Mineral Concentration in Blood of Grazing Goats and Some Forage in Lahar-Laden Area of Central Luzon, Philippines

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ABSTRACT : The mineral status of native goats and forage species, namely; *Cynodon plectostachyus, Pennisetum purpureum, Eleusine indica, Cynodon dactylon, Calopogonium muconoides, Centrosema pubescens, Leucaena leococephala*, and *Mimosa pudica* in lahar affected areas of Concepcion, Tarlac, Philippines were determined. Forage and blood samples were collected six times in 1996-97, and analyzed for calcium, phosphorus, magnesium, sulfur, copper, iron, molybdenum, selenium, and zinc. Forage calcium and sulfur are non-limiting. Most species had low phosphorus, copper and selenium, while some had magnesium and zinc levels lower than the critical limit because of low mineral content and high percolation rate of lahar deposits. Iron and molybdenum were in excess. The effect of seasonal variation was observed only in copper, sulfur and iron. Average blood mineral concentration of the animals was above critical limit, but there were no significant differences between seasons. All the animals had plasma phosphorus and magnesium above critical level; but 20 % had low copper, zinc and selenium especially in dry season possibly due to insufficient amount of these elements and excessive molybdenum and iron in most forage. Conversely, calcium in forage was high; but 40 % of the animals had low plasma calcium concentration. Although no clinical signs of mineral deficiencies were observed, supplemental feeding would be important since the condition of the pasture in lahar-laden areas is not expected to improve in the next five years. Intensified use of *L. leucocephala* with better mineral profile would be ideal. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 3 : 422-428*)

Key Words : Tarlac, Philippines, Lahar-Laden, Minerals, Goats, Forage Species

INTRODUCTION

As of 1998, there are about 260,000 goats raised in Central Luzon region, representing 10 % of the total goat population in the country. About half of the goats' population in the region is found in Tarlac, one of the provinces hard hit by the eruption of the Mt. Pinatubo in 1991. Region and country wise, 99 % of the goats are under backyard management, where the animals subsist mainly on available grasses, legumes, and other fibrous crop residues. The trace minerals derived by goats from these feedstuffs are sometimes insufficient to meet requirement, yet, they do not receive supplemental diet. As a result, the animals exhibit subclinical signs of mineral deficiencies particularly in copper, selenium and zinc (Kumagai, et al., 1990b; Fujihara, et al., 1992b, and Serra, et al., 1997). Lahar and ash deposits of about 2 meters depth had affected crops and livestock productivity in the region. Some of the desert-like lands were converted as pasture areas for cattle and goats where forage species such as *Cynodon plectostachyus* (K. Schum.) *Pilger, Eleusine indica* (L.) *Gaertn and Mimosa pudica* (L.) grow predominantly, while other species grow sporadically. However, growth and quality of forage crops are affected because the lahar-laden areas are sandy in texture, dry, acidic with sulfur content 10 times more than the normal organic or mineral soils, and infertile because of nil amount of organic carbon and nitrogen. The effect of the seasonal changes on forage maybe more serious because the soil is drier during summer and more infertile during wet season. In the absence of mineral supplements, forage should contain sufficient macro and micro elements essential to the growth and reproduction of goats and other grazing animals. Otherwise, the animals are greatly affected, i.e., disorders in livestock production are due to naturally occurring deficiency of one or more of the essential elements in forage or feedstuffs (Masters, et al., 1993a). While this problem occurs even in more favorable pasture areas, there is a high possibility that the problem is worse in the lahar affected areas. This study determined the mineral content of forage species and grazing goats in lahar-laden areas. The effect of season on these parameters was also determined. The mineral content of forage, as well as the mineral status of goats grazing in lahar-laden areas is a new area of study. Most studies on minerals conducted in the past were from goats grazing and forage grown in areas structurally different. Information on these aspects as well as the effects of season on the mineral levels of forage and goats are very important to identify what measures should be done to improve the nutritional status of the animals.

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MATERIALS AND METHODS

Study area

The study was conducted at the experimental area of the Research, Extension and Training Office of the Central Luzon State University in Sta. Rita, Concepcion, Philippines, one of the low lying towns of Tarlac (15.29 °N; 120.35 °E) which was hard hit by the eruption of

Mt. Pinatubo in 1991. The area is characterized by two distinct seasons, dry (December - May) and wet (June - November) with mean annual temperature of 27.4 ℃ and average rainfall of > 1500 mm.

