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EVALUATING THE NUTRITIONAL STATUS OF BEEF CATTLE HERDS FROM FOUR SOIL ORDER REGIONS OF FLORIDA. II. TRACE MINERALS[1]

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Summary

An experiment was conducted to determine the trace mineral status of grazing cattle from four selected soil type regions in Florida. Animal tissue, forage and soil samples were collected during the wet (September-October) and dry (February-March) seasons from nine ranches located in four different regions. On the basis of reported critical forage levels, mean forage Co (<.1 ppm), Zn (<30 ppm) and Se (<.1 ppm) and liver and hair Se (<.25 ppm), were low during both seasons. Soil Se (<.50 ppm) and extractable soil Zn (<1.5 ppm) were low in all regions except the southeast. Mean forage Se was low in all regions. Of all animals studied in the wet season, 36 and 32% had low liver Cu (<75 ppm) and Se (<.25 ppm) concentrations, respectively. In the dry season, 20 and 39% of the animals had low liver Cu and Se concentrations, respectively. Hair Se was low (<.25 ppm) in 90% of the samples during the wet season and in 100% during the dry season. During the wet season, forage Zn, Mn, Co and Se were low in 89, 26, 63 and 84% of the samples, respectively, while extractable (double acid) Zn, Mn, Co and total Se were low in 57, 79, 63 and 100% of the soils, respectively. In the dry season, 80, 20, 40 and 80% of forages were low in Zn, Mn, Co and Se, respectively. Of the seven trace minerals studied, Se and Zn are most likely to be deficient, with Co and Cu insufficiency probable in selected areas.

(Key Words: Mineral Status, Florida, Beef Cattle, Trace Minerals.)

Introduction

Mineral deficiencies or imbalances in soils and forages have long been held responsible for low production and reproduction problems among Florida beef cattle (Cunha et al., 1964; Becker et al., 1965). Research from other warm climate regions has shown mineral supplementation to increase calving percentages by 20 to more than 100%, to increase growth rates from 10 to 25% and to reduce mortality significantly (McDowell and Conrad, 1977). The first world reports of Cu or Co deficiency in grazing cattle originated in Florida (Becker et al., 1965). Nutritional anemia or "salt sick" in cattle, later established as a deficiency of Fe, Cu and Co, was noted as early as 1872 (Becker et al., 1965). More recently, white muscle disease has been reported in the Florida locations of Branford, Gainesville and Wauchula (L. R. McDowell, personal communication), with low forage Se concentrations previously established by Shirley et al. (1966).

As a consequency of modern farming systems, acute deficiencies of most minerals for grazing animals have disappeared in Florida (Becker et al., 1965) and in other parts of the world (McDowell, 1976; Underwood, 1977; Conrad and McDowell, 1978). In the present experiment, therefore, we examined the current mineral status of Florida beef cattle from four

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soil type regions. Nutritional status of the macroelements, vitamin A and protein were reported in the previous article (Kiatoko et al., 1982); the present paper evaluated the trace minerals.

Experimental Procedure

Liver biopsy, blood, hair, feces and forage samples were collected for mineral analysis from nine ranches within four soil order regions during the wet and dry seasons. Soil samples were collected only during the wet season. Description of cattle, ranch location and methods for the collection and preparation of samples have been described by Fick et al. (1979) and Kiatoko et al. (1982).

Liver biopsy samples (.2 to .6 g) were pre-ashed on a hot plate with concentrated nitric acid and then ashed overnight in a muffle furnace at 500 C. Ash was solubilized by digestion first with 50% nitric acid, secondly with 10% nitric acid and finally, with distilled water. Solutions were filtered, diluted to the appropriate detection level and analyzed by spectrophotometry for Cu, Fe, Mn and Zn (Perkin-Elmer, 1973). Liver Mo and Co were determined with a atomic absorption spectrophotometer equipped with a graphite furnace and D_2 corrector. Plasma containing 2% glycerol was prepared for Cu and Zn analysis by flame atomic absorption as described above for liver. Plasma and liver Se were analyzed by the fluorometric procedure described by Olson et al. (1975).

Hair samples were soaked in a solution of acationex for 2 d, washed with distilled water, rinsed with 10% hydrochloric acid, washed again with distilled water and dried in an oven at 60 C for 3 d. Hair was analyzed for Mn and feces for Co, while Cu, Se and Zn were determined in both types of samples. Solutions of hair and feces were prepared and analyzed in the manner described for liver.

