A STUDY ON THE MINERAL STATUS OF BEEF AND DAIRY CATTLE AND BUFFALO IN CENTRAL THAILAND

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Summary

Nutritional status of minerals of beef and dairy cattle and buffalo in central Thailand were investigated by evaluating the mineral concentrations in feedstuff and blood plasma of animals. Three crossbred beef cow herds, a native cow herd, a buffalo female herd and 3 dairy cattle herds which consisted of the herds of lactating cows, dry cows and heifers were studied in both rainy and hot seasons. Low Na concentrations (<0.07% on a dry matter basis) in pasture samples from the fields for a crossbred beef cow were observed. Copper concentrations in all the pasture samples ranged from 3.7 to 13.5 mg/kg. Iron and Se concentrations in pasture samples had a wide variety ranging from 185 to 1,345 and 0.033 to 1.127 mg/kg, respectively. The concentrations of K, Ca, Mg, P, Zn and Mn in total diets were higher than the requirements for beef and dairy cattle. Some animals with subnormal plasma Cu concentrations (<0.65 μg/ml) existed in each herd. The animals which showed subnormal plasma Se concentrations (<0.03 μg/ml) were observed in beef cow herds. The concentrations of Ca, Mg and Zn in plasma of animals were normal. Attention should be paid to the deficiencies in Na, Cu and Se of the animals in central Thailand.
(**Key Words** : Cattle, Buffalo, Mineral Status, Central Thailand)

Introduction

Mineral deficiencies and toxicities in ruminants are the limiting factors in improving the animal performances. Several investigations have indicated that the mineral deficiencies occurred in many regions in the world where the ruminants depend largely upon forages to supply their mineral requirements. Sodium, K, Ca, Mg, P, Cu, Co, I, Zn and Se deficiencies and Fe and Se toxicities in cattle have been observed in several regions of south America (McDowell et al., 1983). Copper, Co and Se deficiencies in sheep were reported in Australia and New Zealand (Davis, 1987; Levender, 1987; Smith, 1987). Mineral status in ruminants in south east Asia was studied in some regions. Kumagai et al. (1990a, 1990b) reported low inorganic phosphorus concentrations in plasma samples and low Cu concentrations of plasma and liver samples from beef cattle in Java of Indonesia raised by native pasture grasses. Low Se and Cu concentrations in blood plasma of goats were observed in Luzon island of the Philippines (Fujihara et al., 1992).

Recently improved grassland and exotic breeds of beef and dairy cattle have been introduced to Thailand to advance cattle performances. However, few research works on the mineral status of cattle raised in the new system have been done. The present study was conducted to get basic information of the mineral status of cattle raised in central Thailand by analyzing pasture and blood samples.

Materials and Methods

Location and season for sample collection

Studies were conducted at Kamphaengsaen, Nakorn Pathom located at 90 km west of Bangkok in Thailand from July 20th to 29th (early rainy season) in 1993 and from March 10th to 18th in 1994 (early hot season). The samples were collected at the beef and dairy cattle stations of Kasetsart University. The annual precipitation in this area was 765.8 mm in 1993. The average monthly precipitation was 60.7 mm from March to June, 129.5 mm from July to October and 1.6 mm from November in 1993 to February in 1994.

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Animals

Thirty nine or 40 beef cows and 10 buffalo females from the herds of beef cattle station were examined in each sampling time. The beef cows consist of 10 native cows, 10 crossbred cows between Brahman bulls and native cows (Bra × Nat), 9 or 10 crossbred cows between Charolais bulls and native cows (Cha × Nat) and 10 crossbred cows between Charolais bulls and Bra × Nat cows {Cha × (Bra × Nat)}. The age of native cows, Bra × Nat, Cha × Nat, Cha × (Bra × Nat) and buffalo females was 13.8, 14.2, 12.4, 6.8 and 5.1 years on an average, respectively.

Thirty female cattle from the herds of dairy cattle station were examined in each sampling time. The animals consist of 10 lactating cows, 10 heifers and 10 dry cows. The age of lactating cows, heifers and dry cows was 3.8, 2.3 and 5.9 years on an average, respectively. The average milk yield of lactating cows was 9.1 kg/day. The animals have from 75 to 93.75% of their genes from Holstein Friesian.

