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Effects of mineral and protein supplements on sheep fed mulga under field conditions

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Summary

Two experiments were conducted in which sheep fed mulga under field conditions were supplemented with either mineral licks or cottonseed meal and a mineral lick.

A preliminary experiment was conducted to determine the most promising of three mineral licks when fed to Merino wethers. A molasses based mineral lick produced a 7.38 kg liveweight advantage over unsupplemented controls during the 29 week supplementation period compared with a 3.33 kg advantage for a solid lick and a 3.03 kg advantage for a loose lick. All licks produced a significant increase in clean wool production per unit area at some stage during 3 measurement periods. The molasses based lick produced 62% more wool than the controls during the last 8 weeks of supplementation.

A subsequent experiment with pregnant and lactating ewes showed that ewe and lamb survival rate and lamb liveweight can be significantly improved by providing a molasses based mineral lick and a cottonseed meal supplement. Ewe survival rate improved by 52%, lamb survival rate by 82% and lamb liveweight by 33% following supplementation for 17 weeks. Supplementation had no effect on the other parameters measured.

1. INTRODUCTION

Under drought conditions mulga *(A. aneura)* is frequently the only fodder available for sheep and cattle over extensive areas of inland Queensland. McMeniman and Little (1974), Entwistle and Baird (1976), Hoey, Norton and Entwistle (1976) and McMeniman (1976) have shown that liveweight status and wool production of sheep fed mulga can be improved by supplementation with phosphorus and molasses.

Hoey *et al.* (1976) further showed that the response to molasses supplementation was due to the minerals contained in the molasses and suggested that the principal elements were sulphur and calcium. Further investigation under pen conditions (Gartner and Niven 1978) showed that most of the response was due to sulphur, the quantity required being 0.6 g per head per day; supplementary calcium had no beneficial effect. McMeniman, Niven, Crowther, Gartner and Murphy (1981) have also reported significant responses in sheep fed mulga to supplements of cottonseed meal when fed under pen conditions.

This paper describes a preliminary field experiment designed to examine the effect of supplementing sheep fed mulga with several proprietary licks and a more comprehensive field experiment to evaluate the effect of the most promising lick fed with cottonseed meal. Previous responses to mineral and protein supplements had been obtained under pen conditions and a field trial under more practical conditions was warranted. Liveweight, wool production and survival rate were considered.

In the preliminary experiment three mineral licks were fed to wethers. The licks were modified where necessary so that they contained sufficient phosphorus and sulphur to supply the sheep's theoretical requirements (that is, 2 g per day each) for these elements. In the main experiment, a molasses based mineral lick and cottonseed meal were fed to pregnant and subsequently lactating ewes. Both experiments were carried out on the Charleville Experimental Reserve.

2. MATERIALS AND METHODS

Animals and management

Preliminary experiment

Forty two-tooth Merino wethers were allocated by stratified randomisation on the basis of liveweight into four groups. The sheep were drenched with a broad spectrum anthelmintic (Thibendazole®, manufactured by Merck, Sharp and Dohme) and run together at pasture *(Eragrostis, Thyridolepis, Aristida* spp.) for 9 weeks. They were then allocated to four 4-ha paddocks in which the predominant vegetation was thick whipstick and tall mulga. The tree density was such that no forage was present on the ground. Bi-weekly cutting of mulga trees began as soon as a browse line developed. During the 29 weeks that the sheep were consuming this mulga diet the experimental supplementation treatments were imposed.

Main experiment

One hundred and twenty full mouth Merino ewes were mated to four rams fitted with sire sine harness for a period of 5 weeks. Crayons were changed fortnightly and mating records were kept.

During the joining period and for the next 2 months the sheep were run in an area with ample pasture *(Eragrostis, Thyridolepis, Aristida* spp.) and low mulga available. The 72 ewes which had joined were than allocated by stratified randomisation on a liveweight basis to the four 4-ha paddocks in the trial site. Little or no ground cover or low mulga was available in this area and mulga was felled bi-weekly to feed the sheep for the 17 weeks during which the supplements were fed. The sheep were drenched (Thibendazole®, manufactured by Merck, Sharp and Dohme), jetted (Dipjet®, manufactured by Merck, Sharp and Dohme) and crutched during the trial to minimise any effects of internal or external parasites.

