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PRELIMINARY STUDY ON WATER AND ELECTROLYTE METABOLISM DURING THERMAL AND DEHYDRATIONAL STRESSS IN TWO BREEDS OF SHEEP

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OPSOMMING: 'N VOORLOPIGE STUDIE MET TWEE SKAAPRASSE AANGAANDE WATER- EN ELEKTROLIETMETABOLISME ONDER HOË TEMPERATUUR- EN DEHIDRASIETOESTANDE

Twee Damara- en twee Suid-Afrikaanse Vleismerinohamels van dieselfde ouderdom is vir sewe dae sonder water gelaat by hoë omgewingstemperatuur. Gedurende die stremmingsperiode het die liggaamsmassa van die diere met 29% gedaal en die daaglikse voedsel-inname en misvog het met tussen 97 en 99% gedaal. Die urinevolumes het in albei rasse gedaal, maar die osmolariteit van die Damara urines het gestyg tot 'n gemiddelde hoogtepunt van 2836 mOsm/l en die Vleismerino's tot 1719 mOsm/l. Die rasverskil is ook gevind by plasma osmolariteit waar die Damaras gestyg het tot 312 mOsm/l terwyl die Vleismerino's so hoog soos 334 mOsm/l bereik het. Daarbenewens het die rooiselvolume by die Damaras 17% gestyg terwyl dit 28% gestyg het in die Vleismerino's. Die resultate dui daarop dat die Damara, veral weens sy beter urinekonsentreringsfunksie, beter aangepas is by dehidrasie onder hoë temperatuurtoestande as die Vleismerino.

SUMMARY

Two Damara and two South African Mutton Merino wethers of the same age were deprived of water for seven days under high environmental temperatures. During this time the body mass of both breeds decreased by about 29% and daily feed consumption and total faecal water declined between 97 and 99%. Urine volume decreased similarly in both breeds but the osmolarity of the Damara urine reached a mean peak of 2836 mOsm/l while the Mutton Merinos only reached 1719 mOsm/l. This difference was reflected in plasma osmolarity with the mean for the Damaras reaching 312 mOsm/l and the Mutton Merinos 334 mOsm/l. Furthermore the packed cell volume (PCV) in the Damaras increased only 17% while in the Mutton Merinos it increased 28%. These differences suggest that the Damara, due mainly to its superior renal concentrating ability, is better adapted than the Mutton Merino to dehydrational stress in a hot environment.

The conservation of body water is important to animals inhabiting hot, arid areas. In fact, it has been shown that sheep inhabiting or orginating from such areas economise water better than types from mesic areas. For instance, MacFarlane (1968) reported that British breeds maintained high flow rates of urine by the third day of heat stress and dehydration while Merinos under similar circumstances reduced urine output by the second day. Furthermore, Slagsvold (1970) showed that New Zealand Romney Marsch had a higher faecal water content than arid zone breeds such as Somali, Merino and Karakul; Daly and Carter (1955) observed higher water intakes in European breeds than in Merinos, while the Merinos again used more water than such breeds as the Namaqua Afrikaner (Erasmus, 1967). Erasmus and de Kock (1965) demonstrated that Merinos decreased their dry matter intake significantly when water intake was restricted to half the normal quantity, while there was no effect in Namaqua sheep similarly treated.

This experiment was designed to compare the effect of heat stress and dehydration on some aspects of water and electrolyte metabolism between the South African Mutton Merino of the Western Cape and the Damara imported from an arid area of northern South West Africa.

Procedure

Two Mutton Merino wethers and two Damara wethers of the same age were used. The experiment consisted of a three day period of termperature conditions with water *ad lib.* followed by seven days at elevated temperatures during which time they were deprived of water and then a final three days when water was once again supplied. Feed was available at all times.

The animals were kept in crates in a climatic chamber and carried harnesses for the separate collection of urine and faeces. The temperature in the climatic chamber could not be precisely controlled and was mainly solar dependent. Ambient temperature was recorded on standard maximum-minimum thermometers and humidity on a recording aneroid barometer (Casella 11923).