Diets

In the beef cattle station the native cows and buffalo females were grazed in mixed pasture fields. The dominant species of pasture were paragrass (*Brachiaria mutica*), stargrass (*Cynodon plectostachyus*), bermudagrass (*Cynodon dactylon*), fingergrass (*Digitaria abscendens*) and marvelgrass (*Dichanthium annulatum*). Bra × Nat and Cha × Nat cows were grazed in the field where rusigrass (*Brachiaria rusisiensis*) was the dominant species and Cha × (Bra × Nat) cows were grazed in the field where paragrass was the dominant species. No concentrate was fed to the cows and buffalo. In the dairy cattle station the lactating cows were fed with soiling crops carried from the field where paragrass was the dominant species and supplemented with 7 kg purchased concentrate per day per head on an average. The dry cows and heifers were grazed where paragrass was the dominant species and supplemented with 1.7 kg purchased concentrate per day per head on an average.

All the pasture fields except for the field for native cows and buffalo were irrigated. All the animals from both stations were fed mineral block *ad libitum*. One kilogram of mineral block supplied 280 g Na, 0.58 g K, 89 g Ca, 1.82 g Mg, 13 g P, 0.27 g Cu, 4.2 g Fe and 0.33 g Zn.

Collection of samples

Blood samples were collected from jugular vein of animals and heparinized immediately. Blood plasma was prepared by centrifuging and put in acid washed glass tubes. Pasture samples, sampled from 16-24 points of 0.5 × 0.5 m square areas from paddocks in each field which had recently been grazed in, were collected. All samples from the paddocks in the same grazing field were mixed together, dried at 60℃ for 48 hours and milled.

Analytical methods

Plasma samples were deproteinized by 10% trichloroacetic acid and the supernatant was used for measurement of inorganic phosphorus (Pi), Ca and Mg. One gram of each diet sample and 1 ml of each plasma sample was digested in 5 ml of 4:1 mixture of 60% nitric and perchloric acids and offered to measurement of Cu, Zn and Se concentrations in plasma and Na, K, P, Ca, Mg, Cu, Mo, Fe, Zn, Mn and Se concentrations in diets. The P concentrations were determined by the colorimetric method of Gomori (1942) and the concentrations of Na, K, Ca, Mg, Cu, Mo, Fe, Zn and Mn were determined by atomic absorption spectrophotometry (Price, 1979). The Se concentrations were measured by the fluorescent method of Watkinson (1966).

Statistical analysis

The values of plasma mineral concentrations of animals from each station were statistically analyzed by the following mathematical model:

$$Y = \mu + H_i + S_j + (HS)_{ij} + E_{ijk}$$

where:

Y : each value

μ : the overall mean

H_i : the effect associated with herd

S_j : the effect associated with sampling season

$(HS)_{ij}$: the interaction effect between herd and sampling season

E_{ijk} : residual

All statistical analyses were conducted through the least square analysis of variance procedure by Harvey (1985).

Results and Discussion

Beef cattle and beffalo

Mineral concentrations in pasture samples from beef cattle station are presented in table 1. NRC (1984) recommended that the Na requirement for beef cattle is 0.06 to 0.10% on a dry matter basis. The Na concentration of pasture samples from the field grazed by Bra × Nat cows was 0.009% in the rainy season and 0.066% in the hot season that were much lower than and similar to the minimal requirement, respectively.

The Se concentrations of pasture samples had a wide variety ranging from 0.033 to 1.127 mg/kg. Most of the concentrations were within the range between minimal and maximal requirement that is from 0.05 to 0.30 mg/kg.

The concentrations of K, Ca, P, Zn and Mn in pasture samples from each field were higher than the upper range of the requirement. No pasture samples from beef cattle station showed the Mg concentrations below 0.10% that is the suggested value of the requirement (NRC, 1984).

