The effect of high salt intake or restricted water intake on diet selection by sheep

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1. In three experiments sheep were offered a choice of two rations: one high in NaCl (7·5 or 15 %) and one low in NaCl. The intake of each ration was recorded when fresh water was freely available, when increasing amounts of NaCl were added to the drinking water and when the amount of fresh water available was restricted.

2. Low levels of NaCl in the drinking water or mild restriction of available water were without effect on the diet selected. At higher levels, total food intake was reduced and the reduction was sustained entirely by the high-salt ration. The intake of the low-salt ration remained the same or increased, so that the selected diet then contained an increased proportion of the low-salt ration. The effects of adding NaCl to the drinking water and of water restriction were similar.

3. It was concluded that sheep with a choice of high- and low-salt rations can partly avoid the stress of saline drinking-water or restricted water supply by changing the proportion of each ration eaten.

Sheep exhibit definite dietary preferences, eating some plants and rejecting others, and preferring leaves before stems. However, the work of Gordon & Tribe (1951) and Gordon, Tribe & Graham (1954) with diets deficient in protein and phosphorus suggests that the dietary preferences of sheep have no nutritional significance. The exception to this conclusion is sodium, as Denton & Sabine (1961) found that sodium-deficient sheep were able to correct accurately their deficiency by selecting solutions of sodium bicarbonate or sodium chloride to drink. Furthermore, Arnold (1964) found that sodium-deficient sheep preferentially selected grasses of high sodium content.

In arid areas both herbage and drinking water can have a high salt content, so that sheep may have an excessive intake of sodium (Wilson, 1966). In view of the selective appetite for sodium shown by sodium-deficient sheep, it is possible that sheep could avoid an excess of sodium by selecting plants of low sodium content, even though the alternative plants may be of lower nutritive value. Furthermore, high sodium intakes are associated with high water intakes (Wilson, 1966) and it would be an advantage for sheep with restricted water supply to choose a diet low in sodium. It has been observed by Taneja (1966) that sheep with restricted water supply are able to avoid water deficiency by selectively grazing plants of high moisture content. However, in most instances plants with a high moisture content are high in salt content and the selection of a low-salt diet may differ from the selection of a high-moisture diet.

This paper reports several experiments on the effects of saline drinking-water and water deprivation on the sheep's preferences for rations of high or low sodium content.

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EXPERIMENTAL

Three experiments were conducted with individually penned Merino wethers (mean weight 44·2 kg, aged 15 months) which were offered *ad lib.* a choice of rations, one high in NaCl content and the other low. The details of these rations are given in Table 1. The high-salt ration was prepared by dissolving NaCl in water and spraying it on to lucerne chaff as it revolved in a paddle-type mixer. The salty lucerne was then dried in forced draught ovens at 80°. The composition of the low-salt rations is shown in Table 1. No NaCl was added to these and the rations for the three experiments contained 0·70, 0·86 and 0·49% sodium respectively.

The treatments applied were of two types. In the first, increasing amounts of NaCl were added to the drinking water, and in the second, the amount of fresh water available was restricted. Details of the number of sheep used, the treatments applied and the experimental designs are shown in Table 1.

In Expts 1 and 2 the low-salt ration was of poor quality so that the initial preference was for the high-salt ration, but in Expt 3 the two rations were chosen so that initially they were eaten in equal amounts. The amount of each ration offered was adjusted daily to allow a residue of about 200 g. The positions of the feeding troughs containing these rations were alternated daily in Expt 3, but in Expts 1 and 2 they were changed only occasionally.

The intakes of each ration and of water, and in Expt 3 the faecal output, were recorded daily. Samples of the rations, the residues and the faeces were taken daily and dried at 105°.

Expt 1. In Expt 1 *a* the high-salt ration contained either 7·5% or 15% NaCl and NaCl was added to the water at a level of 0·0, 0·5, 1·0 or 1·5% (w/v). At the completion of Expt 1 *a* it was apparent that a still higher concentration of NaCl in the water could have been used. As four of the sheep were still available, an extra period with 15% NaCl–lucerne and 2% NaCl in the water was begun 5 weeks after the completion of the main experiment, and is shown in Table 1 as Expt 1 *b*.

Expt 2. This experiment was of three periods. In the first, three sheep were offered water *ad lib.* and two sheep were allowed only 3·5 l./day and these treatments were reversed in each subsequent period.

