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MINERAL SUPPLEMENTATION FOR BEEF CATTLE IN THE CENTRAL THAI VILLAGES[1]

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The effect of mineral supplementation on growing yearling cattle of two breed groups was carried out during different periods of the year. The effect of minerals on reproductive performance in seven villages was also evaluate. Forage analyses indicated adequate concentrations of Ca, K, Mg, S and Zn, high levels of Fe and Mn and deficient levels of P and Cu. Forage protein was deficient during the dry season. One-fourth Brahman crossbreds supplemented with minerals had 26% higher gains than controls whereas supplemented native cattle showed an 18.3% improvement. Mineral supplements increased claving percentages by 16.9%. Among the three periods under study, mineral supplementation during the dry period yielded the greatest economic return because animals had free access to more energy adn protein.

Keys Worlds: Minerals, beef cattle, Thailand, indigenous cattle.

Beef cattle production in Thailand is often suboptimum, characterized by slow growth rates and low reproductive efficiency. Mature animals will gain up to 40 kg during the wet season from June to August while during the dry season (September through November), the cattle will lose at least 30 kg (Prucsasri 1976). Insufficient quantities of energy and protein during times when rice straw, the predominant feedstuff, is administered may likely be responsible for much of the low production rates. Little attention, however, has been paid to the deleterious effects of mineral deficiencies or imblances on cattle production parameters.

In most tropical areas, mineral deficiencies, imbalances and toxicities severely inhibit ruminant livestock production (McDowell 1976; Conrad and McDowell 1978). Grazing livestock in many tropical countries usually do not receive mineral supplementation except for occasionally common salt and must depend almost exclusively upon forages or low quality roughages (i.e., rice straw) to meet their mineral requirements. Unfortunately, tropical forages are generally deficient in certain minerals A review of geographical locations of mineral deficiencies or excesses for ruminants in Asia and the Pacific has been made (McDowell et al 1981a; McDowell et al 1981b). From Thailand, nonsupplemented cattle during the wet season gained 176 g per head daily during and 180 day study compared to 230 g for those receiving mineral supplement (Tumwasorn et al 1980).

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The present study was intended to 1) examine the response of beef cattle to mineral supplementation during three different periods of the year, 2) examine mineral concentrarions in blood plasma and available native grasses throughout the year and 3) determine the cost-benefit relationship of mineral supplementation.

Materials and Methods

Location: Six village in Kamphaeng Saen district, Nakorn Pathom province, were selected according to their similarities in cattle feeding and management systems. These villages area located 100 km west of Bangkok at approximately 5 meters above sea level. The region is characterized by sandy loam type soils, with precipitation averaging 7,000 mm per annum. Average temperature throughout the year is 28 °C (23 to 38°C).

Experimental animals: One-hundred-and-fifty head of yearling cattle of two classifications, Thai native and one-fourth American Brahman crossbred, were randomly selected. A total of 48-53 animals 11 - 14 months of age were selected from the six villages. From each village, 8 - 9 animals were utilized and were allotted to the supplemente or control treatments on the basis of breed. A different group of cattle was selected for each of the following time periods: dry season (November - April), combination wet and dry season (February - August) and wet season (May - November). Number of animals per breef and season are shown in Table 1. Supplemented and nonsupplement animals were alloted by number as equally as possible. During the same time periods yearling animals were on experimentation, breeding cows of both breeds,5 - 10 years of age and from seven villages, likewise received treatments. A total of 148 cows were divided among the three time periods.

Table 1:
Distribution of experimental animals by breed group and season

Season	Indigenous Native		¼ American Brahman Crossbred	
	Control	Treatment	Control	Treatment
Dry (November - April)	13	12	13	11
Combination (February - August)	14	12	14	13
Wet (May - November)	12	13	11	12
Total	39	37	38	36

Sample colletion, analysis and mineral supplementation: Body weight measurements and blood samples were collected at the beginning and end of each period of the study. Five to ten native forages were collected four times at 3-months intervals and analyzed for N, Ca, Mg, P, K, S, Co, Cu, Fe, Mn and Zn. In addition to the regular collections, prior to the experiment, blood plasma was colleted during the dry season (November - April) from indigenous cattle representing three physiological classes. Blood collected prior to treatment allotment was analized for Ca, P and K while during the experiment, blood was analyzed for these minerals as well as hemoglobin and hematocrit. Samples were collected and analyzed by standardized procedures (Fick et al 1979), utilizing predominantly atomic absorption and an autoanalyzer. Plasma minerals were analyzed at the Central Laboratory Equipment Center of Kasetsart University while forage minerals were analyzed with the assistance of the Division of Chemistry, Ministry of Agriculture and Cooperatives.

