EFFECTS OF SODIUM AND PHOSPHORUS SUPPLEMENTS FOR STEERS ON NATIVE PASTURES IN THE TROPICAL HIGHLANDS

T. F. Leche*

ABSTRACT

Four groups of 14 steers each were given weekly supplements of either sodium or phosphorus, both or neither for 48 weeks. They grazed together on native pasture.

Liveweight was recorded at 4- or 5-week intervals. Saliva samples were collected at 0, 30 and 48 weeks and blood samples at 0 and 30 weeks. Saliva samples were analysed for sodium and potassium. For blood samples, the concentrations of sodium, potassium, phosphorus, copper and urea in the serum were determined.

Supplementation had no effect on liveweight gain. Steers not supplemented with sodium showed large decreases in sodium, and increases in potassium, in saliva over the experiment. The levels of these elements in serum were normal and generally unaffected by the treatment. Phosphorus, copper, and urea in sera were normal in all groups. Urea content of serum samples was not different among the groups but was lower than normal.

INTRODUCTION

The beef cattle industry in the highlands of Papua New Guinea relies heavily on unimproved native grasslands. Another paper (Leche 1977) showed that native pasture in on area contained inadequate sodium for lactating cows and their calves. In addition, soils of the region generally are phosphorus-deficiant.

This paper describes an experiment which examined the effects of supplementation with sodium or phosphorus on steers grazing native pasture in the highlands.

MATERIALS AND METHODS

Location

The site was the Highlands Beef Research Unit, 10 km south of Goroka, Eastern Highlands Province (6°05' S., 142°25' E.) at 1 600 m above sea level.

Mean annual rainfall is 1 675 mm, most of which falls in the summer monsoon season between October and April.

*Formerly Senior Animal Production Officer (Cattle), Highlands Beef Research Unit, Goroka, Eastern Highlands Province. Present address: CSIRO Division of Animal Production, Blacktown, NSW 2148, Australia.

Experimental Period

The experiment was carried out between 4th April, 1975 and 5th March, 1976, a period of 48 weeks.

The experiment was designed to study sodium and phosphorus supplementation in a 2 x 2 factorial design. However, death of some experimental animals left groups unbalanced and so, in the absence of obvious significant interactions, the effects were tested by analyses of variance with unequal subgroup numbers in a completely randomized design.

Animals

Fifty-six Brahman crossbred steers aged 18.8 ± 3.3 months (mean ± standard error) and 272 ± 5.4 kg liveweight were randomly allocated to four groups of 14 each. One steer which died in the first week was replaced immediately by a comparable animal.

For the previous year these animals grazed native pasture of the type described below. A mineral supplement provided for the first six months was withdrawn for the latter six months. The composition of the supplement was ground limestone (38.8 per cent) bonemeal (38.8 per cent), salt (19.4 per cent), copper sulphate (1 per cent), cobalt chloride (1 per cent) and iodine (0.03 per cent).

