MINERAL STATUS OF GRAZING SHEEP IN THE DRY AREA OF MIDLAND CHINA

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Summary

In the present study, nutritional status of some minerals in sheep grazed on native pasture was investigated in dry area, Ningxia district, of the People's Republic of China. Samples of some forages and blood of sheep were collected for two seasons, dry (March) and rainy (August) seasons. The Ca contents of forages (wheat straw, green-pea straw and some wild grasses) were relatively high as compared with that required ordinarily as standard, but on the contrary, the P content was much lower than that of standard. Consequently, Ca/P ratio was very high in most of the roughages sampled in the region. Trace elements, Cu and Zn, content of forage samples were fairly low, and the contents of Mo and Fe were fairly high, particularly in some wild grasses, when the values were compared with that required normally. The Ca level in blood of sheep was in a range accepted as normal, and the other macro minerals (Mg and P) were contained at relatively high levels as compared with the values observed ordinarily, but not at a toxic level. With trace minerals, the plasma Fe level was extremely high as compared with the standard level, although there were no disorders due to toxicity, and Mo level in plasma was a little lower than the lower limit described as a normal. The plasma levels of other trace elements (Cu, Zn and Se) in all the animals were within the range accepted as normal. There would be no clear differences in mineral nutrition of sheep between dry and rainy seasons. These results could suggest that there is no severe unbalance and/or imbalance, and grazing sheep in the Ningxia area of midland China have no problems relating to the nutritional status of minerals.

(**Key Words** : Mineral Nutrition, Grazed Sheep, Dry Area, Midland China)

Introduction

It is well documented that the mineral content of soil is very variable in the dry areas, tropic and/or sub-tropics of the world and, consequently, the mineral status of the herbages in the pasture could be obviously varied in these areas (McDowell, 1985a). In the dry areas of the world, the feeding of ruminants mostly depend on the native grasses and some of crop residues and agro-industrial by-products. Thus, grazed ruminants under these conditions may be exposed sometimes to the danger of deficiency and/or overintake of some minerals, i.e., some animals appeared to suffer mineral imbalance and/or unbalance (Vijchulata et al., 1983; Hayashi et al., 1985; Kumagai et al., 1990; Fujihara et al., 1992a, b). There are, however, few available information about mineral nutrition of sheep in dry area, in particular, in Asia. In this paper, the nutritional status of some macro and micro minerals of grazing sheep in dry areas of the People's Republic of China (PRC) are described using the results on the mineral level in main forages and blood samples of sheep collected for two seasons, dry and rainy seasons.

Materials and Methods

Location and season for the investigation

The region in midland China objected was Ningxia district, the area of Yellow Soil Table land (the riverside of Yellow River: Hwang Ho) as indicated in figure 1. The forages and blood of sheep (or goats) were sampled mainly at Prefectures in the region as indicated in table 1. The Ningxia district is in a relatively dry area in the middle of midland China (the eastnorth area: DONGBEI), i.e., rainfall may be 300-500 ml per year. Thus, most of the grasses in the pasture usually wither during winter (dry season). The region is also located on a hilly area (about 1,000-2,000 m above sea level). The cultivation of crops in a flat area is mainly maintained by irrigation from

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the Yellow River located in the Northeastern district of midland China. The investigations were done in March (19th-29th) and August (16th-28th), 1990.

