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MINERAL STATUS OF BEEF CATTLE IN EASTERN DOMINICAN REPUBLIC[1]

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An experiment was designed to determine the mineral status of soils, plants and grazing beef cattle in seven ranches consisting of Romana Red, Criollo and Brahman breeds in the eastern region of the Dominican Republic during the dry season. Eight to 14 forage and three to five soil samples were collected per ranch. Twelve to 24 liver (biopsy) and serum samples were collected from mature (3 to 10 years) cattle.
No regional forage difference ($P < 0.05$) was found. However, differences among farms within regions were found for P, Na, Ca ($P < 0.01$) and for Mg and Mo ($P < 0.05$). Mean analyses (and the percentage of samples borderline to deficient) were as follows: protein, 7.0% (50); Ca, 0.48% (24); P, 0.17% (83); K, 1.191% (0); Na, 0.07% (78); Mg, 0.26% (33); Fe, 154 ppm (0); Zn, 22 ppm (86); Cu, 9 ppm (64); Mn, 151 ppm (10); Co, 0.16 ppm (26); Mo, 0.31 ppm (0); and Se, 0.12 ppm (48). Percent borderline to deficient mean soil concentrations were as follows: Ca (< 71 ppm) 0; P (< 5 ppm) 96; K (< 30 ppm) 0; Mg (< 9.1 ppm) 0; Fe (< 4.5 ppm) 65; Zn (< 6 ppm) 85; Cu (< 1 ppm) 54; Mn (< 5 ppm) 0; and Co (< 11 ppm) 12. Percent low or borderline to deficient serum concentrations were: Ca (< 8 mg/100 ml) 30; P (< 4.5 mg/100 ml) 95; Mg (< 2 mg/100 ml) 19; Zn (< 0.4 µg/ml) 97; Cu (< 0.65 µg/ml) 100; and Se (< 0.03 µg/ml) 4. The percentage of low to borderline to deficient liver concentrations were: Fe (< 180 ppm) 8; Zn (< 84 ppm) 4; Cu (<75 ppm) 25; Mn (< 6 ppm) 2; Co (< 0.05 ppm) 0; and Se (<0.25 ppm) 0.
In relation to mineral status, it can be concluded that Ca, K, Mn, Mo, Co and Se were generally adequate; P, Na and Zn were deficient; and Cu could become deficient, depending on year-to-year fluctuations.

Most Caribbean and Latin American tropical countries have reported mineral deficiencies, imbalances and/or toxicities for grazing livestock. Phosphorus deficiency has been reported in 24 of these countries, Ca in 11, K in 4, Na in 6, Mg in 14, Fe in 3, Zn in 8, Cu in 14, Mn in 4, Co in 13 and Se in 10; and toxicity of Mo in 4 and Se in 10 (Fick et al 1978). Mineral deficiencies and imbalances are severely inhibiting the cattle industry in developing tropical countries (McDowell 1976) since these livestock rely almost entirely on forage to supply their requirements. Unfortunately, tropical forages are generally deficient in certain minerals. Forage mineral concentrations below the requirements for grazing cattle were reported in the 1974 Latin American Tables of Feed Composition (McDowell et al 1977).

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The percentage of forage samples below mineral requirements were: Ca, 31; P, 73; K, 15; Na, 60; Mg, 35; Fe, 24; Zn, 75; Cu, 47; Mn, 21; and Co, 43. Of all the mineral deficiencies affecting grazing livestock, P is the most widespread and economically important (Underwood 1966). The most important consequence of P deficiency is its effect on fertility. McDowell and Conrad (1977), in reviewing Latin American literature, reported increments in calving percentage from control cattle fed salt only vs cattle supplemented with P or a complete mineral supplement as follows: Bolivia, 67.5 to 80.0%; Brazil, 55 to 77%, 49 to 72% and 25.6 to 47.3%; Colombia, 50 to 84%; Panama, 62.2 to 68.8% and 42 to 80%; Peru, 25 to 75%; and Uruguay, 48 to 64% and 86.9 to 96.4%. Fick et al (1978) summarized reports on improved growth and reproductive performance in Latin American with P supplementation.

Despite its importance, there has been no systematic research on the mineral status of grazing livestock in the Dominican Republic. The present study was carried out to evaluate the mineral status of seven grazing beef cattle ranches in the eastern Dominican Republic.

