al*. 1990). Evidence from commercial supplement manufacturers (B. Hall, Elanco Animal Health, pers. comm.) indicates that M inclusion in dry season supplements has in recent years extended beyond weaners to older cattle including breeding cows and steers despite the general absence of coccidiosis in these older animals. This implies an expectation of a production response to M independent of any disease mitigation effect.

Without nutritional intervention young recently weaned calves grazing tropical native pastures in northern Australia often lose weight during the dry winter–spring months to the extent that their survival is threatened. Two separate nutritional approaches are commonly used with this class of cattle in order to improve animal performance. The first is to provide a urea-based mix designed to provide additional rumen-degradable protein, stimulate intake of the low energy forage and promote a small liveweight response. Small growth responses in the order of 0.1–0.25 kg/day (Winks *et al*. 1972; McLennan *et al*. 1981; Dixon and Coates 2010) have resulted from this approach which, accumulated over several months, may be sufficient to ensure calf survival until the following wet season. The second is to feed at a higher plane of nutrition, and at higher daily cost, using a protein and/or energy source to directly increase energy intake and thereby promote moderate to high growth during the dry season resulting in a stronger, heavier animal at the start of the growing season (e.g. McLennan *et al*. 1984). Monensin has been included in supplements common to both feeding strategies with largely undefined benefits for improved animal growth performance.

Previous research and reviews have detailed liveweight responses to M by cattle on pasture or fed harvested forages averaging 0.08 (Goodrich *et al*. 1984), 0.10 (Wilkinson *et al*. 1980) and 0.09 kg/day (Potter *et al*. 1986) where the growth of cattle without M averaged 0.61, 0.79 and 0.56–0.61 kg/day, respectively. Similar information is limiting for cattle at maintenance or at low growth rates and for pastures and supplements typical of those described above for northern Australia. In a recent review Bretschneider *et al*. (2008), in examining the published responses to M with forage-fed cattle, predicted growth responses across the full range of expected growth rates, including down to maintenance, but with little supporting research evidence at the lower growth rates. The present study investigates the effect of feeding M to cattle fed a low quality tropical forage at two planes of nutrition, achieved via commercial supplements used in northern Australia.

Materials and methods

Experimental design and animals

The experiment was carried out at Brian Pastures Research Station, Gayndah, Australia (latitude 25°39′S, longitude 151°44′E). Thirty commercial Brahman/Shorthorn crossbred weaner steers ~8–10 months of age and of average liveweight 191.4 kg (s.d. 7.1) were vaccinated against tick fever, botulism and bovine ephemeral fever and treated with an anthelmintic (Cydectin Pour-On) to reduce any parasitic burdens, before the study started. The steers were allocated to one of five treatment diets (six steers per diet) in a randomised complete block design. The diets comprised pangola grass (*Digitaria eriantha* subspecies *Pentzii*) fed *ad libitum* with no supplement (Control) or with commercial supplements of Rumevite Maxi-graze 60 Block (B) or Rumevite Weaner Pellets (WP) each without and with M inclusion in the supplements (B, B+M, WP and WP+M, respectively). The supplements were fed as sold commercially, with the following modifications. For the B+M supplement, M was added as Rumensin 200 at ~1000 mg/kg whereas with the pellets, which already contained ~25 mg/kg M as Rumensin 100, the M was removed for the WP treatment and tylosin was removed from all pellets. The blocks contained, by weight (g/kg, as fed), ~350 molasses, 200 urea, 100 salt, 60 cottonseed meal, 50 gypsum, 50 water and 5 trace mineral mix including Cu, Co, I, Zn and Se and were fed at 100 g/day (air dry) thereby targeting a M intake of 100 mg/day with the B+M treatment. They were formulated to provide a minimum of (g/kg) 45 Mg, 35 Ca, 18 P and 12 S. The remaining ingredients were involved primarily with hardening the blocks. The WP were based on grain and included (g/kg, as fed) ~200 wheat, 419 barley, 200 sorghum, 100 cottonseed meal, 30 molasses, 30 limestone, 6 bentonite, 5 urea, 5 salt plus various macro- and trace minerals (Cu, Se, S, Ca, P, Mg, Zn, Mn, Mo, Co and I) and vitamins (A, D and E). They were fed to steers at 7.5 g/kg liveweight (W).day. Because the blocks and pellets were fed on a different basis with the intake of the former at set level and the latter varying with liveweight change, as might be the case in commercial practice, no attempt was made to equilibrate M intake for the two treatments.