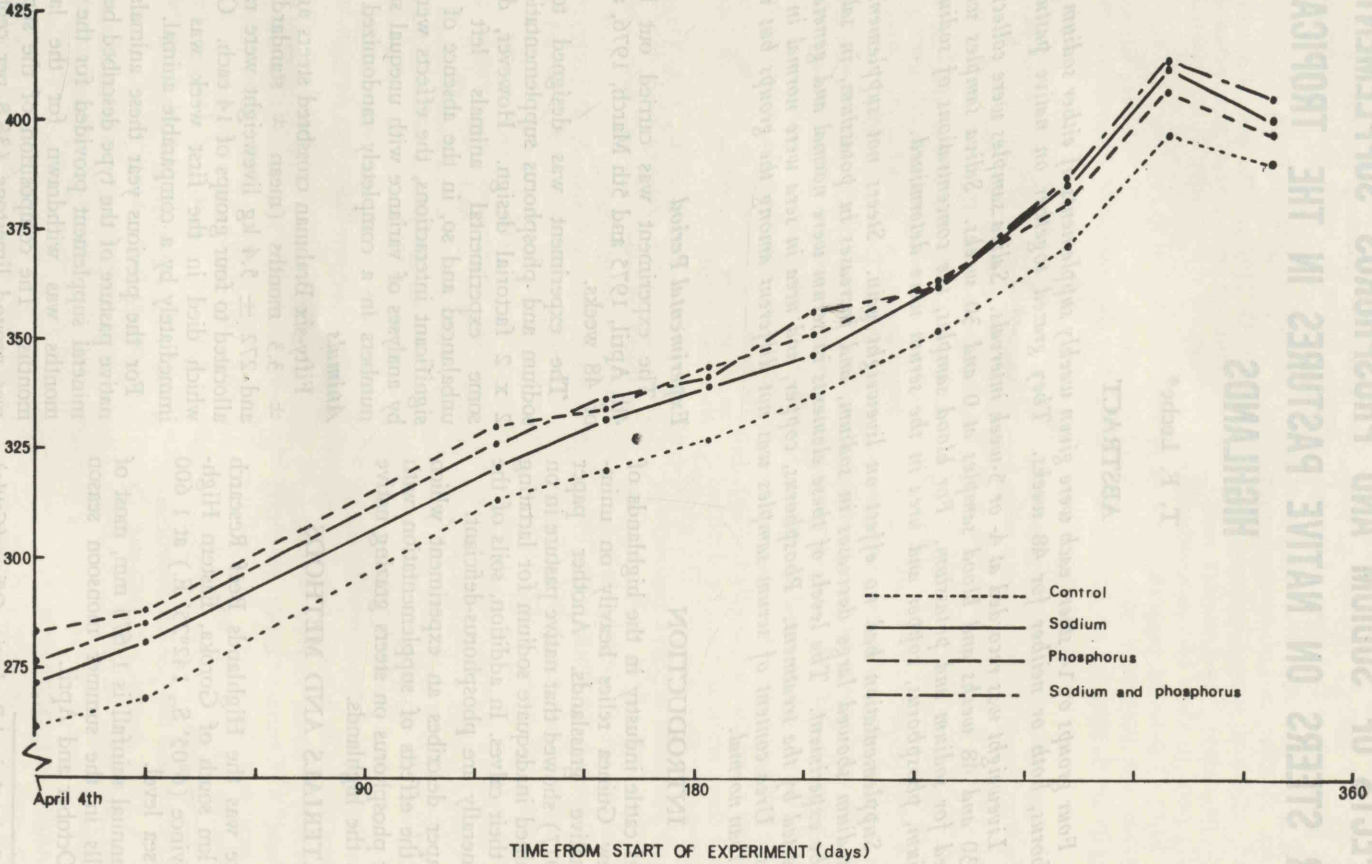

Figure 1.—Plots of mean liveweight for experimental groups at intervals during the experiment

Treatment for Helminths

All steers were drenched for helminths with 1-tetramisole (Nilverm, I.C.I., Lae) on 23rd June, 1975.

Pastures and their Management

The steers were grazed as one group in rotation around three paddocks of 26, 32 and 32 ha, at a mean stocking rate of 0.62 steers per ha.

The pasture was composed of native species, viz, *Imperata cylindrica, Themeda australis, Heteropogon* spp., along with other grasses and weeds in minor proportions.

Supplementation

At the beginning of the experiment, all steers were given the following supplements—

(1) 120 mg copper as a subcutaneous injection of copper glycinate (Coprin, Glaxovet, North Ryde, N.S.W.);

(2) One cattle-sized cobalt bullet (Siroco, 60 per cent cobaltic oxide, 40 per cent comminuted iron). This and an iron grinder were introduced into the rumen by the mouth.

(3) 1 ml of 40 per cent iodine preparation (iodized ethyl esters of the fatty acids of poppy seed oil) by intramuscular injection.

The four experimental treatments were sodium only, phosphorus only, both together or neither. The control group did not receive a placebo treatment.

The supplements were given weekly on Fridays. A length (500 mm approx.) of rigid polythene tubing (30 mm I.D.) was placed medially in the mouth to protect a softer rubber stomach tube (12 mm I.D.) which was put down the oesophagus. The supplements were administered as solutions which were poured down the stomach tube with the aid of a funnel.

Sodium was given as 0.5 l of 2.4 N NaCl which supplied 28 g Na per head per week, and phosphorus was given as 1 l of 4.34 N KH_2PO_4 which provided 45 g P per head per week.

Measurements and Sample Collection

Liveweight was recorded at 4 - or 5-week intervals. Data for the second and third weighings after the initial weighing were discarded later as the weighing machine was found to be faulty.