Supplemented animals received a 1:2 ratio by volume of bone meal and common salt (NaCl). The mineral mixture analyzed 7.5% moistured and a pH value of 8.5. Periodic analyses of the mineral mixtures used in the villages ranged in percentage composition as follows: protein(4.0 - 4.1), P (0.50 - 0.65), K (0.05 - 0.50), Ca (15.05 - 30.80), Mg (0.40 - 0.48), Fe (0.13 - 0.19), Mn (0.07 - 0.08) and Zn (0.003 - 0.005). Supplemented animals were administered the mineral mixture on a free choice basis while control animals received no minerals, not even common salt.

Statistical analyses of data between breeds and treatments were conducted, with multiple range tests (Duncan 1955) used to test differences among means.

Results

Forage analyses: Mean analyses of forage crude protein and minerals are presented in Table 2. Protein and mineral concentrations were gene-

Table 2:
Mean mineral and protein concentrations in native grasses at three-month intervals[a]

Element	Critical level[b]	November (6)	February (5)	May (10)	August (8)
Crude protein, %	7.0	9.44	2.87	7.56	11.13
P, %	0.20	0.18	0.13	0.16	0.20
K, %	0.60	1.40	1.51	1.78	2.53
Ca, %	0.30	0.35	0.28	0.37	0.34
Mg, %	0.20	0.22	0.16	0.21	0.23
S, %	0.10	0.54	0.48	0.51	0.55
Fe, ppm	30	604.8	487.6	575.6	865.8
Mn, ppm	20	230.1	185.9	209.8	280.8
Zn, ppm	30	33.4	30.4	38.6	32.2
Cu, ppm	10	8.3	7.5	7.7	10.6

[a]Numbers in parentheses are numbers of forage samples collected each period.
[b]Reference: McDowell and Conrad (1977).

rally highest in August and lowest in February, corresponding to the late wet and dry seasons, respectively. Deficient protein levels of 2.87% were found in February (dry season). Approximately 7% crude protein is the minimum required for positive N balance in mature grazing animals (Milford and Haydock 1965; Minson and Milford 1967).

On the basis of ARC (1980) and NRC (1976) recommendations for concentrations of minerals in dry matter, all minerals were adequate with the exception of P and Cu. Phosphorus ranged from 0.13% in the late dry season to 0.20% in the late rainy season, with a critical level reported as less than 0.25% (McDowell and Conrad 1977). For adult cattle, the ARC (1980) recommends a Cu requirement ranging from 8 - 20 ppm; during three or the four collection periods, mean forage Cu was less than 10 ppm.

Plasma mineral, hemoglobin and hematocrit analyses: Mean Ca and K concentrations among 3 classes of indigenous cattle are presented in Table 3, and plasma concentration comparisons by season, breed and treatment are given in Table 4. For both the comparisons ot three animal classes and yearling animals on experimentation, plasma Ca concentrations would be considered normal (McDowell and Conrad 1977). Plasma P concentrations were abnormally high, generally ranging from 8 to 12 mg/100 ml, and were not included in Tables 3 and 4.

Table 3:

Mineral status of blood plasma Ca and K in Indigenous cattle grazing natural grassland during the dry season (mg/100 ml)

Class of cattle	Number of animals	Ca		K	
		Mean	S.D.[a]	Mean	S.D.
Less than 6-month old calves	19	10.4	2.1	3.3	1.0
7-18 months	25	9.4	4.5	3.7	1.4
Pregnant cows	17	8.2	1.5	3.2	0.8

[a]Standard deviation.

For plasma Ca, there were differences among cattle classes. The Ca concentration was lowest in pregnant cows (8.2 mg/100 ml) and highest in young calves (10.4 mg/100 ml). In the data comparing plasma concentrations of yearling animals, it was generally found that Ca and K levels in the Brahman crossbreds were higher than those of the local Thai breed. Plasma mineral concentrations in the wet season were higher than in the other two periods. Calcium concentrations found in native growing cattle were lower than the two values of the crossbred cattle within the combination season -period of supplementation.