Before the experimental period the steers were fed hay *ad libitum* over a 7-day equilibration period in pens. They were then weighed, held for 24 h without feed and 16 h without water, re-weighed and allocated by stratified randomisation to treatment groups and individual pens on the basis of this fasted liveweight. Feeding continued over 70 days.

The experimentation was conducted under Animal Ethics approval SA 2006/07/130.

Feeding regimen and housing

Hay was chaffed to a length of ~5 cm and fed once daily at 0800 hours. In order to maintain *ad libitum* intake, the amount fed was adjusted each day following a bunk inspection with the aim to feed ~15% more than was eaten on the previous day. Supplements were fed in a separate trough to the hay ~15 min before feeding the hay. The block supplements were ground to a fine loose form to facilitate ease of feeding and the addition of intake enhancers. To overcome problems encountered with acceptance of the block supplements, a small amount of a molasses/water mixture (50/50, w/w, as fed), not exceeding 30 g/day total, was added to the supplement and mixed in. The WP were fed without additives. Because their intake was determined on a liveweight basis, the actual amount of pellets fed was re-calculated each week after the steers were weighed. Intake was set at 7.5 g/kg of the average liveweight of the steers in the WP and WP+M treatments combined such that all steers in these two groups received the same amount (kg/day) of supplement. Hay and supplement orts were collected and weighed once weekly.

Measurements and sampling

DM intakes of hay and supplements were determined by weighing them into the troughs daily and weighing orts out once weekly. The feeds offered were sampled daily, bulked over a week and dried to steady weight at 60°C for DM determination. Hay and supplement orts were similarly dried on the day they were collected. Feed samples collected daily were pooled over the feeding period, subsampled and chemically analysed.

The steers were weighed once weekly in the morning before feeding. Digestibility of the hay component of the diet was estimated using the six Control steers in week 9 of the experiment. Total faecal output of the steers was collected from the floor of the concrete pens three times daily for 7 days. At each collection the faeces was thoroughly mixed, weighed and a 10% subsample by weight was taken and stored at −20°C. At the end of the collection period the faecal samples were thawed, pooled for each steer, thoroughly mixed, subsampled and dried to constant weight as described above. Total faecal DM was determined using this faecal DM content and the wet weight of faeces voided for the week, and the DM digestibility (DMD) of the hay was calculated for each steer.

Laboratory analyses

Samples of the hay and pellets were ground through a 1-mm screen whereas samples of the block supplements, which had already been ground to a fine form before feeding, were not further processed before being analysed. The ash content of feeds was determined by combusting dry samples in an electric muffle furnace (Thermogravimetric Analyser TGA-601, LECO Corporation, UK) at 600°C for 2 h. Samples were analysed for total N by a combustion method (Sweeney 1989) using an Elementar Rapid-N Analyser (Elementar Analysensysteme, Germany). The crude protein (CP) content was calculated as: CP (%DM) = N (%DM) × 6.25. Crude fibre of the samples was determined following standard AOAC (1975) procedures adapted for the Fibretec 2021 Fibrecap System (application sub-note ASN 3802) by Foss Tecator (Denmark) while neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents were also determined using the Fibretec 2021 Fibrecap System. The NDF content was expressed on an ash-free basis but was uncorrected for residual protein. Lipids in the supplements were extracted with chloroform/methanol by the method of Folch *et al.* (1957) and expressed as ether extract content. Phosphorus concentration was measured by a colourimetric method following ignition at 600°C for 3 h and digestion with concentrated hydrochloric acid (AOAC 1980). Monensin concentration in supplements was determined by the liquid chromatography technique following the standard method 997.04 of AOAC (2006).

Statistical analyses

The experimental design was a randomised complete block, with pen/steer as the experimental unit and blocking on pen position and steer weight. Each variable representing performance of the steers over the duration of the trial was analysed by ANOVA with terms for block and treatment. The treatment effect was partitioned to compare means for supplemented against Control steers and within supplements to test the main effects of supplement type (B versus WP) and M, and to test for interaction between supplement type and M. Pair-wise comparisons between means for the five groups were also done using the protected l.s.d. procedure. Assumptions of the analyses were checked by residual plots; based on these no data transformation was needed to achieve homogeneity of variance. The residual plots also showed no statistically outlying values.