The pasture area, an open land measuring about 10 ha is totally covered with lahar deposit. *Cynodon plectostachyus* (K. Schum.) *Pilger, Eleusine indica* (L.) *Gaertn* and *Cynodon dactylon* (L.) Pers. dominate the vegetation, but *Calopogonium mucunoides* Desv., *Centrosema pubescens* Benth, *Mimosa pudica* L., and *Leucaena leucocephala* (Lam.) de Wit. grow sporadically. *Pennisetum purpureum* (Schumach) also grows but it was only introduced for trial purposes. Rainfall serves as the main source of irrigation. Thus, during dry months most of the vegetation experience wilting.

The experimental animals were allowed to graze in the pasture area during the day and herd at night time in a barn with elevated slat floor and galvanized iron sheet roofings. The animals were not given any form of supplementation.

Sampling and analytical methods

The forage and blood samples of goats were collected at the same time thrice, each time with two months interval. Collection of samples started from December, 1996, at the onset of the dry season, until September, 1997.

A total of 60 Philippine indigenous does (10 does per sampling) were randomly selected from a herd of 86 does grazing in the area. About 10 ml blood samples were drawn from the jugular vein of each animal using heparinized vacuum tube (VT-100H, veno jet, Terumo Co., Tokyo, Japan). From which, 1 ml each of whole blood and plasma were taken and transferred individually to an acid-washed test tube. The whole blood sample was used in measuring selenium, while the plasma for the determination of other minerals. Whole blood and plasma samples were dried slowly over a hot plate at a temperature of about 95-100 ℃.

Samples of forage species were collected by hand plucking from the pasture area where the animals were grazing. These samples were cleaned of possible contaminants, dried and ground to pass through a Willey mill with 2 mm sieve.

Forage, blood serum and plasma samples were stored properly and shipped to Japan for mineral analysis. All samples were subjected to wet ashing with nitric and perchloric acids before mineral analysis. Selenium concentration was measured by fluorometric detection of the 2,3-diaminonaphthalene following procedure of Watkinson (1966). The fluorescence spectrophotometer used was Hitachi 204 (Hitachi Ltd., Tokyo, Japan) at 377 nm excitation and 520 nm emission. The other mineral elements, such as calcium (Ca), phosphorus (P), magnesium (Mg), sulfur (S), cobalt (Co), copper (Cu), molybdenum (Mo), and zinc (Zn) were determined by Inductively Coupled Plasma Emission Spectrometer (ICPS-2000, Shimadzu Co., Kyoto, Japan). All glasswares and pipette tips used were acid-washed to prevent possible contamination.

Statistical analysis

Average mineral concentrations during dry and wet season were compared statistically using t-test.

RESULTS AND DISCUSSION

Mineral contents of the forage

The highly varied mineral content of forage species grazed by goats in lahar-laden areas in Sta. Rita as affected by species differences and seasonal variations is depicted in tables 1 and 2.

Table 1. Macro mineral composition of some pasture species in lahar-laden areas of Sta. Rita, Concepcion, Tarlac, Philippines, dry and wet season, 1996-97

Species	Ca	P	Mg	S
			%	
Critical level[1]	0.30	0.25	0.20	0.20
Grasses:				
Pennisetum purpureum				
Dry	0.40	0.20	0.16	0.21
Wet	0.42	0.22	0.18	0.19
Cynodon plectostachyus				
Dry	0.45	0.28	0.21	0.48
Wet	0.47	0.22	0.19	0.50
Eleusine indica				
Dry	0.40	0.18	0.19	0.27
Wet	0.40	0.19	0.17	0.31
Cynodon dactylon				
Dry	0.27	0.16	0.23	0.17
Wet	0.28	0.25	0.20	0.20
Average: Dry	0.38	0.20	0.20	0.28
Wet	0.39	0.24	0.18	0.30
SEM	0.02	0.014	0.09	0.038
Legumes:				
Calopogonium mucunoides				
Dry	0.68	0.09	0.18	0.25
Wet	0.67	0.14	0.19	0.35
Centrosema pubescens				
Dry	0.70	0.08	0.19	0.22
Wet	0.67	0.17	0.21	0.27
Mimosa pudica				
Dry	0.91	0.37	0.26	0.28
Wet	0.87	0.29	0.28	0.33
Leucaena leucocephala				
Dry	1.27	0.19	0.30	0.38
Wet	1.28	0.18	0.30	0.42
Average: Dry	0.89	0.18	0.23	0.28
Wet	0.87	0.19	0.24	0.34*
SEM	0.07	0.02	0.016	0.019