TABLE 1. MINERAL CONCENTRATIONS IN DIETS FROM BEEF CATTLE STATION

Herds[1]	Species of diets	Seasons	Na	K	Ca	Mg	P	Cu	Mo	Fe	Zn	Mn	Se
			······(% on a dry matter basis)······					······(mg/kg on a dry matter basis)······					
Bra × Nat	Rusigrass	Rainy	0.009	2.62	0.432	0.227	0.448	4.20	0.89	253	51.8	353	0.033
	Rusigrass	Hot	0.066	4.10	0.601	0.277	0.559	8.17	2.21	710	42.7	156	0.484
Cha × Nat	Rusigrass	Rainy	0.117	2.50	0.404	0.219	0.422	5.38	1.49	185	42.7	251	0.094
	Rusigrass	Hot	0.550	2.44	0.713	0.258	0.219	6.76	2.09	478	40.7	837	0.098
Cha × (Bra	Paragrass	Rainy	0.423	2.05	0.293	0.202	0.293	6.49	1.66	569	40.8	168	0.126
× Nat)	Paragrass	Hot	0.420	2.74	0.535	0.377	0.443	11.23	2.09	1,141	55.7	341	0.069
Native	Mixed pasture	Rainy	0.135	1.54	0.442	0.144	0.322	6.29	0.97	700	40.2	111	0.281
	Mixed pasture	Hot	0.092	2.09	0.549	0.230	0.318	5.33	2.20	470	34.4	229	0.102
Buffalo	Mixed pasture	Rainy	0.135	1.54	0.442	0.144	0.322	6.29	0.97	700	40.2	111	0.281
	Mixed pasture	Hot	0.425	3.00	0.562	0.320	0.359	13.51	3.39	842	46.5	464	1.127
Requirement[2]			0.06 - 0.10	0.6	0.19 - 0.28	0.05 - 0.25	0.19 - 0.22	4-10	–	50	20-40	20 - 50	0.05 - 0.30

[1] Bra × Nat : crossbred between Brahman bulls and native cows, Cha × Nat : crossbred between Charolais bulls and native cows, Cha × (Bra × Nat) : crossbred between Charolais bulls and Bra × Nat cows.
[2] Source : NRC standard for beef cattle (1984).

Mineral concentrations in plasma samples from beef cattle station are in table 2. Although the P concentrations in pasture samples during the hot season were not always lower than those during the rainy season, the Pi concentrations of plasma samples from each herd decreased in the hot season ($p < 0.01$).

The critical level of plasma Cu concentration of cattle was 0.65 μg/ml (McDowell et al., 1985). The cows which showed lower plasma Cu concentrations than the critical level were observed in each herd (table 5). Namely, the concentrations of plasma samples from Cha × Nat and Cha × (Bra × Nat) cows and buffalo females were low. NRC (1984) suggested that the range of Cu requirement for beef cattle is from 4 to 10 mg/kg and that the requirement is affected by a variety of dietary and animal factors. Most of the Cu concentrations in the pasture samples were within the range of requirement. Ward (1978) indicated that a high level of Mo (> 20 mg/kg) or a narrow Cu : Mo ratio (< 2.0) induced Cu deficiency in cattle. Molybdenum in the diets of this study might not have influenced Cu status of animals since the maximal Mo concentration in diets was 3.39 mg/kg and no sample showed a Cu : Mo ratio below 2.0. Standish et al. (1969) suggested that Cu concentrations in liver of steers were decreased by Fe as little as 400 mg/kg in diet. Campbell et al. (1974) reported that plasma Cu concentrations in cattle were decreased when Cu deposition in liver was drained in the condition of excessive Fe contents in diets. The concentrations of Fe in pasture samples from each field were high on the whole. Namely, the Fe concentrations in pasture from Cha × Nat field in the hot season, from Cha × (Bra × Nat) field in both of the seasons and from buffalo field in both of the seasons exceeded 400 mg/kg. It is likely that the Cu status of animals were decreased by the marginal Cu concentrations and extremely high level of Fe in pasture.