Experimental Procedure

Location and animals: In the eastern Dominican Republic, samples were collected during the dry season (June to August 1980) from seven randomly selected ranches located within three subregions differing in soil and climatic conditions. The three regions have a humid climate with a first-quater dry season. Regions 1, 2 and 3 have a parent material and an annual rainfall and temperature of "Lutita Toba" and 1,300 - 1,500 mm and 25 - 26 C; Volcanic Tuff and 1,500 - 2,000 mm and 25 - 26 C; and Coral Limestone and 1,000 - 1,300 mm and 26 - 27 C, respectively.

Selected cattle were grazing native and introduced pasture receiving no fertilization in two of the ranches, and 59.1 kg urea/ha/2 year in the others. The animals were crosses of Romana Red, Criollo and Brahman and represented mature animals from 3 to 10 years of age, weighing 300 to 450 kg. Cattle from selected ranches were receiving molasses and urea on a regular basis but no mineral supplementation. Some animals appeared in good condition, but had poor growth and reproductive performance, with approximately 1 to 2% exhibiting rough hair coats. Twelve to 24 liver biopsy and blood serum samples were obtained from animals on these ranches. From each ranch, 8 to 14 forage and 3 to 5 soil samples were collected.

Sample Collection and Analysis: Procedures for collection and analysis of liver biopsy, blood serum and forage samples for mineral concentrations have been described (Fick et al 1979). Blood samples were taken in the morning with 2 to 4 hr allowed for serum formation before centrifugation. Liver biopsy samples (0.2 to 0.6 g) were pre-ashed on a hot plate with concentrated nitric acid and then ashed overnight in a muffle furnace at 550 C. Ash was solubilized by digestion, first with 50% nitric acid and finally with distilled water. Calcium, Mg, Cu and Zn in serum and Mg, Fe, Zn, Cu and Mn in liver were analyzed by flame atomic absorption spectrophotometry using a Perkin-Elmer Model 306; Co in liver and Mo in forage were analyzed by flameless atomic absorption spectrophotometry using a Perkin-Elmer Model 503 (Perkin-Elmer 1974). Serum P was determined by the colorimetric technique described by Harris and Popat (1954). Serum and liver Se were determined by a modification of the fluorometric method(Whetter and Ullrey 1978). Forage samples were analyzed for all the same minerals determined for liver and serum plus K, Na and Mo as previously described. Neutral detergent fiber (NDF) was determined by the method described by Van Soest (1973) and protein by the procedure of Technicon Industrial Systems[7].

One or two 200 g soil samples from five to eigh randomly selected sites were collected in the same pasture where forages were sampled, using a stainless steel tube at a depth of 10 to 15 cm and analyzed by the method described by Mitchell and Rhue (1979) for the same minerals as analyzed in forages, excluding Se. Soil organic matter was determined by the Walkley-Black procedure (Allison 1965) and P with the Technicon Autoanalyzer II[8]. Soil pH was determined using a 1:2 soil-to-water ratio in a standard glass electrode and a calomel reference electrode.

Statistical design: The data were subjected to analysis of variance appropriate for a nested design with unequal subclass numbers (Snedecor and Cochran 1973) while a multiple range test (Kramer 1956)was used for testing differences among means. Data were analyzed by the General Linear Model procedure of the Statistical Analysis System (Barr et al 1976). Correlation coefficients of animal tissue parameters with soil and forage minerals were estimated. However, correlations were not estimated between soils and forages with animal tissue concentrations since there was no way of pairing samples. Furthermore, the number of observations was insufficient for obtaining good estimates.

The word "critical" is used in this paper to note a concentration in forages below (or above with excesses) what is considered the requirement for cattle. This assumes the expected consumption as estimated by the NRC (1976). Total grams of minerals consumed per day and not forage concentration determines the true adequacy of a mineral. Critical animal tissue concentrations are levels below or above values associated with specific clinical signs as reported in the literature.