[1] As recommended by McDowell (1985).
* Significantly higher seasonal average ($p<0.05$).

The mineral concentrations were compared with the critical needs of ruminants recommended by McDowell (1985). Most of the samples had low P, Cu and Se contents, while some species had low Mg and Zn. Iron and Mo were exceedingly high particularly during dry

season. There is a wide range in the Ca content of pasture species investigated, from 0.27 to 1.27% in dry season and 0.28 to 1.28% in wet season. All but one forage species showed sufficient Ca content during wet and dry seasons. Only the Ca concentrations of *C. dactylon* during dry and wet seasons are below the critical level. Result supports the findings of Norton (1994) that calcium is rarely limiting in forage diets. As expected Ca contents in legumes are higher than in grasses. The difference between the levels of Ca in legumes and grasses is a reflection of the higher Ca demand in legumes than in grasses at the tissue level (Marschner, 1993). The genotypical difference in Ca requirement is closely related to the binding sites in the cell wall, CEC, which could possibly explain the higher Ca in legumes than grasses.

Table 2. Micro mineral composition of some pasture species in lahar-laden areas of Sta. Rita, Concepcion, Tarlac, Philippines, dry and wet season, 1996-97

Species	Cu	Fe	Mo	Zn	Se
	mg/kg				μg/kg
Critical level[1]	10	30	>6	30	100
Grasses:					
Pennisetum purpureum					
Dry	8.53	385.00	10.60	16.93	19.47
Wet	7.40	163.00	17.19	18.90	14.32
Cynodon plectostachyus					
Dry	7.60	440.00	12.24	32.70	17.23
Wet	9.20	368.00	8.53	40.60	15.58
Eleusine indica					
Dry	7.70	531.00	12.53	57.46	19.12
Wet	9.20	484.00	12.81	42.57	21.24
Cynodon dactylon					
Dry	7.40	160.00	17.19	18.90	14.32
Wet	10.55	129.00	17.92	23.87	14.85
Average: Dry	7.82	379.00	13.05	31.51	15.54
Wet	9.38*	314.00	12.80	32.42	18.73
SEM	0.30	40.20	0.95	3.80	0.98
Legumes:					
Calopogonium mucunoides					
Dry	9.55	239.00	15.08	17.53	35.16
Wet	11.45	208.00	18.39	25.56	37.56
Centrosema pubescens					
Dry	9.80	301.00	6.63	16.28	36.26
Wet	11.43	218.00	8.25	18.55	38.76
Mimosa pudica					
Dry	10.42	337.00	26.04	49.45	43.13
Wet	11.39	281.00	29.77	51.95	45.03
Leucaena leucocephala					
Dry	8.12	365.00	24.79	42.82	>100
Wet	8.36	339.00	23.12	47.64	>100
Average: Dry	9.47	311.00*	18.14	31.53	53.64
Wet	10.61	262.00	19.88	36.00	55.34
SEM	0.40	16.20	2.40	4.30	7.98

[1] As recommended by McDowell (1985).

* Significantly higher seasonal average ($p<0.05$).

