Tropical Animal Production 1984 9:95-102

MINERAL DEFICIENCIES AS A FACTOR LIMITING CATTLE PRODUCTION IN THE PLAINS OF VENEZUELA
2. RESPONSE TO MINERAL SUPPLEMENTATION

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A study was made of the effects on performance of mineral supplementation in cattle on three farms in the Venezuelan lowlands where deficiencies had been detected previously. The supplement used consisted of a mixture in the proportion 1:1 with common salt of a product containing 25.5% Ca, 19.2% P, 2.3% Na, 1.2% Mg with trace elements and vitamins. Control groups received common salt and had similar access to pasture and water. The experimental period covered 2.5 months of drought and 3-5 months of rains. On Farm 1, 40 crossbred zebu cows in milk were used. There was no effect due to supplementation on milk yield or on pregnancy rates, but it did reduce ($P < .05$) the loss of body weight which occurred during part of the experimental period. On Farm 2, the cattle were 96 young zebu animals of between 1 and 2 years of age. Supplementation increased growth rates by 39.6% ($P < .01$) in part of the period and by 12.1% ($P < .01$) over the whole experiment. On Farm 3, the mixture in 1:1 proportion with salt was compared with the same product mixed with salt at the rate of 1:4. All animals had received the 1:4 mixture during the 6 months previous to the start of the trial. No effect was found on the weight changes or pregnancy rates, using a total of 118 zebu heifers of 2 and 3 years of age. It was concluded that the variable responses to supplementation of Farms 1 and 2 were related to the variable availability of energy and protein in the pastures and that the use of the 1:4 mixture on Farm 3 had been sufficient to correct any deficiencies present. Efforts should be made to provide mineral supplements in periods of abundance of forage and not only in the dry season as is common practice in the region.

Key words: Mineral supplementation, milk yield, pregnancy rates, body weight changes, extensive grazing, Venezuelan lowlands.

In the first part of this study, it was found that deficiencies of Ca and P exist in commercial cattle herds in part of the Venezuelan plains (Portuguesa State) throughout the year, and that deficiencies of Mg were widespread seasonally (Vaccaro et al 1984). However, it was also clear that other factors such as energy and protein shortages and problems of health and poor management were sufficiently important to account by themselves for the low production levels observed. In view of the relative ease with which mineral deficiencies may be corrected in the field, compared with other environmental improvements, the second part of this study was undertaken in order to determine the biological response to mineral supplementation under the prevailing extensive conditions.

Materials and Methods

A general description of the 36 farms originally included in the study, together with information on animal production and mineral deficiencies present in the blood of cattle in the dry and rainy seasons of the year 1981 is given by Vaccaro et al (1984). In the following year, 1982, three of the same farms were chosen for a mineral supplementation trial. The criteria used in selecting the farms were: i) the existence of deficiencies of Ca, Mg or P, or a combination of these, based on results obtained in 1981, ii) facilities for weighing cattle and iii) the willingness of the farmer to carry out the trial without interfering the experimental procedures. A summary of the information on Ca, Mg and P levels in soils, pastures and blood obtained in 1981 from the three selected farms is given in Table 1. The supplementation trial began in January, 1982 and finished between June and August of the same year, depending on the farm. Thus, 2.5 months of drought (January-March) and 3-5 months of the rainy season (April-June/August) were covered. A commercial supplement* was used with a chemical composition (%) of Ca: 25.5; P: 19.2; Na: 2.3; Mg: 1.2 besides trace elements and Vitamins A, D and E_3. The supplement was mixed proportionally 1:1 with common salt so that the animals receiving the treatment consumed a mixture approximately 13% Ca, 10% P and 0.6% Mg, with a Ca:P ratio of 1.3:1.0. In all cases the performance of the animals receiving the supplement was compared with a control group which had similar access to pastures, salt and water throughout the trial. The specific details of the experiment varied according to the type of animal and routine management on each farm and are described below.