Results and Discussion

Forage and Soil Analysis: Mean mineral analyses by region for soils and forages are presented in Tables 1 and 2, respectively. No forage regional difference ($P < 0.05$) was found. However, forage differences among farms within regions were found for P, Na, Co ($P < 0.01$) and for Mg and Mo ($P < 0.05$). Forage correlation coeficients ($P < 0.05$)above $\pm$ 0.5 were noted for P - K ($r = 0.52$), P -protein ($r = 0.56$), K-Cu ($r = 0.54$),K -protein ($r = 0.58$), Mg-Cu ($r = 0.52$), Zn-protein ($r = 0.52$), Mg-N.D.F. ($r = 0.59$), Zn-N.D.F. ($r = 0.51$) and Cu-N.D.F. ($r = 0.71$). A positive correlation between forage P and protein has been reported previously by McDonald(1968). According to Underwood (1966), Mg concentration declines as plants mature, and its level in feed tends to follow those of protein and P. Forage K content drops with maturity (Gomide et al 1969). Magnesium and K move similarly inside the plant (Thompson and Throeht, 1978). Loneragan (1975) stated that N, P and K move freely and rapidly inside the plant. As plants mature, concentrations of protein and N.D.F. decrease and increase, respectively (Whiteman 1980).

[7]*Technicon Industrial Systems, Industrial Method No.506-771, Tarrytown, NY*
[8]*Technicon Industrial Systems, Industrial Method No.90-70W/8, Tarrytown, NY*

Table 1:

Soil Mineral element concentrations, pH and organic matter as related to region and critical levels[a,b]

Parameter[c,d]	Region 1 Mean	Region 2 Mean	Region 3 Mean	Critical level[e]	% below critical level
Ca*	2197	1410	2153	< 71	0
P*	3.75	2.87	3.67	< 5.0	96
K*	114	73	111	< 30	0
Na	88	113	65		
Mg	394	201	583	< 9.1	0
Fe**	4.2	15.8	2.0	< 4.5	65
Zn**	2.3	6.5	0.5	< 6.0	85
Cu	0.92	1.45	0.53	< 1.0	54
Mn*	48	59	22	< 5.0	0
Co**	0.22	0.48	0.20	< 0.11	12
pH**	6.6	5.9	6.1		
Organic matter	4.75	3.67	4.93		

[a]Values are in ppm for minerals and percentage for organic matter.

[b]Means are based on the following number of samples: Region 1 (18), Region 2 (15) and Region 3(3).

[c]Significant variation among ranches within region - * (P < 0.05).
** (P < 0.01).

[d]Only difference detected among regions was Mg (P < 0.05).

[e]Critical levels based on the following references: Ca, P and Mg (Breland 1976); K (Warnke and Robertson, 1976); Fe (Cox and Kamprath, 1972); Zn (Blue et al., 1982); Cu and Mn (Gammon, 1976); and Co (Kubota, 1964).

Most forage concentrations were inadequate in P, Na, Zn, Cu and protein based on recommendations of the NRC (1976). Mean forage P levels for regions 1, 2 and 3 were 0.17, 0.17 and 0.18%, respectively, and below the critical level of 0.25% suggested by McDowell and Conrad (1977). Of the 69 total forage samples analyzed, 83% were below this critical level. However, most forage samples would be adequate for the 0.12 and 0.13% required for growing yearling cattle as recommended by Little (1980). Extractable soil P means for regions 1, 2 and 3 were 3.75, 2.87 and 3.67 ppm, respectively. Of the 26 total soil samples, 96% were below the critical level of 5.0 ppm P suggested by Breland (1976). Improved growth and reproductive performance in cattle supplemented with P and pasture fertilization has been reported in several Latin American countries (Fick et al 1978). The most prevalent mineral deficiency for grazing cattle in the world is P (Underwood 1966), with a deficiency reported in at least 38 tropical developing countries (McDowell 1976; Fick et al 1978).

The Ca:P ratio in forage for the three regions is within the recommended limits of 1:1 to 7:1 (Beeson et al 1975). Blue and Tergas (1969) stated that Ca:P ratios generally reach excessive values during the dry season.