Apparently, there is a sufficient amount of Ca in the forage, although the wet and dry seasons average of the four grass species are lower than the $0.52 \pm 0.09\%$ (mean $\pm$ SEM) dietary Ca consumed by goats from pasture dominated by *C. plectostachyus* and *P. purpureum* in other parts of Central Luzon (Fujihara et al., 1992a; Serra et al., 1996b). Calcium concentration of grasses is higher during wet season, which corroborated with the findings of Kumagai et al. (1990a) that forage collected during rainy season in Java, Indonesia had higher ($p<0.01$) Ca content than during dry season. On the other hand, the leguminous species exhibited the reverse, i.e., Ca content is higher during dry season than during wet season. The reason behind this difference is not clearly understood (Little et al., 1989), however, results demonstrate that plant species and seasonal changes influence mineral concentrations. Conversely, there is much to be desired on the P and Mg contents of the forage. Except for *C. plectostachyus* and *M. pudica* for P, and in addition, *C. dactylon* and *L. leucocephala* for Mg, other species had P and Mg contents below the critical level. Nevertheless, the Mg level of the species below critical limit are not substantially low to possibly effect sub-clinical signs of deficiency among the animals. It is unlikely for Mg to be critically low in tropical forage (Minson, 1990). Magnesium as well as P were never deficient in *P. purpureum, E. indica, C. mucunoides,* and *C. pubescencens* grown in clay loam soil of Central Luzon during wet and dry seasons (Fujihara et al., 1992a and Serra et al., 1996c). Minson and Norton (1984) also reported that only 14 % of the commonly used tropical grasses for livestock feeding contained less than 2g Mg/kg DM.

Lahar deposit with low available P value of 8-10 ppm (Bray P_2) might have caused the low forage P level. Seasonal average also indicated P is below critical level in both grasses and legumes. These results agree with the report of Masters et al. (1993a) and Spear (1994) that low forage P is associated with low soil P and dry seasonal period. Selenium was found to be critically low among the forage species. Only *L. leucocephala* have Se concentration above the critical level. The high S content of lahar deposit in the area could have greatly induced this condition. Its S content of 3.7% is 10 folds higher than the 0.03-0.30% S concentration of normal soil and 0.03-0.40% of organic soil (Allen, 1989). The interrelationship between S and Se in plants had been demonstrated by Zayed and Terry (1992) where they observed sulfate and selenate compete for common uptake sites in the roots and that Se uptake can be significantly decreased with high S supply. Average Zn content of the forage ranged from 16.28 to 57.46 mg/kg DM during dry season and 18.90 to 51.95 mg/kg DM during wet season. The lower values were observed in *C. dactylon, P. purpureum, C. mucunoides,* and *C. pubescens*. These species showed relatively high Zn level when grown in other parts of the region. Serra et al. (1996a and b) reported average Zn values of 50.5,

60.8 and 40.4 mg/kg DM for *P. pulpureum, C. mucunoides* and *C, pubescens*, respectively, under clay loam soil of Nueva Ecija, Philippines. The low dietary Zn in some of the species could be due to practically nil amount of Zn in the soil as indicated by the chemical analysis conducted in the area. Likewise, Cu concentration of *E. indica, P. purpureum, C. plectostachyus*, and *L. leucocephala* were below 10 mg/kg DM during dry and wet seasons. This finding was contrary to the result of Fujihara et al. (1992b) that the dietary Cu levels of two commonly grown pasture species (16.4 mg/kg DM for *P. purpureum* and 16.5 mg/kg DM for *C. plectostachyus)* in northern, central and southern Luzon, Philippines is sufficient to meet the requirement of goats. The inherently low total Cu content of coarse textured soils (Alloway and Tills, 1984), typical of lahar deposits, might have contributed to the low Cu levels of some forage grown in the area.

Iron concentration of forage that grow in lahar is above the critical level. Although dietary Fe level are extremely high, grazing goats are unlikely to suffer from toxicity because the highest value of 531 mg Fe/kg DM of *E. indica* is still below the 600-6000 mg Fe/kg DM concentration that could elicit chronic toxicity (Grace, 1991).

Likewise, forage Mo concentration is above the critical level. Majority of the values is three times higher than the requirement that could interact with Cu. High Mo intake depresses Cu availability and may produce a physiological Cu deficiency in ruminants (Fleming, 1973; Grace, 1991; and Suttle, 1991). With most species having Cu level below critical, it is more likely that high Mo aggravates Cu deficiency. Previous reports have shown that Mo toxicity and Cu deficiency exists in some parts of the Philippines (McDowell, 1985).