Treatments

Preliminary experiment

Group 1	Control
Group 2	Lick A (solid lick)
Group 3	Lick B (loose lick)
Group 4	Lick C (molasses based lick)

The composition of the three licks is presented in Table 1. The licks were placed close to the felled mulga and were replenished as required. During the first month of supplementation the intake of the loose lick B was exceptionally high, that is, 108 g per head per day. To overcome this problem, a salt free form of the lick was fed for the remainder of the supplementation period.

Table 1. Composition of the licks (%)

	Lick		
	A (solid)	B (loose)	C (molasses based)
Crude protein (NPN)	3.0	28.0	30.0
Molasses	10.0	0	73.8
NaCl	30.0	10.0*	2.0
Sulphur	2.0	3.0	1.5†
Phosphorus	2.0	18.0	1.36
Calcium	30.0	23.0	2.2
Copper	0.05	0.03	0.013
Cobalt	0.002	0.003	0.0004
Iodine	0.003	0.003	0.0004
Mangnesium	0.2	0.3	0.25
Zinc	0.0001	0.0001	. .
Manganese	0.0003	0.004	0.018

* After the first month a salt free lick was fed.
† Includes sulphur in the molasses.

Main experiment

Two replicates were given no supplement while the other two replicates were given access to a molasses based lick plus cottonseed meal. The composition of the lick is as for lick C in Table 1; and it was made available *ad libitum.* Cottonseed meal was fed bi-weekly in covered troughs with coarse salt added to restrict the intake of the cottonseed meal to 30 g per head per day. Supplements were placed near watering points.

Measurements

Preliminary experiment

Liveweights were recorded monthly. Clean wool production data were obtained using the dyeband technique (Chapman and Wheeler 1963). Dyeband samples were taken from eight sheep per group for three 8-week periods during which the supplements were fed.

Main experiment

Liveweights of the ewes were recorded at the beginning of the trial, again following lambing and finally after weaning. Data were obtained on joining percentage and survival rates of the ewes and lambs. The lactation status of the ewes was determined by palpation of the udder at the conclusion of the trial.

The concentrations of blood phosphorus, faecal nitrogen and phosphorus, and rumen ammonia were measured on samples obtained from 10 random sheep per group after lambing. Rib bone samples from a total of 14 sheep per group were obtained using the technique of Little (1972). Five per group were sampled following joining. Samples were also taken from nine others per group before supplementation began and the 20 of these which survived were then resampled after lambing.

Wool growth was measured on 10 sheep per group using a clipped patch technique. Two measurements, one of 4 weeks and one of 6 weeks duration, were made in the period before supplementation began and one measurement of 17 weeks during the supplementation period.

Supplement intakes were recorded.

Statistical analyses

All results except survival were analysed using analysis of variance: liveweight changes and wool growth rates during pre-supplementation periods were used as covariates when appropriate. Survival was analysed by analysis of deviance.

3. RESULTS

Preliminary experiment

The liveweight changes and supplement intakes of the sheep are shown in Table 2.

Table 2. Liveweight change and mean Lick intake of sheep during the 29 week supplementation period (mean ± s.e.)

	Control	Lick A	Lick B	Lick C
Liveweight change (kg)	−3.88*a* ±1.30	−0.55*a* ±1.16	−0.85*a* ±1.16	3.50*b* ±1.16
Lick intake (g per head per day)		28.7	44.7	55.8

Values on the same line with different letters are significantly different ($P < 0.05$).

All forms of supplementation had an effect on liveweight change. The liveweight change of the group receiving the molasses based block C was significantly different ($P < 0.05$) from that of the other three groups.

Licks A and B prevented some of the liveweight loss recorded in the control group. The mean lick intake was highest in the group consuming the molasses based lick C. Once the salt free form of lick B was offered the intake of licks A and B was about the same, that is, 29 and 22 g per head per day respectively. The calculated per head sulphur intakes were 0.58, 0.66 and 0.84 g per day respectively for sheep consuming licks A, B and C.

The wool growth rates in sheep receiving lick B were superior during the first period of supplementation (Table 3); by the third period the growth rate of those consuming licks B and C was superior to that of the controls and sheep on lick A. In all groups rate of wool production fell during the period of supplementation.

