MINERAL STATUS OF GRAZING PHILIPPINE GOATS
Ⅱ. THE NUTRITION OF SELENIUM, COPPER AND ZINC OF GOATS IN LUZON ISLAND

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Summary

Nutritional status of trace minerals (Se, Cu and Zn) in goats grazed on the native pasture was investigated during 2 years in Luzon Island, Republic of the Philippines. Three regions (South, Central and North) were objected to collect the samples of blood of goats and forages on the pasture. Se content of major species forages in the pasture was 24.7 μg/kg DM, and was clearly lower than the value (200 μg/kg DM) required commonly for ruminant feed. The Cu and Zn contents of all forage samples ranged from 7.6 to 24.3 and 11.4 to 50.6 mg/kg DM, respectively, and these values almost exceeded the dietary level required for sheep. The blood Se levels in about 55% of goats grazed alone were under the normal range (20 μg/l), but it in goats fed some concentrates as a supplement were almost within a normal ranges (20-200 μg/l). Plasma Cu levels of some goats with or without supplements were under the critical level (0.6 mg/l), though the Cu content of forages almost exceeded the dietary level required commonly. The 4-13% of plasma samples of goats without supplement showed the Zn level below the lower limit (0.6 mg/l) of normal range. The Zn deficiency was mostly improved by the addition of a small amount of concentrates. From these results, it will be necessary to study about unstable Cu status of grazed goats in Luzon Island regarding an interaction of Cu and other elements known to relate to the malabsorption of dietary Cu.

(**Key Words**: Grazed Goats, Dietary Se, Cu and Zn, Plasma Se, Cu and Zn, Luzon Island of the Philippines)

Introduction

In tropical and/or subtropical areas of the world, the ruminant feeding largely depends on the native grasses and some of agro-by-products. It is well known in general that heavy rainfall, which is a characteristics of the climate in the tropics, induces a fairly losses of minerals from the soil on which the herbages of the pastures to be consumed by grazed ruminants are grown. Thus, the grazed animals are easily exposed to the danger of deficiency of some minerals under these conditions (McDowell, 1985a). In the tropical Asia, it has been reported that some of cattle grazed on a native grassland appear to be deficient for some macro and/or micro minerals (Vijchulata et al., 1983; Hayashi et al., 1985). Kumagai et al. (1990) have reported the nutritional status of trace minerals of cattle grazed in Java, Indonesia by evaluating trace mineral concentrations in diets, liver and blood plasma samples. Their investigation indicates that there are relatively low Cu and Zu concentrations in the diets, and then the levels of them in the blood plasma of grazing cattle show a deficiency.

Regardless goats are very important farm animal in tropical and sub-tropical areas, in particular in Asia, available information about trace mineral status of them is limited. Nutritional status of Selenium (Se), Cu and Zn of grazing goats in Luzon Island of Philippines are described using the results on Se, Cu and Zu levels in diet and blood samples collected for 2 years. A brief acount of part of the present work has been published (Shimizu et al., 1989).

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Materials and Methods

Location and season for investigation

The regions in Luzon Island objected were 3 as follows; Los Banos (Southern area), Munoz, Nueva Ecija (Central area) and Baguio (Northern area). As shown in table 1, the sampling of forage and the blood of goats had been done in the 3 experimental stations as follows; University of the Philippines at Los Banos (UPLB), Central Luzon State University (CLSU) and Baguio Dairy Farm (BDF).

Luzon Island is in a sub-tropics, and thus, the climate is a monsoon type, i. e., there are two typical seasons of dry (October-June) and rainy (July-September). Thus, the most of grasses on pasture in flat areas usually wither on late of the dry season, if there are no irrigation systems. Baguio, however, is located on a mountainous area (about 1,000 m above sea level) being relatively low temperature and high rainfall throughout year, therefore, the withered grasses on pasture are very few even in dry season.

Conditions of the pastures and animals

The pastures of the 3 areas investigated in this study were the improved but left for a long time without any reforming. The dominant species of forages grazed by goats were Star-grass, Cogon and Napier grass, though there were some other species mixed as small groups. The most of pasture in Luzon Island generally have not been fertilized for long time.