The sheep were weighed periodically, water intake was recorded before and after the restriction period and total feed intake and faeces and urine output were measured daily. Aliquots of 250 g of faeces were taken every second day, placed in airtight plastic bags and stored at $-15^{\circ}C$. The urine was collected by a rubber funnel over the preputial opening and a polythene tube leading to a dark bottle surrounded by ice in an expanded polystyrene box; daily aliquots were taken and stored at $-15^{\circ}C$. Blood was drawn every 48 hours from the jugular vein by means of disposable plastic syringes and, after a sample had been removed for packed cell volume (PCV) determination in standard Wintrobe tubes, centrifuged and the plasma stored at $-15^{\circ}C$.

Urine and plasma samples were analysed for sodium and potassium (EEL Clinical Flame Photometer) and osmolarity (Hi-precision Research Osmometer), while faecal

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samples were dried to a constant weight in a forced draught oven at 100°C to determine moisture content.

Results and discussion

The temperatures and relative humidities recorded during the experiment are presented in Table 1. Although solar dependency led to wide variations it is felt that the added heat load during water deprivation was sufficient to further stress the animals.

Table 1

The maximum and minimum room temperatures and the respective relative humidities when maximum and minimum temperatures prevailed

Time (days)	Max. T° (°C)	R.H. (%)	Min. T° (°C)	R.H. (%)
1	29,4	56	15,5	76
2	24,4	61	15,0	76
3	28,3	58	15,5	79
*4	39,8	18	15,5	50
5	35,5	20	15,5	58
6	39,4	18	15,5	56
7	37,8	22	15,0	62
8	23,3	37	13,3	67
9	27,8	30	16,7	67
10	38,9	20	22,2	53
*11	44,4	15	14,4	81
12	28,3	60	14,4	82
13	28,9	61	15,5	81

*The initiation and conclusion of the stress period.

Table 2

Live weight changes in the four sheep prior to, during and after dehydration in a hot environment

Number of sheep	Initial body mass (kg) A	Body mass after dehyd. B	Change (%) $\frac{A-B}{A} \times 100$	Body mass after water intake C	Change (%) $\frac{C-B}{B} \times 100$	Body mass after recovery D	Change (%) $\frac{D-B}{B} \times 100$
D1	43,9	31,5	−28,3	35,8	+13,6	36,1	+14,6
D2	36,1	25,1	−30,5	30,8	+22,7	30,1	+19,9
M1	52,6	36,0	−31,6	41,6	+15,5	44,8	+24,4
M2	48,7	35,8	−26,5	45,5	+13,1	45,0	+25,7

The live weight changes of the sheep are presented in Table 2. There were no real differences between the two breeds and the average body mass decreased by approximately 29 per cent during the period of water deprivation. The water consumed at the end of the restriction period immediately increased the body mass considerably and in fact the 22,7 per cent recorded in the one Damara resulted in diarrhoea in this animal.

Feed intake was drastically reduced during dehydration. The intake of Damaras decreased from 39,7 g/kg body mass to 0,4 g/kg body mass and the Merinos from 35,1 g/kg body mass to 0,3 g/kg body mass. These observations are similar to those of Weeth, Sawney & Lesperance (1967) and Gordon (1965).

During the period of water deprivation, fluid loss was markedly reduced by a fall in the amount of urine and faecal moisture (See Figure 1) which was similar for both breeds, although the average volumes were always higher in the Mutton Merinos. It is interesting to note that