Concentrations of hemoglobin and hematocrit for yearling animals by season are found in Table 5. There were no apparent differences in hematocrit or hemoglobin concentrations as a result of mineral supplementation. However, wet season calves tended to obtain higher values of hematocrit and hemoglobin than animals from the other two periods. For cat-

Table 4:

Mean concentrations of plasma Ca and K (mg/100 ml) for growing cattle by breed, season and treatment

Season/Treatment	Indigenous Native				¼ American Brahman Crossbred			
	Ca		K		Ca		K	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Dry (November - April)								
Unsupplemented	10.1	9.8	2.8	3.0	13.5	15.6	2.3	2.3
Supplemented	8.9	9.5	3.0	3.1	12.8	14.6	2.2	2.4
Combination (February - August)								
Unsupplemented	8.9	9.1	3.0	3.8	14.8	14.9	3.4	3.3
Supplemented	9.9	16.3	3.1	5.2	12.5	15.8	3.4	3.5
Wet (May - November)								
Unsupplemented	12.4	13.0	3.5	4.0	15.1	15.0	3.5	4.0
Supplemented	13.5	15.8	3.3	3.8	16.2	16.1	3.5	4.1

Table 5:

Mean concentrations of hematocrit (%) and hemoglobin (g%) by breed, season and treatment

Season/Treatment	Indigenous Native				¼ American Brahman Crossbred			
	Hemoglobin		Hematocrit		Hemoglobin		Hematocrit	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Dry (November - April)								
Unsupplemented	8.2	8.2	31.5	30.6	7.8	8.0	36.4	38.1
Supplemented	8.0	8.0	32.4	30.8	8.1	8.2	38.2	40.2
Combination (February - August)								
Unsupplemented	7.2	7.0	31.2	29.5	8.1	8.0	36.0	48.8
Supplemented	7.0	7.0	30.4	30.0	8.4	8.4	34.5	35.1
Wet (May - November)								
Unsupplemented	8.9	9.0	35.5	36.4	7.0	7.2	34.8	32.5
Supplemented	9.3	9.4	40.1	42.1	6.9	7.9	35.6	43.6

tle, Swenson (1970) reported normal hemoglobin concentrations above 10 g/100 ml and hematocrit ranging from 32 to 45%. In the present study, all mean hemoglobin concentrations would be low and hematocrit during the dry and combination seasons was slightly low for indigenous native cattle.

Animal performance: Daily gains of yearling cattle on the basis of treatment, breed and season of the year are presented in Table 6. Mineral consumption averaged 35 g per animal per day. For each time period and for each breed, animals receiving the complete mineral supplement had higher gains. The one-fourth Brahman crossbreds had higher gains than the indigenous native breef with or without minerals. Body weight increase, expressed as the percentage of the nonsupplemented control, revealed that one-fourth American Brahman crossbreds had higher responses to mineral supplementation than the indigenous native breed. The average improvement of these two breed groups of animals was found to be 26.0 and 18.3%, respectively. When considering the period of supplementation, animals during the dry period yielded the greatest gains while animals during the wet period had the lowest response. The combination supplementation period showed intermediate results in both breeds.

Table 6:

Average daily gain (g) of growing cattle receiving mineral supplements

Season	Indigenous Native					¼ American Brahman Crossbred				
	Treatment		Control		Improvement (%)	Treatment		Control		Improvement (%)
	Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.	
Dry (November - April)	165	55	85	46	23[a]	139	75	106	65	31[b]
Combination (February - August)	195	77	166	69	18[a]	289	83	230	74	26[b]
Wet (May - November)	197	69	173	91	14[a]	313	91	258	89	21[b]

[a,b]Percentages comparing breed groups within a row with different superscripts differ ($P < 0.05$)

Table 7 shows the improvement in reproductive rate as a result of minerals supplementation. From the combined data of 148 cows, mineral supplementation improved ($P < 0.05$) the conception rate by an average of 16.9%. Percent improvement varied among village from zero up to 52.3%.

Table 7:

Improvement in conception rate of breeding cows receiving mineral suplementation in seven villages (percentage)[a]

Village No.	Control	Supplemented	% Improvement
I	36.3[c]	53.8[b]	17.5
II	70.0[b]	72.7[b]	2.7
III	14.3[d,e]	66.6[d]	52.3
IV	100[b]	100[b]	0
V	93.7[b]	100[b]	6.3
VI	54.5[e]	100[d]	45.5
VII	90[b]	100[b]	10
Combined	66.6[c]	100[b]	16.9

[a] Represents 148 cows

[b,c] Means within a row different superscripts differ ($P < 0.05$)

[d,e] Means within a row different superscripts differ ($P < 0.05$)

Discussion

Mean forage mineral concentrations were generally adequate for Ca, Mg, K, S and Zn deficient in P and Cu while levels of Fe and Mn were generally in excess of requirements. Mineral imbalances, including excesses of Fe and Mn, may interfere with metabolism of other minerals (Lebdosoekojo et al 1980). For graing cattle in tropical regions through the world, P deficiency is the most prevalent mineral deficiency, with at least 38 developing tropical countries reporting such a problem (McDowell 1976; Fick et al 1978).