Mean extractable soil Na for regions 1, 2 and 3 was 88, 113 and 65 ppm, respectively, while mean forage concentrations were 0.1, 0.06 and

Table 2:

Forage mineral elements, protein and neutral detergent fiber (N.D.F.) concentrations for all samples in the eastern region and percentage of samples below critical level[a,b]

Nutrient[d]	Region 1 Mean	Region 2 Mean	Region 3 Mean	General Mean[c]	% below critical level[e,f]
Ca	0.57	0.53	0.98	0.48 (69)	24
P**	0.17	0.17	0.18	0.17 (69)	83
K	1.99	2.07	1.97	1.91 (69)	0
Na**	0.10	0.06	0.07	0.07 (69)	78
Mg	0.27	0.28	0.25	0.26 (69)	33
Fe	190	147	160	154 (69)	0
Zn	23	25	35	22 (69)	86
Cu	13	14	19	9 (69)	64
Mn	116	227	96	151 (69)	10
Co**	0.16	0.6	0.18	0.16 (69)	26
Mo*	0.38	0.22	0.53	0.31 (69)	0[f]
Se	0.13	0.13	0.14	0.12 (33)	48
Protein	7.1	8.1	8.6	7.0 (38)	50
N.D.F.	58	59	62	61 (38)	

[a]Least squares estimates of the means for regions and general mean.

[b]Ca, P, K, Na, Mg, protein and N.D.F. in % and trace minerals in ppm.

[c]Number of observations for regions 1, 2 and 3 is N_1=31, N_2=30 and N_3=8 for all responses except for protein and N.D.F. which is N_1=17, N_2=17 and N_3=4, and Se which is N_1=14, N_2=16 and N_3=3. Number of observations for the general mean are indicated in parentheses.

[d]Significant variation among farms within regions - * ($P < 0.05$); ** ($P < 0.01$).

[e]Critical forage concentrations are as follows: protein (7.0%), Ca (0.30%), P (0.25%), K (0.60%), Na (0.06%), Mg (0.20%), Fe (30 ppm), Zn (30 ppm), Cu (10 ppm), Mn (30 ppm), Co (0.1 ppm), Mo (> 6 ppm) and Se (0.1 ppm) (McDowell and Conrad, 1977).

[f]Above 6 ppm is considered critical level for Mo toxicosis.

0.07%, respectively, which is adequate according to the NRC (1976) requirements of 0.06%. However, of the 69 total forage samples analyzed, 78% were below the critical level. Nevertheless, for the ARC (1965) Na requirements of 0.1%, only one region mean is adequate. About 60% of 146 Latin American forages averaged less than 0.1% Na (McDowell et al 1977). Sousa (1978) observed severe Na deficiency in six ranches in Mato Grosso, Brazil.

Forage Zn concentrations for regions 1, 2 and 3 were 23, 25 and 35 ppm respectively, while mean soil extractable Zn levels were 2.3, 6.5 and 0.5 ppm, respectively. Of the 26 total soil samples, 85% were below the critical level of 6 ppm Zn (Blue et al 1982),but only 30% were below the critical level of 1 ppm suggested by Gammon(1976). Sánchez(1976)stated that the critical soil Zn level for plants is 1.5 ppm and that this value is associated with a concentration of 14 ppm Zn in plant tissue. Although not different ($P > 0.05$), forage Zn concentration was higher and soil Zn concentration was lower in region 3. However, soil pH in region 3 (6.1) was similar to that of the other two regions. Only region 3 forage concentrations was adequate to meet the Zn requirements of 30 ppm for beef cattle (NRC 1976). Of the 69 total forage samples, 86% were below that critical level. Legg and Sears (1960) reported Zn deficiency in cattle grazing forage with 18 to 42 ppm from Guyana.

Mean forage Cu levels for regions 1, 2 and 3 were 13, 14 and 19 ppm, respectively. Forage Cu concentrations were variable, ranging from 1.2 to 47.9 ppm. Although the three regions have mean forage Cu concentrations above the critical level of 10 ppm (ARC 1965), 64% of the 69 total forage samples were below the critical concentration. Mean forage Mo levels were also low, ranging from 0.05 to 1.32 ppm. McDowell and Conrad (1977) considered levels above 6 ppm as a critical level for Mo toxicity. Mean extractable soil Cu for regions 1, 2 and 3 were 0.92, 1.45 and 0.53 ppm, respectively. Of the 26 total soil samples, 54% were below the critical level of 1 ppm Cu suggested by Gammon (1976). A soil deficient for pasture growth contains less than 0.6 ppm Cu (Horowitz and Dantas 1973).

