

Effects of sodium chloride on sheep. 1. Diet composition, body mass changes and wool production of young Merino wethers grazing native pasture

H.O. de Waal,* Margarietha A. Baard & E.A.N. Engels

Agricultural Research Institute, Private Bag X01, Glen 9360, Republic of South Africa

Received 5 June 1987; accepted 29 June 1988

Supplementary salt (NaCl) and crude protein (CP) were provided to young Merino wethers grazing native pasture. Twenty-eight wethers were divided into 7 groups and given the following supplements daily *via* rumen cannulae: 0, 5 (Control), 15 and 30 g NaCl; and 5, 15 and 30 g NaCl + 20 g CP each. During the experimental period (1 year) the wethers gained respectively 44,4%, 67,1%, 52,6%, 40,7%, 70,1%, 57,2% and 47,6% in body mass. The effect of NaCl on the growth rate of the wethers became evident within 4 weeks. Rate of clean wool production (g day⁻¹) by the wethers during the first 9 months was 9,02, 10,85, 9,32, 7,65, 10,53, 9,42 and 9,06, respectively. It was evident that young sheep grazing native grass pasture in the central Orange Free State do have a nutritional requirement for NaCl, but excessive ingestion from licks could depress growth rate and wool production. Furthermore, supplementary CP, in combination with high levels of NaCl, alleviated the adverse effect of NaCl to some extent.

Aanvullende sout (NaCl) en ruproteïen (RP) is op veldweiding aan jong Merinohamels verskaf. Sewe groepe van 4 hamels elk, het die volgende aanvullings daaglik *via* rumenkannules ontvang: 0, 5 (Kontrole), 15 en 30 g NaCl; en 5, 15 en 30 g NaCl + 20 g RP elk. Tydens die proefperiode (1 jaar) het die hamels onderskeidelik 44,4%, 67,1%, 52,6%, 40,7%, 70,1%, 57,2% en 47,6% in massa toegeneem. NaCl het na 4 weke reeds 'n merkbare invloed op die groeitempo van die hamels uitgeoefen. Tempo van wolproduksie gedurende die eerste 9 maande was onderskeidelik: 9,02, 10,85, 9,32, 7,65, 10,53, 9,42 en 9,06 (g skoonwol dag⁻¹). Dit was duidelik dat jong skape op natuurlike grasweiding van die sentrale Oranje-Vrystaat 'n voedingsbehoefte aan NaCl het, maar oormatige inname vanaf lekke kan groeitempo en wolproduksie benadeel. Verder het aanvullende RP, in kombinasie met hoë NaCl-peile, die nadelige effek van NaCl in 'n mate verminder.

Keywords: Body mass changes, crude protein, grazing sheep, NaCl, supplementation, wool production

* To whom correspondence should be addressed

Introduction

Numerous efforts to rectify the deficiency of specific nutrients in native pastures (veld), have given rise to the now accepted practice of providing grazing ruminants with various mineral, energy and rumen-stimulating (nitrogen) supplements (licks) (Louw, 1979). In addition to various other constituents, these licks invariably contain sodium chloride (NaCl). The NaCl serves a dual purpose, namely to control the voluntary lick intake by the animals (Morris, 1980) and, as a secondary aim, to satisfy their specific nutrient requirement for NaCl (Agricultural Research Council, 1980). However, in practice, the latter aim has been grossly neglected in comparison with the attention given to NaCl as a regulating agent in controlling voluntary lick intake. Ruminants do have a specific appetite for salt (Denton, 1969; Pamp, Goodrich & Meiske, 1976; Conrad, McDowell, Ellis & Loosli, 1986) and according to Morris (1980), the drive to consume salt has frequently been interpreted by livestock owners as a physiological and dietary need, rather than a specific appetite for sodium (Na) which results in luxury consumption. Furthermore, when NaCl is included in energy and crude protein (CP) licks to regulate intake, the total daily consumption of NaCl may be substantially higher, and at times even excessive, than in those cases where it is provided as a mineral lick only. Little, if any, attention is also given to the wide range of NaCl intake, both from feed and water, to which grazing ruminants are subjected. However, owing to the ability of ruminants to excrete

large quantities of NaCl *via* the kidneys (Tomas, Jones, Potter & Langsford, 1973; Wilson & Dudzinski, 1973; Potter & McIntosh, 1974; Bell & Sly, 1979; Moseley, 1980; Godwin & Williams, 1986), a high intake of NaCl is not regarded as a serious problem, especially when there is free access to water (Agricultural Research Council, 1980; Morris, 1980; National Research Council, 1980).