Forage Cu concentrations were quite low, with mean concentrations in three of four collections less than the critical level of 10 ppm (McDowell and Conrad 1977). The reported Cu requirement established by the NRC (1976) is lower at 4 ppm. However, in diets high in Mo and S, the Cu requirement may be increased two- or threefold (NRC 1976). Since forages were not analyzed for Mo, an assessment of the Cu status is somewhat conjecture. In addition to Mo, forage and animal tissues were not analyzed for Na, Se and Co. Deficiencies of each of these minerals have been shown to be detrimental to grazing livestock. McDowell (1976) reported Co deficiency for grazing livestock in 19 developing tropical countries and more recently (McDowell et al 1981a) for the Asian countries of India, Malaysia and the Philippines.

Plasma Ca and K were normal, P was high, hemoglobin was low and hematocrit slightly low. Mineral supplementation had little effect on these blood parameters. Abnormally high plasma P concentrations were found, contrary to the deficient levels of this mineral found in forages. Stress, exercise, hemolysis, elevated temperature and increased serum separation time are all factors that cause increases in serum P levels (Dayrell et al 1973; Fick et al 1979; Mtimuni 1982). Animal stress is suggested as one of the main causes for the high P concentrations since this factor was difficult to control under the conditions of the experiment.

Improved weight gains from mineral supplementation were dramatic for each of the seasons and for both breed groups. For unsupplemented animals, Southcombe et al (1979) reported considerably lower growth rates of 47 and 100 g per head per day in the dry and wet seasons of the year in Northeastern Thailand. Cattle grazing native grasses in the present study had around 95% better performance than the mentioned data from the Northeastern part of the country. After mineral supplementation, the overall improvement in percentage of gain was 18 and 26 in the Thai native and the Brahman crossbred animals, respectively. Previous research in Thailand (Tumwasorn et al 1980) and a number of studies from tropical regions in Latin America have noted growth benefits from mineral supplementes containing P (Fick et al 1978; Lebdosoekojo et al 1980).

Dramatic increases ($P < 0.05$) in reproductive rates were found in three of seven villages, with no difference in one village and the remaining three favoring supplemented animals but not at a significant level. A comparison of all breeding females indicated mineral supplementation increased calving percentage an average of 16.9%. In review, McDowell and Conrad (1977) listed ten experiments from Latin America in which reproductive rates were increased by mineral supplementation. In the Philippines, mineral supplementation increased the calving percentage from 57% for the controls up to 79% for the supplemented group (Calub and Amril 1979).

The specific minerals in the supplement responsible for the dramatic improvement in both growth and reproduction in this study are unknown. It is obvious from the chemical analyses of the mineral supplement that it was highly variable and that the bone meal had been adulterated. The high Ca (16.05 - 30.80%) and low P (0.50 - 0.65%) would suggest that the bone meal was adulterated with calcium carbonate. The anlyzed minerals K, Mg, Fe, Mn and Zn were likely too low in concentration to provide a response. It is possible that part of the beneficial response was due to Na. Falvey (1980) reported Na deficiencies in cattle from the Thai highlands (Chiang Mai) and overall production increased by 20% when supplementary Na was provided.

The average period of 6-month supplementation was found to be effective under Thai farming conditions. Percentage return to investment from mineral supplementation was highest during the dry season since in the wet season most of the animals are kept tied on the farm while owners spend most of their time in the rice field. From the results presented in Table 6, improvement of growth after mineral supplementation had a tendency to increase when more grazing area was given to the animal. Holmes (1981) reported research from New Guinea where percent return to investment was as high as 155% during 6 months rainy season administra tion compared to 164% for mineral supplementation during the entire year.

Above all, socioeconomic conditions of cattle owners themselves played an important role in the decision to purchase minerals. It was observed that the percentage of improvement from mineral supplementation was not very apparent to villagers. This was probable because feeding minerals did not result in sudden additional income. Again, even though fertility, which is believed to be one of the most important factors, had been improved, it was not perceived as such by the owners. If the economic return to meat production in Thailand is increased, the mineral supplementation will be very profitable.

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