The trace elements Co, Cu, Fe, Mn, Mo, Se and Zn were analyzed in both forages and soils as previously described (Kiatoko et al., 1982). Statistical procedures have also been described by Kiatoko et al. (1982).

Results and Discussion

Forage and Soil Analysis. Mean analysis of trace minerals in soils, by region, and in forages, by season and region, are presented in tables 1 and 2, respectively. For each forage trace mineral, no differences ($P>.05$) were found between seasons, regions or ranches within regions and there were no season × region or season × ranch-within-region interactions. However, regional differences ($P<.05$) existed in soil Fe concentrations and ranch-within-region differences ($P<.05$) were found for Mn and Se. Significant correlations ($P<.05$) were observed between soil and forage Cu ($r = .51$), Mn ($r = .59$) and Co ($r = .47$) concentrations. Becker et al. (1965) reported a relationship between Co content of soils and forages and the Co status of animals. However, Hartmans (1974) found

TABLE 1. SOIL MICROELEMENTS, BY REGION[a]

	Region							
	Southeast		Southwest		Central		Northwest	
Element	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	ppm							
Co	.10	.04	.07	.03	.09	.08	.21	.03
Cu	1.3	.7	1.6	.5	.6	1.4	2.1	.5
Fe	51.9[b]	5.9	12.1[d]	4.2	22.2[cd]	11.9	27.9[c]	4.8
Mn	5.0	9.4	2.1	6.6	12.4	18.8	34.5	7.7
Mo	.023	.005	.022	.003	.024	.009	.024	.004
Se	.022	.008	.020	.006	.024	.016	.038	.007
Zn	6.0[b]	1.5	1.2[c]	1.1	1.3[c]	3.0	.8[c]	1.2

[a]Means are based on the following numbers of samples: southeast (4), southwest (8), central (1) and northwest (6). Standard error (SE) of the mean in each case is based on five degrees of freedom.

[b,c,d]Means within a row with different superscripts differ ($P<.05$).

TABLE 2. FORAGE TRACE ELEMENT CONCENTRATIONS BY SEASON AND REGION (PPM DRY BASIS)[a,b]

		Region								Season Mean	
		Southeast		Southwest		Central		Northwest			
Mineral	Season	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Co	Wet	.11	.03	.09	.02	.10	.06	.12	.03	.11	.02
	Dry	.12	.03	.15	.09	.26	.21	.15	.08	.16	.02
Cu	Wet	12.2	19.0	89.1	13.4	112.0	38.0	17.5	15.5	51.5	8.7
	Dry	11.0	3.6	36.3	41.4	35.0	42.4	5.5	2.1	22.3	12.0
Fe	Wet	100.8	66.2	56.1	46.8	71.0	132.5	259.7	54.1	130.6	30.4
	Dry	93.3	26.3	79.7	36.2	128.0	127.3	248.0	206.5	127.2	41.9
Mn	Wet	82.8	19.1	35.2	13.5	15.0	38.3	119.2	15.6	70.7	8.8
	Dry	131.3	53.0	61.7	47.4	60.5	38.9	72.5	19.1	84.7	12.1
Mo	Wet	.86	.33	.22	.23	.22	.65	.24	.26	.36	.15
	Dry	1.16	.82	.70	.99	.20	.07	.27	.23	.65	.21
Se	Wet	.08	.02	.07	.01	.02	.04	.06	.02	.07	.01
	Dry	.03	.02	.04	.04	.13	.10	.02	.01	.05	.01
Zn	Wet	30.1	7.7	16.8	5.4	16.9	15.4	17.3	6.3	19.8	3.5
	Dry	29.6	12.3	25.1	21.9	19.5	10.8	16.3	5.0	23.6	4.8

[a]Means are based on the following number of samples: wet season—southeast (4), southwest (8), central (1) and northwest (6); dry season—southeast (3), southwest (3), central (2) and northwest (2). Standard error (SE) of the mean in each case is based on three degrees of freedom.

[b]No differences between seasons or among regions within season were found (P>.05).

no connection between cattle Cu deficiency and the Cu status of soil and forages.