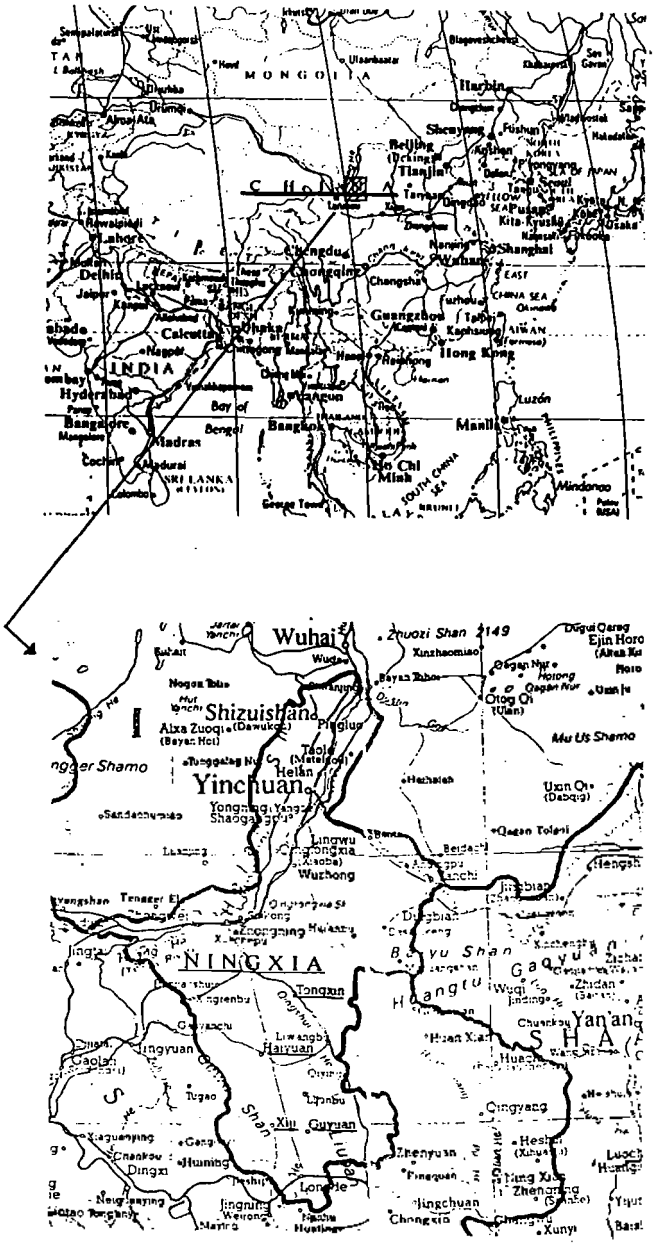

Figure 1. Location for collecting samples in Ningxia district, the People's Republic of China.

Conditions of pastures and animals

The pastures investigated in this experiment were mostly native grassland as shown in figure 2 without any managing through the year. The dominant species of forages grazed by sheep were Cogon (*Imperata cylindrica*), Eulalia (*Miscanthus sineniss*), Mugwort (*Artemisia indica*), and *Salola passerina* which is a peculiar plant in a desert area. Roughages fed to sheep during housing were mostly wheat straw and green-pea straw.

The sheep adopted in this study, in principle, were grazed in day-time, and during the night, were kept in a barn or backyard of the farm. Therefore, in some farms, the sheep receive some forages with small amounts of agro-industrial by-products, such as wheat bran, in the evening after coming back from grazing.

Figure 2. Sheep grazed on native grassland.

Sampling of blood and forages, and analytical methods

In the present investigation, 91 healthy sheep (mostly lamb: native in China, so called, Tan Yang: originally "fat tail sheep") were used in sampling 10 ml of heparinized blood through the jugular vein. Most of them (66 lambs blood-sampled in August) were also weighed using a carrying-type balance (AG 350, Tru-Test Distributors Ltd., New Zealand) before sampling blood, and also 59 lambs were blood-sampled along the road side or in the native pasture. The forage samples were collected by hand-picking method whenever the sheep were blood-sampled on the pasture, in backyard of the farm. However, the forage samples collected along the road side or in native pasture, where the blood of sheep was not sampled, are also cited in the same Table. Then, the values of nutrient contents of forage samples (table 1 and 2) and plasma mineral concentration in sheep (table 5) will not always be related directly.

After wet digestion with nitric acid and perchloric acid, Se in whole blood was analyzed by the fluorometric method of Watkinson (1970), and other minerals in blood plasma were analyzed after same digestion procedure using an Inductively Coupled Plasma Emission Spectroscopy (ICPS-2,000, Shimadzu Co., Kyoto, Japan).