Mean forage protein contens for regions 1, 2 and 3 were 7.1, 8.1 and 8.6%, respectively. Mean region forage protein levels were adequate; however, one ranch in region 2 and two in region 3 had means below the critical level of 7.0% indicated by Minson and Milford (1967). Furthermore, 50% of the 38 total forage samples analyzed for protein were below that critical level. Protein is one of the most limiting nutrients for grazing ruminants (Whiteman 1980).

All forages were within the normal limits for K, Fe and Mo. Also,only a small percentage of forages, 24, 33, 10 and 26%, were borderline to deficient in mean concentrations of Ca, Mg, Mn and Co, respectively,while about 48% of all Se forage concentrations were below the requirements of 0.1% (NRC 1976). Mean extractable soil Ca in regions 1, 2 and 3 was 2,197,1,410 and 2,153 ppm, respectively, being far above 141 ppm, the figure suggested by Breland (1976) as high. Thompson and Throeht (1978) stated that excessive soil Ca may interfere with solubility of P, Fe, Zn and Mn in the soil solution. All soil samples were above the critical levels for Ca, K, Mg and Mn. However, most soil samples had concentrations below the critical levels for P, Fe and Zn, while 54 and 12% of the samples were below the critical levels for Cu and Co, respectively.

Liver and Blood Serum Analysis: Mean liver and blood serum concentrations are presented in Table 3. Regional differences ($P < 0.05$) for tissue minerals were found only for liver Co which was higher in region 3. Differences ($P < 0.05$) among farms within regions were found for serum Ca, P, Cu, Se ($P < 0.01$) and Mg ($P < 0.05$), and for liver Mg, Fe, Cu, Mn ($P < 0.01$) and Zn ($P < 0.05$). No correlations ($P < 0.05$) were found between those minerals analyzed in both liver and serum (Mg, Fe, Zn and Cu).

Mean serum Ca concentrations for regions 1, 2 and 3 were 7.9, 8.6 and 9.0 mg/100 ml, respectively. Only mean serum Ca for region 1 was slightly below the critical level of 8 mg/100 ml suggested by Cunha et al (1964) and Underwood (1966). Of the 73 total serum samples measured, only 30% were below that critical level. Calcium deficiency is not likely to be expected under grazing conditions (Underwood 1966).

Mean serum P concentrations for regions 1, 2 and 3 were 2.2, 1.6 and 1.9 mg/100 ml, respectively. Of the total serum samples analyzed for P, 95% were below critical levels of 4.5 mg/100 ml suggested by Underwood

Table 3:
Mineral concentration of cattle tissue[a,b]

Item[c,d]	Region 1 Mean	Region 2 Mean	Region 3 Mean	Critical level[e]	% below critical level
<u>Blood serum</u>					
Ca, mg/100 ml**	7.9	8.6	9.0	8	30
P, mg/100 ml**	2.2	1.6	1.9	4.5	95
Mg, mg/100 ml*	2.1	2.3	2.7	2	19
Zn, μg/ml	0.18	0.19	0.19	0.4	97
Cu, μg/ml	0.14	0.09	0.11	0.65	100
Se, μg/ml	0.07	0.08	0.10	0.03	4
<u>Liver (ppm, dry basis)</u>					
Mg**	311	324	336		
Fe**	369	336	312	180	8
Zn*	107	123	120	84	4
Cu**	117	200	156	75	25
Mn**	12	13	9	6	2
Co	0.39	0.42	0.65	0.05	0
Se	0.83	1.02	1.07	0.25	0

[a]Least squares estimates of the mean.

[b]Number of observations for regions 1, 2 and 3 in serum is N_1=33, N_2=25 and N_3=15 for all responses except for P which is N_1=23, N_2=16 and N_3=11, and for Se which is N_1=7, N_2=8 and N_3=4; and in liver, N_1=24, N_2=27 and N_3=16 for all responses except for Se which is N_1=5, N_2=7 and N_3=5, respectively.

[c]Significant variation among farms within regions - * ($P < 0.05$); ** ($P < 0.01$).

[d]Only difference detected among regions was liver Co ($P < 0.05$).