Mean soil Co values in the four regions varied from .07 to .21 ppm. Kubota (1968) reported mean extractable soil Co values in the range of .11 to 1.40 ppm in healthy pastures. Of all the soils analyzed, 57.9% had low Co concentrations of .11 ppm or less. Although the differences were not significant (P>.05), Co concentrations in the southwest on Spodosol and in the central region on Entisol were less than one-half those in the northwest region on Ultisol. These results are in close agreement with reports (Kubota, 1968) indicating that low soil Co is expected in the sandy Spodosol while Ultisols usually have higher Co concentrations.

Forage Co levels varied from .09 to .12 ppm among the four regions in the wet season and from .12 to .26 ppm during the dry season. On the basis of mean analyses, Co values generally were above the NRC (1976) requirement of .1 ppm. However, evaluation of individual forage concentrations indicated that 63 and 40% of all samples analyzed were low in Co (<.1 ppm) during the wet and dry seasons, respectively.

Mean forage Cu values were 22.3 and 51.5 ppm in the dry and wet seasons, respectively. These forage Cu concentrations would be considered adequate compared to the minimum requirement of 4 ppm (NRC, 1976) in the absence of high forage Mo. Mean forage Mo concentrations were .36 and .65 ppm in the wet and dry seasons, respectively. To avoid Cu deficiency, Florida pastures with 2 to 3 ppm Mo should contain at least 10 ppm Cu, while forages with more Mo should contain 50 ppm Cu or more (Davis, 1954). Mean extractable soil Mo in the four regions varied from .022 to .024 ppm, while soil Cu varied from .6 to 2.1 ppm. Horowitz and Dantas (1973) suggested that normal soil Cu levels are on the order of 2 to 79 ppm, with less than .60 ppm deficient for pasture production.

Mean forage Fe levels were 130.6 and 127.1 ppm in the wet and dry seasons, respectively. No differences (P>.05) were found between seasons, regions and ranches, with all concentrations exceeding the estimated requirement of 10 ppm for growing cattle and mature cows (NRC, 1976). Soil Fe concentrations in the four regions ranged from 12.1 to 51.9 ppm, with the southeast having higher (P<.05) concentrations than the other regions. Sanchez (1976) reported that 20 ppm Fe in soil was sufficient to prevent Fe deficiency in crops. Under natural grazing conditions, Fe deficiency is not likely to occur in cattle (Underwood, 1977). In Florida, however, Fe deficiency has been reported in cattle grazing on sandy soils (Becker et al., 1965).

Forage and soil Mn concentrations in the four regions ranged from 42.5 to 107.5 ppm and 2.1 to 34.5 ppm, respectively. Soil Mn levels in the southeast and southwest were the lowest. These results are in agreement with those of Rothwell (1966) indicating that Ultisols in north Florida contained more exchangeable Mn than the Spodosols of south Florida. Dantas (1971) suggested that 20 ppm of extractable soil Mn is sufficient for plant growth. On this basis, Mn levels were adequate in the northwest (34.5 ppm) but low in the other regions, ranging from 2.1 to 12.4 ppm. However, mean forage Mn concentrations in the four regions were above the requirement of 20 ppm but below the toxic level of 150 ppm for beef cattle (NRC, 1976).

Mean exctractable soil Zn levels were 6.0 ppm in the southeast and ranged from .8 to 1.3 ppm in the other three regions. Sanchez (1976) indicated that the critical soil Zn concentration for plants is 1.5 ppm and that this value was associated with a concentration of 14 ppm Zn in plant tissues. By this criterion, soil Zn was adequate only in the southeast. Likewise, although not statistically different (P>.05), forage Zn levels were higher in the southeast than in the southwest, central and northwest regions (30.0 vs 19.1, 18.7 and 17.1 ppm, respectively.) On the basis of a Zn requirement for beef cattle of 30 ppm (NRC, 1976), forage from the southeast region was adequate while forage from the other regions was deficient. Zinc was low (<1.5 ppm) in 57.9% of all soil samples and deficient (<30 ppm) in 89.5 and 80.0% of the forages during the wet and dry seasons, respectively. A suspected Zn deficiency has been reported in Clermont, Florida (F. Neal, personal communication); cattle responded to Zn supplementation, with control animals exhibiting a great loss of hair.