The low concentration of P, Mg, Zn, Cu, and Se in some of the forage grazed by goats in Lahar-Laden areas is indicative of the quantity and availability of these mineral elements in the soil (Fleming, 1973; Reid and Horvath, 1980). Volcanic materials such as ash falls and lahar deposits are inherently infertile with negligible amount of organic matter and clay contents which are active exchange sites for nutrients. Furthermore, the high infiltration rate of lahar deposit, which is above 2 mm/min could have enhanced nutrient loss through leaching eventually reducing uptake of these important elements.

Data seem to demonstrate that the mineral concentrations of pasture species were affected by the type of soil where they are grown. This supports the findings of Norton and Poppi (1995) that the reported trace mineral values of tropical forage are more indicative of the soil types and their deficiencies than any other factors.

Seasonal changes also contributed to the variation in the mineral concentration of the forage. Sulfur in legumes were significantly higher ($p<0.05$) during wet season. Marked differences ($p<0.05$) were also noted in Fe and Cu contents; Fe in legumes was higher during dry season while Cu in grasses was higher during wet season. The significant seasonal variation in these elements could be related to the fluctuations in climatic elements. Rainfall, temperature and sunlight exert greatest influence on forage by altering leaf to stem ratio eventually affecting morphology and plant chemical components (Burton and Fales, 1994). Wet season is the period of active plant growth, or regrowth following defoliation. The decline in some forage mineral concentration is probably due to the natural dilution process, i.e., DM production surpasses mineral uptake (Fleming, 1973). Similarly, Kabaijan and Smith (1989) reported that the higher ($p<0.05$) Fe, Mn and Zn contents of *G. sepium* and *L. leucocephala* were due to seasonal changes.

Caution was made in interpreting the comparison between computed mineral concentration and their critical levels. While values less than the predicted requirement may indicate deficiency level, values above them do not necessarily indicate sufficiency. Not all elements are fully available for use by the microbial population in the rumen or for absorption in the intestines of the animals (Norton, 1994).

Mineral contents of blood

The plasma Ca, P, Mg, Cu, and Zn, and serum Se contents of the goats grazing in lahar-laden areas and their seasonal differences are presented in table 3. Nutrient concentration in the blood is indicative of the animals' condition. Although the validity of using blood concentration to study specific nutrient seems dependent on the physiological factors affecting serum level, it could be used as yardstick in assessing nutritional state of a particular animal (Herdt, 1994).

Mean mineral concentration in the blood of the animals are above the critical limit during dry and wet seasons, but there is no significant differences in the level between seasons.

Goats grazing in lahar-laden areas had P and Mg concentrations above critical level during dry and wet seasons. However, more than 20 % of the animals had low levels of Ca, Cu, Zn, and Se during dry season. While the percentage of the animals with Cu, Zn and Se decreased during wet season, the percentage of animals with low levels of Ca increased. The better growth of forage and higher concentration of Cu, Zn and Se during wet season could have contributed to this effect.

The low Mg content in some of the forage species did not result to any low plasma Mg level among goats. Similarly, the animals had blood P above the critical level in spite of low forage P. A plausible reason could be that the reserve P from the animals' bones could have been drawn during inadequate P intake, which is the same conclusion made by Spears (1994) in his report on ruminants.

Plasma Ca below critical level was reported among 33 % of the animals during dry season and 47 %

Table 3. Blood mineral concentration of goats grazing in lahar-laden areas of Sta. Rita, Concepcion, Tarlac, Philippines, dry and wet seasons, 1996-97

	Ca	P	Mg	Cu	Zn	Se
	mg/l					μg/l
Critical level[1]	90	40	15	0.6	0.6	20
Mineral concentration[2]						
Dry Season	94.58±2.61	65.14±3.38	30.05±1.11	1.01±0.61	1.00±0.61	21.66±1.21
Range	72.3-119.30	41.30-90.86	21.89-28.52	0.42-1.58	0.34-1.86	12.50-46.66
Wet Season	100.03±3.34	63.59±3.37	29.40±1.09	1.18±0.96	1.15±0.98	24.16±1.66
Range	78.0-130.5	42.13-96.15	23.90-39.20	0.55-1.29	0.48-1.92	17.50-53.33
Percent of animals below Critical conc. (n=30)						
Dry season	33.3	0	0	30.0	23.3	40.0
Wet season	46.7	0	0	10.0	3.3	26.7

[1] As recommended by McDowell (1985); [2] Mean ± SEM.

during wet season. In spite of the apparently sufficient supply of Ca (table 1) in the forage, it could be plausible that Ca is not available for absorption due to the presence of calcium oxalate (Ward et al., 1979). Blaney et al. (1982) reported that Ca availability in tropical grasses containing calcium oxalate was reduced by about 20%. Another possibility is that the control mechanism for maintaining Ca level in the body of the animals is highly toned as a result of the differences in the individual physiological needs (McDowell, 1985 and Fujihara et al., 1992a).