Analyses of variance were carried out to determine the effects of treatment (mineral supplement vs. salt control), season (dry months vs. rainy months) and their interaction on body weight changes (3 farms) and milk production (1 farm). Differences in the proportions of pregnant and not-pregnant cows due to treatment were detected by Chi squared tests (2 farms).

Farm 1: Two groups of 20 crossbred zebu cows in milk were used, of which one animal in each group was pregnant at the start of the trial. The groups were balanced according to the month of previous calving and, as far as possible, according to their milk yield at the start, since no previous production information was available. The mean initial live-weight of the cows was 354 ± 6 kg, with no difference between groups. The group which received the mineral supplement was identified by painting their horns. They were given 60 g/head/day of the mineral-salt supplement mixed with molasses to ensure rapid consumption. The mixture was offered in the corral where the cows were collected before milking and was always consumed completely. The control group received salt mixed with molasses in a separate corral. Both groups were grazed together in pastures of mainly *Hyparrhenia rufa* and *Panicum maximum*, but there was an increasing shortage of pasture as the trial proceeded, so

*Pecutrin, Bayer, Caracas.

that the cows occasionally had to graze pastures 5 km distant from the milking facilities. The cows were exposed continuously to 2 bulls and milking was carried out twice daily with the calves present. The data collected included: milk production (am and pm) every 15 days, monthly body weights and pregnancy diagnosis by rectal palpation every two months in the 38 cows which were open at the start of the experiment. The trial finished on the 30th of June.

Farm 2: Ninety-six zebu cattle of both sexes and between 12 and 24 months of age were divided at random in two groups of 48. Their mean initial liveweight was 241 ± 5 kg. The experimental group was given the mineral-salt mixture *ad libitum* at pasture, while the controls had free access to common salt. All animals were wormed at the start of the trial. The two groups were kept in separate fields of similar botanic composition and the same stocking rate (0.5 head/ha). The most common forage species were *H. rufa*, *Axonopus* spp., *Leersia hexandra* , *Panicum laxum* and *Centrosema pubescens*. Forage availability was considered to be plentiful at the start of the trial but limited later on. The cattle were weighed individually at the start of the experiment and monthly thereafter until the trial finished on the 19th June.

Farm 3: Seventy-six 2-year old and 42 3-year old zebu heifers were used, with initial mean liveweights of 230 ± 43 and 277 ± 27 kg, respectively. The heifers in each age class were divided into two groups at random. The two experimental groups received the mineral-salt mixture *ad libutum* in the proportion 1:1 as was used on the other farms, while the two control groups received the same mixture but in the proportion 1:4 (minerals-salt), as this represented the routine practice on that farm ever since deficiencies has been detected in the stock the year before. The cattle grazed pastures composed chiefly of *H. rufa*, *Paspalum plicatulum*, *Brachiaria decumbens* and sorghum stubble with 10-15 % native legumes. Forage availability was considered to be limited and then adequate during the dry and rainy months of the trial, respectively. From the 21st June onwards, the cattle all received an energy supplement (molasses or ground rice, 1.0 to 1.5 kg/head/day), but this was evenly distributed between the experimental and control groups. The mating season began in May, using natural mating for the 2-year old heifers and artificial insemination for the 3-year old females. The heifers were weighed monthly and pregnancy was diagnosed by rectal palpation at the finish of the trial on the 27th of August.

Results

Farm 1: Table 1 summarises the results obtained from Farm 1 with respect to milk yield, pregnancy rates and body weight changes, according to treatment and season of the year. Milk production decreased significantly ($P < .01$) with time in both groups of cows and no difference due to mineral supplementation was observed in any of the time

Table 1:

Ca, Mg and P levels in soils, pastures and blood of cattle on the farms studied.