TABLE 1. CHEMICAL COMPOSITION OF FORAGES (% OF DRY MATTER)

Forage species	Region	Organic matter	Crude protein	Crude fibre	Crude fat	N F E*
		(%)				
(March)#						
Wheat straw	Guyuan (A)**	90.5	3.0	42.2	1.2	44.1
Wheat straw	Guyuan (B)	91.3	3.2	39.4	1.0	47.7
Green-pea straw	Guyuan (A)	88.9	20.5	25.7	2.8	39.9
Green-pea straw	Guyuan (B)	90.7	10.8	38.6	1.7	39.6
Wild grass (*Salsola passerina*)	Tongxin	76.1	–	–	–	–
(August)#						
Wheat straw	Guyuan (C)	93.2	2.6	44.3	1.3	45.0
Green-pea straw	Guyuan (C)	93.4	5.5	51.0	1.9	35.0
Wild grass (Cogon, Eulalia, Mugwort)	Haiyuan (D)	83.6	10.8	31.2	4.3	37.2
Wild grass	Haiyuan	89.8	–	19.0	2.5	–
Wild grass	Xiji	75.3	13.3	21.5	3.0	34.8
Wild grass (*Salsola passerina*)	Yinchuan	74.5	14.7	18.0	1.9	36.3

Season when samples were collected.
* Nitrogen-free extract.
** Farm where samples were collected.

TABLE 2. MINERAL CONTENTS OF FORAGES (mg / kg DRY MATTER)

Forage species	Region	Calcium (Ca)	Magnesium (Mg)	Phosphorus (P)	Copper (Cu)	Iron (Fe)	Molybdenum (Mo)	Zinc (Zn)	Selenium** (Se)
(March)#									
Wheat straw	Guyuan (A)*	1,164.7	605.9	168.7	2.3	172.2	2.4	4.3	18.6
Wheat straw	Guyuan (B)	970.0	525.0	126.8	2.6	160.1	2.6	2.6	19.5
Green-pea straw	Guyuan (A)	9,260.2	2,542.8	745.4	6.8	415.3	13.3	13.9	31.7
Green-pea straw	Guyuan (B)	10,552.1	2,729.9	403.5	7.3	445.8	15.9	5.7	33.6
Wild grass (*Salsola passerina*)	Tongxin	3,789.4	9,249.9	1,015.3	11.5	3,594.7	52.6	29.6	116.9
(August)#									
Wheat straw	Guyuan (C)	1,490.5	668.9	37.8	1.9	159.1	3.8	2.1	12.0
Green-pea straw	Guyuan (C)	13,117.6	1,896.9	545.2	5.1	411.8	7.8	10.5	15.4
Wild grass (Cogon, Eulalia, Mugwort)	Haiyuan (C)	5,787.5	2,925.2	1,966.7	5.2	3,205.6	18.6	29.2	28.9
Wild grass	Haiyuan	5,688.3	1,601.3	1,005.3	7.8	3,180.1	7.6	23.6	29.6
Wild grass	Xiji	20,170.1	4,501.8	3,313.3	14.0	3,554.0	42.6	54.0	65.1
Wild grass (*Salsola passerina*)	Yinchuan	13,053.3	240.3	2,426.3	10.7	2,255.6	96.3	44.7	84.9

Season when samples were collected.
* Farm where samples were collected.
** μg/kg dry matter.

The same method was adopted for analysis of the minerals in forage samples after drying (60℃, 48 hrs) and grinding them.

Nitrogen in the forages were analyzed by the Kjeldahl method, and the contents of crude fibre, crude fat and crude ash in the forages were determined according to AOAC method (Hoitz, 1960).

Results and Discussion

The nutrient contents of forage feed

Table 1 shows the chemical composition of wheat straw and green-pea straw, which will be the main roughages for sheep during winter season (dry season), and of some wild grasses collected on the pastures where the sheep were grazed. As recognized generally, the content of crude protein in wheat straw was very low, the crude fibre content was quite high, i.e., the quality of wheat straw as roughage feed was very similar to that of rice straw (Lili Warly et al., 1992a, b). Although there will be wheat straw abundantly, supplementation with some agro-industrial by-products, such as wheat bran, will be also needed to improve the utilization of them as roughage feed for sheep. On the other hand, the green-pea straw (dried) contained relatively more crude protein and smaller amounts of crude fibre, than those contained in wheat straw, though there was a quite big variation in quality of the green-pea straw among the farms where the samples were collected. The green-pea straw, in any case, could be thought to be a good quality roughage-feed for sheep during winter season, if they could be managed in a good manner, such as drying after harvesting beans.

