Tropical Animal Production 1984 9:185-195

MINERAL DEFICIENCIES AS A FACTOR LIMITING ANIMAL PRODUCTION IN THE PLAINS OF VENEZUELA
1. DESCRIPTION OF THE FARMS, ANIMAL PRODUCTION AND BLOOD LEVELS OF Ca, Mg AND P

Lucía de Vaccaro[1], Blanca de Andina, J F Arias, Rosario Cardozo, J R Casal, L S Faría, S Fariñas, W García, J Guerrero, E A Mejía, F Morales, F Rodríguez, R Rodríguez, L Urriola y M Venegas

Universidad Nacional Experimental de los Llanos Ezequiel Zamora Guanare, Portuguesa, Venezuela

With the objective of determining the importance of mineral deficiencies as a factor limiting the production of cattle in the State of Portuguesa, a study was made of animal production, farm management and levels of Ca, Mg and P in the blood of cattle on 36 commercial farms. The herds were kept on natural grazings, mainly without fertilization. Thirty-nine percent of farms offered some energy supplement to their stock, but this mainly consisted (25% farms) of molasses given in the dry season. The percentage of farms offering mineral supplements was 64, but only one of the products used contained more than 10% P. Animals positive to anaplasmosis, babesiosis and brucellosis were found on 82, 18 and 45 % of the farms, respectively. The ratio of bulls to cows plus heifers exceeded 1:25 on 79% of the farms. From a total of 9203 cows, 44.9% calves and 14.7% 2-year old heifers were found in herds which did not sell females, suggesting a loss of 15.5% between weaning and 2 years of age. The mean liveweights of cattle sold at 12-15, 22-24, 30-36 and 40-42 months old were 220, 278, 338 and 387 kg/head. Using 438 samples from 34 farms for the determination of Ca and P samples from 10 farms for Mg, the following mean levels were obtained for young stock in the dry season: 7.84 ± .10 (Ca), 1.24 ± .03 (Mg) and 6.83 ± .10 (P) mg/100 ml. In the rainy season, 113 (Ca), 154 (Mg) and 169 (P) samples were analysed from 9 of the same farms, giving mean values of 8.15 ± .35 (Ca), 2.67 ± .09 (Mg) and 6.34 ± .14 (P) mg/100 ml for young stock and 7.93 ± .47 (Ca), 2.56 ± .08 (Mg) and 5.92 ± .14 (P) mg/100 ml for lactating cows. In general, district where the farms were located, season of the year and class of stock had significant effects on the levels of the three minerals in the blood. It was concluded that deficiencies of Ca throughout the year and of Mg seasonally were important in the region and that the levels of P obtained in the study probably overestimated the true status of the cattle with respect to that element. Apart from mineral deficiencies, deficits of energy and protein in the pastures, problems of health and poor management were in themselves of sufficient importance to explain the low levels of production observed.

Key words: Cattle, extensive grazing, reproduction, growth, survival, haematoparasites, brucellosis, serum Ca, serum Ng, serum P, Venezuelan lowlands.

In the four states which make up the western plains of Venezuela (Apure, Barinas, Cojedes and Portuguesa), there exists a population of 3.1 million cattle (MAC, 1981) which contributes approximately 40% of the total agricultural product of the region. Productivity is, however, extremely limited due to low growth rates and, especially, to low reproduction rates. Official data available from the four states since 1973 show a mean birth rate in cattle of 39% (MAC, 1976, 1978) and the situation in Portuguesa is particularly critical, reaching only 27.4% in 1976 (MAC, 1979).

[1]*Present address: Instituto de Producción Animal, Facultad de Agronomía, Universidad Central de Venezuela, Maracay, Venezuela*

Mineral deficiencies are to be expected under the extensive grazing conditions which prevail in the Venezuelan plains (Underwood, 1981), and although no systematic information is available from the region, deficiencies have been reported in forage and in the blood of cattle in parts of the area as well as in adjoining zones (Chicco and French, 1959; French and Chaparro, 1960; French and Chicco, 1961; Corrales and González, 1973; Corrales et al 1973; Faría et al 1981). In view of the marked effect which mineral deficiencies have on growth and reproduction in cattle (McDowell et al 1979) and of the relative ease with which they may be corrected at field level, this study was carried out to determine their importance as a factor limiting production in one area of the western plains: the State of Portuguesa. The results refer to animal production in a sample of commercial farms in the State, to the levels of minerals in the blood of cattle on the same farms and to some other environmental factors which may help explain the low levels of productivity which were found. In a second article, Arias et al (1984) report on the response of cattle to adequate mineral supplementation. A description of the soils and forages on the farms, including their mineral content, has been given by Vaccaro et al (1982).