Cary et al. (1967) indicated that soil Se concentrations of less than .50 ppm are found in areas where Se deficiency in livestock occurs. In the present study, soil Se in the four regions ranged from .020 to .038 ppm, with all samples containing less than the critical level (<.50 ppm). No difference (P>.05) in forage Se concentrations was found among regions or between seasons. Mean forage Se varied from

.02 to .08 ppm among regions and was .02 and .13 ppm for the wet and dry seasons, respectively. Only in the central region during the dry season was forage adequate (.13 ppm) in relation to the requirement of .1 ppm (NRC, 1976). Of all forage samples analyzed, 84.2 and 90.0% were deficient (<.1 ppm) during the wet and dry seasons, respectively. Low forage Se values ranging from .02 to .06 ppm were reported previously by Shirley et al. (1966) in Florida pastures.

Mean forage Cu (<4 ppm), Fe (<30 ppm) and Mo (>3 ppm) concentrations were adequate on the nine ranches studied during the wet season, while two, one, eight and eight ranches had low average Co (<.1 ppm), Mn (<20 ppm), Se (<.1 ppm) and Zn (<30 ppm) concentrations, respectively, during the wet season. During the dry season, two, six and five of seven ranches had low forage concentrations of Co, Se and Zn, respectively, with Cu, Fe, Mn and Mo in normal concentrations.

Trace Element Tissue Concentrations. Mean liver and blood plasma concentrations by region and season are presented in table 3, while hair and fecal concentrations are given in table 4. Seasonal differences (P<.05) were found, with plasma Se, liver Mn, hair Cu and hair Zn higher in the dry season and fecal Co and Se higher in the wet season. Differences (P<.05) among regions were found for liver Co and Cu, hair Cu and fecal Co during both the wet and dry seasons, for liver Mn and hair Mn during the wet season, and for liver Se during the dry season. Season × ranch-within-region interactions (P<.05) were found for trace element concentrations in liver (Cu, Fe, Co), plasma (Cu, Zn, Se), hair (Zn, Mn, Se) and feces (Cu, Zn, Co, Se).

During both seasons, regional differences (P<.05) existed in liver and fecal Co concentrations, with the central region having the highest concentrations, the southwest region intermediate levels, and the southeast and northwest regions the lowest. Liver Co (P<.001) was positively correlated with fecal Co (r = .727). Mean liver Co concentration was 1.06 ppm in cows and .88 ppm in heifers, and mean fecal Co levels were significantly higher (P<.05) in cows than heifers (.37 vs .27 ppm, respectively).

Liver Co concentrations have been reported to be a good indicator of the Co status of grazing animals, with levels of .07 ppm or below considered as critical concentrations (Cunha et al., 1964; Underwood, 1977). Forage and soil Co concentrations were deficient in some areas; however, liver Co was adequate (>.07 ppm) for all animals. The likely explanation for this is the large amount of Co found in free choice mineral supplements.

Hair Cu was higher (P<.01) during the dry season (8.3 vs 5.0 ppm for wet season), with no season effect (P>.05) observed in liver Mo or liver, plasma and fecal Cu concentrations. Liver Cu was highest in the southeast region and lowest in the northwest in both seasons. No difference was found (P>.05) among regions in liver Mo or plasma and fecal Cu during either season. No difference (P>.05) was found between heifers and cows in concentrations of liver Mo or of Cu in the liver, plasma or hair, although fecal Cu was higher (P<.05) in heifers (20.4 vs 14.9 ppm for cows). Although relatively low, correlations (P<.01) were found between liver Cu and Cu concentrations in plasma (r = .20), hair (r = .46) and feces (r = .37), between plasma Cu and fecal Cu (r = .13) and between hair Cu and fecal Cu (r = .37), and a negative correlation was found between plasma Cu and hair Cu (r = −.13). Hartmans (1974) reported a positive relationship between plasma and liver Cu only when the Cu status of the animal was low, with liver the better indicator of the status.