As shown in table 1, the pasture grasses, harvested at the border of field, consisting of Cogon, Eulalia and Mugwort, were of fairly good quality as roughage feed (Farm D, Haiyuan prefecture). The quality of pasture grasses, however, would be markedly changed with change in their growth stage (McDonald et al., 1973), i.e., a relatively early growing stage will be a better time to use them.

As shown in table 2, the contents of minerals in forages fairly changed among species and also the area where they were sampled in, and this could be mainly due to the difference in mineral contents of the soil on which the herbages were grown. Concerning the mineral contents of forages, it will be better to discuss and/or compare the contents of minerals in the forages with the amounts required generally in the feed (such as a feeding standard). The amounts (or extent) of some minerals required in the feed for sheep (NRC, 1985) were extracted as in table 3. The calcium contents of green-pea straw were quite high as compared with that of standard, and this would be due to the characteristics of legume plant accepted generally (Cullison, 1979). The levels of green-pea straw listed in table 3 are obviously higher than that required for feeding of sheep if they are fed alone to sheep during the year. The calcium content of some other forages were also high as compared to the standard. These findings would show that the Ca content of soil seems to be fairly high in the areas investigated in this study (McDowell, 1985b). The content of phosphorus in all the forages collected in the present investigation tended to be lower than that required generally, and the ratio of P to Ca (Ca/P) was fairly high. If the sheep in those areas do not receive any supplements of concentrate, they will suffer from some diseases due to P deficiency. In some forages (wild grasses), the Mg contents were quite high, whereas its level in wheat straw was fairly low as compared to the requirement (see table 3). The Mg content of green-pea straw was within the range required as standard.

TABLE 3. MINERAL REQUIREMENTS OF SHEEP* (mg / kg OF DIET DRY MATTER)

Nutrient	Requirement	Maximum Tolerable Level
Calcium	2,000 - 8,200	20,000#
Magnesium	1,200 - 1,800	4,000#
Phosphorus	1,600 - 3,800	10,000
Ca/P	1.0 - 1.6	
Copper	7.0 - 11.0	25.0
Iron	30 - 50	500
Molybdenum	0.5	10.0 (20.0)**
Cu/Mo	–	2.0
Zinc	20 - 33	750
Selenium	0.1 - 0.2	2.0

* NRC standard (1985).
** McDowell, L.R. (1985).
# For cattle.

The copper contents of some forages were relatively high, whereas that in wheat straw and green-pea straw, which are cultivated plants, were lower than that required as standard. The content of iron in forages (wild grasses) were extremely high, and although, of course, the relation to other elements will be important, there will be a toxic effect of Fe if some of these forages were fed to sheep for a long time. The Fe contents of wheat straw were about 3-4 times higher, and of green-pea straw was about 10 times higher, than that required in feed for sheep as a standard, but these values do not exceed the level which will

constitute poisoning. The contents of Molybdenum in forages shown in table 2 mostly exceed the reguirement for feed accepted generally, and this might affect the absorption of Cu in some cases. The zinc content of wheat straw or green-pea straw was fairly lower than that of standard, whereas that of forages (wild grasses) were within the normal range required generally. The selenium contents of all the samples collected were extremely lower than that of standard (100-200 μg/kgDM), although the values in the wild grass (*Salsola passerina*) were near to the lower limit required commonly in the feed for sheep. (NRC, 1985).

