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Studies on the Trace Elements in Soil-Plant-Animal System II. Comparison of mineral status of Kawatabi, Taneyama and Abukuma-kogen ranches.

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Summary

The status of minerals such as Cu, Zn, Fe, Ca and Mg of herbage and cattle blood was surveyed in Abukuma-kogen, Taneyama and Kawatabi farm of Tohoku University which were in the typical large grazing fields located in the mountain region of Tohoku district in Japan. The mineral circumstances for livestock differed among these stock farms although the mineral contents in herbage and blood of cattle were within the range of normal. The variation of Cu was the most remarkable of the minerals in both herbage and blood. Abukuma-kogen had a good mineral status for livestock compared with the others. The precautions should be taken in the future for prevention of Cu deficiency of livestock in Kawatabi and Cu and Mg deficiency in Taneyama.

Our previous paper (1) showed that the grazing cattle at Kawatabi farm of Tohoku University exhibited a subclinical Cu deficiency derived from low levels of available Cu in soil of the grazing field. It has been also known that such soil is widely distributed in upland fields in Japan (2, 3).

Recently many large grasslands have been improved in Tohoku district in Japan and used for grazing and mowing for forage of livestock. It can be presumed that the mineral circumstances for grazing livestock differed among those stock farms because of the variety of soils and field management methods.

The present investigation was carried out in order to obtain information on the status of minerals such as Cu, Zn, Fe, Ca and Mg of herbage and livestock in the typical large grazing fields located in the mountain region of Tohoku district in Japan.

Materials and Methods

This study was carried out at three stock farms: Abukuma-kogen, Fukushima Prefecture, in the Abukuma mountain region; Taneyama, Iwate Prefecture, in Kitakami mountain region; and Kawatabi farm of Tohoku University, Miyagi Prefecture, in the Ohu range, which were in different localities of Tohoku district in Japan. The blood samples of cattle were collected from twenty grazing heifers (ten Japanese Blacks and ten Holsteins) at each farm and herbage samples were collected from five spots in each pasture. Main herbage species in every pasture were orchard grass and white clover. Consequently, orchard grass and white clover were collected from all farms, but red top was only collected from Taneyama and Kawatabi, timothy from Taneyama and Abukuma-kogen, meadow fescue from Taneyama and reed canarygrass from Abukuma-kogen, respectively. Sampling dates were 4 September at Abukuma-kogen (herbage and cattle blood), 18 September at Taneyama (herbage and blood), and 13 August and 27 September (herbage) 21 August, 1973, (blood) at Kawatabi farm. Minerals such as Cu, Zn, Fe, Ca and Mg in herbage and blood samples were determined with the atomic absorption flame photometer as reported previously (1).

TABLE 1. *Mineral concentrations of herbage in Kawatabi, Taneyama and Abukuma-kogen.*

	Cu ppm	Zn ppm	Fe ppm	Ca %	Mg %
Kawatabi					
Orchard grass ¹⁾	6.0±1.6	53.5± 5.9	110±16	0.25±0.05	0.32±0.04
Orchard grass ²⁾	5.0±1.4	60.9± 3.8	116±13	0.28±0.00	0.35±0.10
Red top ¹⁾	6.6	28.8	113	0.39	0.28
Red top ²⁾	4.1	32.8	113	0.56	0.42
White clover ¹⁾	3.7±0.7	46.5± 3.7	138±40	0.81±0.12	0.43±0.03
White clover ²⁾	3.1±0.7	56.7±12.2	107±21	0.82±0.13	0.36±0.04
Taneyama					
Orchard grass	8.1±1.1	31.7± 3.0	102±10	0.21±0.06	0.15±0.03
Timothy	7.2	36.4	121	0.27	0.14
Red top	6.0	42.8	108	0.29	0.13
Meadow fescue	8.9	45.9	99	0.26	0.16
White clover	6.8±2.0	30.4± 4.3	94±10	1.27±0.28	0.22±0.03
Abukuma-kogen					
Orchard grass	7.8±0.8	23.4± 2.4	110±10	0.20±0.05	0.20±0.03
Timothy	5.6	26.6	191	0.21	0.09
Reed canary grass	8.6±2.3	32.7± 3.7	90± 6	1.19±0.07	0.32±0.04
White clover	6.8±1.4	30.8± 3.1	105± 7	0.99±0.12	0.27±0.00

