

Responses of Tswana goats to various lengths of water deprivation

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Abstract

The aim of this trial was to determine the water intake of Tswana goats and investigate the effects of short term water deprivation in summer or winter (6000 ml water offered either once every 72 h, 48 h, 24 h or *ad libitum*) on feed intake, dry matter digestibility, growth rate and health. Goats were fed a diet comprising 60% *Cenchrus ciliaris* hay and 40% *Medicago sativa* hay. Feed intake per kg metabolic weight was inversely related to water intake. Body weight gains decreased with longer watering intervals, rectal temperatures were unaffected but respiratory rate, packed cell volume, pulse rate, haemoglobin level and mean corpuscular haemoglobin concentration was highest with the 72 h watering interval. Feed intake and daily weight gains were higher in winter than summer, but animals drank more water in summer than in winter, and showed more signs of dehydration in summer. Dry matter digestibilities (%) were 66.8, 66.7, 64.2 and 65.2 for water intake intervals of *ad lib*, 24 h, 48 h and 72 h respectively; digestibilities of organic matter, crude protein and crude fibre followed the same trend. Urine output, faecal output per kg metabolic weight and faecal moisture content decreased with increased length of water deprivation. It was concluded that Tswana goats are well adapted to semi-arid zones and can be watered once in 72 h without severe dehydration.

Keywords: Water, intake, digestibility, health, goat, ruminant

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Introduction

Botswana is a semi-arid country with low and erratic rainfall, and the scarcity of surface water limits the use of pastures and determines the availability of drinking water for animals. In addition to this, water intake is known to influence feed intake and digestibility. Goats are important ruminants in Botswana. The country has a goat population of 1.84 million, 80% of which are found in the traditional sector where formal management and housing is almost non-existent (CSO, 1995). These animals are subject to varying periods of water deprivation. Various reports on responses of ruminants to water deprivation in similar harsh environments have been published for West Africa (Aganga *et al.*, 1988), East Africa (Schoen, 1968) and Southern Africa (Sibanda *et al.*, 1997). However, information on the Tswana goat is limited and there are no published reports on the effects of water deprivation in Tswana goats. This study was designed to investigate the effect of restricted water intake during winter or summer on feed intake, nutrient digestibility and health of Tswana goats.

Material and methods

The study was conducted in Gaborone, located in the semi-arid south-east area of Botswana, and consisted of an intake trial and a digestion study. Twenty male Tswana goats, aged nine months at the start of the study, were used for the intake study which lasted for 365 days. There were four watering treatments with five replicates per treatment. Goats were offered 6000 ml water either *ad libitum*, every 24 h, every 48 h or every 72 h. For the latter three treatments, the water allocation was offered during two periods of two hours each during which the animals were allowed to drink to satiety. The amounts of feed and water consumed were recorded every morning before fresh feed and water was offered. Evaporative water loss was determined by placing six litres of water in empty pens to simulate prevailing conditions. Water intake was adjusted for evaporative loss. Animals were housed in individual pens and fed a diet consisting of 60% *Cenchrus ciliaris* hay (buffalo grass) and 40% *Medicago sativa* (lucerne) hay at a level of 4% of body weight (dry matter basis). A mineral supplement was freely available. The volume of water ingested with the diet was estimated from the dry matter content of the roughage. Animals were weighed every two weeks and monthly measurements were made for rectal temperature, pulse rate, packed cell volume (PCV), haemoglobin (Hb) and mean corpuscular haemoglobin concentration (MCHC).

The digestibility experiment was conducted using feed and watering treatments identical to that used in the intake study. Sixteen castrated Tswana goats (average weight 26.9kg), were randomly allocated to watering treatments and confined in metabolism crates. There were four replicates per treatment. Digestibility was measured over a 21-day period following a 14-day adjustment period. Faeces were collected daily, weighed and a 2% sub-sample stored at 5°C. Stored faeces were bulked on weekly basis, oven dried at 70°C and ground for laboratory analysis. Urine was collected daily.