Saliva samples were collected by a modification of the method of Murphy and Connell (1970) on 3rd April and 31st October, 1975 and on 5th March, 1976.

Blood samples (c. 10 ml) were taken by tail bleeding on 3rd April and 31st October, 1975. Serum was separated by centrifugation and frozen at 20°C.

The levels of sodium and potassium in the saliva and serum samples were determined by direct flame photometry.

Urea content of serum was determined by the phenol-alkaline hypochlorite method (Henry 1966).

The concentration of copper in serum was determined only on the samples collected on 31st October, 1975, by atomic absorption spectrophotometry after precipitation of protein with 8 per cent trichloracetic acid.

RESULTS

Liveweight Gain

Growth curves of the groups are shown in *Figure* 1. The mean daily liveweight gains for the entire experimental period appear in *Table* 1.

The phosphorus-only grew more slowly but this difference was not significant. Growth rates of the other groups were very similar and are typical for steers on this type of pasture (Leche, unpublished data).

Sodium and Potassium Concentrations in Saliva

The levels of sodium and potassium in saliva collected at the three samplings are illustrated in *Figure* 2. The corresponding means with standard errors are presented in *Table* 2.

There were no significant differences among groups in concentration of sodium or potassium in saliva at the start of the experiment. Therefore, the treatment effects on these concentrations were tested by analysis of variance using the changes in concentration between first and last samplings for individual steers (*Table* 2).

At the beginning, sodium was lower and potassium higher than is normal, for all groups (Murphy and Plasto 1973). This probably

Table 1.—Mean liveweight gain per day of steers over the experimental period

Treatment group	Number of steers	Mean liveweight gain per day (± s.e.), kg*
Control	14	0.378 ± 0.012
Sodium	12	0.372 ± 0.017
Phosphorus	13	0.338 ± 0.022
Sodium + phosphorus	12	0.378 ± 0.019

* No significant differences.

results from the extremely low sodium content of these pastures (Leche 1977) and the six-month period before the experiment when the steers were denied a mineral supplement.

By the second sampling the sodium level had increased and the potassium decreased to more normal values for the two groups being given sodium. There was no significant change for the phosphorus-only group but in the control group the sodium concentration had fallen 17.1 m-equiv/l and potassium had risen by 1.4 m-equiv/l). These changes in the control group are indicative of developing sodium deficiency.

Between the second and third samplings, the control group suffered a further decrease of 25.3 m-equiv/l for sodium and an increase of 18.8 m-equiv/l for potassium. Even greater changes in the same directions were experienced by the phosphorus-only group; sodium fell 32.0 and potassium rose 20.3 m-equiv/l. For the two groups receiving sodium, with or without phosphorus, sodium concentration fell and potassium increased but the actual values were still within the normal range.

By the end of the experimental period, the provision of sodium resulted in average saliva sodium levels 47.2 m-equiv/l higher and potassium levels 37.5 m-equiv/l lower, than for the groups not receiving it ($P < 0.01$).

Serum Composition

(1) Sodium and Potassium

The sodium content of serum samples was normal and not significantly different among groups at either sampling (*Table* 3).

This was the case also for potassium at the first collection. However, at the second sampling, the mean for the control group was normal but higher than for the sodium-only group ($P < 0.05$).

(2) Phosphorus

The mean levels of phosphorus in serum samples taken on two occasions were not significantly different among groups or between samplings and the pooled mean (± standard error) was 6.18 ± 0.20 mg/dl. All samples had concentrations of phosphorus within the normal range.

(3) Copper

The concentration of copper in serum was normal and not significantly different among the groups. The overall mean (± standard error) was 67.5 (± 0.97) mg/dl.

(4) Urea

There were no significant differences in concentration of urea in serum samples at either sampling. The mean (± standard error) pooled over all groups and both samplings was 7.43 ± 0.28 mg/dl.

Mortality

Six steers died during the experiment: three from accidental drowning while being drenched, and three from throat infections probably arising from injury during drenching. All but one occurred in the first seven weeks, indicating that the difficulty was due mainly to inexperience with the technique. The throat injuries were likely caused by abrasive marks on the polythene tube, which were made by the teeth of the steers.

Near the end of the period, the polythene tubing was replaced by a smooth steel pipe and no more trouble of this sort occured.

