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The use and macro-mineral content of saline water for goat production

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Abstract

To overcome a lack of data on the use and acceptability of saline water for goats, a survey of saline water use by drought affected goat producers in Australia was completed. The responses (n = 31) from all but one contributor indicated that the goats survived on saline water sources without any noticeable problems. The range in the acceptable total dissolved salts (TDS) was (median; minimum; maximum): 2,300; 200; 11,000 mg/L; electrical conductivity (EC) 4,200, 400, 16,000 μS/cm; total alkalinity 240; 0; 550 mg $CaCO_3$/L; pH 7.5; 3.7; 8.5; total P 0.03; 0.01; 0.17 mg/L; total N 1.1; 0.09; 14.0 mg/L; Mg 110; 0; 470 mg/L; Na 560; 50; 3,200 mg/L; Cl 970; 25; 4,600 mg/L. Two producers noted that goats walk past fresh ground water to drink bore water with 11000 mg TDS/L and survived. One case of saline poisoning was related to water with a TDS of 33,000 mg/L and a Mg concentration of 1,300 mg/L. The application of the results is discussed. Goats can tolerate water with high salinity levels, but they need to be adapted to saline water. Long-term effects of increased saline water intake and elevated trace element exposure in adapted goats should be investigated.

Keywords: Water quality, conductivity, total dissolved salts, magnesium, mortality
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Introduction

Provision and quality of water is a constant management issue for goat producers in Africa, Australia, the Middle East and other parts of Asia. Water maybe supplied to livestock from oases, lakes, rivers, canals, bores, natural soaks, dams or troughs. Water use by animals is related to the liveweight of animals to the power 0.82, as water is used for intermediary metabolism and for evaporative cooling (Wilson, 1989). All natural waters contain some dissolved salts, referred to as salinity. Salinity levels are measured directly as total dissolved salts (TDS) and indirectly by EC (electrical conductivity). Over large areas of Australia the water supply for livestock comes from saline surface or ground water. The provision and quality of saline water are critical for livestock production, especially during periods of drought. For example, during the recent drought in southern Australia, a goat producer experienced the sudden death of three Angora does caused by drinking water with a TDS of 33,000 mg/L and a Mg concentration of 1,300 mg/L. The water originated from a waterhole in a river that had stopped flowing.

As there is little published information on the likely saline and mineral exposure to goats via drinking water (McGregor, 2004), a survey of saline water provided to goats in Australia was conducted in 2003.

Materials and Methods

Farmers (n = 45) were contacted in the area of interest and 31 participated in the survey. They were provided with a water sampling kit with instructions and a brief questionnaire. Water samples were returned by post and stored under refrigeration at 4 °C. Water testing was conducted at the Ellinbank Water Laboratory, Department of Primary Industries, Ellinbank, Victoria, a NATA Accredited Laboratory. The Test methods follow the standard tests of the American Public Heath Association (Anon, 1998). Total dissolved salts and EC were directly measured as some farmers have equipment to measure EC on their farms. Test results were analysed to determine the mean, median, maximum, minimum and standard deviation in the measurement data. One sample was not included in this analysis as it was associated with the premature deaths described in the introduction.

Results

Samples were received from New South Wales, South Australia, Victoria and Western Australia. The analysed results for the samples are given in Table 1. The responses from all but one contributor indicated that the goats survived on the water sources without any noticeable problems. For example, the contributor of a sample of bore water with 11000 mg TDS/L and 470 mg Mg/L, stated that "goats walk past fresh groundwater to drink this". Similarly for another sample of bore water (11000 mg TDS/L, 400 mg Mg/L) the contributor stated that sheep and goats did well. Despite prompting, none of the following symptoms of salt poisoning were reported: watery scour; discharge from nostrils; uncoordinated walking; swellings under the jaw and belly.

Table 1 Mean, median, s.d. and range in the water test data (TDS: total dissolved solids (180 °C); EC: electrical conductivity)

	TDS mg/L	EC µS/cm	Hardness mg $CaCO_3$/L	Total alkalinity mg $CaCO_3$/L	pH	Total P mg/L	Total N mg/L	NO_3-NO_2 mg N/L
Mean	3600	5900	900	250	7.4	0.05	2.20	1.60
Median	2300	4200	540	240	7.5	0.03	1.1	0.25
Minimum	200	400	6	0	3.7	0.01	0.09	0.01
Maximum	11000	16000	3100	550	8.5	0.17	14.0	13.0
s.d.	3300	4900	860	190	0.9	0.04	3.10	3.00

	Al mg/L	B mg/L	Ca mg/L	Cl mg/L	Cu mg/L	Fe mg/L	K mg/L	Mg mg/L	Mn mg/L	Na mg/L	S mg/L	SAR	Zn mg/L
Mean	2.7	0.75	130	1600	0.10	2.10	32	150	0.19	950	150	14.0	0.12
Median	0.3	0.22	68	970	0.03	0.12	11	110	0.01	560	48	10.0	0.03
Min.	0.1	0.03	2.2	25	0.03	0.01	0.2	0	0.01	51	0.3	2.1	0.03
Max.	62	3.4	520	4600	1.8	19	160	470	2.60	3200	850	42	0.69
s.d.	11.0	0.96	140	1400	0.31	4.50	49	140	0.54	900	220	10.0	0.20

Hardness is caused mainly by the presence of calcium and magnesium salts and is often observed as a build up of scale on surfaces and in pipes. If water has a hardness of < 100 mg/L (expressed as Ca-carbonate) it is regarded as soft water. Of the submitted samples most were hard as only 4 had < 100 mg/L of hardness. Two bore samples were very acid and five bore samples were alkaline. In these cases corrosion of metal pipes and fittings may occur. Many samples had total N levels (n = 22) and total P levels (n = 11) greater than recommended and 11 samples had high levels of both N and P. This indicates that under typical drought conditions these waters may experience algal blooms. The level of minerals in all but one of these submitted waters must have been within tolerance ranges as no stock mortality and other signs of ill-health were reported (although intake was not measured, nor trace element exposure). The exception is that associated with mortality of Angora goats (see introduction). The level of 1300 mg Mg/L may have been the cause of death as it is recommended that Mg levels be kept below 600 mg/L (Cummings 2002).