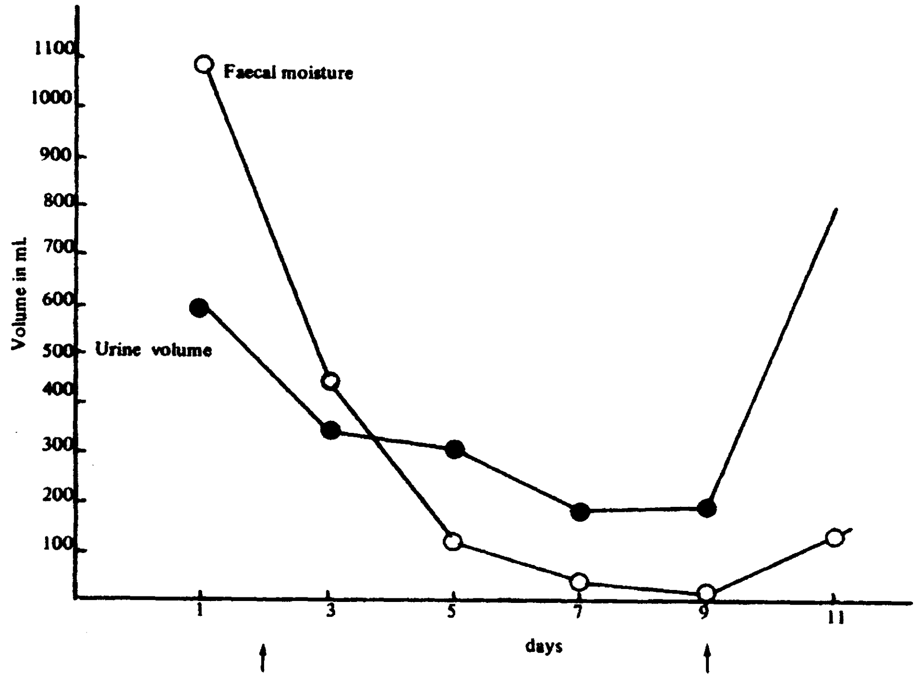

Fig. 1. *The average decrease in faecal moisture and urine volume in the four sheep during dehydration.*

Table 3

The average total output of faeces and faecal water of the sheep during the dehydration – heat stress trial.

	Damaras			Mutton Merinos		
Days	Faeces output (g)	Faecal water (g/100g DM*)	Total water (g)	Faeces output (g)	Faecal water (g/100g DM)	Total water (g)
1	1569	195	1038	1682	204	1129
3	708	149	423	746	155	453
5	216	117	113	266	97	132
7	77	99	36	96	94	47
9	38	44	13	55	80	25
11	126	67**	48**	377	141	217

* DM =Dry matter.

** Only the values of D_1 were incorporated in the estimation as a result of the diarrhoea developed by D_2.

after two days of dehydration the water loss in the faeces was less than the urinary loss. This dramatic decrease in faecal moisture is the result of a decrease in the amount of moisture per unit of faeces as well as an actual decrease in the amount of faeces formed (Table 3). It appears then that the decreasing food intake during dehydration-heat stress is advantageous as it results in less faeces being formed and therefore less faecal moisture loss.

Plasma osmolarity increased in all the animals (figure 2), but there was a definite difference between the breeds. On the final day of water deprivation for instance the osmolarity in the Mutton Merinos had reached an average of 334 mOsm/1 while the Damaras were only 312 mOsm/1. These figures decreased rapidly after dehydration and within two days the osmolarity of both groups was 262 mOsm/l.

The volume of water consumed by one Damara was so large that haemolysis was noted the day after rehydration.

There was a similar but far more dramatic increase in urine osmolarity during dehydration (Figure 2) and once again there was a breed difference. Whereas the Mutton Merinos were only able to concentrate solutes to a peak of 1719 mOsm/l, the Damaras reached an average of 2836 mOsm/l.

From these plasma and urine figures it is clear that the Damara is superior to the Mutton Merino in its ability to minimise plasma changes during dehydration by excreting a more concentrated urine. These figures are however lower than those reported for the Merino. For instance MacFarlane, Kinne, Walmsley, Siebert & Peters (1967) reported a maximum plasma osmolarity of 490 mOsm/1 during rapid dehydration while MacFarlane (1968) states that urine osmolarity can reach 3800 mOsm/l.

