EFFECTS OF SODIUM DEPLETION IN CATTLE FED SORGHUM GRAIN

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Summary

Three steers with rumen fistulae received an all-sorghum grain ration low in ($P<0.001$) of 0.928 was found between the Na/K ratio in saliva and ruminal fluid was determined weekly and decreased rapidly from initial values of 14 and 9 respectively to about 1 within 9 weeks. A significant correlation coefficient ($P<0.001$) of 0.928 was found between the Na/K ratio in saliva and ruminal fluid. The lowest concentrations of Na in saliva and ruminal fluid were 30.3 and 17.3 m-equiv. /0 1. respectively.

Four balance trials were done on two Na deficient steers fed sorghum grain. During the last trial, steers were supplemented with 8.74 g Na per day. The mean Na retention over the first three trials was close to zero whereas 97.8% was retained when Na was supplemented. The minimum concentration and daily excretion of Na in the urine was 0.02 m-equiv./ 1. and 0.01 g respectively. Corresponding minimum values for Na in faeces were 54 p.p.m. and 33.9 mg respectively.

I. INTRODUCTION

The effects of adding sodium (Na) to an all-sorghum grain ration on the performance of growing steers were reported by Morris and Gartner (1970). Changes were found in the Na and potassium (K) concentrations of saliva and ruminal fluid and in the Na concentration in urine and faeces.

This paper reports (i) the changes with time and the relationship between the Na and K concentrations in saliva and ruminal fluid in steers fed sorghum grain low in Na, and (ii) the excretion of Na and K in Na deficient and replete steers maintained on these rations.

II. MATERIALS AND METHODS

(a) Water and Feed

Animals received demineralised water (less than 0.001 per cent Na), hybrid ***Sorghum vulgare*** grain containing 26 p.p.m. Na and 3,240 p.p.m. K on a dry

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matter (D.M.) basis and the mineral and vitamin mix used by Morris and Gartner (1970). The grain was coursely rolled.

(b) Analytical Methods

Na and K concentrations were estimated by flame photometry. For saliva and blood, an Instrumentation Laboratories Model 143 was used. For urine, feed and faeces, an Eel instrument was used and allowances were made for interferences of calcium and phosphorus.

(c) Design

(i) Experiment I

Three steers fitted with permanent rumen fistulae were used to examine the relationship between the Na and K concentrations of saliva and ruminal fluid. One was 7 years old and weighed about 650 kg. The other two were 3½ years old and weighed 250 and 420 kg. These animals were adjusted to an all-grain ration over a period of 28 days. Thereafter, they were maintained in concrete yards and group fed *ad libitum.*

Samples of saliva, blood and ruminal fluid were collected at weekly intervals from each steer for 21 weeks. Three samples of mixed saliva were collected on each occasion from each animal as described by Murphy and Connell (1970). The animals were withdrawn from feed and water 30 min before samples were taken.

(ii) Experiment 2

Na and K balance was determined in two Na deficient Hereford steers. They were 20 months of age, weighed about 360 kg and had received sorghum grain rations providing a mean daily intake of about 133 mg Na for eight months (Morris and Gartner 1970) prior to the present experiment. They were maintained on this ration for a further period of 15 weeks. Three balance trials were done over periods of 14, 10 and 21 days followed by one over 16 days during which sodium chloride was added to a portion of the drinking water to provide a daily intake of 8.74 g Na.

The daily D.M. output of faeces was determined. Samples were hammer milled and mixed and a sub-sample obtained for each collection period. The weight of urine was measured and an aliquot of each day's output was analysed. Periodic checks were taken on the Na status of the steers by analysis of saliva. At the conclusion of the last balance trial, the steers were slaughtered.

III. RESULTS

(a) Experiment 1

The mean daily intake of grain was 6.6 kg. However, intake decreased over the last 6 weeks of the experiment and was 3.8 kg daily over the last 2 weeks. One animal died after 18 weeks.

There was a marked fall in the Na concentrations of saliva and ruminal fluid with a corresponding increase in K concentrations. Most of this change occurred after 5 to 9 weeks of feeding grain. The correlation coefficients between the ratio of Na/K in saliva and ruminal fluid were significant for each steer ($P<0.001$), being 0.850, 0.990 and 0.833. The mean value for each sampling period and the changes with time are shown in Figure 1. The overall correlation coefficient of 0.928 was significant ($P<0.001$).