Discussion

Limited evidence suggests that goats have slightly greater tolerances to salt in water compared with sheep. Bell (1959) reported on the thresholds for taste discrimination using British dairy goats. Bell defined the acceptance threshold at the concentration point when the goats showed no discrimination between fresh water and the test solution, i.e. 40 to 60% of the total fluid intake was the test solution. For salty tastes, at dilutions below the acceptance threshold (1.25 g/100 mL), goats preferred salty water to fresh water. Dunson (1974), Abou Hussien *et al*. (1994) and Burke (1994) provided useful data on saline water intake by goats. Dunson (1974) and Burke (1990) reported seawater consumption of feral goats on isolated oceanic islands. Burke reported that the conductivity and thus the salinity of water used were identical to that of water from the ocean (EC 51,000 µS/cm). Burke calculated that these goats could produce urine more than twice the osmolarity of seawater, probably enough to allow them to realise a net gain of free water from drinking seawater. It is possible that by drinking seawater it allowed the goats to increase urine volume to enable them to excrete larger amounts of other solutes such as urea. These goats had access to a good supply of browse vegetation with a moisture percentage of 17 to 48. The goats drank from temporary rainwater puddles when available. The goats remained relatively inactive during the day and fed primarily at dusk and dawn.

Abou Hussien *et al*. (1994) examined the response of bucks (38 kg body weight) and rams (55 kg) to drinking water salinity by increasing the TDS of tap water (260 mg/L) to either 9,500 or 17,000 mg/L. Increasing salinity to 17,000 mg/L increased total water intake of goats by 59% to 376 mL/kg$^{0.82}$ and that of sheep by 99% to 500 mL/kg$^{0.82}$. Increase in water intake was associated with greater urinary water loss and little change in faecal and insensible water loss (sweating, breathing). Intake of water with 9,500 mg TDS/L reduced the dietary intake of sheep but not of goats. Increasing the salt content from 9,500 to 17,000 mg TDS/L reduced the dietary intake of both sheep and goats.

Macfarlane (1982) concluded that since most Merino sheep become partly intoxicated by salt at 1.3% (220 mmol/L) in water (Peirce, 1968) and Turkana goats tolerate 1.5% (257 mmol/L) of salt in drinking water that these goats must be more adapted to higher salt loads by having slightly better sodium pumps than sheep. Macfarlane (1982) noted that within four days of being exposed to saline water there is an induction of NaK ATPase enzymes in the ileum, liver and kidney, which is a powerful adaptive mechanism.

There may be differences between goat breeds in their tolerance to salinity but this survey is not able to provide objective evidence to clarify breed tolerance or palatability differences to salinity. (Table 1 illustrates a range of salinity and mineral concentrations in water supplied to different goat breeds that may provide useful information to breeders during subsequent drought. Cummings (2002) provided guidelines for farmers to use when providing water to livestock. He suggested that water with an EC of < 5800 μS/cm is suitable for all livestock. In the present survey 13 samples had EC of > 5800 but < 16500 μS/cm. These samples are suitable for non-lactating small ruminants and are unsuitable for weaned sheep. Caution is required when providing such water to lactating small ruminants. Electrical conductivity levels > 16500 up to 25000 μS/cm are suitable for non-lactating stock and EC levels > 25000 μS/cm are not recommended for livestock.

The evidence from the literature (McGregor, 2004) suggests that goats adapted to water of high EC can grow and lactate when water as concentrated as seawater (EC about 50,000 μS/cm) is used, provided adequate green herbage and shade is available. However, non-adapted goats do not perform well when high EC water is provided and in drought situations adequate green herbage will not be available. For goats adapted to saline water it appears that in all but one situation it would have been possible for contributors to the survey to provide water of higher salinity level up to a maximum of 25000 μS/cm to adult dry goats during drought feeding. During drought goat producers should monitor the salinity of their water supply, particularly farm dams. Test results should be checked against the tables of recommended water quality guidelines and with the data in this report. When water is purchased or goats are transferred to an unknown water source, the water quality should be checked. As goats grazing unshaded dry pastures in Australia consume 50% more water than Merino sheep (104 ± 4 mL/kg$^{0.82}$/day compared with Merino sheep: 70 ± 3 mL/kg$^{0.82}$/day, McGregor, 1986) drought affected goat farmers need to frequently monitor water quality, water use and water supplies.

Conclusions

All but one of the water samples tested was suitable for goats when livestock production is expected to be low or zero. Goats safely used saline water with up to 11,000 mg TDS/L and 470 mg Mg/L. It appears goats can tolerate water with high salinity levels and prefer water with up to 12,500 mg/L to fresh water, but they need to be adapted to saline water. Evidence of the ability of goats to survive on seawater was found and in all circumstances the goats were adapted and had access to shade and moist herbage. During drought goat producers should monitor the salinity of their water supply, particularly new sources of water. Long-term effects of increased saline water intake and elevated trace element exposure in adapted goats should be investigated.

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