Table 4 shows the comparison of mineral contents in the forages collected in this study and the requirements for adult sheep (see table 3). The contents of some minerals (Ca, Fe and Mo) in the forages were fairly high as compared with that of standard (NRC, 1985), and the levels of those were 1-2 times higher than that supposed to induce a toxic disease, i.e., if the sheep fed these forages alone during year, they will suffer from poisoning. Under practical conditions, however, farmers usually feed sheep using many kinds of feed, and the roughage and/or some concentrates (agro-industrial by-products) given to the sheep will be obviously changed seasonally within the year. Therefore, a harmful effect of some minerals contained in the forages will not appear at once. On the other hand, the same thing can be said about the minerals which occur at a relatively low level in feed, i.e., it will induce some diseases caused by a deficiency when the feed was used alone for a long time.

TABLE 4. MINERAL CONTENTS OF FORAGES AND MINERAL REQUIREMENTS OF SHEEP

Forage species	Region	Ca	P	Ca / P	Mg	Cu	Mo	Cu / Mo	Fe	Zn	Se
(March)*											
Wheat straw	Guyuan (A)**	↓	↓↓	↑	↓	↓↓	—	↓	—	↓↓	↓↓
Wheat straw	Guyuan (B)	↓↓	↓↓	↑	↓	↓↓	—	↓	—	↓↓	↓↓
Green-pea straw	Guyuan (A)	↑	↓↓	↑↑	—	—	↑	↓	—	↓	↓
Green-pea straw	Guyuan (B)	↑	↓↓	↑↑	—	—	↑	↓	—	↓↓	↓
Wild grass (*Salsola passerina*)	Tongxin	—	↓	—	↑↑	—	↑↑	↓↓	↑↑	—	—
(August)*											
Wheat straw	Guyuan (C)	↓	↓↓	↑↑	↓	↓↓	—	↓	—	↓↓	↓↓
Green-pea straw	Guyuan (C)	↑	↓↓	↑↑	—	—	↑	↓	—	↓	↓↓
Wild grass (Congon, Eulalia, Mugwort)	Haiyuan (D)	—	—	—	—	↓	↑	↓	↑↑	—	↓
Wild grass	Haiyuan	—	↓	—	—	—	↑	↓	↑↑	—	↓
Wild grass	Xiji	↑↑	—	↑	↑	—	↑↑	↓	↑↑	—	↓
Wild grass (*Salsola passerina*)	Yinchuan	↑	—	—	↓	↓	↑↑	↓↓	↑↑	—	↓

* Season when samples were collected. ** Farm where samples were collected.
↑ : Maximun × 1.0, ↑↑ : Maximum × 2.0 or more (Ca, Mo and Fe).
↓ : Lower than requirement, ↓↓ : requirement × 1/2 or lesser (Cu, Zn, P, Ca).
↑ : 6.0 or more, ↑↑ : 12.0 or more (Ca/P).
↓ : Below 2.0, ↓↓ : Below 1/4 (Cu/Mo).
↓ : Lower then requirement × 1/2 ~ 1/5, ↓↓ : Lower the requirement × 1/10 (Se).

In the districts which were the object of investigation in this study, in practice, the sheep were reared mainly by grazing regradless of their number in each farm during the day and during the night, they were managed in a barn in the backyard of each farm. The stored roughage, i.e., wheat straw or green-pea straw etc., was given to sheep only at evening or morning, i.e., just before or after grazing. Therefore, the contents of Mg and P in the wheat straw and green-pea straw were quite low as compared with that required for sheep as mentioned above. The sheep, however, will be able to receive the minerals which are relatively low level in the straws, from forages on the pasture during grazing. As a result, the high or low level of minerals in the forage samples shown in table 2 will not always be reflected directly in the mineral status of sheep in the present investigation. At this time, we did not take a sample of agro-industrial by-products which will be used as supplemental feed for sheep, although the main

crops in this area were wheat and green pea, whose by-products could be used for sheep as concentrate feed. The green pea is used as a raw material for "Harusame", a type of Chinese noodle, which is one of the special products in this district, so that residues from making the noodle could be used for sheep as a supplement to supply some of the elements lacking in forages.

From these results, it can be inferred that the concentrations of minerals indicated in table 4 will not always be reflected in the nutritional status, in particular mineral nutrition, of sheep in these areas as shown in table 5. However, the figures should have a role to set up a standard for feeding sheep reared in those areas.