The PCV and plasma sodium and potassium concentrations appear in Table 4. There was a predictable and similar rise in PCV in both breeds. Furthermore, the sodium concentrations increased and as reflected in the osmolarity, this was more marked in the Mutton Merino. In both breeds the plasma potassium rose at the beginning of dehydration; this was sustained in the Mutton Merino, but decreased in the Damaras, a difference which is unclear at this stage; When the animals rehydrated the concentrations of all these parameters declined considerably.

The results of urinary sodium and potassium concentrations and total amounts excreted are presented in Table 5. Once again there was an increase in both electrolytes during dehydration which agrees with the results of previous workers (Kinne, MacFarlane & Buldtz-Olsen, 1961; MacFarlane *et al*, 1967). The total output of sodium and potassium remained elevated during dehydration although food intake was dramatically reduced. As the plasma concentrations remained reasonably constant this indicates decreasing pool sizes in the body and emphasizes the necessity of body fluid volume determinations during such an experiment. The decreased food intake during dehydration, therefore, results not only in a decreased faecal moisture loss but also decreases the kidney solute load allowing the animal to reduce obligatory renal fluid

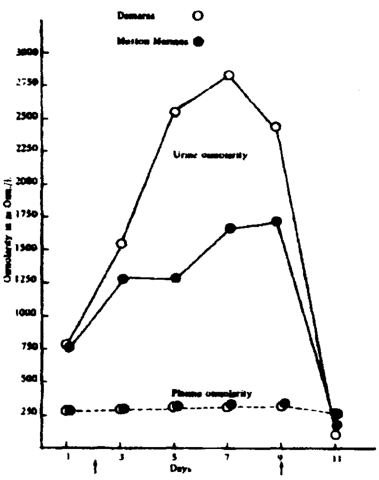

Figure 2. *The average urine and plasma osmolarity in the two breeds during the stress period.*

Table 4

The mean concentrations of plasma sodium, potassium, plasma osmolarity and packed cell volume in the two breeds during dehydration and heat stress

Days	Damaras				Mutton Merinos			
	Na (mg/100 ml)	K (mg/100 ml)	Osmol. (m Osm./l)	PCV. (%)	Na (mg/100 ml.)	K (mg/100 ml.)	Osmol. (m Osm./l)	PCV. (%)
1	340	18,1	284	30	333	15,2	284	28
3	360	18,3	297	29	351	17,3	299	27
5	360	19,3	304	33	363	16,9	309	30
7	358	17,7	312	33	367	18,1	318	32
9	360	15,6	312	35	381	18,9	334	36
11	298	9,9	262	30	301	15,2	262	30

Table 5

The average concentration of sodium and potassium in the urine, their total output and urine osmolarity of the two breeds during dehydration and heat stress

Days	Damaras					Mutton Merinos				
	Na^+ conc. (mg/100 ml.)	Na^+ total (mg.)	K^+ conc. (mg/100 ml)	K^+ total (mg)	Osmolarity (m Osm./l)	Na^+ conc. (mg/100 ml)	Na^+ total (mg)	K^+ conc. (mg/100 ml)	K^+ total (mg)	Osmolarity (m Osm./l)
1	27	148	458	2514	781	20	128	828	5307	766
2	17	80	448	2101	894	26	173	487	3239	670
3	207	646	1101	3435	1546	203	798	1277	5019	1273
4	559	1263	984	2224	1765	540	1912	1013	3586	979
5	688	1589	1101	2543	2552	787	2991	887	3371	1267
6	614	976	789	1255	2302	396	832	419	880	1604
7	516	562	467	509	2836	310	933	409	1231	1660
8	497	1054	702	1488	2306	342	776	737	1673	1034
9	407	1681	725	2994	2435	339	2420	682	4869	1719
10	17	105	349	2150	921	53	522	195	1950	183

loss.

From the results obtained, then, it appears that due mainly to superior renal concentrating ability the Damara is better able to withstand dehydration under hot ambient conditions than the German Merino.

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