Overall mean Cu concentrations were normal when compared to the suggested critical levels of 75 ppm for liver (Cunha et al., 1964) and .065 mg/100 ml for plasma (Netherlands Committee on Mineral Nutrition, 1973). However, 36.4% of all liver samples were low (<75 ppm) in Cu during the wet season, and 20.2% had low concentrations during the dry season. Mean liver Cu was low (<75 ppm) on one ranch in the northwest during both seasons and was low on another ranch in the southwest during the wet season. Mean liver Mo contents were 2.8 and 3.0 ppm during the wet and dry seasons, respectively. These values are in agreement with approximate normal levels of 2 to 4 ppm indicated by Underwood (1977) and suggest that Mo was not present in high enough concentrations to interfere greatly with Cu metabolism.

Liver Fe and Mn concentrations were above the critical concentrations of 180 and 6 ppm, respectively (McDowell and Conrad, 1977), on all ranches during both seasons. Liver Fe concentrations did not exhibit a season × region interaction (P>.05). Liver Mn was higher (P<.05) in the dry season, with the southwest (11.0 ppm) and northwest (12.9 ppm) regions

TABLE 3. LIVER AND PLASMA TRACE MINERAL CONCENTRATIONS BY SEASON AND REGION (PPM DRY BASIS)[a]

		Region								Season Mean	
		Southeast		Southwest		Central		Northwest			
Item	Season	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Plasma											
Cu,	Wet	.10	.01	.09	.01	.09	.02	.10	.01	.10	.01
mg/100 ml	Dry	.08	.01	.08	.01	.08	.02	.08	.01	.08	.01
Zn,	Wet	.10	.01	.10	.01	.10	.02	.11	.01	.10	.01
mg/100 ml	Dry	.11	.01	.09	.01	.08	.02	.06	.01	.09	.01
Se,	Wet	5.0	.8	5.0	.7	4.0	1.0	4.0	.7	4.6^{f}	.3
μg/100 ml	Dry	7.0	.8	7.0	.7	6.0	1.8	6.0	.8	4.1^{e}	.4
Liver, ppm											
Co	Wet	$.79^{cd}$	.16	1.02^{c}	.15	2.89^{b}	.24	$.46^{d}$	.14	1.3	.1
	Dry	$.74^{cd}$	.18	1.03^{c}	.18	3.44^{b}	.35	$.53^{d}$	.17	1.4	.1
Cu	Wet	236.7^{b}	30.5	125.7^{c}	26.4	101.0^{c}	44.6	90.6^{c}	24.6	138.5	14.6
	Dry	294.8^{b}	31.0	152.9^{c}	27.1	174.9^{bc}	59.0	71.5^{c}	31.0	173.5	16.3
Fe	Wet	283.3	109.7	424.1	95.0	358.6	160.6	304.9	39.6	342.7	52.9
	Dry	425.5	101.9	482.2	96.2	602.1	277.2	347.7	113.6	464.4	58.9
Mn	Wet	8.4	.4	8.5	.4	9.6	.6	8.7	.3	8.8^{f}	.2
	Dry	10.3^{bc}	.4	11.0^{bc}	.4	9.7^{c}	.8	12.9^{b}	.4	11.0^{e}	.2
Mo	Wet	3.0	.2	2.8	.2	2.8	.3	2.5	.2	2.8	.1
	Dry	2.6	.2	2.9	.2	3.9	.4	2.7	.2	3.0	.1
Se	Wet	$.30^{b}$	.02	$.28^{b}$	.02	$.19^{c}$	.03	$.24^{bc}$	.02	.25	.01
	Dry	.28	.03	.23	.03	.28	.05	.42	.03	.30	.02
Zn	Wet	100.8	26.2	182.3	22.7	139.7	38.4	136.3	21.4	139.8	12.6
	Dry	106.9	26.7	131.4	23.0	137.8	50.8	99.5	26.7	118.9	13.9

[a]Means are based on the following number of samples, for: (1) plasma minerals, (2) liver Co, Cu, Fe, Mn, Mo and Zn and (3) liver Se, respectively, wet season—southeast (52, 30, 27), southwest (68, 40, 34), central (24, 14, 11) and northwest (75, 45, 30); dry season—southeast (52, 28, 15), southwest (64, 39, 16), central (12, 8, 4) and northwest (55, 29, 14).

[b,c,d]Means within a row with different superscripts differ ($P<.05$).

[e,f]Seasonal means within a column with different superscripts differ ($P<.05$).