The concentrations of minerals in blood of sheep

Table 5 shows the plasma levels of minerals (Se: whole blood) and haematocrit values in sheep adopted in this experiment, with their body weight and the location where the samples were collected. Table 6 shows the standard levels (or range) of some minerals in blood of sheep selected from NRC (1985) standard.

In the present study, the main objective was to investigate the mineral nutrition in grazing sheep on natural grassland in the area under study. The sampling of blood from sheep were mainly done in relatively young individuals as much as possible, because the effect of deficiency or overintake of minerals was thought to appear more easily in young animals than in older ones. Therefore, the average body weight was relatively low, 30-35 kg in each group that was adopted in this study (see table 4). The haematocrit values were over 30 on average except for some animals included in the groups blood-sampled in Guyuan and Yinchuan suburbs, and there was no condition of ill-health noticed in any of the animals.

The concentration of each mineral in blood plasma was expressed as an average value of all groups sampled in the same place (see table 5). The average values of Ca level in plasma of all the groups were 87.8-121.9 mg/l, and these figures were slightly lower than that of standard

TABLE 5. THE CONCENTRATIONS OF MINERALS IN BLOOD PLASMA OF SHEEP

Region	No. of sheep	Body weight	Ht value	Calcium (Ca)	Magnesium (Mg)	Phosphorus (P)	Copper (Cu)	Iron (Fe)	Molybdenum (Mo)	Zinc (Zn)	Selenium (Se)
(March)*		(kg)		.....	(mg/l)	.....	.....		(μg/l)	.....	.....
Xiji	13	–	30.2##	97.8	24.2	74.4	795.8	2.2	299.6	864.6	93.1
(Road side)			(3.7)**	(3.9)	(3.1)	(15.4)	(256.4)	(0.7)	(94.4)	(373.4)	(24.3)
Guyuan	6	–	31.3	103.7	25.3	78.6	605.5	2.8	163.0	1,075.3	90.0
(Farm A)			(3.1)	(8.5)	(2.0)	(11.6)	(100.4)	(0.6)	(21.9)	(648.2)	(30.0)
Guyuan	6	–	36.0	87.8	20.1	70.0	356.2	6.0	444.0	790.2	51.0
(Farm B)			(1.9)	(12.1)	(3.5)	(8.0)	(147.5)	(3.4)	(84.0)	(262.8)	(21.3)
(August)*											
Haiyuan	6	26.2	30.2	110.7	30.6	89.3	1,125.0	3.6	429.0	900.8	17.7
(Nankasan)		(6.8)	(3.5)	(4.0)	(5.8)	(6.5)	(166.0)	(0.9)	(194.0)	(265.0)	(10.4)
Hajyuan	10	36.0	38.7	109.5	41.6	92.5	970.0	4.0	266.0	942.0	66.6
(Farm C)		(3.6)	(4.4)	(9.3)	(11.6)	(8.1)	(171.0)	(0.8)	(193.0)	(350.0)	(35.0)
Guyuan	15	37.6	34.0	98.9	43.3	97.4	846.0	4.8	439.0	1,464.0	99.1
(Road side)		(6.4)	(3.4)	(7.6)	(14.5)	(11.9)	(175.6)	(1.5)	(263.9)	(768.0)	(61.4)
Tongxin	10	24.0	34.2	112.4	38.4	80.9	564.0	4.7	484.2	1,363.0	160.2
(Farm D)		(5.0)	(2.0)	(24.7)	(19.4)	(11.8)	(251.3)	(1.3)	(213.8)	(373.0)	(40.1)
Guyuan	15	36.7	27.0	108.3	52.3	80.9	717.0	3.8	339.0	1,591.0	144.0
(Road side)		(5.7)	(5.4)	(10.2)	(34.9)	(20.3)	(339.3)	(2.3)	(184.9)	(473.9)	(66.8)
Yinchuan	10	25.2	21.1	121.9	67.1	115.2	156.6	9.1	466.2	866.9	152.0
(Suburb)		(5.8)	(5.3)	(46.0)	(32.5)	(57.6)	(92.5)	(5.9)	(272.7)	(340.3)	(121.4)
Xiji#	3	–	32.3	97.8	30.4	104.8	157.7	2.6	197.0	1,328.0	76.1
(Dairy farm)			(3.5)	(3.9)	(11.9)	(5.1)	(59.3)	(0.7)	(106.0)	(661.7)	(25.2)

* Season when samples were collected. ## Mean of No. of animals.

