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# Mineral Balance of Cambodian Cattle Based on Their Faecal and Urinary Excretion

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**Abstract:** The nutrient composition of six forage types from two zones in Cambodia was compared against faecal and urinary excretion of macro minerals by growing cattle in these regions. The forage types were rice bran, rice straw, para grass, cassava foliage (leaves and petioles), leucaena leaves and water hyacinth leaves. One sample of each forage type was collected from four different sites representing two major agro-ecological zones of Cambodia. Potential mineral deficiency was investigated by analysing the mineral composition of faeces and urine samples collected from 28 non-pregnant, non-lactating cows of the Local Yellow breed, equally distributed between the two zones. The analyses showed that Ca and P levels varied markedly between the different forages. The P concentration in rice bran matched animal requirements but that in rice straw was low and that in cassava foliage, leucaena leaves, para grass and water hyacinth was marginal. The concentration of all minerals in faeces dry matter was slightly higher in one of the two regions. The data obtained on faecal and urinary excretion of minerals indicated that Ca, P, Na and Mg intake was insufficient in the cattle sampled. The results also indicated that several of the commonly used forages in Cambodia have a mineral composition that does not fully cover the requirements of growing cattle. However, it would be possible to meet the requirements by mixing these forages.

**Key words:** Forages, location, minerals, cattle, Cambodia

## INTRODUCTION

The availability of feed resources and their nutritive value constitute the principal technical constraints for livestock production in Asia (Devendra and Sevilla, 2002). Free grazing or tethered animals utilising native grassland, fodder trees, crop residues and crop by-products are the most common systems in Cambodia (Sath *et al*., 2008). In addition, floating water hyacinth is used for grazing cattle when land forages are limited. In order to optimise livestock production, the most common feeds for cattle need to be identified and their potential nutritive value and optimum utilisation strategy need to be investigated. Local research on feedstuffs has so far primarily focused on providing protein and energy for animals while information on the mineral composition of typical feeds for cattle in this region appears to be lacking. Minerals are vital for normal growth, reproduction, health and proper functioning of the animal's body (Underwood and Suttle, 1999). Some mineral elements are most likely limiting under grazing conditions and therefore there is a need to identify the critical requirements in cattle, determined by both direct and indirect methods (McDowell, 1996).

However, the consumption of minerals is influenced by changes in animal requirements with physiological stage and production level and there are seasonal variations in forage supply. The mineral composition of pasture has a direct effect on the animal's mineral status (Orden *et al*., 1999) and only rarely can tropical forages completely satisfy all nutrient requirements, especially those of minerals (McDowell, 1985). The route of mineral excretion differs for different minerals and is also dependent on feed intake (Khorasani *et al*., 1997), the bio-availability of the mineral in question and interactions between minerals (Underwood and Suttle, 1999). Some minerals such as Sodium (Na) and Potassium (K) are almost entirely absorbed and the surplus is mainly excreted via urine while any surplus of other minerals, such as Phosphorus (P) and Calcium (Ca) is virtually entirely excreted with faeces (Underwood and Suttle, 1999). Some minerals in forages are bound to other compounds or to undigested nutrient fractions resulting in slow release and rather low availability (Playne *et al*., 1978).

The present study investigated the nutrient composition of six common forages from two of the four major agro-ecological zones of Cambodia with the focus

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on macro minerals. Furthermore, in order to identify potential mineral deficiencies, faecal and urinary excretion of minerals was studied in cattle grazing in these two zones.

## MATERIALS AND METHODS

**Study sites:** Each of the four major agro-ecological zones in Cambodia has specific conditions that determine agricultural practices and production systems. The two main agro-ecological zones selected for this study were chosen due to their high population density, the reliance of most of the population on agriculture for their livelihood and the high density of cattle farming. These zones were the great lake floodplain of Tonle Sap lake (TS) and the Mekong floodplain of the Mekong river (MK). The climate in the regions is divided into a rainy season (May to October) and a dry season (November to April). The provinces of Kampong Cham and Seim Reap were chosen as representatives of the MK and TS regions, respectively based on information about the number of cattle and available roughages obtained from a report of the Provincial Department of Agriculture, Cambodia. Roughage samples were collected in July 2008 and cattle faeces and urine samples in November 2009.

**Data collection:** Six types of forages considered to be common feed supplements for cattle in the two regions were collected for determination of nutrient composition, particularly macro mineral content. These forages were rice bran, rice straw, para grass, cassava foliage (leaves and petioles), leucaena leaves and water hyacinth leaves. One sample of each forage was collected from four different sites within each of the two regions at the time when these roughages are usually harvested or grazed giving a total of 48 samples. After collection, all samples were placed in plastic bags and kept frozen until analysis for Dry Matter (DM), Crude Protein (CP) and Neutral Detergent Fibre (NDF).