A study on supplementary feeding at this Institute (De Waal, Engels, Van der Merwe & Biel, 1981), pointed to the possibility that high levels of NaCl had adversely affected the growth of young sheep grazing veld. Furthermore, the results indicated that supplementary CP, in addition to the NaCl, had alleviated the detrimental effect to some extent. The current study was therefore initiated in order to obtain more information on this important aspect of supplementary feeding strategies to grazing ruminants.

Procedure

The study was conducted at Glen in the central Orange Free State. In a botanical survey made during March 1981, *Themeda triandra*, *Eragrostis chloromelas* and *Cymbopogon plurinodis* comprised 56% of the basal plant cover of the native pasture (De Waal, 1986). A number of different trials are run concurrently on the same block of pasture, while it is managed collectively in a 5-camp rotational grazing system at an annual stocking rate of one sheep ha⁻¹. As a routine practice, one third of the pasture is annually conserved in rotation during

the latter part of the active growing season (February to April), to serve as grazing during the winter and early spring. The trial lasted from January 1981 to January 1982.

In accordance with studies by Langlands (1969), De Waal, Engels & Van der Merwe (1980), De Waal *et al.* (1981) and De Waal (1986), a new approach was adopted by providing the supplementary feeding on a daily basis *via* cannulae directly into the rumen. Thus, the usual variation in daily lick intake was completely eliminated. Furthermore, by running the experimental sheep in the different treatment groups as a single flock, confounding effects, due to possible differences in basal plant cover of the camps, and thus the digestible nutrient intake by the sheep, were also eliminated.

At the age of 9 months, 28 young Merino wethers which were cannulated at the rumen (De Waal, Engels & Biel, 1983), were shorn, weighed and divided according to mass into 7 treatment groups. The experimental design (fully randomized) with the number of wethers per treatment, as well as the levels of NaCl and CP supplementation, are presented in Table 1.

The wethers were weighed monthly without prior fasting directly off the pasture between 07h30 and 08h30. On 15 January 1981 the wethers were shorn in order to eliminate existing differences in wool production. They were shorn again on 15 October 1981 and the total fleece mass of each wether was recorded. Mid-rib wool samples (300 g) were taken from both sides of each fleece for objective measurement of clean yield, staple length and fibre diameter.

Three oesophageally fistulated (OF) wethers were used to collect samples from the pasture on a regular basis. The sampling was done on three successive days with each of the three OF wethers. They were fasted overnight in order to minimize the possibility of regurgitation during sampling. Drinking water was always available during the fasting periods. The liquid in the samples collected by the OF wethers was squeezed

Table 1 Experimental design with the number of wethers per treatment

Treatment	Daily level of supplementation ^a	Number of wethers per treatment
1	0 g NaCl ^b	4
2 (Control)	5 g NaCl + 2,5 g P ^c	4
3	15 g NaCl + 2,5 g P	4
4	30 g NaCl + 2,5 g P	4
5	5 g NaCl + 2,5 g P + 20 g CP ^d	4
6	15 g NaCl + 2,5 g P + 20 g CP	4
7	30 g NaCl + 2,5 g P + 20 g CP	4

^a Administered daily *via* rumen cannulae directly into the rumen.

^b NaCl – Sodium chloride.

^c P – Phosphorus, derived from 15 g dicalcium phosphate.

^d CP – Crude protein (provided by 33 g High Protein Concentrate 60 and 61% of the CP derived from urea).

through four layers of cheesecloth, the liquid fraction discarded and the solid fraction dried at 50°C in a force draught oven. After drying, the samples of each OF wether for the three days were pooled, ground in a Wiley mill to pass a 1-mm screen and stored in screw cap glass containers before being analysed.