** Standard deviation.

The data of dairy goats.

(see table 6), although they were not so severe to be judged as a deficiency. The Mg concentrations in blood plasma of sheep were generally high and, in particular, the figures in summer were about twice as high as those in spring (March) in some groups. The plasma level of P in some groups of sheep was high and exceeded the range indicated in table 6. This could be due to the difference of concentrate supplemented in each farm, because the P contents of concentrates (agro-industrial by-products) was high in general.

TABLE 6. AN EXTENT OF MINERAL LEVEL IN BLOOD OF SHEEP FOR JUDGING NUTRITIONAL STATUS AS A STANDARD*

Nutrient	Extent of concentration	Deficient or Excess**
Calcium (mg/l)	115 - 128	90
Magnesium (mg/l)	22 - 28	10 - 15
Phosphorus (mg/l)	50 - 73	40
Copper (μg/l)	580 - 1,600	600
Iron (μg/l)	1,700 - 2,200	2,500
Molybdenum (μg/l)	500 - 900	1,000 - 2,000#
Zinc (μg/l)	800 - 4,000	800
Selenium (μg/l)	20 - 200	20

* NRC standard (1985).
** Marginal level for deficiency.
# Poisoning level.

The level of copper (Cu) in plasma, could be related to molybdenum (Mo) level, in sheep subjected in Yinchuan suburbs, Guyuan district and Xiji area (goats) was very low as compared with the lower limit within the general range accepted (see table 5). The level of Fe in blood plasma was relatively high in many groups of sheep subjected. In particular, the figures of plasma Fe level in some groups blood-sampled in August were fairly high as compared with that indicated in table 6, though there were no toxic symptoms. The plasma level of Mo was low on average in some areas than that in the normal range (see table 6), though it would not be thought to severely affect their health. In general, as in Japan, there is commonly a toxic symptom induced by overintake of Mo rather than the deficiency, however, the data obtained in this area gives us an impression of a minor shortage of Mo as a whole. The zinc level in plasma was within a range accepted as standard in all the groups and also all the area subjected to the present study, so there will be no problem of Zn deficiency in the nutrition of sheep. The selenium level in blood was mostly within the normal range, except a group of sheep blood-sampled in Haiyuan district (Nankasan) which were at a relatively low level as compared with that of standard (see table 6).

Implications

In general, the requirement of minerals for animal nutrition will differ from that of other major nutrients, such as protein or carbohydrate, which could be needed daily in relatively large amounts. Minerals as nutrient have no characteristic that will be stored in the body after consuming large amounts at a time, than they will be needed to constantly maintain a normal condition in the physiology of the animal. So, some minerals will be excreted, in principle, into the urine or into the gut when they were absorbed in an excess amount, but when the amounts absorbed are larger than the upper limit, then the toxic symptoms seems to appear for all the minerals (McDowell, 1985c). The range of daily requirement above which intake will induce some disorders is quite narrow for some elements, such as Se. As shown in table 6, a deficiency disease is thought to appear when the mineral is markedly deficient in the feed for a long time. Therefore, there is a certain limit to the use of plasma levels of some minerals as an index for checking the conditions of mineral nutriton. To offer a more pertinent criteria for judging the nutritional status of minerals in grazing sheep, it will be better to discuss the mineral contents of main organs (liver, kidney etc.) together with the concentrations of minerals in blood plasma. In the present study, however, samples of organs related to the mineral metabolism in sheep could not be collected. As a whole, the results obtained could suggest that there were no severe unbalance and/or imbalance, so the grazing sheep in Ningxia area will have no particular problems in mineral nutrition.

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