The goats adopted in this investigation were basically grazed on the pasture in all seasons by tethering or freely fed. As shown in table 1, some of goats have been sometimes fed a small amount of concentrates such as rice bran, ground corn and/or their mixture. They also appeared to be given salt or other minerals throughout the year.

Sampling of blood and forages, and analytical methods

In this study, 122 healthy adult goats were sampled 10 ml of heparinized blood through the jagular vein. The forage samples were collected by a hand-picking method whenever the goats were blood-sampled on the pasture.

After wet digestion with nitric acid and perchloric acid, Se in whole blood and diets (forages and concentrates) was analyzed by the fluorometric method of Watkinson (1979), and Cu and Zn in plasma and diets by using an Inductively Coupled Plasma Emission Spectroscopy (ICPU-2000, Shimadzu Co. Kyoto, Japan).

Statistical analysis of the data was made by t-test.

Results and Discussion

As shown in table 2, the average value of all the samples was 24.7 μg/kg DM, and the values in any species investigated are clearly lower than the value (100-200 μg/kg DM) required commonly in the feed for ruminants (NRC, 1984). Se contents of Stargrass and Napier grass tended to be lower than those of other species. The two grasses are main species on the pasture in Luzon Island, and this would be probable reason for inducing an under-nutrition of Se in the goats grazed there. Thus, it could be easily understood that the grazing ruminants in Luzon

TABLE 1. LOCATION AND SEASON FOR COLLECTING SAMPLES

Region / Year	Los Banos (UPLB)[1]	Munoz (CLSU)[2]	Baguio (BDF)[3]
1988	March	September	–
	November	November	–
1989	March	March[4]	March[4]
	September	September[4]	September[4]
	November	November	November[4]

[1] University of the Philippines at Los Banos.
[2] Central Luzon State University.
[3] Baguio Dairy Farm.
[4] The blood-sampled goats were supplemented with some concentrates.

TABLE 2. MINERAL CONTENTS OF MAJOR SPECIES OF FORAGES GRAZED BY GOATS, AND OF CONCENTRATES (Se: μg / kg DM, Cu and Zn: mg / kg DM)

Forage species	No. of samples	Selenium	Copper	Zinc
Star grass (*Cynodon plectstachyum*)	8	16.3 ± 2.4[1] (9.4 – 27.4)[2]	16.5 ± 1.6 (11.7 – 24.3)	25.9 ± 3.1 (16.8 – 36.7)
Cogon grass (*Imperata cylindorica*)	4	27.4 ± 6.2 (18.1 – 44.2)	13.1 ± 1.9 (7.6 – 16.3)	28.4 ± 5.4 (21.6 – 44.2)
Napier grass (*Pennisetum purpureum*)	2	17.8 ± 5.7 (11.5 – 23.4)	16.4 ± 2.1 (14.3 – 18.5)	34.0 ± 3.9 (30.1 – 37.8)
Mixed samples	16	33.3 ± 2.8 (17.5 – 70.1)	14.1 ± 0.8 (10.4 – 21.3)	27.9 ± 2.6 (11.4 – 50.6)
Concentrates	3	108.3 ± 12.6 (83.3 – 130.7)	15.4 ± 0.9 (14.5 – 16.2)	60.2 ± 25.2 (35.2 – 85.1)

[1] Mean ± S.E. of number of samples.
[2] The figures in parenthesis are range of values.

Island should obviously require some Se supplementation by any means. The Cu content of forages was in a range from 7.6 to 24.3 mg/kg DM, and these figures were clearly higher than the lower limit of dietary Cu content (7.0 mg/kg DM) indicated for sheep by NRC (1985). Furthermore, the highest value in this study did not exceed the upper limit (maximum torelable level .25 mg/kg DM). The Cu contents of forages in the present study was comparable to that (7.1-20.2 mg/kg DM) reported by Kumagai et al. (1990), and that (8.99 + 4.6 mg/kg DM) reported by Hayashi et al. (1985), which measured with forages collected from pastures in Java and Medan, Indonesia.