TABLE 4. MINERAL CONTENT OF HAIR AND FECES, BY SEASON AND REGION (DRY MATTER BASIS)[a]

Mineral	Season	Region: Southeast Mean	Southeast SE	Southwest Mean	Southwest SE	Central Mean	Central SE	Northwest Mean	Northwest SE	Season Mean: Mean	Season Mean: SE
		ppm									
Hair											
Cu	Wet	6.8[b]	.3	4.2[c]	.3	3.9[c]	.4	5.1[c]	.2	5.0[f]	.1
	Dry	10.8[b]	.3	6.8[c]	.3	8.7[bc]	.6	6.6[c]	.3	8.3[e]	.2
Mn	Wet	15.2[b]	3.3	3.9[c]	2.9	9.0[bc]	4.8	13.7[b]	2.7	10.4	1.6
	Dry	15.8	3.3	12.1	3.0	19.8	7.0	19.4	3.4	16.8	1.8
Se	Wet	.18	.02	.08	.02	.07	.03	.16	.02	.12	.01
	Dry	.11	.02	.11	.02	.11	.05	.14	.03	.12	.01
Zn	Wet	62.9	6.8	50.1	6.0	55.4	9.9	59.4	5.6	57.0[f]	3.3
	Dry	89.1	6.7	82.9	6.1	76.1	14.7	70.0	6.6	79.5[e]	3.6
Feces											
Co	Wet	.16[d]	.04	.56[c]	.04	1.08[b]	.06	.15[d]	.04	.49[e]	.02
	Dry	.13[d]	.03	.37[c]	.04	.78[b]	.09	.19[cd]	.04	.37[f]	.02
Cu	Wet	27.7	10.4	10.6	9.4	19.3	17.8	11.9	9.6	17.4	5.4
	Dry	27.7	9.8	12.8	9.5	32.4	22.7	12.8	10.4	21.4	5.6
Se	Wet	.13	.01	.11	.01	.18	.02	.14	.01	.14[e]	.01
	Dry	.10	.01	.09	.01	.08	.03	.13	.01	.10[f]	.01
Zn	Wet	78.0	20.0	20.0	17.7	37.4	33.3	32.1	18.6	41.9	10.3
	Dry	112.7	20.1	45.6	18.3	79.2	43.7	45.1	20.7	70.6	11.0

[a]Means for hair and fecal mineral based on the following number of samples respectively: wet season–southeast, (52, 52), southwest (67, 65), central (24, 11) and norhtwest (75, 55); dry season–southeast (52, 52), southwest (67, 63), central (18, 22) and northwest (61, 52). Standard error (SE) of the mean in each case is based on four degrees of freedom.

[b,c,d]Means within a row with different superscripts differ ($P<.05$).

[e,f]Seasonal means within a column with different superscripts differ ($P<.05$).

containing the highest concentrations. Hair Mn was highest in the central (19.8 ppm) and northwest (19.4 ppm) regions during the dry season. Hair Mn was negatively correlated ($P<.0001$, $r = -.36$) with liver Mn, indicating that hair is not a good indicator of Mn status. Other researchers (Netherlands Committee on Mineral Nutrition, 1973; Hartmans, 1974) considered hair to be of no value in assessing Mn status since results are difficult to interpret. Hartmans (1974) found no difference ($P>.05$) in hair Mn when identical twin cattle were fed either 21 or 130 ppm Mn.

No seasonal differences ($P>.05$) were found in liver, plasma or fecal Zn, while hair Zn concentrations were higher in the dry season (79.5 vs 57.0 ppm). This finding is contrary to that of Hidiroglou and Spur (1975), who reported higher Zn values in the summer than in the winter. Among the tissues analyzed for Zn, there were no differences ($P>.05$) between classes of animal or ranch-within-regions, and there were no season × region, and season × ranch interactions. With the exception of hair and fecal Zn ($r = .44$), all correlations between plasma, liver, hair and fecal Zn concentrations were low ($r = \pm .20$). Forage and fecal Zn were highly correlated ($P<.05$, $r = .68$). Miller et al. (1966) reported that high fecal Zn may denote a high Zn intake, while animals with a low Zn intake have reduced Zn excretion.