Table 3. Clean wool production (mg cm^{-2} day^{-1}; mean ± s.e.) of sheep fed mulga supplemented with various licks

Group	Supplementation period		
	10 weeks	10 weeks	9 weeks
Control	0.48*b* ± 0.025	0.42*c* ± 0.031	0.29*b* ± 0.026
Lick A	0.48*b* ± 0.022	0.49*bc* ± 0.026	0.36*b* ± 0.022
Lick B	0.62*a* ± 0.023	0.60*a* ± 0.028	0.44*a* ± 0.024
Lick C	0.53*b* ± 0.023	0.54*ab* ± 0.028	0.47*a* ± 0.024

Values in the same column with different letters are significantly different at least at $P < 0.05$.

Main experiment

By the end of the first week of joining 24% of the ewes had been marked with sire sine crayons. This rose by 45% by the end of the second week and to 60% by the end of the fourth week. As no more ewes were joined in the subsequent week it was suspected that ewes which did not mate were already pregnant and they were removed from the trial.

The supplemented ewes were significantly heavier than the controls after lambing as were the lambs from this group (Table 4). When the effect of rearing a lamb was eliminated the difference in ewe weights after weaning approached significance. The lambs in the supplemented group retained their weight advantage from post-lambing until post-weaning. Ewe survival rate in the treated group (69.4%) was significantly higher than that in the control group (33.3%) ($\chi^2 = 9.6$, $P < 0.01$). Two lambs in the control group survived the trial compared to 11 in the supplemented group. Two ewes in the treated group were dry on udder palpation while all other surviving ewes in both groups had either reared a lamb or lambed and lost.

Table 4. Liveweights of ewes and lambs fed mulga with and without a molasses lick and a cottonseed meal supplement (mean ± s.e. of difference)

	Liveweight (kg)			
	Initial	Post-lambing	Post-weaning	Post-weaning with effect of rearing a lamb eliminated
Ewes	*n*	*n*	*n*	
Control	33.5 (34)	32.5*a* (11)	35.1 (11)	34.5*
Supplemented	33.6 (35)	35.9*b* (25)	37.3 (24)	37.2*
s.e. of difference between means	±0.86	±1.3	±1.4	±1.4
Lambs				
Control		5.3*c* (3)	9.0*e* (2)	
Supplemented		8.2*d* (12)	13.5*f* (11)	
s.e. of difference between means		±1.1	±1.4	

Values in the same column with different letters are significantly different ($P < 0.05$).
* Approaching significantly different ($P = 0.053$).

No significant differences were found in clean wool production (Table 5), blood phosphorus levels or rumen ammonia concentrations (Table 6). The supplemented group had significantly higher faecal nitrogen and phosphorus concentrations (Table 6).

Table 5. Clean wool production (mg $cm^{-2}day^{-1}$) of ewes fed mulga with and without a molasses lick and a cottonseed meal supplement (mean ± s.e. of difference)

	Before Supplementation		During supplementation
	Period I 4 weeks	Period II 6 weeks	17 weeks
Control	0.45	0.78	0.39
Supplemented	0.47	0.75	0.38
s.e. of difference	±0.04	±0.07	±0.04

No significant differences.

Table 6. Blood inorganic phosphorus, rumen NH_3-N and faecal N and P concentrations of ewes fed mulga with and without a molasses lick and a cottonseed meal supplement (mean ± s.e. of difference)

	Blood P (mg per 100 mL)	Rumen NH_3-N (mg per 100 mL)	Faecal N (%)	Faecal P (%)
Control	8.96	5.62	2.5*a*	0.28*c*
Supplemented	8.62	3.64	2.8*b*	0.36*d*
s.e. of difference	±0.88	±2.15	±0.07	±0.03

Values in the same column with different letters are significantly different ($P < 0.05$).

The data obtained from the bone analyses are shown in Table 7. These results show that, except for percentage fat free dry bone after lambing, there were no differences between treatments on any one sampling date. While no statistical comparisons were made between values obtained on different dates, it can be seen from the data that there was an increase in all the parameters measured from pre- to post-lambing.

The average daily intake of the molasses based block was about 39 g per head.