The technique of giving mineral solutions to individual steers proved very useful in this experiment. By allowing all the animals to be run together it eliminated differences in pasture quality in various paddocks as a potentially important source of variation. It also ensured that the intake of supplement was known and constant for all animals within a group.

The mortality rate was regrettably high but after initial difficulties were overcome, the technique was simple and effective.

DISCUSSION

Supplementation with sodium or phosphorus or both did not affect growth rate of the steers in this experiment. This is in contrast to the effect that sodium supplementation had on lactating cows and their calves on the same pasture (Leche 1977) but agrees with results for steers on native pasture in northern New South Wales (Hennessy 1971). However, provision of sodium did prevent large changes in saliva composition which usually indicate sodium deficiency.

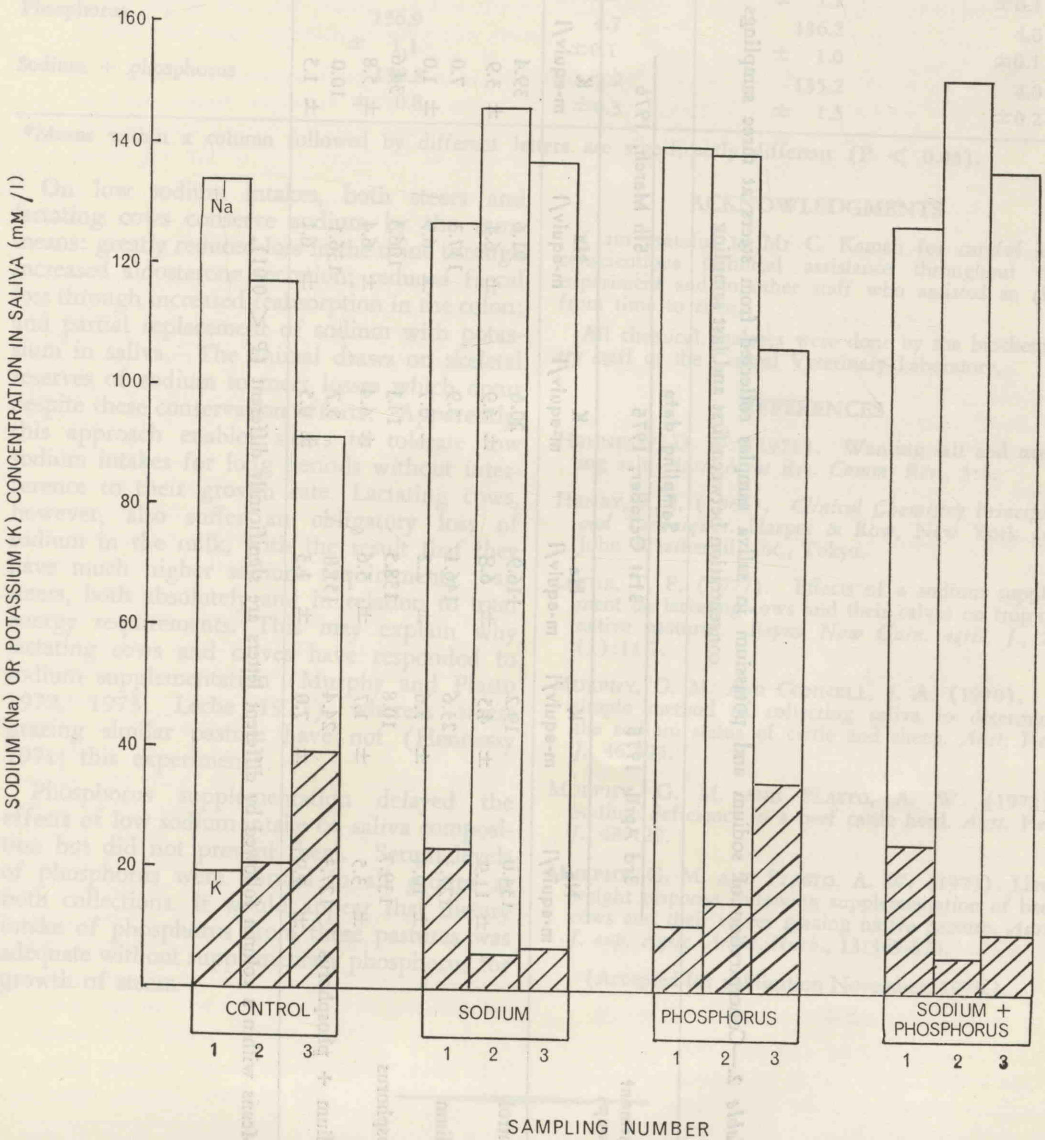

Figure 2.—Histogram showing concentration of sodium and potassium in saliva samples from four treatment groups at three samplings (1 = 3rd April, 1975; 2 = 31st October, 1975; 3 = 5th March, *Table* 2.—Concentration of sodium and potassium in saliva samples collected from steers at three samplings and mean differences in concentration between first and last sampling

Treatment groups	Sampling date: 3rd April, 1975		31st October, 1975		5th March, 1976		Change between 3rd April, 1975 and 5th March, 1976*	
	Na m-equiv/l	K m-equiv/l	Na m-equiv/l	K m-equiv/l	Na m-equiv/l	K m-equiv/l	Na m-equiv/l	K m-equiv/l
Control	134.0 ± 11.9	19.2 ± 4.5	116.9 ± 6.8	20.6 ± 4.9	91.6 ± 6.4	39.4 ± 3.9	-42.4 a ± 12.0	20.2 a ± 6.0
Sodium	127.3 ± 10.4	23.6 ± 7.6	146.1 ± 2.2	5.9 ± 0.7	137.3 ± 6.7	7.0 ± 1.0	10.0 b ± 9.5	—16.6 b ± 7.5
Phosphorus	139.7 ± 3.5	10.8 ± 1.7	138.5 ± 5.6	14.3 ± 4.4	106.5 ± 6.4	34.6 ± 5.8	—33.3 a ± 5.2	23.8 a ± 5.1
Sodium + phosphorus	127.3 ± 7.9	24.4 ± 7.0	151.8 ± 1.3	5.7 ± 0.5	136.1 ± 6.1	10.0 ± 1.5	8.8 b ± 8.1	—14.4 b ± 6.7

* Means within a column followed by different letters are significantly different ($P < 0.01$).