Plasma Se concentrations of animals in the beef cattle station ranged from 0.018 to 0.145 μg/ml widely. Eighty percent of samples from Cha × (Bra × Nat) cows in the hot season showed lower Se concentrations than the critical level that is 0.03 μg/ml (table 5).

No cows showed lower plasma Ca, Mg and Zn concentrations than the critical level (table 5). Judging from mineral concentrations in pasture and plasma samples, K, Ca, Mg, Zn and Mn in the pasture were likely to be sufficient for the animals.

TABLE 2. MINERAL CONCENTRATIONS (MEANS AND SEM) IN BLOOD PLASMA OF ANIMALS FROM BEEF CATTLE STATION

Herds[1]	Seasons	N	Ca	Mg	Pi	Cu	Zn	Se
			··· (mg/dl) ···			··· (μg/ml) ···		
Bra × Nat	Rainy	10	9.30(0.15)	2.17(0.04)	5.76(0.24)	0.76(0.03)	0.81(0.02)	0.040(0.004)
	Hot	10	9.07(0.15)	2.20(0.04)	5.46(0.19)	0.72(0.06)	1.00(0.12)	0.042(0.003)
Cha × Nat	Rainy	9	9.38(0.19)	1.82(0.09)	5.73(0.24)	0.85(0.04)	0.71(0.03)	0.069(0.012)
	Hot	10	9.18(0.20)	1.83(0.07)	5.08(0.18)	0.52(0.06)	0.83(0.03)	0.052(0.002)
Cha × (Bra × Nat)	Rainy	10	9.31(0.18)	2.10(0.05)	6.51(0.25)	0.56(0.05)	0.94(0.03)	0.065(0.007)
	Hot	10	9.35(0.14)	2.09(0.07)	5.35(0.25)	0.40(0.08)	1.15(0.04)	0.026(0.002)
Native	Rainy	10	8.93(0.14)	1.96(0.06)	5.91(0.29)	0.89(0.04)	0.77(0.02)	0.060(0.005)
	Hot	10	9.07(0.14)	1.81(0.05)	5.21(0.27)	0.79(0.07)	1.07(0.07)	0.063(0.002)
Buffalo	Rainy	10	9.48(0.13)	2.36(0.07)	5.46(0.37)	0.28(0.03)	0.73(0.02)	0.083(0.008)
	Hot	10	10.02(0.26)	2.40(0.10)	5.19(0.22)	0.23(0.03)	1.07(0.04)	0.092(0.005)
					Significance			
Herds			**	**	NS	**	**	**
Seasons			NS	NS	**	**	**	*
Herds × Seasons			NS	NS	NS	*	NS	**

[1] Bra × Nat : crossbred between Brahman bulls and native cows, Cha × Nat : crossbred between Charolais bulls and native cows, Cha × (Bra × Nat) : crossbred between Charolais bulls and Bra × Nat cows.
* $p < 0.05$, ** $p < 0.01$ and NS : not significant.

TABLE 3. MINERAL CONCENTRATIONS IN DIETS FROM DAIRY CATTLE STATION

Herds	Species of diets	Seasons	Na	K	Ca	Mg	P	Cu	Mo	Fe	Zn	Mn	Se
			···(% on a dry matter basis)···					···(mg/kg on a dry matter basis)···					
Lactating cows	Paragrass	Rainy	0.587	1.78	0.321	0.189	0.223	5.67	1.37	459	26.5	171	0.080
	Paragrass	Hot	0.454	1.45	0.369	0.278	0.300	3.69	2.19	551	31.9	174	0.044
Dry cows	Paragrass	Rainy	0.258	2.13	0.353	0.245	0.314	10.39	1.45	425	47.4	209	0.152
	Paragrass	Hot	0.254	2.01	0.719	0.283	0.286	7.56	1.95	753	35.2	362	0.088
Heifers	Paragrass	Rainy	0.191	2.61	0.404	0.181	0.316	7.12	3.47	1,345	31.4	170	0.160
	Paragrass	Hot	0.149	2.89	0.468	0.271	0.451	10.56	1.61	484	42.2	107	0.068
	Concentrate A[1]		0.590	1.02	0.908	0.311	0.798	17.69	1.26	275	100.1	141	1.044
	Concentrate B[2]		0.271	1.02	0.785	0.298	0.598	12.82	0.84	239	77.6	111	0.370
							Requirement[3]						
Lactating cow[4]			0.18	0.90	0.43	0.20	0.28	10	–	50	40	40	0.30
Dry cow			0.10	0.65	0.39	0.16	0.24	10	–	50	40	40	0.30
Heifer			0.10	0.65	0.39	0.16	0.24	10	–	50	40	40	0.30