According to NRC standard (1985), the requirement of Zn in the diet for sheep is in a range from 20 to 33 mg/kg DM, and the maximum tolerable level is 750 mg/kg DM. The overall mean of Zn content of forages in this study was 28.4 ± 1.1 mg/kg DM (mean ± S.E.), and it stays within the range as normal level of diet for sheep presented by NRC (1985). The values as an average in each grass (table 1) are fairly lower than that reported by Kumagai et al. (1990): the Zn contents of forages (41 samples) in 3 places of Java, ranged from 36.9 to 58.6 mg/kg DM. Hayashi et al. (1985) also reported a wide range (9.5-462.5 mg/kg DM) in Zn contents of forages collected from pasture around Medan.

Table 3 shows the seasonal changes in Se, Cu and Zn contents of mixed forages collected in the 3 regions. In each region, Se contents of forages are also lower in both dry and rainy season than that required in the feed for ruminants (NRC, 1984). The Cu contents of forage diets were almost similar in both rainy and dry seasons at all the 3 regions. The overall mean of Cu content in forages collected in all the 3 regions was 14.5 + 0.9 mg/kg DM, and this value seemed to be a little higher than that (12.6 mg/kg DM) observed by Kumagai et al. (1990) using 41 samples collected in Java. They found no significant seasonal variation in both rainy and dry seasons. The dietary Cu level estimated in this study might satisfy the requirement of goats, and also it would not exceed the toxic level suggested by NRC (1985). The Zn contents of forages tended to be lower in rainy season than in dry season at all the regions investigated. Kumagai et al. (1990) also reported the Zn contents of forages were slightly higher in dry season than in rainy season at 2 places, but at another place, it was high conversely in rainy season at Java. They also reported no significant differences of Zn contents in forages among 3 regions objected for collecting samples.

In the group of goats without any supplements, blood Se level in about 55% of goats

TABLE 3. SEASONAL CHANGES IN MINERAL CONTENTS OF FORAGES IN 3 REGIONS (Se: μg/kg DM, Cu and Zn: mg/kg DM)

Region	Season	No. of samples	Selenium	Copper	Zinc
Los Banos	Rainy	4	22.2 ± 2.1[1] (10.0 – 35.2)[2]	17.2 ± 1.5 (14.3 – 18.9)	23.9 ± 3.7 (11.4 – 44.2)
	Dry	8	32.5 ± 4.5 (10.7 – 70.1)	16.3 ± 1.3 (12.1 – 24.4)	30.8 ± 5.6 (21.7 – 40.8)
Munoz	Rainy	4	19.0 ± 7.9 (18.9 – 28.5)	14.5 ± 1.7 (10.4 – 18.7)	27.8 ± 6.0 (16.8 – 38.6)
	Dry	6	27.8 ± 6.2 (18.8 – 47.1)	15.0 ± 1.7 (10.7 – 16.8)	31.3 ± 4.1 (25.3 – 50.6)
Baguio	Rainy	4	25.3 ± 2.1 (19.4 – 30.8)	12.3 ± 0.5 (11.2 – 13.1)	26.9 ± 4.3 (19.4 – 30.8)
	Dry	4	16.2 ± 2.5 (9.4 – 20.6)	11.8 ± 1.4 (7.6 – 13.8)	29.7 ± 4.0 (22.3 – 36.7)

[1] Mean ± S.E. of number of samples.
[2] The figures in parenthesis are range of values.

objected were below normal range (less than 20 μg/l), and that in 8% of goats were clearly lower than the level as the lowest criteria for the diagnosis of Se deficiency (10 μg/l). (table 4) Furthermore, the levels observed in rainy season were significantly ($p < 0.01$) lower than those in dry season at both of Los Banos and Munoz. According to McDowell (1985b), during rainy season both plant growth and the body weight of grazing animal on pasture increase comparably, because a plenty of grasses grown. Consequently, the requirements of minerals in animal body obviously increase with an increased body mass. During dry season, however, the plant growth in clearly suppressed by a lack of water, and then the growth rate of grazing animals is also limited by a shortage of grasses on the pasture. Consequently, the requirements of minerals in animal body decrease obviously. Thus, it can be presumed that the blood Se level of grazing animals will be low in rainy season, and also tended to be high in dry season on tropical or sub-tropical area. In the goats with some supplement, some were still in shortage of Se, although the Se content of supplements was 108.3 mg/kg DM on average, being a level which meets Se requirement in ruminant. This would be due to an unequal intake of supplements within individuals in group feeding. It is clearly shown, however, that the small amount of concentrate supplement can improve Se status of goats grazed on the pasture (table 4).