The two-stage *in vitro* technique (Tilley & Terry, 1963), with slight modifications pertaining to the addition of nitrogen (N) as described by Engels & Van der Merwe (1967), was used to determine the *in vitro* digestibility of organic matter (OM) in the OF collected samples. The OM digestibility (DOM) of the pasture was estimated in accordance with the procedure described by Engels, De Waal, Biel & Malan (1981). The N content of the samples was determined by means of the basic Kjeldahl method, using the Tecator system (Digestion System 6 1007 Digester and Kjeltect System 1002 Distilling Unit). Owing to small losses of N in the liquid fraction during the squeezing of the samples, the equation provided by Engels *et al.* (1981) and which relates the N content of the original extrusa with the N content of the solid fraction, was used to estimate the N content of the samples.

Results

The monthly precipitation for the period November 1980 to January 1982, as well as the long-term average precipitation (1922 — 1983) for Glen, are presented in Figure 1.

The monthly precipitation during the experimental period was, with a few exceptions, substantially higher than the long-term average (Figure 1). It was calculated that the total precipitation during the experimental period (852,5 mm) was 158% of the long-term average (540,3 mm). Furthermore, the high precipitation during November 1980 and January and February 1981, yielded a high dry matter (DM) production, leading to a dense

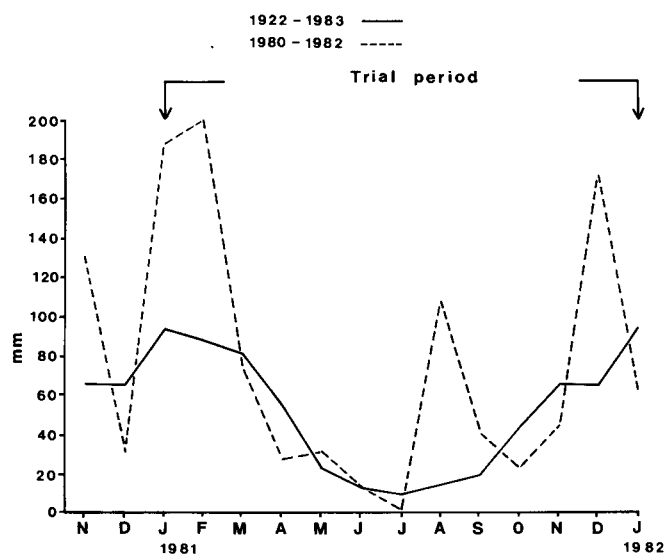


Figure 1 Monthly precipitation for the period November 1980 to January 1982, as well as the long-term average precipitation (1922—1983) for Glen.

and overgrown stand of pasture which was carried over into the winter months of the experimental period.

The CP content and DOM of the pasture, as selected by OF wethers during the experimental period, are presented in Table 2.

Although the trial commenced in January 1981, regular sampling of the pasture by OF wethers could only start at the beginning of May 1981. The DOM of the pasture was always in excess of 54%, whereas the CP content of the pasture declined from 8,8% in May 1981 to reach a low of 5,9% at the beginning of July 1981 (Table 2). During the remainder of the trial period the CP content and DOM of the pasture were relatively high (Table 2).

The average initial, monthly and final body mass of the wethers in the different treatments during the experimental period, are presented in Figure 2.

At the start of the trial, the average body mass of the wethers in the respective treatment groups differed less than 3 kg. One year later at the conclusion of the trial, the average body mass of the different treatment groups varied by 13,8 kg. It is also evident that the effect of the different levels of NaCl on the body-mass changes of the wethers became apparent within the first 4 weeks of the trial (Figure 2).

From May 1981 all the wethers started to lose body mass and at the beginning of July, some of the wethers in Treatments 1 and 4 were very emaciated. At this stage, one wether in Treatment 4 could not stand on its own any more and despite every effort to save it, eventually died. Therefore, on 7 July 1981 the rest of the wethers were withdrawn from the veld, penned in pairs according

Table 2 Crude protein (CP) content and digestibility of organic matter (OM) of samples collected by oesophageally fistulated (OF) wethers

Date	CP ^a content (%)	Digestibility of OM (%)
7 May 1981	8,8	56,2
21 May 1981	8,3	58,4
16 June 1981	7,0	54,2
1 July 1981	5,9	55,2
22 September 1981	12,2	62,6
5 November 1981	15,7	63,9
26 November 1981	9,4	62,5
18 December 1981	15,5	63,6
15 January 1982	8,5	58,7

^a CP content expressed on an ash-free (OM) basis.

to treatment and fed milled lucerne hay *ad lib*. During their stay in the pens, the daily supplementation *via* rumen cannulae was continued. Within 6 weeks, the general condition of the wethers, especially those in Treatments 1 and 4, had improved markedly and on 21 August the wethers were returned to the veld. Despite marked gains in body mass by all the wethers during their stay in pens, the relative order of differences between treatments was however maintained (Figure 2).

