EFFECT OF WATER, NITROGEN AND POTASSIUM LOADING ON SODIUM RETENTION BY CATTLE ON A LOW SODIUM INTAKE

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Summary

Steers grew at 0.25 kg per day for over a year on a ration containing 0.008% sodium (Na) and providing only 10 per cent of the published Na requirement. A low Na:K ratio developed in the saliva. Loadings with water or nitrogen (urea + casein) had no significant effect on Na balance. A simultaneous loading with potassium (as potassium bicarbonate) and nitrogen caused a transitory reduction in Na balance with the animals subsequently adapting to the load.

It was concluded that the salivary Na:K ratio was not a sensitive indicator of the adequacy of a sodium intake for growth and that this adequacy is not likely to be significantly affected by high water, nitrogen or potassium intakes.

I. INTRODUCTION

Sodium (Na) and chlorine are essential nutrients for animals, with Na being the more likely limiting factor on natural diets (Underwood 1966). Sodium chloride has long been given to grazing livestock but a growth response has not generally occurred (Skinner 1964), although Bott et al. (1964) suggested that a Na deficiency was likely to occur in grazing cattle in some areas. This suggestion was based on the finding of low salivary Na:K ratios and low urinary Na concentrations in animals eating pastures containing little Na. However, these criteria may not be associated with depressed productivity but may merely reflect an adaptation to a low Na intake. Factors other than Na intake may also be important in Na retention by grazing animals (Underwood 1966).

The present experiment was directed at examining the effect of water, nitrogen (N) and potassium (K) loadings on Na retention by grazing cattle on a diet low in Na, and at assessing the sensitivity of the salivary Na:K ratio as an indicator of whether there is adequate Na for growth.

II. MATERIALS AND METHODS

Young, growing cattle were held in stalls to observe their growth and to measure their retention of Na by balance experiments, involving complete collections of urine and faeces for seven-day periods over 14 months. Six Aberdeen Angus steers aged 18 months were used initially, but only four were available
for the final trials because of the death of two from the group. The studies commenced after the steers had been on the low Na diet for 8 months.

The diet was fed to the steers appetite and consisted of 65 per cent cotton linters* (94 per cent cellulose) and 35 per cent finely crushed maize with mineral additives and urea. The diet contained 0.008 per cent Na, 0.37 per cent K and 1.4 per cent N. Drinking water was distilled or collected rain water containing, 0.0001 per cent Na, sometimes. supplemented with town water containing 0.005 per cent Na, during periods of high water demand. Intake of Na by each steer from the diet averaged 0.49 ± S.E. 0.26 g/day over the 14-month period. Vitamins A, D, and K were given regularly as intramuscular injections.

Water loading was undertaken by raising the voluntary level of intake by the steers from 4.4 kg/kg dry matter consumed to 10 kg/kg by drenching them with water three times each day. Potassium intake was increased from 22 to 254 g/head/day by adding KHCO₃ to the diet, and N intake was increased from 86 to 320 g by adding urea and casein. After two years on the diet, 30 g of sodium chloride was added to the daily ration of each steer with observations being made on growth of the steers for two months.

Growth was estimated from weighings of the animals throughout the experiment. Mixed saliva samples were taken once a month by rubbing a polyurethane sponge inside the cheek of a steer, prior to its eating. Care was taken to avoid sampling saliva from around or underneath the tongue.

Various samples of pasture types of the Northern Tablelands and North Coast of N.S.W. were analysed to determine the relative amounts of water, N, K and Na in such pastures as a basis for comparison with the experimental treatments imposed.

Feed and faeces samples were prepared for N, K and Na determinations by a technique of “wet ashing”, and solutions of the residue were analysed by the Auto Analyser?.

III. RESULTS

From an initial liveweight of 300 kg, the steers grew at 0.25 ± S.E. 0.03 kg/day for 14 months during the experiment. Plasma Na concentrations averaged 134 ± S.D. 1.2 m-equiv./1 during this period, while salivary Na:K ratios ranged from 0.68 to 1.8. However, the ratio was determined as 3.0 after sodium chloride had been supplemented for six weeks, during which time the plasma Na concentration increased to 140 ± S.D. 1.7 m-equiv./1.

Water loading had no significant effect on Na retention (Figure 1) despite a threefold increase in urine volume, because there was a concomitant reduction in the Na concentration.

Nitrogen loading did not significantly affect Na retention or urinary loss (Figure 1), although a 30 per cent reduction in faecal loss (P < 0.01) increased the retention in the second and third weeks of the treatment.

*Suppliers by the Cotton Marketing Board, Queensland.