[1] Supplemented for lactating cows.
[2] Supplemented for dry cows and heifers.
[3] Source : NRC standard for dairy cattle (1989).
[4] The performance is 400 kg liveweight, 7 kg/day milk yield, 5.0% milk fat concentration and 0.22 kg/day gain.

The concentrations of Ca, Mg and Se from plasma samples of buffalo were higher than those of beef cows ($p < 0.01$). The plasma Cu concentrations of buffalo were much lower than those from beef cows in contrast ($p < 0.01$). The higher plasma Mg and the lower plasma Cu levels of buffalo than those of cattle corresponded with

TABLE 4. MINERAL CONCENTRATIONS (MEANS AND SEM) IN BLOOD PLASMA OF ANIMALS FROM BEEF CATTLE STATION

Herds	Seasons	N	Ca	Mg	Pi	Cu	Zn	Se
			.... (mg/dl)		....	.... (μg/ml)		....
Lactating cows	Rainy	10	9.45(0.11)	2.23(0.05)	6.23(0.12)	0.86(0.07)	0.77(0.05)	0.065(0.003)
	Hot	10	9.70(0.16)	1.96(0.07)	5.36(0.24)	0.75(0.06)	0.85(0.06)	0.085(0.002)
Dry cows	Rainy	10	9.51(0.13)	1.97(0.04)	5.50(0.24)	0.71(0.08)	0.77(0.02)	0.051(0.004)
	Hot	10	9.42(0.36)	1.83(0.11)	4.99(0.18)	0.89(0.06)	0.78(0.05)	0.069(0.002)
Heifers	Rainy	10	9.80(0.10)	2.18(0.04)	6.59(0.31)	0.59(0.05)	0.83(0.03)	0.053(0.003)
	Hot	10	9.94(0.16)	2.00(0.05)	6.38(0.40)	0.58(0.08)	0.85(0.05)	0.065(0.003)
					Significance			
Herds			NS	**	**	**	**	**
Seasons			NS	**	*	NS	**	**
Herds × Seasons			NS	NS	NS	NS	NS	NS

* $p < 0.05$, ** $p < 0.01$ and NS : not significant.

TABLE 5. PERCENTAGES OF THE PLASMA SAMPLES OF ANIMALS FROM BEEF AND DAIRY CATTLE STATIONS SHOWING MINERAL CONCENTRATIONS BELOW CRITICAL LEVELS[1]

Herds	Seasons	Ca	Mg	Pi	Cu	Zn	Se
		...... Beef cattle station					
Bra × Nat	Rainy	0	0	0	0	0	20
	Hot	0	0	10	30	0	30
Cha × Nat	Rainy	0	0	11	11	0	0
	Hot	0	0	10	70	0	10
Cha × (Bra × Nat)	Rainy	0	0	0	70	0	0
	Hot	0	0	10	80	0	80
Native	Rainy	0	0	0	0	0	0
	Hot	0	0	30	10	0	10
Buffalo	Rainy	0	0	20	100	0	0
	Hot	0	0	10	100	0	0
		...... Dairy cattle station					
Lactating cows	Rainy	0	0	0	10	0	0
	Hot	0	0	0	40	0	0
Dry cows	Rainy	0	0	0	30	0	0
	Hot	0	0	20	0	0	0
Heifers	Rainy	0	0	10	60	0	0
	Hot	0	0	10	60	0	0

[1] Critical levels of Ca, Mg, Pi, Cu, Zn and Se are 8 mg/dl, 1 mg/dl, 4.5 mg/dl, 0.65 μg/ml, 0.6 μg/ml and 0.03 μg/ml, respectively, according to McDowell et al. (1985).

the results in a previous survey (Hayashi et al., 1985). The high plasma Se concentrations of buffalo might have been caused by the comparatively high Se concentration in pasture grazed. Except for the plasma Se concentrations, the differences of plasma mineral concentrations between buffalo and beef cows could not be explained by the variety of mineral concentrations in pasture since the concentrations of Ca, Mg, Cu and Fe in pasture grazed by buffalo were not largely different from those grazed by cattle. Physiological differences of metabolism of these minerals between species might have caused the differences of plasma mineral concentrations.