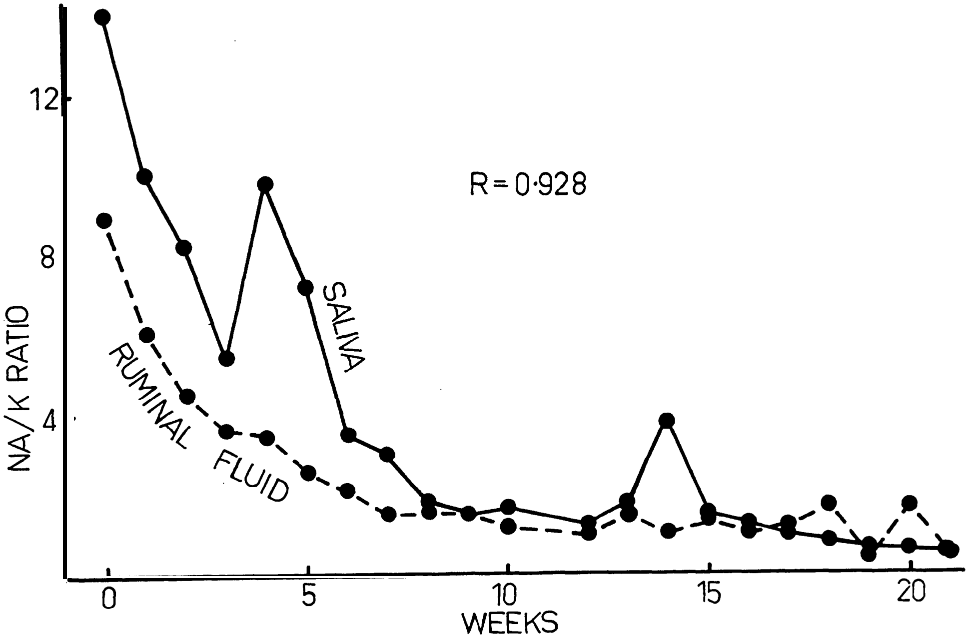

Fig. 1. — Changes with time and relationship between the Na/K ratios of saliva and ruminal fluid in steers fed sorghum grain low in Na.

The lowest concentration of Na in either saliva or ruminal fluid was 30.3 and 17.2 m-equiv./1 respectively. The highest K concentrations were 110.6 and 116.7 m-equiv./1 respectively. The mean values for rumen Na and K were 7.5 per cent lower and 14.9 per cent higher than the concentration of the respective ions in saliva.

Although values for plasma Na and K fluctuated, there was no trend with time. The mean concentrations were 138.8± S.D. 3.72 and 3.99± S.D. 0.43 respectively.

(b) Experiment 2

Results of the four balance experiments are given in Table 1. Steer 1 consistently had a smaller feed intake than steer 2 and a greater water intake resulting in a greater volume of urine. The feed intake in both animals increased by almost 30 per cent after Na supplementation. Differences in the amounts of faeces and urine voided resulted in small differences between animals in Na and K balance.

Appreciably more Na was excreted through the faeces than the urine, whereas more K was excreted through the urine. The mean Na retention over the first three balance periods was close to zero, but 97.8 per cent of the Na was retained in the final period. A predominantly positive K balance changed to a negative balance when Na was supplemented.

The minimum and maximum concentrations of Na found in any sample of urine were 0.02 and 8.8 m-equiv./1 respectively, and the minimum and maximum amounts excreted over 24 h were 8.8 and 860.9 mg respectively. Corresponding extremes for Na in faeces were 54 and 177 p.p.m., and 33.9 and 204.4