Toluene (25ml) and sulphuric acid (25ml of a 50% solution) were added to the urine collection vessels every morning to prevent evaporation and to maintain acidity at pH 3. The volume of urine was measured daily and a 50 ml sub-sample was taken and stored at 5°C and then bulked on weekly basis. Dry matter (DM), ash, crude protein (CP) and crude fibre (CF) content of both feed and faeces was determined (AOAC, 1995). The experimental design was a completely randomised design and results were subjected to analysis of variance and regression analysis (SAS, 1990; Mead & Curnow, 1992).

Results and discussion

The mean minimum and maximum environmental temperature and relative humidity for both experiments is shown in Table 1. The composition of the diet is presented in Table 2. There were interaction effects for total water intake per kg metabolic weight ($W^{0.75}$), total water intake and free water intake ($p < 0.05$). The F-values in the analysis of variance, however, showed that interaction effects were small and were far outweighed by the main effects; therefore only main effects are discussed here.

Table 1 Mean temperatures and relative humidity at the experimental site during the intake and digestion studies

	Temperature (°C)		Relative humidity (%)	
	Intake trial	Digestion trial	Intake trial	Digestion trial
Minimum	2.8	19.6	46	39
Maximum	34.1	34.1	66	65

Table 2 Composition of experimental diet (60% *Cenchrus ciliaris*, 40% *Medicago sativa*) Tswana goats subject to varying lengths of water deprivation

Components	Content (%)
Dry matter	91.6
Crude protein	11.1
Crude fibre	37.6
Ash	11.8
Phosphorus	0.19
Calcium	0.64

Feed intake, water consumption and animal performance are shown in Table 3. Feed intake per kg metabolic weight increased ($p < 0.01$) as water intake decreased from the *ad lib* to the 72 h watering interval. The *ad lib* and 24 h treatments did not differ but were lower ($p < 0.05$) than the 48 h and 72 h treatments which also did not differ from each other ($p > 0.05$). When feed intake was regressed on water intake using pooled data, the correlation was negative ($R^2 = 0.20$; $p < 0.01$). This implies that 20% of the variation in feed intake was due to amount of water ingested. This is reflected in water to feed intake ratios which decreased ($p < 0.01$) from 2.6 (*ad lib*) to 1.5 (72 h treatment). Neither efficiency of feed conversion nor average daily weight gain differed ($p > 0.05$) between the *ad lib* and 24 h treatments or between the 48 h and 72 h treatments, but the former two were higher than the latter two ($p < 0.01$). A decrease in water to feed ratio with increasing watering interval was also reported by Ikhatua *et al.* (1985) working with bulls and Utley *et al.* (1970), but contradicts findings by Aganga *et al.* (1988). This increase in feed intake with reduced water consumption could be due to an increase in the space available for feed in the reticulo-rumen, as Campling *et al.* (1961) have shown a direct relationship between rumen fill and intake in cows fed hay.

Table 3 Intakes of feed and water and weight gain of Tswana goats subject to varying lengths of water deprivation

	<i>ad lib</i>	Watering interval			s.e.
		24 h	48 h	72 h	
Feed intake (g DM/day)	762	743	742	758	15.9
Liveweight (kg)	36.1 ^a	34.7 ^b	31.3 ^b	31.3 ^b	1.02
Feed intake (g DM/kgW ^{0.75})	55.1 ^b	55.5 ^b	58.9 ^a	60.2 ^a	1.13
Free-water intake (ml/day)	1895 ^a	1785 ^a	1259 ^b	1047 ^c	48.9
Feed-water intake (ml/day)	64.0	62.4	62.4	63.6	1.34
Total water intake (ml/day)	1960 ^a	1847 ^a	1321 ^b	1111 ^c	49.6
Total water intake (ml/kgW ^{0.75})	136.2 ^a	133.7 ^a	102.6 ^b	86.3 ^c	3.5
Ratio: intake of water to feed (ml/g DM)	2.6 ^a	2.5 ^a	1.8 ^b	1.5 ^c	0.05
Average daily gain (g/day)	85.5 ^a	81.9 ^a	64.3 ^b	65.6 ^b	1.41
Feed conversion efficiency (g feed/g gain)	9.3 ^b	9.3 ^b	12.1 ^a	12.1 ^a	3.43