Mean liver Zn levels varied from 139.8 ppm in the wet season to 118.9 ppm in the dry season, while mean plasma Zn values were .10 and .09 mg/100 ml during the wet and dry seasons, respectively. All mean liver Zn values were within the range of 84 to 150 ppm Zn reported in beef cattle livers by Powell et al. (1964) and Miller et al. (1968). However, according to the Netherlands Committee on Mineral Nutrition (1973), blood plasma is the best indicator of Zn status in grazing animals, with levels below .04 mg/100 ml suggesting Zn deficiency. Less than 10% of all animals in either season had critical Zn liver (<84 ppm) and plasma (<.04 mg/100 ml) concentrations.

Plasma Se was higher and fecal Se lower during the dry season ($P<.05$), while no seasonal differences ($P>.05$) were found in liver or hair Se. For liver, plasma, hair and fecal Se concentrations, no region or class of animal differences ($P>.05$) existed, with correlations among the four tissues low or nonexistent. Mean liver Se values were .25 and .29 ppm in the dry and wet seasons, respectively. McDowell (1976) suggested that normal Se levels in the livers of cattle are above .25 to .50 ppm (dry basis), while values on the order of 5 to 15 ppm are suggestive of an excessive Se intake. On this basis, the mean liver Se levels reported in this study were low during both seasons. Mean plasma Se contents were 4.5 and 7.1 μg/100 ml during the wet and dry season, respectively. These levels appeared to be normal compared to the plasma Se levels of 2.4 and 7.3 μg/100 ml reported by Perry et al. (1976) in cattle fed control and .40 ppm supplemental Se diets, respectively. Mean hair Se concentrations were .123 and .118 ppm in the wet and dry seasons, respectively. Hidiroglou et al. (1965) found that cows with hair Se values ranging from .06 to .25 ppm produced calves with white muscle disease. On this basis, the mean hair Se values obtained during the two seasons would be suggestive of low Se nutritional status. Mean fecal Se was .10 ppm in the dry season and .14 ppm in the wet season.

Like forage and soil Se, liver and hair Se concentrations were deficient. Liver Se concentrations were below critical levels (<.25 ppm) in 32.2 and 38.8% of the samples in the wet and dry seasons, respectively. Hair Se was low (<.25 ppm) in 90.2% of the samples of the wet season and in 100% of the samples in the dry season.

Conclusions Related to Trace Element Status

In the 1930's, it was established that nutritional anemia or "salt sick" in Florida cattle is caused by a deficiency of Co, Cu and Fe (Becker et al., 1965). Forage and soil analyses for the ranches studied in the present experiment showed adequate concentrations of Cu and Fe, with no excess of Mo. The majority of forage and soil Co concentrations, however, were below critical levels. High levels of Co in ranch mineral mixtures were reflected by adequate liver Co. Although above critical concentrations in soil and forage, Cu was low in 33 and 25% of the livers analyzed during the wet and dry seasons, respectively. Hartmans (1974) previously found no relationship between soil or forage Cu concentrations and Cu status in cattle.

In general, Fe and Mn analyses indicated adequate concentrations. Of the trace minerals normally supplied in mineral supplement mixtures, Fe and Mn are least likely to be deficient for grazing cattle. Except in animals with severe parasitism or in those that are hemorrhaging, Fe deficiency is considered rare among grazing cattle because of generally adequate pasture concentrations together with contamination of plants by soil (McDowell, 1976).

Forage and soil Zn analyses indicated deficient concentrations, while tissue levels were generally adequate. As with Co, individual ranch mineral supplementation programs have probably provided sufficient dietary Zn. The possibility of a widespread, mild or borderline deficiency of Zn may exist without clinical signs. Mayland (1975) reported increased weight gains in cattle supplemented with Zn in the absence of Zn deficiency signs.

The most pronounced findings from the analyses of samples in all regions was the low Se status of pastures, soils and animal tissues. No effect of Se administered in mineral supplements existed, as samples were collected before the Food and Drug Administration's approved dietary additions of this element. The inadequate Se status observed in this study, plus persistent reports of white muscle disease in the state, emphasizes the need for increasing dietary intake of Se.

Mineral deficiencies are often "area" problems. Nevertheless, the study reported herein, and the companion paper (Kiatoko et al., 1982) indicated that P, Se and Zn deficiencies were present in all of the four regions studied. Protein, vitamin A, K, Mg, Na, Cu and Co deficiencies were found in certain regions and were related to season of the year.

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