The drop in average body mass of the wethers from 30 September to 27 October 1981, as depicted in Figure 2, is

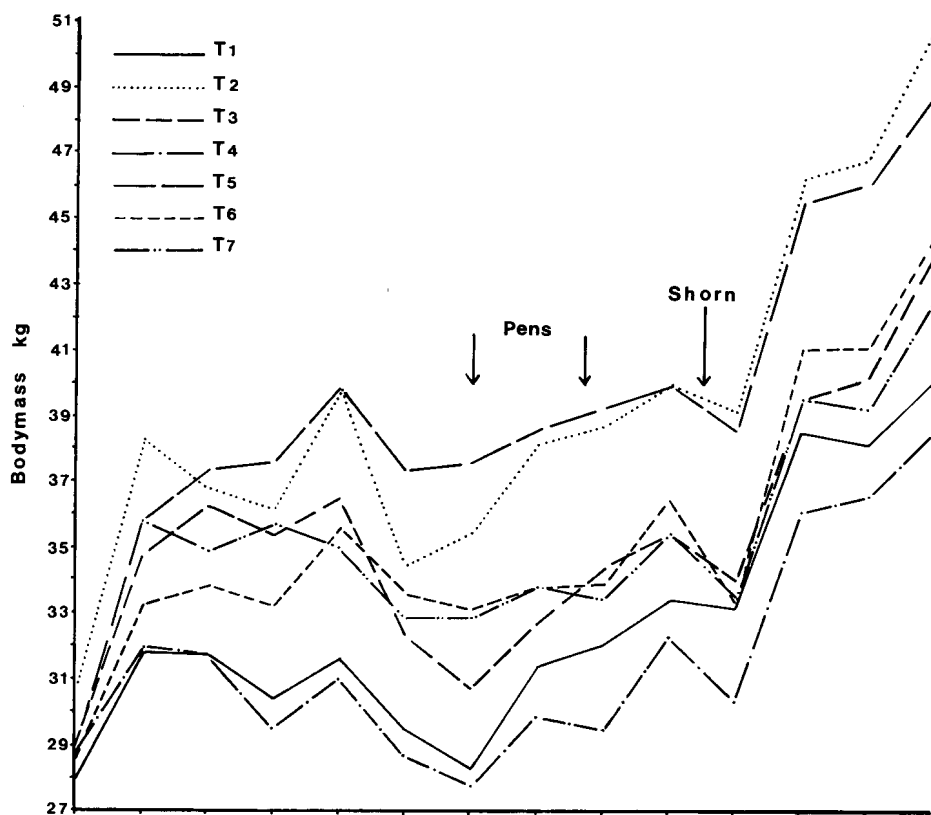


Figure 2 The average initial, monthly and final body mass of the wethers in the different treatments.

accounted for by the fact that the wethers were shorn on 15 October 1981. During the remainder of the trial, the wethers in all the treatments gained in body mass. The differences in average body mass between the respective treatment groups were however maintained.

Results pertaining to the body mass changes of the wethers in the different treatments during the experimental period, are presented in Table 3.

Different levels of NaCl, administered to the wethers, had a marked effect on their body-mass gains (Table 3). The wethers in Treatments 2 and 5 performed the best, followed by those in Treatments 3, 6 and 7 and lastly those in Treatments 1 and 4. It was also evident that the supplementary CP tended to alleviate the adverse effect of the high levels of NaCl on body-mass gain to some extent. However, the differences in body-mass gain (Table 3) were not significant ($P \leq 0,05$) (Harvey, 1976). By omitting the data for Treatment 1 and analysing the remaining treatments as a 3×2 factorial (3 NaCl \times 2 CP levels), only the difference in body-mass gain between the 5 and 30 g NaCl day⁻¹ levels was significant ($P \leq 0,05$).