Possible changes in treatment effects on hay and total DM intakes (%W/day) across time were tested by repeated-measures ANOVA. In both cases these showed a significant time by M interaction, so the intakes for each week were analysed by ANOVA in the same way as the other variables to indicate times at which the effects changed.

All significance tests were at the $P = 0.05$ level. The GENSTAT statistical package (GENSTAT 2006) was used for all analyses.

Results

Animal health

All steers remained healthy throughout the experiment. No steers showed any obvious signs of coccidiosis such as diarrhoea.

Feed composition

The composition of the pangola grass hay and supplements is shown in Table 1. Pangola grass hay alone (Control diet) had a DMD of 497 g/kg. The estimated metabolisable energy content of the hay, from calculations based on this DMD and the equation of Freer *et al.* (2004), was 7.1 MJ/kg DM, while that for the B and WP supplements was 7.1 and 12.4 MJ/kg DM, respectively, from calculations based on their proximate analysis (MAFF 1975). DM content of the blocks and pellets averaged 838 and 921 g/kg over the total feeding period. The low quality of the hay was confirmed by its low CP and high NDF and ADF contents. Conversely, the CP in the WP averaged 160 g/kg DM. The apparent high CP content of the B-type supplements reflected their urea inclusion (equivalent CP) as they contained little true protein. The concentration of M in the B+M (excluding the added molasses) and WP+M supplements was 1099 and 34 mg/kg DM, respectively.

Feed intake

The WP were highly palatable and their intake, with or without M inclusion, was complete for all steers from the first day of feeding. Measured intake of the pellets is shown in Table 2. Based on these intakes, the WP+M steers consumed 49 mg/day of M. Intake of the B block supplements was highly variable both between steers

Table 1. Nutrient content (g/kg DM) of the pangola grass hay and supplements

See Materials and methods for a description of the supplements. CP, crude protein/crude protein equivalent (= N × 6.25)

	OM	CP	EE	NDF	ADF	CF	P
Hay	944	57	n.d.[A]	729	372	n.d.	1.4
Supplements: B	613	739	3	n.d.	n.d.	7	20.2
B+M	621	740	4	n.d.	n.d.	5	21.8
WP	906	163	27	130	71	41	3.6
WP+M	901	156	27	132	70	42	4.2

[A]Not determined.

Table 2. Effect of feeding supplements of Rumevite Maxi-graze 60 block (B) and Rumevite Weaner Pellets (WP), with and without monensin (M), on the intake of pangola grass hay and total (hay + supplement) DM and on liveweight gain by steers over 70 days

See Materials and methods for a description of the treatments. The intakes of B and B+M supplements include added molasses. l.s.d., least significant difference; $P = 0.05$. Within rows, means with the same letters within 'Supplement type' and 'M inclusion' groups are not significantly different from each other ($P = 0.05$)

	Control	B	B+M	WP	WP+M	l.s.d.	Supplement type			M inclusion	
							Control	B	WP	No	Yes
Supplement DM intake[A]											
(kg/day)	0	0.09	0.09	1.43	1.43	–	0	0.09	1.43	0.76	0.76
(g/kg W.day)	0	0.4	0.4	6.9	6.7	–	0	0.4	6.8	3.7	3.5
Hay DM intake											
(kg/day)	3.66	3.99	4.00	3.42	3.66	0.276	3.66a	4.00b	3.54a	3.71	3.83
(g/kg W.day)	18.6	19.8	19.4	16.5	17.0	1.33	18.6a	19.6a	16.8b	18.2	18.2
Total DM intake											
(kg/d)	3.66	4.08	4.09	4.85	5.09	0.277	3.66a	4.08b	4.97c	4.47	4.59
(g/kg W.day)	18.6	20.2	19.8	23.4	23.6	1.33	18.6a	20.0b	23.5c	21.8	21.7
Liveweight gain (kg/day)	0.17	0.29	0.40	0.52	0.64	0.088	0.17a	0.35b	0.58c	0.41a	0.52b

[A]Differences not tested statistically as part of treatment design.

and over time, but improved in the second half of the experiment. Intake was not apparently related to the presence of M but improved generally with the addition of the molasses/water mixture. The average DM intake of added molasses was only 0.011 and 0.010 kg/day for the B and B+M treatments, respectively. Actual intakes of B-type supplements (block + molasses) are shown in Table 2. Monensin intake averaged 84 mg/day for the B+M group.