Dairy cattle

Mineral concentrations in feed samples from dairy cattle station are in table 3. The concentrations of Na, K and Mn in pasture samples from each field for animals were higher than NRC standard (1989). The range of Fe concentrations in pasture samples was from 425 to 1,345 mg/kg. The concentrations were higher than 400 mg/kg that influenced Cu metabolism in cattle (Standish et al., 1969).

The concentrations of Ca, Mg, P, Cu and Zn in several pasture samples were lower than the requirement. On the total feed basis, however, the concentrations of these minerals were similar to or higher than the reguirement since the contents of these minerals in concentrate were much higher than those in pasture.

Mineral concentrations in plasma samples of animals from dairy cattle station were shown in table 4. Although the P concentrations in pasture samples during the hot season were not always lower than those during the rainy season, the Pi concentrations of plasma samples from each herd decreased in the hot season ($p < 0.01$). Besides the plasma Pi concentrations in animals from the beef cattle station, the cause of seasonal change of the plasma Pi concentrations in animals from the dairy cattle station was not clear.

Forty percent of samples from the lactating cows during hot season, 30% of samples from the dry cows during rainy seasons and 60% of samples from the heifers during both seasons showed lower plasma Cu concentrations than the critical level (table 5). The low Cu status of animals might have been due to the high Fe concentrations in rations.

No plasma samples showed lower Se concentrations below the critical level (table 5). Judging from plasma Se concentrations, there was little possibility that the animals in dairy cattle stations might be deficient in Se. The plasma Se concentrations of lactating cows were higher than those from dry cows and heifers ($p < 0.01$). The high Se concentrations in concentrate fed to lactating cows is likely to be reflected in their plasma Se concentrations.

No cows showed lower plasma Ca, Mg, and Zn concentrations than the critical levels for cattle (table 5). Judging from the concentrations of rations and blood plasma of animals, Na, K, Ca, Mg, Fe, Zn and Mn in the rations were likely to be sufficient for lactating cows, dry cows and heifers.

Conclusion

Vijchulata et al. (1983) examined mineral status of native cattle in villages in central Thailand fed on native grass. Thirty five percent, 23%, 8%, 85% and 8% of the forage samples showed the Na concentrations below 0.06 %, the P concentrations below 0.18%, the Fe concentrations below 100 mg/kg, the Cu concentrations below 10 mg/kg and the Zn concentrations below 10 mg/kg, respectively. The average concentrations of Ca, Mg, Pi, Cu and Zn in blood plasma from cattle were 10.2 mg/dl, 2.31 mg/dl, 7.79 mg/dl, 0.4 μg/ml and 1.2 μg/ml, respectively. The study indicated that the Na, P and Cu concentrations in feedstuff particularly tended to be insufficient for the cattle. In the present study, not only native cattle grazed on native grass but crossbred beef cattle grazed on improved grass and dairy cattle fed with improved grass and concentrate were examined. Possibilities of the deficiencies of K, Ca, Mg, P, Fe, Zn and Mn of the beef and dairy cattle were likely to be low since the mineral concentrations in diet and/or plasma samples were normal. On the other hand, a pasture sample of which Na concentration was much lower than the requirement existed. The cattle would be deficient in Na if Na supply from the mineral blocks was limited. Marginal Cu and Se concentrations in pasture and subnormal plasma Cu and Se concentrations were observed. Thus attention should be paid to the deficiency in Na, Cu and Se of animals even in the new management systems of cattle and grassland in central Thailand.

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