[e]Critical level for liver Mg not established. All other values from McDowell and Conrad (1977) except serum Zn and Se (Underwood, 1977)

(1966). Under grazing conditions during the dry season, P deficiency signs may not show up because energy and protein are more limiting than P in mature forage (Van Niekerk 1974). Nevertheless, for those animals receiving molasses and urea, the analyses showed agreement between the low P in soil, forage and serum. It is evident, then, that serum P is a good indicator of the animal P status even during the dry season if the animal is receiving energy and protein supplementation and if caution is exercised in collection and sample preparation of the blood samples. Low P status in the animal may also be due to high levels of dietary Ca (Chicco et al 1973)and/or high Fe (Rosa 1980). Most current literature concerning grazing livestock suggestes that P is the most prevalent mineral deficiency (McDowell 1976).

Mean serum Mg concentrations for regions 1, 2 and 3 were 2.1, 2.3 and 2.7 mg/100 ml, respectively. Of the 73 serum samples analyzed for Mg, only 19% exhibited concentrations below the critical level of 2 mg/100 ml (McDowell and Conrad 1977). Most forage concentrations (67%) were adequate in Mg. Kemp (1960) observed a positive correlation between the Mg content in forage and serum.

Mean serum Zn concentrations for regions 1, 2 and 3 were 0.18,0.19 and 0.19 μg/ml and in liver, 107, 123 and 120 ppm, respectively. Almost all (97%) of the 73 total serum samples anlyzed for Zn were below the critical level of 0.4 μg/ml recommended by Underwood (1977), while only 4% of the liver samples were below low concentrations of 84 ppm (McDowell and Conrad 1977). However, 87 and 97% of forage and serum samples, respectively, were below corresponding Zn critical levels. McDowell (1976) has indicated that serum Zn concentrations are a better indicator of cattle status than levels of this element in hepatic tissue.

Mean serum Cu concentrations for regions 1, 2 and 3 were .14, .09 and 0.11 μg/ml, and in liver, 117, 200 and 156 ppm, respectively. All serum samples were below the critical level of 0.65 μg/ml suggested by McDowell and Conrad (1977) and 25% of all the livers analyzed exhibited Cu concentrations below the critical level of 75 ppm (McDowell and Conrad 1977). This proportion would likely be higher if Mo were in concentrations high enough to limit Cu utilization. Pasture containing 5 ppm Cu needs to contain 7 ppm Mo or more to cause Mo toxicity (Gupta and McLeod, 1975), Hartmans (1970) reported no relationship between soil or forage Cu concentrations and Cu status of cattle. Liver Cu levels are more reliable than blood levels in assesing the Cu status of the animal (Doyle and Spaulding 1978). With the exception of P and possibly Co, Cu is the most limiting mineral for grazing cattle in developing tropical countries (McDowell 1976).

Liver Mn concentrations for regions 1, 2 and 3 were 12, 13 and 9 ppm, respectively. Only one liver sample of the 56 total analyzed for Mn was below the critical level of 6 ppm (McDowell and Conrad 1977). All forage samples were likewise adequate in Mn. Liver and ovaries are thought to be the organs with more detectable variation in Mn concentration as dietary Mn levels vary (Egan 1975). McDowell et al (1978) indicated that Mn is one of the trace elements least likely deficient for grazing livestock on acid soils.

Liver Co concentrations for regions 1, 2 and 3 were 0.39, 0.42 and 0.65 ppm, respectively. All the samples analyzed for Co were above the critical level of 0.05 ppm suggested by McDowell and Conrad (1977). Houser et al(1978) indicated that liver Co concentration is a good indicator of the Co status of the grazing ruminant. Only 26% of the forage samples were below the critical level of 0.1 ppm suggested by McDowell and Conrad (1977). Grazing animals can also ingest substantial quantities of Co directly from the soil (Healy 1973). McDowell et al (1977) reported that 43.1% of 140 Latin American forages analyzed for Co were borderline to deficient in this mineral.

Mean serum Se concentrations for regions 1, 2 and 3 were 0.07, 0.08 and 0.10 μg/ml and in liver, 0.83, 1.02 and 1.07 ppm, respectively. Only one of the 19 total serum samples analyzed for Se was below the critical level of 0.03 μg/ml suggested for sheep (Underwood 1977). All liver Se samples were above the critical level of 0.25 ppm suggested for cattle by McDowell(1976). Both serum and liver appear to be good indicators of the Se status of the animal.