A subset of samples was chopped and dried in a microwave oven and then kept in a freezer until mineral determination.

A total of 28 non-pregnant, non-lactating cows (14 in each province) of the Local Yellow breed were randomly selected from smallholder farms to check mineral excretion through faeces and urine in the early dry season. The cows were in their first or second parity and weighed approximately 300-400 kg. The cattle owners were asked to provide basic information about their cattle management system with particular emphasis on their feeding routines. According to this information, the cows relied completely on free grazing during the day and were confined at night. Faeces and morning urine samples were collected from all cows. After collection, the faeces samples were frozen until drying. Before drying the samples were thawed and thereafter immediately dried to constant weight in a microwave oven. To keep urine pH below 4.0 and prevent ammonia losses, 10 mL 10% sulphuric acid ($H_2SO_4$) were added to all urine samples. The urine samples were kept in the freezer until analysis of minerals.

**Chemical Analytical Methods:** The forage samples collected were analysed for DM as described by Undersander *et al.* (1993), CP (N×6.25) was determined according to AOAC (1990) and NDF using the procedure of Goering and Van Soest (1970). The Ca, P, K, Na, Magnesium (Mg), Sulphur (S) and Manganese (Mn) concentrations in forage and faeces samples were determined by inductively coupled plasma optical emission spectroscopy (Spectroflame, Spectro Analytical Instruments GmbH, Kleve, Germany) using $HNO_3$ for extraction according to Balsberg-Pahlsson. The Ca, P, Mg, K, Na and S concentrations in urine were analysed by the same method.

**Statistical analysis:** Each forage (Table 1) was analysed separately by Analysis of Variance (ANOVA) with a completely randomised one-factorial design. Data on mineral excretion (Table 2) were analysed with a similar

Table 1: Mean nutrient concentrations (g $kg^{-1}$ DM) in common forages used for feeding cattle in two regions of Cambodia (MK and TS)

| | Cassava foliage | | Leucaena leaf | | Para grass | | Water hyacinth | | Rice straw | | Rice bran | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | MK | TS | MK | TS | MK | TS | MK | TS | MK | TS | MK | TS |
| DM | 223±120 | 235±260 | 282±34 | 259±7 | 172±6 | 183±10 | 127±13 | 135±12 | 870±60 | 869±15 | 910±90 | 913±7 |
| CP | 183±21 | 252±9** | 283±35 | 268±28 | 153±29 | 128±3 | 197±35 | 215±40 | 43±4.7 | 40±4.70 | 81±900 | 94±14 |
| NDF | 454±34 | 445±66 | 369±23 | 384±8 | 673±27 | 697±22 | 622±20 | 675±35* | 745±8 | 740±5 | 534±29 | 408±81* |
| Ca | 15.3±3.6 | 16.8±0.5 | 16.2±4.9 | 13.5±1.5 | 3.3±0.40 | 2.6±0.5 | 17.9±1.8 | 17.3±5.6 | 3.9±0.80 | 2.9±0.70 | 0.5±0.2 | 0.8±0.6 |
| P | 3.7±0.30 | 4.9±0.60** | 2.1±0.20 | 2.4±0.90 | 2.6±0.10 | 2.7±0.1 | 3.4±1.50 | 5.2±1.40 | 0.7±0.20 | 0.6±0.30 | 7.1±2.0 | 7.8±1.1 |
| Mg | 4.6±1.00 | 4.9±1.50 | 4.1±0.90 | 2.8±0.20* | 2.2±0.10 | 1.8±0.4 | 5.4±2.80 | 3.8±0.20 | 1.4±0.40 | 1.1±0.10 | 3.5±1.1 | 4.0±0.6 |
| K | 15.9±3.1 | 20.7±2.7* | 16.4±2.5 | 21.3±2.8* | 35.9±4.7 | 33.1±3 | 42.8±8.3 | 45.3±3.2 | 16.1±4.2 | 17.2±2.0 | 7.7±1.5 | 7.9±0.8 |
| S | 2.7±0.30 | 2.1±0.20** | 3.4±0.80 | 3.1±0.08 | 3.0±0.50 | 2.5±0.3 | 2.3±0.90 | 3.8±2.40 | 0.7±0.10 | 0.5±0.05** | 1.0±0.2 | 1.1±0.2 |