	Farm 1		Farm 2		Farm 3	
Season:	Dry	Rainy	Dry	Rainy	Dry	Rainy
Soils[1]:						
Ca (me/100 g)	7.8	--	5.0*	--	1.2*	--
Mg (me/100 g)	1.1*	--	2.1	--	0.6*	--
P (ppm)	4.4*	--	4.9*	--	Traces*	--
Pastures[2]:						
Ca (% DM)	.30*	.22*	.25*	.23*	.32	.24*
Mg (% DM)	.22	.26	.27	.29	.28	.24
P (% DM)	.16*	.15*	.14*	.14*	.15*	.14*
Blood:						
Ca (mg/100 ml)	8.1*	--	6.1*	4.1*	8.4*	8.5*
Mg (mg/100 ml)	1.7*	3.0	1.3*	2.7	1.7*	2.6
P (mg/100 ml)	7.7	5.9*	7.[illegible]	5.6*	2.9*	6.5

[1] Composite samples, depth 0-20 cm.

[2] Composite samples of most common grazed species.

* Deficient levels according to Walsh and Beaton (1973) (soils), NRC (1976) (pastures) and Underwood (1981) (blood of young cattle).

Table 2:

Effect of mineral supplementation on milking cows (Farm 1).

Characteristics	Season	Treatment	
		Minerals + salt	Salt
Milk yield (kg/cow/day; $\bar{x} \pm$ SE)	February-March	3.7 ± .33	4.2 ± .36
	April-May	2.7 ± .20	3.2 ± .28
	June-July	1.7 ± .18	1.9 ± .20
Pregnancy %	March	5.3	0
	June	26.3	26.3
	July	36.8	36.8
Body weight change (g/cow/day; $\bar{x} \pm$ SE)	January-March	138 ± 42	130 ± 48
	April-July	- 13 ± 34[a]	-118 ± 31[b]

Values in same line accompanied by different letters are significantly different ($P < .05$).

periods. Neither was any effect observed on the rate of pregnancy diagnosed on three occasions during the trial. Overall, only 37% of the 38 cows which were not pregnant at the start of the experiment had conceived by the end of the trial, even though at least 7 months had elapsed since their previous calving. Despite the fall in milk yield, both groups started to lose weight in the period April-July and the significant difference ($P < .01$) in weight change between time periods reflects the increasing shortage of pasture on the farm during the experiment. Mineral supplementation reduced ($P < .05$) the weight loss observed in the period April-July, but the effect over the whole duration of the trial (January-July) was not significant.

Farm 2: The weight changes obtained in the cattle on Farm 2 are presented in Table 3, according to treatment and season of the year. An

Table 3:
Effect of mineral supplementation in growing cattle (Farm 2).

Characteristics	Season	Treatment	
		Minerals + salt	Salt
Body weight change(g/head/day; $\bar{x} \pm SE$)	January-March	729 ± 58[a]	522 ± 64[b]
	April-June	338 ± 38	356 ± 33

Values in same line accompanied by different letters are significantly different ($P < .05$).

Table 4:
Effect of mineral supplementation on heifers in service (Farm 3).

Characteristic	Age (Years)	Season	Treatment	
			Minerals + salt(1:1)	Minerals + salt(1:4)
Body weight change (g/head/day, $\bar{x} \pm SE$)	2	February-March	39 ± 21	58 ± 18
		April-July	394 ± 18	390 ± 17
	3	February-March	148 ± 42	184 ± 30
		April-July	271 ± 23	348 ± 29
Pregnancy %	2	August	21	21
	3	August	47	5[illegible]

important effect ($P < .01$) was found due to supplementation in the period January-March, and the growth rate of the cattle receiving minerals exceeded that of the controls by 39.6%. There was a significant treatment x season interaction and no effect of the treatment was found in the period April-June when the weight gains of both groups fell considerably. Taking the experimental period as a whole, the treated group gained 12.1% ($P < .01$) more weight than the controls.

Farm 3: Table 4 shows the results from Farm 3, by treatment, age of heifer and season of the year. Both the 2-year old and the 3-year old heifers gained more weight ($P < .01$) in the period April-June than at the start of the trial, but there was no evidence of any beneficial effect due to the greater concentration of minerals in the supplement. Neither was any effect observed due to treatment on the proportion of heifers which were diagnosed pregnant after 3.5 months in service.