Materials and Methods

Portuguesa State is located in the western part of central Venezuela, a zone classified as dry tropical forest. Altitudes range from 100 to 250 m above sea level and mean annual temperatures are about 27°. Average annual rainfall varies between 1300 and 1800 mm, with a distinct dry season between December and March. However, in 1981, the year in which this study was carried out, rainfall was abnormally heavy and 175% of the previous 10 years' average was recorded. As a result, pastures started growing unusually early that year and new growth was available in February which is usually the month of most severe drought.

The study was carried out in 36 commercial farms located in the Districts of Araure (4 farms), Esteller (1), Guanare (9), Guanarito (13), Ospino (8) and Sucre (1). The distribution of the farms in each district was related chiefly to the density of the cattle population in each one. The farms were all located in soils considered suitable for livestock production (Class IV to VII) and the final criterion of selection was the interest expressed by the farmer in participating in the project.

In February-March (dry season) of 1981, blood samples were collected from 10-15 cattle chosen at random from the young stock (males and females) available on each farm. It was impossible to restrict the sample to animals of a specific age, due to the widespread practice of not dividing herds according to age, and although the cattle were all known as "mautes", a term which refers to young animals of between approximately one and two years old, dental examinations carried out during the sampling suggested that their real age varied from 12 to 36 months. However, none of the animals were still suckling their dams or had calved themselves. Simultaneously, information was obtained on the production and management of the herds, using questionnaires given to the

farmers and systematic inspections of the farm conditions carried out by agronomists and veterinarians. In June-July (rainy season) of the same year, blood samples were taken again from 9 of the same herds. Because of the mineral deficiencies generally encountered in the young stock during the dry season, it was considered desirable to include in the second sampling samples from another class of stock liable to show deficiencies. Thus, in the sample obtained in the rainy season, blood was obtained from 5-10 lactating cows as well as from 5-10 young stock per farm.

The blood samples were analysed for the content of calcium (Ca), phosphorous (P) and magnesium (Mg). Blood was collected from the jugular vein into 20 cc demineralised test tubes which were kept in a sloping position at environmental temperature until coagulation. Thereafter, samples were kept at approximately 5° and centrifuged at 5000 rpm between one and three hours after collection. Serum was refrigerated until time for analysis. For the determination of mineral content, the commercial methods of Labtest* (Ca and P) and Merck** (Mg) were employed, which are more commonly used in human medicine. They are based on the use of prepared reactives and determination of atomic absorption by electrophotometry. Due to a failure in the electricity supply, part of the serum samples was lost, leaving a total of 438 samples from 34 farms for the analysis of Ca and P and of 49 samples from 10 farms for analysis of Mg in the dry season. Of the samples collected in the rainy season, 113 from 8 farms were used for analysis of Ca, 169 samples from 9 farms for P and 154 samples from 9 farms for Mg.

Advantage was taken of the blood sampling to carry out tests for brucellosis by blood agglutination in 31 of the 32 farms visited which did not vaccinate their stock against the disease. In addition, the presence of haematoparasites was determined by microscopic examination of blood drawn from the ears of the cattle sampled on 22 of the farms.

Analyses of variance were carried out to determine the effects of district on mineral levels during the dry season. Using the rainy season data, the effect of age (young stock vs. cows in milk) was also studied. Then combining the data of the young stock sampled in both seasons of the year, the effect of season was determined.

Results

The farms in the study ranged from 15 to over 6000 ha in area, with between 23 and over 2000 cows per farm. In several cases, neither the exact area nor the precise number of cattle was known by the owner and was estimated to the nearest hundred. Three of the farms produced milk as their chief activity, in one of them part of the herd was milked and the rest were breeding herds. In most cases, the cattle had to walk long distances to the corrals where the blood samples were taken and, on two farms, it was necessary to cast the animals onto the ground to sample them due to the complete lack of working facilities.