^{a,b,c}Row means with different superscripts differ significantly ($p < 0.05$)

Apparent digestibility (%) of organic matter decreased (Table 4) from 66.8 for the *ad lib* treatment to 65.5 for the 72 h treatment ($p < 0.01$). Similar responses occurred for dry matter digestibility (Table 4). Crude protein digestibility decreased from 67.6 to 62.4 from the *ad lib* to the 72 h treatment ($p < 0.01$); crude fibre digestibility showed a similar trend but no differences occurred between the *ad lib* and 24 h treatments or between the 48 h and 72 h treatments ($p > 0.05$).

Table 4 Effect of water deprivation on digestibility parameters in Tswana goats subject to varying lengths of water deprivation

	<i>Ad lib</i>	Watering interval			s.e.
		24 hour	48 hour	72 hour	
Feed intake (kg/day)	1.08 ^a	0.99 ^{ab}	0.81 ^c	0.90 ^{bc}	0.035
Water intake (ml/day)	3200 ^a	1546 ^b	1252 ^c	1022 ^d	55.0
<i>Digestibility (%)</i>					
Dry matter	66.8 ^a	66.7 ^a	64.2 ^b	65.2 ^b	0.39
Organic matter	66.8 ^a	66.6 ^{ab}	64.4 ^c	65.5 ^{bc}	0.41
Crude protein	67.6 ^a	66.6 ^b	64.3 ^c	62.4 ^d	0.33
Crude fibre	66.5 ^a	66.3 ^a	64.1 ^b	63.9 ^b	0.40
Faecal output (g DM/day)	403.6 ^a	376.2 ^{ab}	336.7 ^c	358.7 ^{bc}	12.22
Faecal water content (g/kg DM)	159.8 ^a	135.9 ^b	119.6 ^c	115.2 ^c	4.35
Faecal water output (g/kg W ^{0.75})	13.5 ^a	11.7 ^b	10.9 ^c	9.4 ^d	0.25
Urine output (ml/day)	781.9 ^a	460.1 ^b	366.5 ^c	294.8 ^d	21.66
Water intake/urine output	4.12 ^a	3.77 ^a	3.83 ^a	4.15 ^a	0.37

^{a,b,c}Row means with different superscripts differ significantly ($p < 0.05$)

A water medium is needed both for the physical softening of feed and the biochemical digestion of feed. An adequate supply of water could therefore aid the breakdown of feed and hence facilitate the fermentation and digestion processes. This could account for the higher digestibility observed when watering was more frequent. Furthermore, numbers of rumen bacteria and protozoa tend to decrease following water deprivation (Fluharty *et al.* 1996), and this could also have contributed to the lowered digestibility at less frequent watering intervals. These differences in digestibility could account

for the differences in feed conversion efficiency and daily gains (Table 3), and support the findings of Umunna *et al.* (1981) and Aganga (1992), who also reported a decrease in weight gains as watering frequency was increased. The digestibility indices, however, conflict with reports by Devendra (1971) who observed increased digestibility as length of water deprivation increased. Furthermore, Thornton & Minson (1973) and Merchen *et al.* (1977) found a decrease in organic matter and crude protein digestibility as a result of lowered retention time due to increased dry matter intake. This could also have occurred in this study.

There was no clear effect of water deprivation on feed intake (Table 4), possibly due to the short duration of the digestion study. Volume of urine voided decreased ($p < 0.01$) with increasing level of water deprivation. The ratio of water intake to urine voided was, however, similar ($p > 0.05$) for all treatments (Table 4) which means that goats voided volumes of urine proportional to the volume of water drunk. This agrees with the report of Aganga *et al.* (1988) and would result in less moisture loss by the water-deprived animals. Faecal moisture content also decreased ($p < 0.01$) with increased water deprivation, suggesting that animals were able to adjust their water output to their water intake.