In groups of goats without supplement, plasma Cu level tended to be higher in dry season than in rainy season at Los Banos, whereas in Munoz no seasonal change in the plasma level of Cu was found. In the supplemented groups, plasma Cu level on average tended to be higher in dry season than in rainy season at Munoz, whereas it was fairly lower in dry season than in rainy season at Baguio. The most average values of plasma Cu in table 4 were within a normal range suggested by Kaneko (1989) (0.58-1.60 mg/l of goat plasma), NRC (1984) (more than 0.6 mg/l of cattle plasma) and NCMN (1973) (0.6-1.5 mg/l of sheep and cattle plasmas). As one can see in table 4, however, when goats were not supplied concentrates, 25% of samples in rainy season at Los Banos showed the plasma Cu level below the lower limit of normal range (0.6 mg/l). When the goats were supplied some concentrates, 15% of samples in rainy season at Munoz and 47% of samples in dry season at Baguio also showed the plasma Cu level below the lower limit mentioned above. Although the normal range is relatively wide, plasma level of Cu also obviously

TABLE 4. SEASONAL CHANGES IN MINERAL CONCENTRATIONS OF PLASMA OF GOATS WITH OR WITHOUT SUPPLEMENTS (Se: μg/l, Cu and Zn: mg/l)

Region	Season	No. of samples	Without supplement			With supplement[4]		
			Selenium (20)[5]	Copper (0.6)	Zinc (0.6)	Selenium (20)	Copper (0.6)	Zinc (0.6)
Los Banos	Rainy	8	14.3 ± 5.3[ab] (5 – 21)[2] (87.5)[3]	1.10 ± 0.15 (0.41 – 1.70) (25)	1.88 ± 0.27 (0.89 – 3.16) (0)	– – –	– – –	– – –
	Dry	29	29.3 ± 14.6[b] (3 – 66) (34.1)	1.30 ± 0.05 (0.77 – 1.52) (0)	1.02 ± 0.09 (0.49 – .95) (0)	– – –	– – –	– – –
Munoz	Rainy	16(13)[6]	7.3 ± 2.8[c] (9 – 19) (100)	1.12 ± 0.08 (0.62 – 1.59) (0)	1.02 ± 0.05(13)[7] (0.66 – 1.47)(12)[6] (0)	54.1 ± 38.3[d] (9 – 144) (16.6)	1.00 ± 0.09 (0.41 – 1.70) (15)	1.03 ± 0.04 (0.64 – 1.22) (0)
	Dry	23	27.3 ± 12.8[de] (7 – 56) (56.6)	1.12 ± 0.07 (0.63 – 1.80) (0)	1.38 ± 0.48 (11) (0.42 – 4.46) (12) (13)	68.3 ± 16.3[f] (43 – 103) (0)	1.16 ± 0.04 (0.97 – 1.44) (0)	1.69 ± 0.09 (1.29 – 2.32) (0)
Baguio	Rainy	9	– – –	– – –	– – –	41.3 ± 29.1 (7 – 91) (33.1)	1.25 ± 0.05 (0.97 – 1.43) (0)	1.72 ± 0.06 (1.49 – 2.01) (0)
	Dry	15(16)[6]	– – –	– – –	– – –	53.3 ± 26.1 (7 – 110) (12.6)	0.65 ± 0.66 (0.28 – 1.09) (47)	1.23 ± 0.15 (0.65 – 2.08) (0)

[1] Mean ± S.E. of number of goats used.
[2] The figures in parenthesis are range of values.
[3] Percentage of blood samples less than the lower limit in plasma level.
[4] The goats were supplemented some concentrates.
[5] The lower limit suggested by NRC (Se, Cu) (1984) and McDowell (Zn) (1985).
[6] The number of samples for Se analysis.
[7] The number of goats used with supplement in Munoz.
a-b, c-d, e-f: Significantly different ($p < 0.01$).

reflect the dietary Cu status. Thus it may be concluded that fairly number of goats grazed in Luzon Island were in a deficient Cu status regardless of season. As described above, the Cu contents of forages collected from 3 regions in Luzon Island have clearly satisfied the requirements for sheep, and thus, it would be assumed that the Cu absorption was affected by the presence of other elements (S or Mo), which influences clearly Cu absorption, in the diets, though these elements status in the diets and animals were not clarified in this study.