* Labtest Sistemas Diagnósticos Ltda, Belo Horizonte, Brazil.
** Merck - COFASA, Caracas, Venezuela.

Feeding: All the cattle were maintained permanently on grazing. The most common forage species, in order of importance were: *Axonopus* spp., *Hymenachne amplexicaulis*, *Hyparrhenia rufa*, *Leersia hexandra*, *Panicum laxum*, *Panicum fasciculatum*, *Paspalum plicatulum* and *Sporobolus indicus*. Fertilizers were applied to the pastures on three of the farms: urea was used in three cases and a 12:12:17 compound in one case, so that only one of the 36 farms applied nutrients other than nitrogen to the soil.

Thirty nine percent of the farms used some kind of feed supplement other than salt or minerals, but this consisted chiefly of molasses offered in the dry season (25% of the farms). Where concentrate feeds, ground cereals or cotton seed meal were offered (11% of the farms), they were given to the cows in milk or to the fattening steers. Thus, in general, the breeding herds had very little access to minerals or other nutrients in the form of supplementary feeds.

Sixty four percent of the farms fed mineral supplements to their cattle and 28% more fed salt alone. The chemical composition of the 11 commercial mineral supplements used is shown in Table 1. Only three of

Table 1:
Chemical composition of commercial mineral supplements used on farms in Portuguesa State.

Product N°	Percentage Ca	P	Mg	Ca:P ratio	Number of farms which use product
1*	25.5	19.2	1.2	1.3:1	2
2*	20.0	18.5	-	1.1:1	1
3	20.1	10.1	0.7	2.0:1	1
4	13.5	7.5	0.4	1.8:1	1
5	12.5	6.0	-	2.1:1	1
6	17.1	4.1	-	4.2:1	1
7	16.0	3.6	2.0	4.4:1	1
8	3.5	2.0	-	1.8:1	1
9	15.0	0.9	2.0	16.7:1	6
10	Composition not shown				6
11	Composition not shown				3

* Manufacturers recommend use mixed with salt, so that P content is reduced to 4-6 %

the products contained more than 10% P and, of these, two had less than 10% P in the proportions of mixture with common salt which the manufacturers recommend. In addition, the mixtures of poor or unknown quality are those which were most widely used and in one case, the proportion of Ca:P was 16.7:1.0 which is widely different from the limit of 4:1 usually recommended and which might lead to problems of absorption.

Animal health: Results of tests for brucellosis and haematoparasites are shown in Table 2. A high incidence of brucellosis and of

Table 2:
Incidence of haematoparasites and brucellosis on commercial farms in Portuguesa State.

	Number of farms sampled	% of farms with ≥ 1 animals	
		Positive	Suspected
Anaplasmosis	22	82	-
Babesiosis	22	18	-
Brucellosis	31	45	23

anaplasmosis was observed on the farms studied.

Animal production: Only one of the farms used artificial insemination and reliable information concerning the ratio of bulls to cows and heifers was available from 28 of the others. Six of these used one bull for a maximum of 25 females, while the ratio of bulls to cows plus heifers was 1:26-45 in 15 farms, 1:46-65 in 4, and 1:66 or more in 3 of the herds. The number of calves present amounted to 44.9% of the total number (9203) of cows (Table 3). This figure slightly underestimates the real birth rate since early calf mortality is not accounted for. As shown in Table 3, the number of 2-year old heifers in farms which do not

Table 3:
Productives parameters of commercial farms in Portuguesa State.

Total No. of cows:		9203	
Reproduction:			
	% calves[1]	49.9	
	% 2-year old heifers[2]	14.7	
Survival:			
	Between weaning and 2-years of age (%)	84.5	
Growth:			
	Mean liveweight (kg/head)of groups of:	$\bar{x}$	Range
	12-15 months old	220	150-266
	22-24 months old	278	250-317
	30-36 months old	338	290-405
	40-42 months old	387	304-425

1 Number of calves as % number cows present.

2 Number of heifers as % total cows present, in herds which do not sell females.

sell females represented 14.9% of the number of cows. The difference suggests a loss of 15.5% of youngstock between calfhood and 2-3 years old.