Water deprivation tended to cause some physiological stress to animals at the 72 h watering interval (Table 5). Although rectal temperature did not differ between treatments ($p > 0.05$), MCHC tended to be higher, whilst respiratory rate, pulse rate and PCV were highest ($p < 0.01$) at the 72 h watering interval. Haemoglobin concentration was highest at the 48 h and 72 h watering intervals ($p < 0.01$). These observations suggest that water deprivation raised the concentrations of blood biochemical constituents due to dehydration at the 72 h watering interval (Table 5).

Table 5 Effect of water deprivation on health indicators in Tswana goats

	Watering interval				s.e.
	<i>Ad lib</i>	24 hour	48 hour	72 hour	
Rectal Temperature (°C)	38.3	38.3	38.3	38.3	0.09
Respiratory rate (breaths/min)	15.9 ^b	15.6 ^b	16.1 ^b	17.3 ^a	0.29
Pulse rate (beats/min)	89.5 ^a	86.2 ^b	86.7 ^{ab}	80.1 ^c	1.12
Haemoglobin (%)	9.6 ^b	9.8 ^b	10.5 ^a	10.6 ^a	0.13
Packed cell volume (%)	24.5 ^b	25.1 ^b	25.9 ^{ab}	26.5 ^a	0.51
Corpuscular haemoglobin concentration (%)	40.4 ^c	41.1 ^{bc}	43.1 ^a	42.4 ^{ab}	0.57

^{a,b,c}Row means with different superscripts differ significantly ($p < 0.05$)

Table 6 Effect of season on feed and water intake of Tswana goats subject to varying lengths of water deprivation

	Season		
	Winter	Summer	s.e.
Feed intake (g DM/day)	657 ^b	828 ^a	15.9
Feed intake (g DM/kgW ^{0.75})	63.6 ^a	57.6 ^b	1.13
Free-water intake (ml/day)	950 ^b	1889 ^a	48.9
Feed-water intake (ml/day)	55.2 ^b	69.5 ^a	1.34
Total water intake (ml/day)	1005 ^b	1959 ^a	49.6
Total water intake (ml/kg W ^{0.75})	97.8 ^b	134.3 ^a	3.5
Ratio of intake of water to feed (ml/gDM)	1.6 ^b	2.4 ^a	0.05
Average daily gain (g/day)	75.9 ^a	69.2 ^b	1.41
Feed conversion efficiency (g feed/g gain)	9.3 ^b	12.4 ^a	3.43

^{a,b,c}Row means with different superscripts differ significantly ($p < 0.05$)

Because animals drank less water in winter (Table 6), they consumed more feed, converted feed more efficiently and gained more weight ($p < 0.01$) in winter than in summer. This may be due to the rumen-fill effect discussed above. Rectal temperature and respiratory rate did not differ ($p > 0.05$) between seasons, and indicates thermoregulatory adaptation to the extremes of temperature occurring in this region. However, pulse rate, haemoglobin concentration and PCV were higher ($p < 0.05$) in winter than in summer, and MCHC was lower ($p < 0.01$) in winter than in summer (Table 7),

suggesting that animals experienced higher levels of dehydration in summer than in winter, probably due to water loss by thermoregulatory mechanisms and direct evaporation.

Table 7 Effect of season on health indicators in Tswana goats subject to varying lengths of water deprivation

	Season		s.e.
	Winter	Summer	
Temperature (°C)	38.2	38.3	0.09
Respiratory rate (breaths/min)	16.2	16.7	0.29
Pulse rate (beats/min)	88.4 ^a	82.9 ^b	1.12
Haemoglobin (%)	10.8 ^a	10.2 ^b	0.13
Packed cell volume (%)	33.7 ^a	20.9 ^b	0.51
Corpuscular haemoglobin concentration (%)	32.1 ^b	48.7 ^a	0.57

^{a,b,c}Row means with different superscripts differ significantly ($p < 0.05$)

Conclusions

It was concluded that that goats are more at risk to water deprivation in summer than in winter and that goats can be watered once in 72 hours without severe dehydration. The tolerance of indigenous goats to water deprivation may be due to their ability to limit urine and faecal water excretion.

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