Table 7. The mean specific gravity, percentage fat free dry bone (FFDB) and concentrations of phosphorus, calcium and magnesium in rib bone samples obtained from ewes fed mulga alone (c) or with molasses based lick and a cottonseed meal supplement(s) (± s.e. of difference)

	Group	After joining	Before supplementation		After lambing	
Specific gravity	C	1.93 ± 0.014	1.89	± 0.016	2.10	± 0.096
	S		1.87		2.01	
Per cent FFDB	C	84.41 ± 1.00	85.3	± 0.55	91.9*b*	± 0.21
	S		86.2		91.4*a*	
Phosphorus mg cm^{-2} FFDB	C	177.6 ± 6.14	183.2	± 2.65	233.8	± 10.92
	S		182.6		207.9	
Calcium mg cm^{-2} FFDB	C	376.2 ± 14.41	399.2	± 7.51	489.1	± 23.82
	S		401.6		461.1	
Magnesium mg cm^{-2} FFDB	C	0.0056 ± 0.00018	0.0057	± 0.00012	0.0071	± 0.00038
	S		0.0056		0.0068	

Paired values with different letters are significantly different ($P < 0.05$).

4. DISCUSSION

Preliminary experiment

All forms of supplementation had a beneficial effect on maintenance of liveweight and promotion of wool growth. That the sheep supplemented with the molasses based lick C should perform better than those receiving the other forms of mineral supplements is in agreement with other experimental results. It is known that sulphur is responsible for a large percentage of the response when molasses is fed (Hoey *et al.* 1976; Gartner and Niven 1978). However, other minerals in the molasses that add to this response have not yet been identified (Gartner and Niven 1978; McMeniman *et al.* 1981).

Clean wool production steadily declined in all groups during the period of supplementation. However, sheep fed either lick B or lick C produced significantly ($P < 0.05$) more clean wool than the controls during the three measurement periods. The sheep given lick C produced 62% more wool than the controls during the 5th and 6th months of supplementation. This could represent 1.2 kg of clean wool over a 6 month supplementation period.

Main experiment

Supplementation in this experiment resulted in improved ewe survival rates (69.4% vs. 33.3%), improved lamb liveweight and lamb survival rate (11 vs. 2 lambs from 36 ewes) but had no effect on wool production. While these responses to the supplements were significant, the advisability of engaging in a similar feeding programme involving large sheep numbers under practical conditions would have to be determined by an economic decision. Agistment of pregnant ewes may be a more practical alternative when the high costs of supplements are considered.

Cottonseed meal supplementation has been shown to stimulate dry matter intake and production responses of dry sheep consuming a mulga diet (McMeniman *et. al.* 1981) and the reproductive performance of ewes on dry grass pastures (McMeniman, O'Dempsey, Niven, Jordan and O'Brien 1982). Presumably these responses, and a portion of those reported in this experiment, were due to the absorption in the small intestine of the protein (amino acids) in the cottonseed meal that had not been degraded in the rumen.

Under the conditions of this experiment, the phosphorus present in the molasses block did not appear to have any beneficial effect; there were no differences between treatments in blood or bone phosphorus concentrations and faecal phosphorus levels were elevated in the supplemented group suggesting that a large proportion of the supplementary phosphorus was excreted. The apparent lack of response to the phosphorus supplement is at variance with the results of earlier work (McMeniman and Little 1974) which indicated that ewes supplemented with molasses respond to phosphorus supplements. McMeniman and Little (1974) estimated phosphorus intake at 3.8 g per head per day, which compares with an estimated 0.53 g per head per day in this study. This indicates that further work is required to define the conditions under which phosphorus supplementation is warranted.

One interesting observation was that during the lactation period the specific gravity and degree of mineralisation of the rib bones appeared to increase in both treated and untreated groups (Table 7). This result could be explained by the fact that the ribs of the ewes had already been extensively demineralised by the time the pre-lactation samples were taken and the bone samples obtained were composed of denser cortical material. The ewes originated from a region low in phosphorus and they had previously reared lambs in that environment under adverse seasonal conditions. The phosphorus demand for the ensuing experimental lactation may then have been met by mobilising the inner, more dense portions of the ribs and other bones. As a consequence, the rib bone remaining after the experimental lactation would not only be more dense and more mineralised than before but also thinner. Unfortunately, no measurements of bone thickness were obtained in this experiment. D. A. Little (personal communication) has observed that the rib bone remaining in cattle after extended periods of phosphorus depletion is well mineralised, and is of the opinion that, to interpret the results of rib biopsy data, the bone thickness needs to be taken into account.

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