In conclusion regarding the protein and mineral status of grazing livestock in the Dominican Republic, Ca, K, Mn, Mo, Co and Se were generally adequate; protein, P, Na and Zn were deficient and Cu could become deficient, depending on year-to-year fluctuations and management practices of individual ranchers.

References

Allison L E 1965 Organic carbon in: Methods of Soil Analysis Part III (Ed C A Black) American Society of Agronomy Inc Madison W I

ARC 1965 The Nutrient Requirements of Farm Livestock Ruminants Agricultural Research Council London No 2

Barr J A, Goodnight J H, Sall J P & Helwig J T 1976 A User's Guide to SAS 76 SAS Institute Inc Raleigh N C

Beeson W M, Perry T M, Jacobson N L, Wiggers K D & Jackson G N 1975 Literature Review on Calcium in beef and dairy nutrition National Feed Ingredients Association Des Moines IA

Blue W G & Targas L E 1969 Dry season deterioration of forage quality in the wet-dry tropics Soil Crop Science Society of Florida Proceedings 29:224-238

Blue W G, Jacome E O & Afre J L 1982 Corn response to zinc and magnesium in a Florida entisol (in press)

Breland H L 1976 IFAS Soil Science Laboratory Memorandum to Florida Extension Specialists and County Extension Director 'Soil Science Department University of Flo[illegible] Gainesville

Chicco D C, Ammerman C B, Feaster J P & Dunnavant B G 1973 Nutritional interrelationships of dietary calcium, phosphorus and magnesium in sheep Journal of Animal Science 36:986-993

Cox F R & Kamprath E J 1972 Micronutrient soil tests in: Micronutrients in Agriculture (Ed J J Mortvedt, P M Giordana and W L Lindsay) Soil Science Society of Amercia Madison WI

Cunha T J, Shirley R L, Chapman H L Jr. Ammerman C B, Davis G K, Kirk W G & Hentges J F 1964 Minerals for beef cattle in Florida Florida Agricultural Experimental Station Bulletin

Doyle J J & Spaulding J E 1978 Toxic and essential trace elements in meat A revi[illegible]w Jo[illegible]al of Animal Science 47:398-419

Egan A R 1975 The diagnosis of trace element deficiencies in the grazing ruminant in: Trace elements in Soil-Plant-Animal Systems (Ed D J D Nicholas & A R Egan) Academic Press New York

Fick K R, McDowell L R & Houser R H 1978 Current status of mineral research in Latin America in: Latin American Symposium on Mineral Nutrition Research with Grazing Ruminants (Ed J J Conrad & L R McDowell) University of Florida Gainesville

Fick K R, McDowell L R, Miles P H, Wilkinson N S, Funk J D & Conrad J H 1979 Methods of Mineral Analysis for Plant and Animal Tissues (2nd edition) Department of Animal Science University of Florida Gainesville

Gammon N 1976 A rough guide to the micronutrients Fact Sheet Soil Science Department University of Florida Gainesville

Gomide J A, Noller C H, Mott G O, Conrad J H & Hill D L 1969 Mineral composition of 6 tropical grasses as influenced by plant age and nitrogen fertilization Agronomy Journal 61:120-123

Gupta V C & McLeod D C 1975 Effects of sulfur and molybdenum on the molybdenum copper and sulfur concentrations of forage crops Soil Science 119:441-447

Harris W D & Popat P 1954 Determinations of the phosphorus content of lipids American Oil Chemical Society Journal 31:124-137.

Hartmans J 1970 The detection of copper deficiency and other trace element deficiencies under field conditions in: Trace Element Metabolism in Animals Symposium (Ed C F Mills) E & S Livingstone Edinburgh Scotland

Healy W B 1973 Nutritional aspects of soil ingestion by grazing animals in: Chemistry and Biochemistry of Herbage Volume 1 (Ed G W Butler & R W Bailey) Academic Press London

Horowitz A & Dantas H S 1973 The geochemistry of minor elements in Perbambuco soils III Copper in the zone litoral mata Pesquaria Agropecuaria Brasilera Serie Agronomica 8:169-176

Houser R H, McDowell L R & Fick K R 1978 Evaluation of mineral supplements for ruminants in: Latin American Symposium on Mineral Nutrition Research with Grazing Ruminants (Ed J H Conrad & L R McDowell) University of Florida Gainesville