There were 40% of the animals during dry season and 27% during wet season with Se concentrations below the critical limit of 20 μg/l. The low Se content of existing forage (table 1) and the high S in lahar deposit could have triggered this low level. Only *L. leucocephala* contained more than 100 μg/kg DM. Deficiency in Se is an important problem to take into consideration in small ruminant production because it has been suspected to contribute to abortion, still birth and neonatal mortality in sheep (Kott et al., 1983 and Langlands et al., 1991). Thus, Se supplementation using either tree legumes particularly *L. leucocephala*, concentrates or mineral bolus (Serra et al., 1997) which was found to improve Se status among grazing goats in Se deficient pastures is very important. Low levels of Cu in blood was recorded among 30% of the animals during dry season and 10% during wet season. The lowest plasma Cu concentration was 0.42 mg/l, which is 0.18 units below the 0.60 mg/l critical level. It is widely accepted that whole blood or plasma Cu values consistently below 0.60 mg/l indicate deficiency in sheep and cattle. The known interaction of other minerals such as S and Mo may have played a vital role in contributing to this condition (Ward, 1978; Suttle, 1991 and Spears, 1994) as well as the low Cu content of the forage. The high amount of S in lahar deposit coupled with the excessive Mo content of some forage species could have reduced the availability of Cu. Ruminants on pasture may inadvertently consume large quantities of soil as a natural consequence of grazing (Masters et al., 1993a). These two elements could have contributed to the low absorption and metabolism of Cu (Mills, 1987). Sulfur and Mo in the presence of high S level decreased Cu absorption, and reduced Cu in various organs and synthesis of ceruloplasmin which eventually increased the loss of Cu through the urine (McDowell, 1992).

Low plasma Zn level was reported for about 23% of the animals during dry season but was reduced to 3% during wet season. The incidence of deficiency is higher than those reported by Fujihara et al. (1992b) among goats raised in other parts of Central Luzon during dry season. The low plasma Zn level maybe the effect of the drought condition in the lahar affected areas. Findings of this study support the conclusion of Fujihara et al. (1992b) and McDowell (1985) that hot weather contributes to the loss of Zn from the skin of the animals. Recenty, Zorbas et al. (1997) reported that substantial amount of stored Zn in the body is excreted through the urine, feces and sweat when animals are subjected to prolonged stress

CONCLUSION

The porous and infertile characteristics of soil and seasonal changes affected the mineral contents of forage in the lahar-laden areas of Concepcion, Tarlac, Philippines. Selenium concentration of most species was below the critical level. Some of the dominant species also had low Cu and Zn contents. Among all species, *L. leucocephala* had most of the mineral contents above the critical needs of the animals. The effect of season was well pronounced in the levels of S, Fe and Zn, which could be associated with rainfall pattern. Although average blood mineral concentrations were above the critical limit, more than 20% of the animals had low plasma Cu and Zn, and serum Se due to insufficient supply of these minerals in the forage. But, the extremely high amount of Mo and Fe in the forage could have also contributed to this effect. Particular attention should be given on the level of Se as dry season average was very close to the lower limit and significant number of the animals were below the critical

level In addition, the high amount of S in the soil might further aggravate the condition. The low plasma Ca observed in 40% of the animals could have been due to low availability of Ca (Ward et al., 1974 and Blaney et al., 1982) in the forage although supply was sufficient. Results indicate that the mineral levels derived by the animals from the pasture have direct effects on their mineral status. Hence, tree legumes with better mineral profile, like *L. Leucocephala* and other form of supplementation that could provide most of the mineral requirement of the animals should be provided in adequate amount. Further studies on Cu and Se availability to grazing animals in lahar-laden areas should be undertaken to determine their interaction with the excessive forage Mo and high S in the soil.

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