Average intakes of hay and total (hay + supplement) DM over the complete feeding period are shown in Table 2. As there were no significant interactions of supplement type and M inclusion main effects are emphasised below. Feeding WP reduced hay intake (liveweight basis; $P < 0.05$) by 10 and 14% compared with the Control and B treatments, respectively; intakes for the Control and B treatments did not differ significantly. However, total DM intake (liveweight basis) by steers was increased, relative to the Control, with B (by 8%) and with WP (by 26%) supplement, with significant differences between all treatments. There was no overall effect of M inclusion on hay or total intake but there was a trend for M to reduce hay intake slightly in the last 3 weeks of the study and the analysis by time indicated that this effect was consistent across the two supplement types and became statistically significant in week 9.

Liveweight gain

All groups, including the Controls (0.17 kg/day), gained weight during the study (Table 2). Relative to the Control additional gains of 0.18 and 0.41 kg/day were associated with feeding B and WP supplements, respectively, with all differences between main supplement treatments significant. In the absence of any interaction between M and supplement type, the main effect of M inclusion was an increase in growth rate of 0.11 kg/day ($P < 0.05$). The M effect was apparent from the start of feeding and was maintained throughout the feeding period (see Fig. 1).

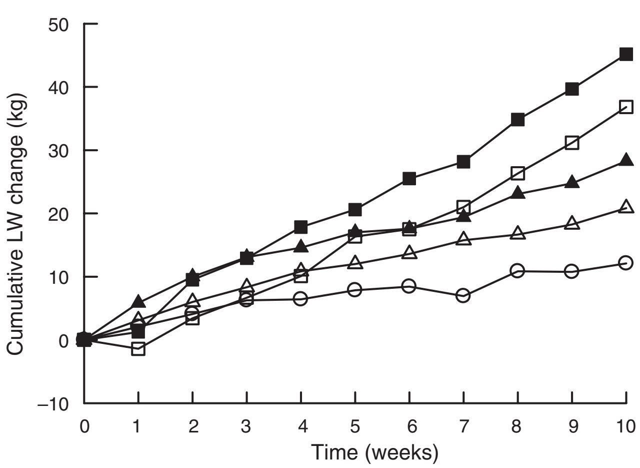

Fig. 1. Cumulative liveweight (LW) change for steers receiving pangola grass hay *ad libitum* alone (open circle), or supplemented with Rumevite Maxi-graze 60 Block (B) without (open triangle) and with (closed triangle) monensin, or with Rumevite Weaner Pellets (WP) without (open square) and with (closed square) monensin. See Materials and methods for a description of the treatments.

Discussion

The difference between growth rates achieved using the two commercial supplements (0.29 and 0.52 kg/day), while small, provided the basis for a comparison of responses to M at low to moderate growth and were consistent with the different DM and also energy intakes by the steers. The B supplement provided essentially a non-protein N source with some added minerals, as is widely fed under commercial grazing conditions in northern Australia, and delivered a growth response relative to unsupplemented steers of 0.12 kg/day. While the pangola grass hay was of relatively low quality, i.e. 57 g CP/kg DM and 497 g/kg DMD, it was probably still higher in nutritive value than that usually encountered by cattle grazing native pastures during the late dry season in northern Australia, as supported by the positive weight change of the Control steers (0.17 kg/day). Dixon and Coates (2010) reported CP content in the selected diet of heifers grazing tropical pasture near Townsville averaging less than 50, and predominantly less than 40 g/kg DM, over three dry seasons. Providing additional energy in the form of WP in our study further stimulated growth of the steers which effectively mimics the use of higher energy/protein supplements such as those based on molasses, urea and true protein for weaners in the same region (e.g. McLennan *et al.* 1984).