Results pertaining to wool production by the wethers in the different treatments during the first 9 months of the trial are presented in Table 4.

According to the results in Table 4, the different levels of NaCl had also exerted an influence on the wool production by the wethers. Furthermore, supplementary CP protein tended to alleviate the adverse effect of high levels of NaCl on wool production to some extent. This was especially evident in the rate of wool production between the wethers in Treatments 4 and 7 (7,645 vs 9,060 g clean wool day⁻¹). However, these differences were not significant ($P \leq 0,05$). By omitting the data for Treatment 1 and testing the remaining treatments as a 3×2 factorial, the differences between the 5 and 30 g NaCl day⁻¹ levels for clean wool yield and rate of clean wool production were significant ($P \leq 0,05$).

Discussion

A seasonal trend in CP content and DOM of the veld, in

which rainfall played a dominant role (De Waal *et al.*, 1980), is evident from the results in Table 2 and Figure 1. If differences in pattern of rainfall as well as total precipitation are taken into consideration, the CP content and DOM of the pasture as selected by OF sheep, were in close agreement with those obtained in previous studies at Glen (Engels, Van Schalkwyk & Hugo, 1969; Engels & Malan, 1978; De Waal *et al.*, 1980; De Waal, 1986). Except for the low CP content of the veld at the beginning of July 1981 (Table 2), the quality of the diet was such that, provided the intake by the wethers was sufficient, it could have sustained a reasonable level of animal production. However, Engels & Malan (1978) found that the voluntary feed intake of Merino wethers grazing veld was at times insufficient to meet maintenance requirements, even though the quality of the diet appeared to be satisfactory. Similar observations were made by Engels & Malan (1979) with regard to lactating SA Mutton Merino ewes and by De Waal *et al.* (1981) with regard to young Merino and Dorper wethers. The seasonal trend in CP content and DOM of the veld is usually also reflected in the body-mass changes of the grazing sheep (De Waal *et al.*, 1980; De Waal *et al.*, 1981; De Waal, 1986). This was also observed in the present study. Furthermore, the adverse effect of high NaCl levels on body-mass changes became evident within four weeks after the trial had started. Since the body-mass losses of wethers in all treatments became more pronounced from the beginning of May 1981 (Figure 2), their voluntary feed intake during this period (De Waal, Baard & Engels, 1989) was evidently insufficient to meet maintenance requirements.

Body-mass changes (Figure 2 and Table 3) and wool production (Table 4) of the wethers in the present study, confirmed the suggestion by De Waal *et al.* (1981) that high levels of NaCl had adversely affected production. Furthermore, the results indicated that supplementary CP, in addition to high levels of NaCl, alleviated the detrimental effect to some extent. Both Devlin & Roberts (1963) and Moseley & Jones (1974) have reported decreasing N retention with increasing Na intake, mainly as the result of an increased urinary

Table 3 Effect of NaCl and crude protein (CP) supplementation on the body mass changes of young Merino wethers

Treatment	Average body mass		Body mass change during trial period	
	16/1/81 kg	12/1/82 kg \pm SEM	kg	%
1	27,9	40,3 \pm 2,52	12,4	44,4
2 (Control)	30,7	51,3 \pm 2,91	20,6	67,1
3	28,9	44,1 \pm 2,52	15,2	52,6
4	27,5	38,7 \pm 2,91	11,2	40,7
5	28,8	49,0 \pm 2,52	20,2	70,1
6	28,5	44,8 \pm 2,52	16,3	57,2
7	29,0	42,8 \pm 2,52	13,8	47,6

^{a,b} Treatments with the same superscript do not differ significantly ($P \leq 0,05$) (Harvey, 1976).