Simultaneously, loading the animals with potassium bicarbonate and N significantly reduced the Na balance during the weeks two, four and six (P < 0.01). However, in the final four weeks, the steers had apparently adapted to this load (Figure 2) by returning to a positive balance. The net Na losses were due to a tenfold increase in urinary excretion, mainly through a diuresis (for the weeks two and four: P < 0.01), and to a twofold increase in the faecal loss during week six (P < 0.01).

The highest K:Na ratio in the experimental diets (500: 1, with 0.008% Na) exceeded that found in the pasture samples (19: 1, with 0.013 % Na) and, similarly, the highest N:Na ratio (650: 1) was greater than the highest ratio found in the pastures (150: 1).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Length of Time on low Na Diet (months)</th>
<th>Mean Na + K Ratio of Mixed Saliva</th>
<th>Concentration of (Na + K) in Mixed Saliva (m-equiv./l)</th>
<th>Mean (± S.D.) of Plasma Na Concentration (m-equiv./l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterloading</td>
<td>12</td>
<td>0.90</td>
<td>143</td>
<td></td>
</tr>
<tr>
<td>K + N loading</td>
<td>14</td>
<td>0.68</td>
<td>116</td>
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<tr>
<td>N loading</td>
<td>16</td>
<td>0.75</td>
<td>114</td>
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<tr>
<td>Control</td>
<td>18</td>
<td>1.80</td>
<td>161</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>19</td>
<td>0.90</td>
<td>138</td>
<td>134 ± 1.2</td>
</tr>
<tr>
<td>K + N loading</td>
<td>21</td>
<td>0.90</td>
<td>138</td>
<td></td>
</tr>
<tr>
<td>K + N loading</td>
<td>23</td>
<td>0.78</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Sodium chloride supplement</td>
<td>2†</td>
<td>3.00⁰⁰</td>
<td>140</td>
<td>140 ± 1.7⁰⁰</td>
</tr>
</tbody>
</table>

†Refers to two months after commencing supplementing animals with 30 g sodium chloride daily.

**P < 0.01 in Student "t" test.

Fig. 1.—Effect of water and nitrogen loadings on the urinary and faecal sodium excretion and on sodium balance.
Animal numbers were reduced to four, when two of the group died from spontaneous haemorrhages. All animals developed a prolonged clotting time of the blood (25 min) after 18 months on the diet, which was not completely corrected by Vitamin K or Na supplementation. Consequently, it is not known whether the delayed clotting was an effect of the Na regimen or due to some anti-clotting agents in the diet.

IV. DISCUSSION

The steers maintained a growth rate of 0.25 kg/day on a dietary Na intake of approximately 10 per cent of that recommended by the Agricultural Research Council (1965) (calculated as 4.9 g/day for 250 kg beasts growing at 0.3 kg/day) and still achieved a positive Na balance. This continued for at least 14 months, despite a transitory net loss of Na following commencement of the K±N loading.

The low plasma Na concentrations and salivary Na:K ratios in the animals during the time they were unsupplemented with sodium chloride were not associated with a depression in growth, relative to that recorded in the final few weeks, when 30 g sodium chloride was added to the daily ration. Both the plasma Na concentration and salivary Na:K ratio increased with the supplement (P < 0.01). This would tend to indicate that neither of these 2 factors was a sensitive indicator of the adequacy of the Na intake, although Bott et al. (1964) and Kemp and Geurink (1966) suggested that a low salivary Na:K ratio was associated with an inadequate Na intake in ruminants. Kemp and Geurink (1966) concluded that ratios less than 0.6 indicated that the body reserves of Na had been seriously depleted.

Where Na balance was reduced initially by a treatment, it was due to an increased urinary loss associated with a diuresis rather than to a change in the
Na concentration. Subsequent recovery to a positive balance (e.g. week 11 in Figure 2) occurred, however, because of a reduction in the Na concentration rather than to a cessation of the diuresis.

An increase in the faecal Na loss was responsible for a significant decrease in Na balance in only one of the seven-day periods during the time of K + N loading.

The cattle appeared to have a capacity to retain Na and grow on a Na intake considerably less than that recommended by the Agricultural Research Council (1965), even when loaded with dietary components which were thought likely to reduce the retention (Kemp 1964; Underwood 1966). However, the small number of animals involved has prevented a critical assessment of whether growth was depressed by a lack of Na. At least there was no change in the rate after sodium chloride supplementation. Whether a similar concentration of Na in a diet, allowing a greater energy intake, would have depressed growth is open to question.

Nevertheless, the experiment indicates that the salivary Na:K ratios are unreliable as indicators of Na deficiency and that an assessment of a critical Na level in diets can be made independently of the levels of water, N and K.

V. ACKNOWLEDGMENTS

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VI. REFERENCES