Expt 3. Three levels of NaCl in the drinking water (0·0, 0·75, 1·5%) and of daily water allowances (unrestricted, 5·0 l., 2·5 l.) were applied. In addition, the most severe treatments (1·5% NaCl in water or 2·5 l./day) were applied to sheep fed without choice on either the high- or the low-salt rations.

RESULTS

Expt 1. The intakes of food, NaCl and water are shown in Table 2. In Expt 1 *b* one of the four sheep ate well for 4 days but its appetite then declined and it was found dead on the 7th day. The values shown in Table 2 are means for the three remaining sheep. Expt 1 *b* and Expt 1 *a* were compared statistically by means of the error derived from the results of Expt 1 *a*. Although not randomized with the main experiment, the results of Expt 1 *b* followed the trend of results in that experiment.

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Table 1. *Summary of experiments*

Expt. no.	No. of sheep and design	Preliminary and collection periods (days)	Rations offered	Drinking water
1 *a*	8 (incomplete randomized block, 4 periods)	9+10	(*a*) Lucerne chaff containing 7·5 or 15% NaCl (*b*) Straw–ryegrass residues–lucerne chaff, 2:2:1	0, 0·5, 1·0, 1·5 %NaCl
1 *b*	4 (single observation)	9+12	(*a*) Lucerne chaff containing 15% NaCl (*b*) Straw–ryegrass residues–lucerne chaff, 2:2:1	2·0% NaCl
2	5 (double reversal)	9+12	(*a*) Lucerne chaff containing 15% NaCl (*b*) Straw–lucerne chaff, 3:1	*ad lib.* or 3·5 l. daily
3	10 (two 5×5 latin squares, completing only 4 periods)	7+10	(*a*) Lucerne chaff contining 15% NaCl	Group 1: 0, 0·75, 1·5% NaCl; 1·5% NaCl with rations *a*/*b* offered alone
			(*b*) Oaten chaff containing 4% urea offered without choice	Group 2: *ad lib.* 5·0 l.; 2·5 l./day with rations *a*/*b* offered alone

The intake of the 7·5% NaCl–lucerne was depressed by the addition of 1·5% NaCl to the water, and that of the 15% NaCl–lucerne was depressed by 1·0, 1·5 and 2·0% NaCl in the water. The intake of the low-salt ration was not influenced by treatments when the alternative food was 7·5% NaCl–lucerne. When the alternative was 15% NaCl–lucerne, the intake of the low-salt ration was increased by the addition of 1·0, 1·5 and 2·0% NaCl to the water, although the increases were small.

Table 2. *Expt 1a and b: food, NaCl and water intakes of the sheep when increasing amounts of NaCl were added to the food and water*

Na content of drinking water	Food intake (g dry matter/day): High-salt ration*	Low-salt ration	Total	Salt intake (g/day)	Water intake (l./day)
	High-salt ration, 7·5% NaCl				
0·0%	1450	139	1589	118	7·7
0·5%	1635	67	1702	185	10·3
1·0%	1421	139	1560	250	13·8
1·5%	1007	199	1206	300	14·4
	High-salt ration, 15% NaCl				
0·0%	1302	226	1528	231	12·6
0·5%	1152	158	1310	273	13·4
1·0%	780	366	1146	257	11·9
1·5%	454	349	803	233	10·0
2·0%	195	484	679	184	7·5
SE of difference	±103	±86	±106		
Least significant difference ($P < 0·05$)	217	182	224		

Details of the experiment are given in Table 1.
* Exclusive of added salt.

Table 3. *Expt 2: food, NaCl and water intakes of sheep when the water was restricted*

Drinking water	Food intake (g dry matter/day): High-salt ration*	Low-salt ration	Total	Salt intake (g/day)	Water intake (l./day)
ad. lib.	839	313	1152	147	8·3
Restricted	351	449	800	63	3·5
SE of difference	±37·6	±21·2	±29·6		
SD	$P < 0·01$	$P < 0·05$	$P < 0·01$		

Details of the experiment are given in Table 1.
* Exclusive of added salt.

Expt 2. The food, NaCl and water intakes for Expt 2 are shown in Table 3. The decline in food intake following restriction of water was sustained entirely by the salty ration and there was a significant but small increase in the intake of the low-salt ration.