Table 4 Effect of NaCl and crude protein (CP) supplementation on wool production by the Merino wethers during the first 9 months of the experimental period

Treatment	Clean wool yield		Staple length	Fibre diameter
	kg \pm SEM	g/day \pm SEM	mm \pm SEM	μ \pm SEM
1	2,46 \pm 0,24	9,02 \pm 0,89	82,2 \pm 5,49	18,78 \pm 0,53
2 (Control)	2,96 \pm 0,27	10,85 \pm 1,03	74,4 \pm 6,34	19,80 \pm 0,61
3	2,54 \pm 0,24	9,32 \pm 0,89	74,9 \pm 5,49	19,78 \pm 0,53
4	2,09 \pm 0,27	7,65 \pm 1,03	82,9 \pm 6,34	18,70 \pm 0,61
5	2,81 \pm 0,24	10,53 \pm 0,89	92,3 \pm 5,49	19,93 \pm 0,53
6	2,57 \pm 0,24	9,42 \pm 0,89	91,6 \pm 5,49	19,13 \pm 0,53
7	2,47 \pm 0,24	9,06 \pm 0,89	76,2 \pm 5,49	19,38 \pm 0,53

^{a,b} Treatments with the same superscript do not differ significantly ($P \leq 0,05$) (Harvey, 1976).

excretion of N (Moseley & Jones, 1974). Supplemental N provided to the wethers in Treatments 6 and 7, have obviously counteracted to some extent the negative effect of increasing Na intake, as displayed by the wethers in Treatments 3 and 4. This peculiar response to supplementary CP has subsequently been observed in lactating ewes as well (De Waal, 1985, unpublished data). In this regard, Godwin & Williams (1986) have also suggested that when roughages low in N are ingested, NaCl intake should be kept below a level of $1,17 \text{ g kg}^{-1} \text{ body mass day}^{-1}$ to prevent a decline in DOM and any consequent reduction in protein availability to sheep. However, Moseley & Jones (1974) have shown that a reduction in DOM was only evident at a level of $1,46 \text{ g NaCl kg}^{-1} \text{ body mass day}^{-1}$. It is therefore possible that in the present study, as well as in the study by De Waal *et al.* (1981), the supplementary CP may have counteracted to some extent any negative effect of NaCl on DOM and protein availability. However, in the present study the highest level of NaCl supplementation (30 g day^{-1}) corresponded to an intake of only about $0,91 \text{ g NaCl kg}^{-1} \text{ body mass day}^{-1}$. Therefore, the possibility of any real effect by NaCl on DOM and protein availability, seems negligible.

With regard to the differences in body-mass change and wool production by the wethers in Treatments 2 and 5 ($5 \text{ g NaCl day}^{-1}$ vs $5 \text{ g NaCl} + 20 \text{ g CP day}^{-1}$), the results in Figure 2 and Tables 3 and 4 suggest that supplementary CP had very little effect overall on the performance of the grazing wethers. This is in close agreement with the conclusions by De Waal *et al.* (1981) and De Waal (1986).

The performance of the wethers in Treatment 1, as opposed to that in Treatments 2 and 5 (Table 3), demonstrates two pertinent points. Firstly, on native pasture of the central Orange Free State, young sheep do have a nutritional requirement for additional NaCl, although it may be as little as $5 \text{ g NaCl day}^{-1}$. Secondly, failure to provide this additional NaCl to young sheep, can be as detrimental to production as the excessive intake of $30 \text{ g NaCl day}^{-1}$. The level of $5 \text{ g NaCl day}^{-1}$, which was provided to the wethers in Treatments 2 (Control) and 5, was based on the results of De Waal *et al.* (1981). These results have shown that the long-term average *ad lib.* intake of NaCl by Dorper and Merino wethers on the same veld type, was $5 \text{ g NaCl day}^{-1}$. There remains a possibility that a phosphorus (P) deficiency may have affected the performance of the wethers in Treatment 1. In spite of common belief to the contrary, various local studies (Read, Engels & Smith, 1986; Engels, Malan & De Waal, 1985, unpublished data) have failed to demonstrate significant visible symptoms of a P deficiency and/or the presence of any adverse effects on the performance of grazing sheep. Yet, the same studies have shown that, in some instances and localities, implementation of a more sensitive and reliable indicator of P status, namely bone P levels, can enable the identification of a P deficiency in reproducing sheep. Therefore, despite a possibility that the wethers in Treatment 1 may have been moderately P deficient, the effects of such a deficiency, if any, on the

performance of the wethers may be regarded as negligible.