1) was sampled on 13 August

2) was sampled on 27 September

Results and Discussion

1. Minerals in plants

As shown in Table 1, the mean mineral concentrations in herbage differed among herbage species and localities of sampling. Cu concentrations in herbage ranged from 3.1 to 8.9 ppm and Cu more than 8.0 ppm was found in orchard grass and meadow fescue of Taneyama and in reed canarygrass of Abukuma-kogen. Cu in orchard grass and white clover, the main herbage species in Tohoku district, were in the following order: Taneyama > Abukuma-kogen > Kawatabi. Cu in herbage of Kawatabi was distinctly lower than the others ($P < 0.05$ for orchard grass, $P < 0.005$ for white clover). The Cu level in herbage satisfied the minimum requirement by Japanese Feeding Standard (4, 5) for beef cattle except white clover of Kawatabi, but not for dairy cattle in all of the herbage species collected from every pasture, although Cu in herbage went up to high levels through the summer into early autumn as shown in the previous paper (1). Zn concentrations ranged from 23.4 to 60.9 ppm. Zn in orchard grass and white clover were in the following order: Kawatabi > Taneyama > Abukuma-kogen, and Zn in herbage of Kawatabi was particularly high. The Zn level in all of the herbage satisfied minimum requirements for beef cattle, but not for dairy cattle in red top of Kawatabi, orchard grass and timothy of Taneyama and all of the herbage species of Abukuma-kogen. Fe concentrations ranged from 90 to 138 ppm and were particularly high in white clover of Kawatabi and timothy of Abukuma-kogen. Fe levels in all herbage satisfied the minimum requirement for both beef and dairy cattle. Ca and Mg concentrations of herbage were higher in legumes than in grasses of every pasture. Ca in orchard grass ranged from 0.20 to 0.28% in the order of Kawatabi > Taneyama > Abukuma-kogen, but the difference among stock farms can not be regarded as significant. On the other hand, Ca in white clover ranged from 0.81 to 1.27% in the order of Taneyama > Abukuma-kogen > Kawatabi, and the difference between Kawatabi and the others was significant ($P < 0.005$). The Ca content of herbage in every pasture satisfied the minimum requirement for beef cattle but not for dairy cattle in the stage of lactation. Mg concentrations ranged from 0.15 to 0.35% in orchard grass and 0.22 to 0.43% in white clover and those of both herbage species were in the order of Kawatabi > Abukuma-kogen > Taneyama. Mg in herbage of Taneyama was particularly low. Although this level of Mg satisfied the minimum requirement for both beef and dairy cattle, precautions should be taken against Mg deficiency of livestock in the future.

According to measurement of extractable Cu with 1 N HCL and Zn with 0.1 N HCL in soil, the mean Cu was 1.6 in Kawatabi, 5.0 in Taneyama and 4.5 ppm in Abukuma-kogen, and Zn was 3.2, 2.8 and 0.6 ppm, respectively. The available Cu in soil was the lowest in Kawatabi and Zn in Abukuma-kogen. These agreed

with the order of Cu and Zn level of herbage among stock farms. It is considered that the difference of content of trace minerals, such as Cu and Zn, in herbages among farms was mainly derived from the different character of soils, but the concentration of major minerals such as Ca and Mg was affected the difference of field management among farms.