Table 3.—Concentration of sodium and potassium in serum samples collected from steers on two occasions

Treatment group	Sampling date			
	3rd April, 1975		31st October, 1975	
	Na m-equiv/l	K m-equiv/l	Na m-equiv/l	K* m-equiv/l
Control	137.6 ± 0.9	5.0 ±0.3	137.6 ± 1.1	4.5 a ±0.2
Sodium	137.9 ± 1.1	5.0 ±0.2	137.0 ± 1.1	3.8 b ±0.1
Phosphorus	136.9 ± 1.1	4.7 ±0.1	136.2 ± 1.0	4.0 ab ±0.1
Sodium + phosphorus	138.8 ± 0.8	5.2 ±0.3	135.2 ± 1.5	4.0 ab ±0.2

*Means within a column followed by different letters are significantly different ($P < 0.05$).

On low sodium intakes, both steers and lactating cows conserve sodium by the same means: greatly reduced loss in the urine through increased aldosterone secretion; reduced faecal loss through increased reabsorption in the colon; and partial replacement of sodium with potassium in saliva. The animal draws on skeletal reserves of sodium to meet losses which occur despite these conservation efforts. Apparently, this approach enables steers to tolerate low sodium intakes for long periods without interference to their growth rate. Lactating cows, however, also suffer an obligatory loss of sodium in the milk, with the result that they have much higher sodium requirements than steers, both absolutely and in relation to total energy requirements. This may explain why lactating cows and calves have responded to sodium supplementation (Murphy and Plasto 1972, 1973; Leche 1977) whereas steers grazing similar pasture have not (Hennessy 1971; this experiment).

Phosphorus supplementation delayed the effects of low sodium intake on saliva composition but did not prevent them. Serum levels of phosphorus were normal in all groups at both collections. It would appear that dietary intake of phosphorus from these pastures was adequate without supplementary phosphorus for growth of steers.

ACKNOWLEDGMENTS

I am grateful to Mr C. Kamen for careful and conscientious technical assistance throughout this experiment and to other staff who assisted so ably from time to time.

All chemical analyses were done by the biochemistry staff of the Central Veterinary Laboratory.

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(Accepted for publication November, 1976.)