Expt 3. The results are shown in Table 4. The effects on food intake of the two treatments (NaCl in water and water restriction) were similar and the results may be

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considered together. At the intermediate levels of treatment (0·75% NaCl or 5·0 l./day) there was no change in the diet selected and only a small change in total intake. At the high levels (1·5% NaCl or 2·5 l./day) the intake of the high-salt ration decreased to half the previous intake, but the intake of the low-salt ration was reduced by only a small amount. Intakes of total dry matter and digestible dry matter were higher than when the high-salt ration was offered alone, and either higher or the same when the low-salt ration was offered alone.

Table 4. *Expt 3: food, NaCl and water intakes of the sheep when either NaCl was added to the water or the amount of water was restricted*

	Food intake (g dry matter/day)				Supplementary	
Drinking water	High-salt ration* (15% NaCl)	Low-salt ration	Total dry matter	Total digestible dry matter	NaCl intake (g/day)	Water intake (l./day)
	NaCl added to drinking water					
0·0% NaCl	558	681	1239	710	99	6·7
0·75% NaCl	511	609	1120	623	153	8·3
1·5% NaCl	260	642	902	521	147	6·7
1·5% NaCl	402	†	402	233	169	6·5
1·5% NaCl	†	786	786	408	53	3·6
SE of difference			±41	±32		
Least significant difference ($P < 0·05$)			95	73		
	No NaCl added to drinking water					
Unrestricted	514	575	1089	612	91	5·9
5 l./day	439	625	1064	607	77	5·0
2·5 l./day	247	494	741	439	44	2·5
2·5 l./day	372	†	372	218	66	2·5
2·5 l./day	†	757	775	403	0	2·3
SE of difference			±39	±26		
Least significant difference ($P < 0·05$)			90	59		

Details of the experiment are given in Table 1.
* Exclusive of added salt.
† Ration not offered to sheep.

DISCUSSION

Low intakes of salt or moderate water restriction had only small effects on the diet chosen by the sheep. However, at high intakes of salt or more severe water restriction the intake of the high-salt ration decreased to less than half the original intake, while that of the low-salt ration increased or decreased only slightly. There was a marked change in the proportion of the two rations eaten.

It may be reasoned that the sheep could have further avoided the stress of water restriction by choosing solely the low-salt ration but intakes of digestible dry matter on the ration chosen were as high or higher than when the low-salt ration was offered alone. It would be unusual to find situations where this was not so, because an initial choice for a high-salt ration would not occur unless the alternative ration was of lower quality.

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In Expt 3 the digestibility of the low-salt ration was only 7 units less than that of the high-salt ration and a balance of intake was only achieved by including urea in the low-salt ration. In the field, when sheep choose a high proportion of the salt-rich *Atriplex* spp., the alternative vegetation is sparse and of low digestibility (Leigh & Mulham, 1967).

The similarity of the effects of salt loading and water restriction suggests that the alteration in dietary preference was mediated by a change in the physiological state of the sheep which was common to both stresses. Water restriction and the inclusion of NaCl in the drinking water both give rise to increases in the osmotic pressure and sodium concentration of the blood (Wolf, 1958; Weeth, Haverland & Cassard, 1960). However, the link between changes in the osmotic pressure of the blood and the regulation of dietary preference is largely a matter of conjecture. It is sufficient here to point out that absorption of the ingested NaCl does not occur immediately, so that as in sodium deficiency (Denton & Sabine, 1961) the sensing of the saltiness of the ration must occur in the mouth.

Because of the general similarity between the effects of NaCl loading and thirst on dietary preference, the reaction of sheep to NaCl excess does not appear to be related to the selection of sodium by sodium-deficient sheep. Beilharz, Denton & Sabine (1962) showed that appetite for sodium in sodium-deficient sheep was independent of the water status of the animal.

With sheep grazing in arid areas, the effects of water deficiency or NaCl excess on the total food intake will remain of great importance, despite the changes in dietary preference. From these and earlier results (Wilson, 1966) it is concluded that, if there is to be no reduction of food intake, levels of NaCl in the drinking water should not exceed 1·0% when the diet contains 50% *Atriplex* spp. or 0·5% when it is 100% *Atriplex* spp. Water deficits or NaCl excesses that are not large enough to affect total food intake have little effect on the choice of diet.

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