Table 3 also shows a summary of information available on the liveweight of groups of cattle which were sold from the farms during 1980. In only 3 of the farms which sold animals at between 3 and 3.5 years old did the mean liveweight exceed 400 kg/head.

Blood mineral levels: Mean levels of calcium, magnesium and phosphorous in the blood of the cattle are presented in Table 4, together with normal values (Underwood, 1981) for comparison. Due to the design of the study, season effects (dry, rainy) were only estimable on the basis of the results from the young stock, while the effect of age (young stock, cows in milk) was only estimable from data obtained in the rainy season.

In the case of Ca, the mean levels were low throughout the year, with no significant difference due to season. The effect of district was important ($P < .01$) in both seasons, with mean levels ranging from 6.72 (Guanarito) to 10.80 (Esteller) mg/100 ml for young stock in the dry season and from 6.51 (Ospino) to 8.87 (Guanare) mg/100 ml in the rainy period. Overall, 68 and 50% of the farms had deficient mean levels in the dry and rainy seasons, respectively (Table 5). No effect was observed due to the age of the cattle (Table 4).

Table 4:

Levels of minerals in blood of cattle (mg/100 ml), according to season of the year and class of stock.

Season	Class of animal	Calcium $\bar{x}$ ± ET		Magnesium $\bar{x}$ ± ET		Phosphorous $\bar{x}$ ± ET	
Dry	Young stock	7.84	0.10^{a} [1]	1.24	0.03^{a}	6.83	0.10^{a}
Rainy	Young stock	8.15	0.35^{ax}	2.67	0.09^{bx}	6.34	0.14^{ax}
	Lactating cows	7.93	0.47^{x}	2.56	0.08^{z}	5.92	0.14^{z}
Range of values considered normal: [2]		9-11		1.82 - 3.2		6-8	

1 Values accompanied by different letters are significantly different ($P < .01$)(a, b, refer to season; x, z, refer to class of stock).

2 Underwood (1981).

The mean levels of Mg were also low in the dry season and all farms had deficient average values (Table 5), with no differences due to district. There was a large and significant increase in Mg levels in the rainy season ($P < .01$) and only one of the farms sampled again presented a deficient average value (Table 5). The mean for cows in milk was slightly inferior to that for young stock ($P < .01$), but both were

Table 5:

Percentage farms with deficient average levels of minerals in the blood of cattle.

Season	Percent farms with deficiencies of:		
	Calcium	Magnesium	Phosphorous
Dry	68	100	21
Rainy	50	11	33

considerably above the minimum normal level.

In the case of P, the overall means for both seasons of the year were within the range of normal values, although the level observed in the rainy season was slightly lower ($P < .01$) than that found in the dry season. There were significant differences due to district, with mean values for young stock ranging from 5.83 (Araure) to 8.00 (Esteller) mg/100 ml in the dry season and from 5.72 (Ospino) to 7.01 (Sucre, Guanarito) mg/100 ml in the rains. Overall, 21 and 33 % of the farms had deficient mean values of P in the dry and rainy seasons, respectively (Table 5). The mean level in cows was lower than that in young stock ($P < .01$).

Discussion

Despite the imprecision of the estimates of productive parameters, the results obtained indicate clearly that the growth, reproduction and survival rates of cattle in the farms studied were low. The growth and reproduction rates found here are similar to those reported from the western plains (Moronta et al 1973; Paredes, 1973; Chicco et al 1977; MAC, 1981). The estimate of losses in young stock between weaning and 2-3 years old appears to be new for farms in the region and, although the figure (15.5%) appears high, it is of the same order as that of 20% reported by Cardozo et al (1980) for 508 dual purpose farms in the neighbouring state of Barinas and may, therefore, estimate the true value fairly closely.

At the same time, the results indicate that the cattle in the majority of the farms suffer from deficiencies of one or more of the minerals studied throughout the year.

With regard to Ca, deficiencies in the blood were to be expected since low levels were also reported in the soils and pastures on the same farms (Vaccaro et al 1982). Although Ca deficiencies in cattle are not very frequent in Latin America (McDowell et al 1979), Venezuela is one of the countries in which they have been reported in forages and cattle (Phillips, 1956; De Alba and Davis, 1957; Chieco and French, 1959; French and Chaparro, 1960; Faría et al 1981).