Each value represents the mean of 4 samples followed by the standard deviation. DM = Dry Matter; CP = Crude Protein; NDF = Neutral Detergent Fibre; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulphur; MK = Mekong river; TS = Tonle Sap lake; *Indicates significant difference between regions (*$p<0.05$, **$p<0.01$)

Table 2: Mineral excretion in faeces and urine of grazing cattle in the MK and TS regions of Cambodia

| | Faeces (g kg$^{-1}$ DM) | | | | Urine (g L$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| Mineral | MK | TS | SEM | p | MK | TS | SEM | p |
| Ca | 5.4 | 5.5 | 0.55 | 0.857 | 0.20 | 0.40 | 0.060 | 0.085 |
| P | 1.9 | 2.5 | 0.22 | 0.058 | 0.01 | 0.01 | 0.001 | 0.519 |
| Mg | 1.9 | 2.1 | 0.21 | 0.596 | 0.60 | 0.50 | 0.090 | 0.544 |
| K | 5.0 | 6.5 | 0.36 | 0.006 | 10.6 | 10.9 | 0.870 | 0.831 |
| S | 1.4 | 1.7 | 0.09 | 0.026 | 2.90 | 1.90 | 0.460 | 0.121 |
| Na | 1.3 | 1.4 | 0.29 | 0.771 | 0.40 | 0.60 | 0.200 | 0.473 |
| Mn | 0.9 | 1.1 | 0.08 | 0.065 | ND | ND | - | - |

Each value represents the mean of 14 samples from each region. SEM 0 Standard Error of Mean. Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulphur; Na = Sodium; Mn = Manganese; MK = Mekong river; TS = Tonle Sap lake; ND = Not Determined

design but separate calculations were made for faecal and urinary excretion. In all models region was the sole factor apart from the error term. All calculations were performed with MINITAB Software, Version 16.1.1 (Minitab, 2010) using the General Linear Model procedure.

## RESULTS AND DISCUSSION

The cattle in the two study regions relied completely on free grazing, mainly on rice straw. Rice straw is characterised as a low quality feed mainly due to its high silica and lignin contents which are difficult to digest by ruminants and it also has a low protein content (Preston and Leng, 1987). The grazing was at times supplemented with rice bran and legume forages when available. The cattle were also observed grazing on water hyacinths floating on lakes or rivers when the forage supply on land was limited. The DM, CP, NDF and mineral concentrations in the six forage materials from the two regions are shown in Table 1. The nutritive value varied markedly between the forages. Interestingly, the P content of rice bran was approximately 10 fold higher than that of rice straw. Thus, dietary supplementation with rice bran would be a way to counteract potential P deficiency in cattle mainly relying on rice straw. Faecal P levels <2.0 g kg$^{-1}$ DM have been suggested to indicate that P intake is too low to prevent deficiency symptoms in grazing cattle (Moir, 1966). In the present study, faecal P excretion was on average 1.9 g kg$^{-1}$ DM with even lower levels found in faeces from cattle in the MK region. This indicates that the cattle in the two study regions were P-deficient. This confirms findings by Kumagai *et al.* (1996) who showed in studies in Thailand that the dietary P intake of grazing cattle generally tended to be insufficient in that country. The P content of faeces is highly correlated to the content in the grass consumed by grazing cattle and it has thus been suggested that faecal P content could be used as a marker of P intake in grazing cattle (Holechek *et al.*, 1985; Mokolopi and Beighle, 2006). In a study on dairy cows where P intake was recorded, faecal P excretion was also well correlated to P intake (Nordqvist, 2012).

Khalili *et al.* (1993) analysed blood plasma and faeces samples from grazing local cattle in the Ethiopian highlands and concluded that a faecal Ca content below 10 g kg$^{-1}$ DM might indicate marginal intake. The Ca content of the faeces samples in the present study was about half that level (5.4-5.5 g kg$^{-1}$ DM) indicating insufficient Ca intake (Table 2). Gowda *et al.* (2004) reported that leguminous forages such as water hyacinths, leucaena and cassava foliage are excellent sources of Ca and Mg while cereal by-products such as rice bran are relatively poor in Ca. Thus, consumption of these leguminous feeds would improve Ca status. However, Ca utilisation is also dependent on its bioavailability, combined with the presence of an adequate level of P and an active form of vitamin D. Thus, Ca and P levels are both important for animal health and each affects absorption of the other. The Ca:P ratio should be between 1:1 and 2:1 in livestock diets to avoid any restrictions in growth and bone formation (Underwood and Suttle, 1999). The Ca:P ratio was markedly higher than this ratio in the leguminous forages investigated in the present study and thus too high an inclusion of these forages in the diet might negatively interact with growth and bone formation. Supplementation of the diet with cereal by products such as rice bran which contain relatively low Ca concentrations but high P concentrations could improve the Ca:P ratio. Therefore, the local farmers' practice of giving rice bran to cattle is a step in the right direction.