The average values of Zn level in plasma of goats with or without supplement in both rainy and dry seasons at all the 3 regions were obviously higher than the normal range reported by McDowell (1985c). As indicated in the table, however, in dry season 4 and 13% of samples of non-supplement groups in Los Banos and Munoz showed the plasma Zn level below the critical level (0.6 ml/l of ruminant plasma) described by McDowell et al. (1984). But the dietary Zn concentrations mostly exceeded the level required for diet of sheep suggested by NRC (1985). The low Zn level would be partly due to some increase in Zn losses from the skin of animal caused by hot temperature during dry season, because Zn excretion occurs through sweat, in particular, in tropical countries (McDowell, 1985c). In the supplement groups, no goats indicated the plasma Zn level lower than 0.6 mg/l regardless of the differences in season and region.

The values observed in this study were fairly high, as compared with the result of Kumagai et al. (1990), in which the plasma Zn level as overall mean was 0.87 ± 0.16 mg/l (mean $\pm$ S.E.) in 138 cattle in Java. They also described no significant seasonal and regional differences in plasma Zn level of cattle in Java. In the present investigation, also no clear differences were found in the plasma Zn levels in goats between seasons or among regions.

The Se contents of some plants except major species of forages in the pasture grazed by goats, in particular during dry season are presented (table 5). The leaves of Ipil-ipil are commonly used for ruminant feed as supplement in tropical areas, because of its high protein contents. Its Se content was quite high and it appeared to meet Se requirement of goats when intaked a certain amount. The other forages were not so popular as feed for goats in Luzon Island. In the Philippines, however, goats are often grazed on the field under the fruit trees (Coconut, Mango and Banana etc.), then they sometimes eat the fallen dried leaves of the fruit trees. The leaves of Coffee, Coconut and Santan flower, which contain relatively high Se, will be useful as an additive for feed of grazing goats after dried and ground. In dry season, the goats move often to search for any edible plants inconsiderably wide range, and then they might eat various plants under certain conditions. This diversity of plants consumed by goats in dry season might results in a relatively large variation of their blood Se level.

TABLE 5. SE CONTENTS OF SOME PLANTS OTHER THAN MAJOR SPECIES OF FORAGES GRAZED BY GOATS (μg / kg DM)

Name of plant	Se content
Ipil ipil (*Leucaena leuccephala*)	102
Coffee tree leaves (*Coffea arabica*)	100
Coconut leaves (*Cocos nucifera*)	97
Santan flower leaves	56
Monky jack fruit leaves (*Artocarpus heterophyllus*)	3
Banana leaves (*Musa sapientum*)	24
Mango leaves (*Mangifera indica*)	19
Rambutan leaves (*Nephelium lappaceum*)	12

In the present investigation, it is shown that most of grazing goats in the 3 regions tended to be deficient for Se, when they do not receive supplemental concentrates, and this is due to the quite low Se contents of dominant species of forages in pastures. In this country, the reproductive efficiency of goats are not so good, because mainly of their prolonged kidding cycle (Kanai et al., 1987). The results obtained in this study might related to the low reproduction of goats in Philippines, because of an important role of Se in reproductive physiology in animals (Hartley, 1963; Trinder et al., 1969; Wu et al., 1973, 1979). As mentioned above, Se deficiency in goats can be easily recovered by addition of small amounts of concentrates. The majority of small farmers in this area, however, concentrate feeding did not practice, except occasional feeding of some agricultural by-products for their animals. Thus, the other simple methods, such as using pelleted or capsuled supplements are desirable for supplying Se as well as other trace minerals to grazing ruminants. It can be also concluded that the nutritional status of Cu of goats grazed in Luzon Island might be clearly in an unsuitable situation. Further studies on Cu should be desirable to analyse the nutritional status of other elements such as Fe, S and Mo, which would influence the absorption of Cu in the diet.

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