Kemp A 1960 Hypomagnesemia in milking cows The response of serum magnesium to alternations in herbage composition resulting from potash and nitrogen dressings on pastures Netherlands Journal Agricultural Science 8:281-304

Kramer C Y 1956 Extension of multiple range test to group means with unequal number of replications Biometrics 12:307-310

Kubota J 1964 Cobalt content of New England soils in relation to cobalt levels in forages for ruminants Soil Science Society of America Proceedings 28:246-251

Legg S P & Sears L 1960 Zinc suplphate treatment of parakeratosis in cattle Nature 186:1061-1062

Little D A 1980 Observations on the phosphorus requirement of cattle growth Research in Veterinary Science 28:258-260

Loneragan J F 1975 The availability of trace elements in soil-plant-animal systems and their relation to movements and concentration of trace elements in plants in: Trace elements in Soil-Plant-Animal systems (Ed D J D Nickolas & A R Egan) Academic Press New York

McDonald I W 1968 The nutrition of grazing ruminants Nutritional Abstracts Review 38: 381 - 400

McDowell L R 1976 Mineral deficiencies and toxicities and their effect on beef production in developing countries in: Beef Production in Developing Countries (Ed A J Smith) University of Edinburgh Centre for Tropical Veterinary Medicine Edinburgh Scotland

McDowell L R & Conrad J H 1977 Trace mineral nutrition in Latin America World Animal Review 24:24-33

McDowell L R, Conrad J H, Thomas J E, Harris L E & Fick K L 1977 Nutritional composition of Latin American forages Tropical Animal Production 2:273-279

McDowell L R, Houser R H & Fick K L 1978 Iron, manganese and zinc in ruminant nutrition in : Latin American Symposium on Mineral Nutrition Research with Grazing Ruminants (Ed J H Conrad & L R McDowell) University of Florida Gainesville

Minson D L & Milford R 1967 The voluntary intake and digestibility of diets containing different proportions of legume and mature Pangola grass (*Digitaria decumbens*) Australian Journal of Experimental Agriculture and Animal Husbandry 7:546-551

Mitchell C C Jr & Rhue R D 1979 Procedures used by the University of Florida soil testing and analytical research laboratory Soil Science Research Report 79-1

NRC 1976 Nutrient Requirements of Beef Cattle Nutrient Requirements of Domestic Animals Series National Research Council National Academy of Science Washington DC

Perkin-Elmer 1974 Analytical methods for atomic absorption spectrophotometry using the HGA graphite furnace Perkin-Elmer Norwalk CT

Rosa I V 1980 Dietary Phosphorus and Trace Element Interrelationship in Ruminants PhD Dissertation University of Florida Gainesville

Sanchez P A 1976 Properties and Management of soils in the tropics John Wiley and Sons New York

Snedecor G W & Cochran W G 1973 Statistical Methods (6th Ed) Iowa State University Press. Ames AI

Sousa J C 1978 Interrelationships among Mineral Levels in Soil, Forage and Animal Tissues on Ranches in Northern Mato Grosso Brazil PhD Dissertation University of FLorida Gainesville

Thompson L M & Throeht F R 1978 Soils and Soil Fertility (4th Ed) McGraw-Hill publucations in the Agricultural Sciences New York

Underwood E J 1966 The Mineral Nutrition of Livestock Central Press Great Britain

Underwood E J 1977 Trace Elements in Human and Animal Nutrition (4th Ed) Academic Press New York

Van Niekerk B D H 1974 Supplementation of grazing cattle Potencial para Incrementar la Producción de Carne en America Tropical Seminario CIAT Cali Colombia

Van Soest P J 1973 Collaborative study of acid detergent fiber and lignin Journal of Association of Official Analytical Chemists 56:781-784

Warncke D D & L S Robertson 1976 Understanding the MSU Soil Test Report Results and Recommendations MSU Ag Facts Extension Bulletin 937 Michigan State University Lansing MI

Whetter P A & Ullrey D E 1978 Improved fluorometric method for determining selenium Journal of Association of Official Analytical Chemists 61:927-930

Whiteman P C 1980 Tropical Pasture Science Oxford University New York

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