Cassava foliage collected from the MK region had lower CP, P and K concentrations than cassava collected from the TS region but the opposite pattern was found for S (Table 1). The higher CP and K content in cassava from 8TS might reflect an earlier stage of maturity. However, the NDF content was not significantly lower in cassava foliage from the TS region. In addition, leucaena collected from MK had a lower K content than leucaena from TS but the opposite pattern was found for Mg. Rice straw collected from MK had higher S than rice straw collected from TS. Forage nutrient composition, particularly mineral composition could be affected by plant uptake of minerals from the soil, time of sampling, plant growth stage and the proportions of leaf and stem in a certain forage. The variability in the nutritive value of rice bran could also be related to processing techniques during milling, e.g., the presence of rice hulls in rice bran would affect the NDF content.

Faecal and urine mineral excretion did not differ significantly between the two regions of Cambodia (Table 2). The concentrations of all minerals analysed in faeces dry matter were higher for the TS region than the MK region although, significantly so only for K and S while the P and Mn concentrations tended to be higher. It is possible that the generally higher mineral faecal excretion pattern of animals in TS reflects different intake. Khorasani *et al*. (1997) reported positive linear correlations between P, Mg and Ca intake and their faecal excretion. It is possible that the cattle in the MK region consumed relatively more rice straw and less of the other forages. The mineral content of rice straw was generally low compared with that in the other forages investigated (Table 1). However, the higher mineral concentration in faeces from TS could also be an indirect effect of higher organic matter digestibility of the feed consumed and thus faeces dry matter would be reduced. Excretion of minerals with faeces and urine is a function of mineral intake relative to requirements. Faeces and urine were sampled in November at a time when pasture had turned yellowish in the MK region but was still green in the TS region. It is thus reasonable to assume that the dry matter digestibility was higher in the TS region.

A Na:K ratio <0.10 in urine has been suggested as a benchmark of Na deficiency in large ruminants (Singh and Rani, 1999). The Na:K ratio in urine of cattle in both regions studied here was <0.10 indicating that the animals were Na-deficient. On the other hand, faecal excretion of Na slightly exceeded the level suggested for cattle with adequate Na nutrition, indicating satisfactory intake (Khalili *et al*., 1993). The rumen digestibility of Na and other minerals in tropical feedstuffs may be markedly reduced by chemical binding to indigestible structures, so it is possible that the faecal Na content did not accurately reflect the Na status of the animals. The present results indicating Na deficiency among the cattle are in line with results from studies performed in central Thailand where Na deficiency appears to be common (Kumagai *et al*., 1996). The high urinary K excretion reflects the high capability for K absorption in ruminants. Khorasani and Armstrong (1990) found that >80% of the K consumed by sheep was excreted with urine. The K concentration was high in all forages studied here except rice bran. Similarly, Kumagai *et al*. (1996) reported high K concentration in pasture compared with cattle requirements and thus K deficiency is uncommon in ruminants (Suttle, 2010).

There was no difference in Mg excretion between the two regions (Table 2). The levels of Mg excretion observed in this study were lower than those observed by Khorasani and Armstrong (1992) who reported faecal and urinary Mg losses in adult Jersey cattle of 5 and 1.3 g $day^{-1}$, respectively. Similarly, Holtenius *et al*. (2008) concluded that urinary Mg losses of 3 g $day^{-1}$ in lactating cows indicate a low Mg diet. Studies with grazing local cattle in the Ethiopian Highlands concluded that deficiency was unlikely if faecal losses of Mg exceeded 4 g $kg^{-1}$ DM (Khalili *et al*., 1993). The results of the present study thus indicate that the Mg status of the cattle was marginal in both regions studied. Water hyacinths are rich in Mg and in areas where they are available they could be used as a supplement in the diet of cattle in order to improve the Mg status.

## CONCLUSION

Analyses of the mineral composition of six forages collected from two regions in Cambodia and faecal and urinary losses from cattle in the same regions indicated that dietary Ca, P, Na and Mg were insufficient for these cattle. There were marked differences in mineral content between individual forages. Thus, combining forages with different mineral contents could improve the mineral status of grazing animals in the regions.

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