TABLE 1

Mean daily intake, excretion and retention of Na and K in steers

Measurements on a Daily Basis	Periods							
	10/iii — 23/iii		24/iii — 2/iv		24/v — 13/vi		14/vi — 29/vi	
	Steer 1	Steer 2	Steer 1	Steer 2	Steer 1	Steer 2	Steer 1	Steer 2
Feed intake (kg)	4.5	5.5	4.8	5.7	4.7	5.4	6.1	6.8
No supplement (g)	0	0	0	0	0	0	8.74	8.74
Water intake (l.)	54.0	24.9	60.7	25.5	42.1	15.0	46.6	21.5
D.M. faeces output (kg)	0.40	1.22	0.59	1.39	0.51	1.08	1.03	2.02
Urine output (l.)	41.6	8.6	49.8	11.0	32.4	5.4	37.6	8.7
Na intake* (mg)	78	95	82	98	81	93	105	118
Na excretion in urine (mg)	24	14	28	13	34	25	151	181
Na excretion in faeces (mg)	71	75	83	75	34	59	68	204
Na retention (mg)	—17	+ 6	—29	+10	+13	+9	+8,626	+8,473
K intake (g)	12.6	15.4	13.4	16.0	13.2	15.1	17.1	19.2
K excretion in urine (g)	10.1	8.6	12.8	9.2	10.9	8.8	21.0	10.4
K excretion in faeces (g)	0.7	3.9	1.0	4.6	1.0	3.6	3.2	9.1
K retention(g)	+ 1.8	+ 2.9	—0.4	+2.2	+1.3	+2.7	—7.1	—0.3

* Contributed by the feed only.

mg respectively. After supplementation of Na, it took from 10 to 12 days before the daily urinary excretion of Na increased from less than 50 mg to about 300 mg.

Eleven days prior to the first collection period, the Na and K values in saliva were 49.9 and 92.2 m-equiv./1 for steer 1, and 84.6 and 70.8 m-equiv./1 for steer 2. Prior to the third collection period, the values were 44.2 and 83.6 m-equiv./1 for steer 1 and 36.3 and 102.1 m-equiv./1 for steer 2. After Na supplementation, the saliva ionic concentrations of steer 1 returned to normal (142 m-equiv./1 Na and 6.3 m-equiv./1 K) and of steer 2 to near-normal (129.1 m-equiv./1 Na and 17.6 m-equiv./1 K). When the steers were slaughtered after this experiment, there was evidence of increased widths of the zona glomerulosae of the adrenals and more extensive duct system in the parotid salivary glands, but no changes in the kidneys.

IV. DISCUSSION

Results from the fistulated steers confirm the observations of Bailey (1961) of a relationship between the concentrations of Na in saliva and ruminal fluid. He found a small variation in the ionic concentrations while a cow was consuming any one diet and a large variation between cows and between diets supplying 4 to 16 g Na daily. Our experiment showed the rapid rate of change in these ionic concentrations in animals ingesting much lower amounts of Na. This resulted in levels of Na and K in saliva which were lower and higher respectively than those quoted by Bailey (1961) in dry cows and by Kemp and Geurink (1966) in lactating cows.

In similar manner to Bailey (1961), we found a lower concentration of Na and a higher concentration of K in ruminal fluid compared with saliva. However, we do not agree with him that the level of Na in ruminal fluid does not generally fall below 60 m-equiv./1 as our results show levels down to 17.2 m-equiv./1. A comparison with the results of Kemp and Geurink (1966) for levels of Na and K in ruminal fluid of cows fed rations low in Na show that our steers reached a greater degree of Na depletion. Despite this very low Na status, the Na content in plasma remained normal.

In the balance trials, Na loss through the skin and by saliva have not been measured and Na retention would thus have been overestimated. Kemp (1964) assumed 2.5 g per day would account for these “other excretions” in lactating cows, but this is an overestimate when applied to our steers because saliva output is greatly reduced under high-grain feeding (Davis, Brown and Beitz 1964) and the concentration of Na in the saliva would have been very low.

The minimum concentration of Na in the urine of the steers was approximately 40 to 60 times lower than minimum values found by Renkema et ***al.*** (1962) and Kemp (1964) in milking cows and by Bott et *al.* (1964) in grazing cattle. Similarly, the minimum total daily urinary excretion of Na was about 50 times lower than the value reported by Kemp (1964) in cows receiving 5.8 to 9 1 .0 g Na daily. This difference is due to the relatively lower intake of Na by our steers, for Kemp (1964) found a linear relationship between Na intake and Na concentration in urine.

Renkema et *al.* (1962) found that the K concentration in faeces of cows increased when daily Na intake decreased from 46 to approximately 4 g. On the other hand, both the concentration and the daily output of K in faeces increased in the present experiment when Na was supplemented.

The concentrations of Na in saliva, urine and faeces in the Na deficient steers were lower than any comparable values cited in the literature.

V. ACKNOWLEDGMENTS

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