2. Minerals in blood of cattle

The mineral concentrations in whole blood of cattle of both Holstein breed and Japanese Black breed were surveyed. Their mean values are shown in Table 2. Cu in blood ranged from 71 to 97 $\mu\text{g}/\text{dl}$ in Holsteins and from 72 to 104 $\mu\text{g}/\text{dl}$ in Japanese Black breed in the following order: Abukuma-kogen > Taneyama > Kawatabi for both breeds. There were significant differences between Abukuma-kogen and the others ($P < 0.05$) in Holsteins, and between Abukuma-kogen and Taneyama ($P < 0.05$) in Japanese Blacks, respectively. The differences between Kawatabi and Taneyama were not significant for either breed. Blood Cu concentrations between 70 and 110 $\mu\text{g}/\text{dl}$ are accepted as characteristic of the normal copper status of cattle (6). Consequently, it was recognized that the cattle of Kawatabi and Taneyama were in the lower part of normal Cu status based upon the concentration of Cu found in the blood. Zn concentrations in blood ranged from 240 to 320 $\mu\text{g}/\text{dl}$ in Holstein breed and 260 to 360 $\mu\text{g}/\text{dl}$ in Japanese Black breed in the following order: Abukuma-kogen > Kawatabi > Taneyama for both breeds. There were significant differences between Abukuma-kogen and the others ($P < 0.05$) in Holsteins and between Taneyama and Abukuma-kogen ($P < 0.005$) in Japanese Blacks, respectively. Fe concentrations in blood ranged from 27.7×10^3 to 35.4×10^3 $\mu\text{g}/\text{dl}$ in Holsteins and 34.0×10^3 to 42.3×10^3 $\mu\text{g}/\text{dl}$ in Japanese Blacks in the following order: Abukuma-kogen > Taneyama > Kawatabi for both breeds. There were significant differences between Kawatabi and Abukuma-kogen ($P < 0.005$) in Holsteins, and between Kawatabi and Abukuma-kogen ($P < 0.005$) and between Taneyama and

TABLE 2. Mineral concentrations in blood of cattle grazed in Kawatabi, Taneyama and Abukuma-kogen.

(μg per dl)

		Cu	Zn	Fe	Ca	Mg
Kawatabi	H	71 \pm 8	250 \pm 20	27.7 \pm 2.0 $\times 10^3$	65.8 \pm 2.0 $\times 10^2$	23.8 \pm 0.9 $\times 10^2$
	J.B.	72 \pm 16	310 \pm 60	34.0 \pm 3.6 $\times 10^3$	60.8 \pm 3.0 $\times 10^2$	22.0 \pm 0.8 $\times 10^2$
Taneyama	H	76 \pm 4	240 \pm 50	30.8 \pm 3.4 $\times 10^3$	64.0 \pm 2.2 $\times 10^2$	22.2 \pm 1.6 $\times 10^2$
	J.B.	74 \pm 9	260 \pm 80	35.1 \pm 4.6 $\times 10^3$	59.0 \pm 3.7 $\times 10^2$	20.7 \pm 1.3 $\times 10^2$
Abukuma-kogen	H	97 \pm 21	320 \pm 70	35.4 \pm 2.2 $\times 10^3$	66.4 \pm 2.4 $\times 10^2$	22.4 \pm 1.3 $\times 10^2$
	J.B.	104 \pm 38	360 \pm 60	42.3 \pm 2.4 $\times 10^3$	60.2 \pm 2.6 $\times 10^2$	21.5 \pm 1.5 $\times 10^2$

H: Holstein breed J.B.: Japanese Black breed

Abukuma-kogen ($P < 0.005$) in Japanese Blacks. Ca concentrations in blood ranged from 64.0×10^2 to 66.4×10^2 $\mu\text{g}/\text{dl}$ for Holsteins and 59.0×10^2 to 60.8×10^2 $\mu\text{g}/\text{dl}$ for Japanese Blacks. Mg concentrations ranged from 22.2×10^2 to 23.8×10^2 $\mu\text{g}/\text{dl}$ for Holsteins and 20.7×10^2 to 21.5×10^2 $\mu\text{g}/\text{dl}$ for Japanese Blacks. There were no significant differences in Ca and Mg concentrations in blood among stock farms. In comparison with that of Holsteins, the blood of Japanese Blacks was richer in Cu, Zn and Fe, but poorer in Ca and Mg.

The results showed that the mineral conditions for livestock differed among stock farms which were in different localities of the Tohoku district, although the mineral content in herbage satisfied the minimum requirement for livestock and that in blood of cattle was also normal (6, 7). The variation of Cu was the most remarkable of all the minerals surveyed in this study. Abukuma-kogen had a good mineral status for livestock compared with the others. Measures to prevent deficiency of Cu in livestock in Kawatabi and of Cu and Mg in Taneyama are recommended, but there is yet no clinical sign of deficiency.

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