Discussion

According to the data presented in Table 1, the cattle on all three farms suffered deficiencies of Ca throughout 1981, and of Mg in the dry season. The earlier analyses of soils and forages suggested that deficiencies of P were also important throughtout the year, even though they were not detected on a wide scale, due to the inexactitude of blood P as an indicator of the real status of the animals with regard to this mineral (Fick et al 1979), particularly under the conditions prevailing in this study (Vaccaro et al 1984). The fact that some response to supplementation was obtained on Farms 1 and 2 suggest that the deficiencies were of biological importance in both cases, while the total absence of response on Farm 3, despite its location on the poorest soils (Table 1), indicates that the routine use of a 1:4 mineral-salt mixture during the six months previous to the start of the trial was sufficient to correct any deficiency which may have existed.

Assuming, therefore, the deficiencies on Farms 1 and 2 to have been real, an explanation is needed for the variable response to supplementation.

Ca and P deficiencies cause a reduction in milk yield of cows (Becker et al 1934; Thompson and Campabadal, 1978) and, under similar conditions in the Colombian plains, a response of 30% was shown in the weaning weight of the calves of dams supplemented with bicalcium phosphate (Lendosoekojo et al 1978). In the present case, it seems probable that the shortage of energy and protein associated with the severe scarcity of pastures on Farm 1 prevented the manifestation of any potential benefits of mineral supplementation. On the other hand, milk obtained in systems where cows are milked with calves present does not reflect total yield very accurately and, although bi-weekly recordings are considered adequate under tropical conditions (Lindstrom, 1976), it is possible that the method used was insufficiently accurate to detect differences due to the treatment.

With regard to reproduction, a clear response to supplementation is to be expected if deficiencies of P are present (McDowell et al 1979) and an even more marked effect may be found in lactating, compared with non-lactating, cows (Grunert and Santiago, cited by Tokarnia et al 1978). Since responses in growth rates tend to occur only when mineral supplementation coincides with periods of abundant energy and protein supply (Van Niekerk and Roman-Ponce, 1978), it is possible that the lack of response in terms of pregnancy rates on Farm 1 was also due to the scarcity of pastures. On the other hand, the last pregnancy diagnosis carried out in this study took place 6.5 months after treatment started. A response in reproduction might possibly have been detected had the treatment been continued over a longer period, especially if the significant difference in weight loss between the treated and control groups had persisted.

In the case of weight changes, the response to supplementation was zero or low in periods of forage scarcity. Thus, on Farm 1, the response was evident only during part of the trial period and was relatively small (-13 versus -118 g/cow/day), while on Farm 2 no benefit was observed in the period of feed shortage. It should be pointed out that the availability of pasture on the farms did not correspond to that usually expected according to rainfall data in the region: in both cases, forage was scarcer from April onwards due to overgrazing, even though the rainy season had started by then. The most important response to supplementation was obtained in young cattle (Farm 2) and the value of their increased weight exceeded the cost of the supplement by 409%. Nevertheless, it proved uneconomical to continue feeding the mineral mixture once pasture supply had decreased.

In conclusion, the results indicate that even where there is evidence of mineral deficiencies in the cattle, variable responses are to be expected from supplementation in the region, of which the three farms studied here were typical. Among the factors limiting production which were identified in the first part of this study (Vaccaro *et al.*, 1984) and which may have conditioned the response to supplementation, the shortage of energy and protein in the diet seem to have been particularly important. The general practice in the area of offering mineral supplements in the dry season only is questioned by the present results. An investment in roofed salt containers would have to be made if minerals are to be fed in the rainy season, but the results obtained here under conditions of pasture abundance suggest that the cost would easily be recuperated. They also indicate that adequate mineral supplementation is a simple and low-cost practice which has a potentially important contribution to make to livestock development in the region.

Acknowledgements

The authors acknowledge with gratitude the financial support of the Consejo Nacional de Investigaciones Científicas, Caracas, in the execution of this study.

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Received April 18, 1984

Translated from Spanish