The similar response to M (~0.11 kg) for the two supplement types can be considered in relation to the predictions of Bretschneider *et al.* (2008). In reviewing the cited effects of dietary M inclusion in forage diets they showed a negative interaction between ‘forage’ quality and the growth response to M. In their review, forage quality was defined by the growth rate of cattle on rations without dietary M inclusion where the diet often included not just forage but also supplements based on protein, mineral and/or energy, as was also the case in our study. Using their derived linear regression equation, the growth responses to M with the B and WP treatments would be 0.10 and 0.08 kg/day, similar to the 0.11 and 0.12 kg/day we recorded, respectively. These predictions were made without consideration of M intake rate but Bretschneider *et al.* (2008) separately reported a quadratic relationship between M intake and growth response with peak response at 80–100 mg/100 kg W.day. In our study where we used commercial supplements containing M, the M intakes averaged 84 and 49 mg/day, or 41 and 23 mg/100 kg W.day for the B+M and WP+M treatments, respectively. It is possible that higher growth responses could have been achieved, especially with the WP+M ration, if M intake was increased but this was not investigated in our study.

While our results have given an insight into the effects of variable plane of nutrition on response to M, as originally designed, they do not cover the effect of inclusion of the ionophore when cattle are just maintaining or even losing weight. The prediction of Bretschneider *et al.* (2008) discussed above, is for a M response of 0.11 kg/day at maintenance but there is little supporting research evidence for such a response in the literature. Gardener *et al.* (1999) limit-fed a 50% concentrate/50% roughage diet in an attempt to restrict growth of steers to maintenance but growth rate of Control steers over 56 days steers was 0.25 kg/day and was increased to 0.31 kg/day with M inclusion in the ration. We have found no published reports of the effects of M where cattle were fed forage only diets *ad libitum* and just maintained weight.

Even at the relatively high inclusion rate of 1100 mg/kg DM in the B+M supplement, M was not associated with a reduction in supplement intake or any obvious adverse effects on the steers. This observation is of practical significance as the commercial adoption of M in dry season supplements, particularly for older cattle, has been partly driven by graziers' desire to limit supplement intake and thereby reduce supplement costs. Over-consumption of dry season supplements is not uncommon in drier years, which increases costs and the risk of urea toxicity. To reduce the risk of toxicity and provide a margin for safety, M has been recommended for inclusion at a maximum 440 mg/kg supplement (Potter *et al.* 1984). The lack of effect on intake of the B supplement in our study, relative to other reports, could result from the low intake of B targeted (~100 g/day) relative to some reported energy-based supplements. The concentration of M in the WP was only 34 mg/kg DM and similarly did not affect supplement intake.

There was similarly no effect of M on hay or total intake with either supplement type. In agreement with this, a summary of the literature by Bretschneider *et al.* (2008) concluded that M had little or no effect on DM intake by cattle consuming forage diets. This contrasts with the feedlot experience where Goodrich *et al*. (1984) showed that feed intake tended to decline as the concentration of M in the diet was increased, the maximum reduction occurring at a M concentration of about 36 mg/kg DM. Notwithstanding the M effect, the inclusion of supplements had predictable effects on forage and total intake. Feeding the urea-based B mix stimulated hay and total intake by 5.4 and 7.5%, respectively, consistent with addition of a rumen degradable N source to a low protein forage. However, this stimulus in hay intake to urea supplementation is considerably lower than that achieved in some other studies with cattle given low quality grass hays (15-65%; Ernst *et al.* 1975; Romero *et al.* 1976) presumably resulting from the higher quality of the hay we used compared with that in these other experiments (3.6-4.7 g N/kg DM). A classical substitution effect (Moore *et al.* 1999) of reduced hay intake (by 9.7%) but increased total intake (by 26.3%) resulted when the WP supplement was fed to the steers. The higher resulting energy intake with the WP supplement was associated with higher growth rate by the steers.

In summary, M increased growth rate of steers receiving diets promoting low to medium growth but the question still remains whether these effects translate to cattle maintaining or losing weight as often occurs under dry season grazing conditions. The cost of including the M in supplements then needs to be balanced against the additional growth and value of the animals following the dry season and the likely losses of this growth response, in part or total, to compensatory growth in the following wet season (Winks 1984). However, overriding these considerations is the question of whether any additional growth by cattle attributable to M, including through anti-coccidial effects in weaners, would increase their survival chances over the dry season.

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