In the case of Mg, deficiencies were not frequent in the soils and the Mg levels in the forages were consistently above those required for cattle (Vaccaro et al 1982). Deficiencies are not common in Latin America (Fick et al 1978) although they have been reported in grazing animals in Peru (Valdivia et al 1974), Brazil (Sutmoller et al cited by Fick et al 1978) and, recently, on a minor scale in the central plains of Venezuela (Farfa et al 1981). The most probable explanation of the low levels found here during the dry season is that forage consumption was insufficient to cover the animals' requirements even though the mineral content of the pastures was apparently adequate. Once pasture availability increased in the rainy season, blood levels tended to become normal. Another possibility is that the cattle selected the very young shoots which were available unusually early in the pastures in the year of the study. The availability of Mg in very young plants is especially low (Kemp et al 1961) and it is possible that they were not properly represented in the samples of the forage which were taken, because they were so short.

The study of soils and forages on these farms consistently showed P to be the mineral in shortest supply of those studied (Vaccaro et al 1982) and have been observed previously in Venezuela (Chicco and French, 1959; French and Chicco, 1961; Velázquez 1971; Farfa et al 1981). It appears contradictory, therefore, that deficiencies were not found more frequently in the cattle studied here. In spite of the widespread use of mineral supplements on the farms, it seems unlikely that this would explain the relatively high levels of P obtained. According to McDowell et al (1979), an adequate mineral supplement for use on deficient soils should contain at least 10% P. Only one of the products used on the farms studied reached this level of P, and it was used in only one of the herds. Among the factors which affect blood P levels are the state of nervousness of the cattle and their water intake (Fick et al 1979). It is likely that both were of considerable importance in the present study and may explain the unexpectedly high levels of P obtained. It would have been impossible to eliminate their effects under the generally difficult working conditions experienced. Most of the producers would not have permitted the sampling of bone or other tissues and this would, in any case, have been impossible without better facilities. Given the deficiencies observed in soils and pastures as well as the uncertain accuracy of the blood P levels as an indication of the animals' real P status, it is possible that P deficiencies are of considerable importance in the region.

Apart from mineral deficiencies, the information collected shows that other environmental factors were probably suffciently important to explain the low levels of production obtained by themselves. One aspect of special importance is the nutritive value of the pastures. The mean crude protein content of the most frequent forage species on a dry matter basis was 8.5 ± .25 and 7.5 ± .59 % in the dry seasons, respectively, with corresponding digestibilities in vitro of 46.4 ± 2.9 and 50.6 ± .7 % (Vaccaro et al 1981). Such levels are insufficient to support reasonable growth and reproduction rates and, on the other hand, it was

evident that the breeding herds received little additional nutrients from supplements.

Herd health must also have affected production levels unfavourably. There appears to be no additional information available concerning the incidence of haematoparasites in the area but the incidence of anaplasmosis is similar to that found by Shroeder et al. (1971) in various other states. This high level of infection, together with its consequent anemia and the general lack of control of endoparasites, must be important factors limiting productivity. With regard to brucellosis, the incidence of at least one positive animal in samples of 10-15 cattle in 45% of the herds visited suggests a much higher rate than the 1.0% officially reported for Portuguesa State in 1978 (MAC, 1981). Part of the explanation may be that most of the herds studied were extremely difficult to reach, had poor working facilities and, consequently, had never been included in official disease control campaigns. This aspect of the results requires urgent investigation since the effective control of venereal diseases is an obvious prerequisite if production levels are to be increased.

In addition, various aspects of general herd management must have contributed to the poor levels of output. The use of one bull for more than 25 females was common and would have resulted in a diminished calf crop under such extensive conditions The high incidence of weeds in the pastures, the generalised overgrazing and the lack of water which was common on the farms will have caused an excessive expenditure of energy as the animal sought their food and water.

In conclusion, it appears that deficiencies of Ca are important throughout the year, and of Mg seasonally in cattle under the extensive grazing conditions of the area. Deficiencies of P probably exist on a wider scale than was detected in this study. Such a situation would be expected to affect production levels to a considerable extent (McDowell et al 1979). However, other factors, such as energy and protein deficits, herd health and management must also have had an important negative effect on production. Combined improvements in all these fields are essential if progress is to be achieved.

Acknowledgements

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

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Received April 18, 1984