According to the National Research Council (1975), the NaCl requirement of sheep varies between 0,1 and 0,25% of DM intake. The Agricultural Research Council (1980) is more specific and categorizes the Na requirement of sheep, according to body mass and growth rate. Thus, the Na requirement of the sheep used in the present study, would have varied between 0,85 and $1,66 \text{ g Na day}^{-1}$ (Agricultural Research Council, 1980). It was calculated from the data in Table 1 that the contribution of Na from the daily supplementation of NaCl to the wethers in the different treatment groups, was as follows: Treatments 2 and 5: $1,97 \text{ g Na day}^{-1}$; Treatments 3 and 6: $5,90 \text{ g Na day}^{-1}$ and Treatments 4 and 7: $11,79 \text{ g Na day}^{-1}$. If this same reasoning is applied to the data of De Waal *et al.* (1981), the *ad lib* Na intake from the licks by the wethers would have varied between $3,34$ and $0,79 \text{ g Na day}^{-1}$.

The daily Na intake *via* the supplementary feeding, was augmented by Na intake from the drinking water and the pasture. The Na content of the bore-hole water and pasture was not determined in the present study. However, since the wethers in the different treatment groups were run as a single flock, confounding effects owing to possible differences in basal plant cover of the camps, and therefore the digestible nutrient and mineral intake by the sheep, were completely eliminated. The same principle applied to mineral intake by the sheep *via* the water. If the potential Na intake from the water and pasture is also taken into account, it may be concluded that the total daily Na intake by the wethers in Treatments 2 (Control) and 5 was slightly in excess of their requirements as proposed by the Agricultural Research Council (1980). Furthermore, the performance of the wethers in Treatment 1 strongly suggests that the Na intake *via* the water and pasture only, was insufficient to satisfy their Na requirement.

Although in general nutritionists are mostly concerned about naturally occurring dietary Na deficiencies (Agricultural Research Council, 1980; Conrad *et al.*, 1986), much attention has been given to toxicity of salt in ruminants (National Research Council, 1980), as well as their tolerance to high levels of salt intake (Agricultural Research Council, 1980; National Research Council, 1980). From these reports it may be concluded that the tolerance of ruminants and more specifically sheep, to high levels of salt, is affected by factors such as body mass, age, diet fed and its NaCl level, other ions involved, duration of the trial, stage of the life cycle and availability of drinking water. Also, despite numerous attempts towards some elucidation, the exact cause of the detrimental effect of NaCl on animals is also still largely unknown.

The adverse effect of high levels of NaCl intake is not peculiar to ruminants only. Drori (1976) has also shown depressed weight gains and fat deposition in rats given high levels of NaCl and concluded that this was due to a disturbance in the water-electrolyte balance induced by hypodipsia (subliminal thirst). NaCl induces thirst and it has been shown with rats (Richter & Mosier, 1954, cited

by Drori, 1976), that free access to water is necessary to maintain a food intake compatible with survival and health. Nevertheless, there is no evidence to indicate that animals offered NaCl in their diet take a sufficient amount of water to maintain normal water and electrolyte balance and unimpaired energy utilization (Drori, 1976). Hence, in the present study the water intake, as well as the frequency of water intake, by the grazing wethers may have been insufficient to maintain normal water and electrolyte balance and unimpaired energy utilization.

Recently, Baldwin, Smith, Taylor & Sharp (1980) have indicated that 20 to 30% of the basal energy expenditure of animals is accounted for by Na^+/K^+ transport across membranes. Therefore, it is possible that the NaCl which was provided to the wethers, might have interfered with the normal functioning of the Na^+/K^+ transport mechanism across membranes. Hence, energy expenditure towards normal ion transport, and therefore maintenance requirement of the animals, would have increased. Less energy would have been available for production, with a concomitant reduction in body-mass gain and wool production. In this regard, indirect evidence has been obtained by De Waal (1985, unpublished data), suggesting that imbalances in Na and K at tissue level, as a result of high levels of NaCl intake by lactating ewes, may be the primary cause of the adverse effect on animal performance.

In subsequent papers some of these aspects will be dealt with. However, cognizance should be taken of the fact that high levels of NaCl intake by sheep from licks, may in some instances be deleterious. Evidence to date suggests that young sheep and lactating ewes may be more susceptible to these adverse effects, especially during periods of nutritional stress.

Acknowledgements

The authors are indebted to Mrs Heila Terblanche, Mr L.C. Biel, Dr Marion Read and the late Dr D.L. Els for valuable assistance rendered during the course of the trial.

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