# Physiological Responses Of Water-Restricted Tswana And Boer Goats

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**Abstract:** The aim of this study was to investigate the effect of 50 % water restriction on body weight and blood parameters status of Tswana and Boer goats while fed teff and lucerne. Twelve (12) Tswana and Boer goat wethers (six of each breed) were randomly allocated to form two groups of 6 goats, comprising of 3 goats of each breed. One group was adapted to teff (*Eragrostis teff)* for 10 days while the other was adapted to Lucerne (*Medicago sativa*). After the adaptation period, the goats continued receiving feed *ad libitum* but their water intake was restricted to 50 % of their average daily intake (calculated for each animal from the adaptation data). Once the first trial period was completed, the trial was repeated by changing the diets of each group. The group that had been on teff was then fed lucerne and vice versa. Both breeds lost 10 % of their body weight when offered lucerne while water-restricted and then regained 13 -14 % of their dehydrated body weight. The haematocrit, total plasma proteins, heart rate and rectal temperature values were not affected by water restriction. Temperature values tended to be higher in goats fed on lucerne hay. Respiration rate increased in both breeds during water restriction. On average, the urine: plasma osmolar ratio for both breeds was about 7:1. Restricting the water intake of these goats to 50 % of their average daily water intake did not tax their maximum physiological capabilities as shown by lack of change in their heart rate and rectal temperature. Tswana and Boer goats can easily survive under arid conditions.

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## 1. Introduction

The productivity of goats in the arid and semi-arid region is limited by a number of environmental constraints namely the chronic scarcity of water and the sparse vegetation of poor quality that also fluctuates with season (King, 1983). Rainfall is erratic and seasonal, thus drinking water for livestock is scarce even during the rainy season. The water scarcity is persistent and much more severe during the dry season. As a result, animals must travel long distances in search of feed and water and they may spend several days without water (Mengistu, 2007). Desert breeds of goats and sheep are known for their adaptability to water shortages (Brosh *et al*., 1987; Silanikove, 1984). Unfortunately, little is known about the water economy of our South African indigenous Tswana and Boer goat breeds (Qinisa & Boomker, 1999). It is therefore important to understand how goats respond to water scarcity when offered high and poor quality feeds. This paper therefore investigates the blood parameters' status of water restricted indigenous Tswana and Boer goats when fed teff and lucerne hay.

## 2. Material and Methods

### 2.1 Study site

This study was conducted at Onderstepoort (Faculty of Veterinary Science, University of Pretoria, South Africa) during the months of September to November 2007.

### 2.2 Experimental animals

Twelve (12) Tswana and Boer goat wethers (six of each breed) obtained from the Northwest Province of South Africa formed the research flock. All the goats were housed individually in metabolic crates. Ambient temperature in the metabolic room was maintained at 23 °C. The goats had an initial body weight of 24.7 ± 2.45 kg. All the goats were about 15 months old. The metabolic crates were designed for easy collection of faeces and urine.

### 2.3 Experimental procedure

The goats were randomly allocated to form two groups of 6 goats, comprising of 3 goats of each breed. One group was adapted to teff (*Eragrostis teff)* for 10 days while the other was adapted to Lucerne (*Medicago sativa*).

During this period each goat was given 5 litres of clean drinking water daily. The daily feed intake and water consumption of each goat was measured and recorded. During the last day of the adaptation period (which served as day 0), blood was withdrawn from the jugular vein, and then again on day 4 and the last day (day 7). The collected blood was analysed for total plasma proteins, haematocrit, osmolarity and blood urea so as to monitor the hydration status of the goats.

The body temperature, heart and respiration rates were also measured on the last adaptation day (day 0) and again during the last day of the experiment (day 7). Rectal temperature (˚C) was measured by carefully inserting a clinical thermometer into the rectum of each restrained experimental animal for 1 minute. The thermometer was cleaned between animals using cotton wool soaked in methylated spirits. Respiratory rate was obtained by counting the movements (per minute) of the thoracic cage of the experimental animals. Heart rate was obtained with the aid of a stethoscope. Body weights were measured on the last day of the adaptation period (day 0), last day of the experiment (day 7) and a day (24 hours) thereafter (day 8). After the adaptation period, the goats continued receiving feed *ad libitum* but their water intake was restricted to 50 % of their average daily intake (calculated for each animal from the adaptation data). Once the first trial period was completed, the trial was repeated by changing the diets of each group. The group that had been on teff was then fed lucerne and vice versa.

**2.4 Chemical and statistical analysis**

The total plasma protein concentration (in g/100ml) was estimated using a hand refractometer. The haematocrit (in percent) was obtained using a microhaematocrit centrifuge and MSE microhaematocrit reader. Plasma osmolality (in mOsm/l) was estimated using the freezing point depression method with the aid of a micro osmometer (Hermann Roebling, Messtechnik, Berlin). Blood urea concentrations (in mMol/l) were measured using the urease method with the Ace Alera Alfa Wassermann analyser (Siemens Medical Solutions, South Africa).

Data were subjected to statistical analysis using the Generalized Linear Model Procedures (GLM) of SAS (2003). The model included the effects of treatment (water restriction), day, breed and diet. All initial values (data prior to the onset of treatments) were used as covariates (control values). Difference among treatment means were compared by Least Significant Difference (LSD).

**3. Results**

The chemical composition of teff and lucerne is presented in Table 1. The nutritive value of lucerne was higher than that of teff as reflected by the higher crude protein concentration and low fibre content.

**Table 1:** Means of proximate analysis of *Eragrostis teff* and *Medicago sativa* on a dry matter basis

| | *Eragrostis teff* | *Medicago sativa* |
|---|---|---|
| DM (g/kg) | 944 | 936 |
| ADF (g/kg) | 439 | 313 |
| NDF (g/kg) | 801 | 475 |
| CP (g/kg) | 71 | 207 |

DM = dry matter; ADF = Acid detergent fibre
NDF = Neutral detergent fibre; CP = Crude fibre

**3.1 Body weight variation**

All the animals in this trial lost weight by the end of the water restriction period. This weight was regained after a day of rehydration (i.e. day 8) (Table 2). In the Boer goats, the body weight loss was only significant at day 7 on lucerne. In the Tswana goats, there was no significant difference between the treatment weights and control values for both lucerne and teff. Both breeds lost 10 % of their body weight when offered lucerne while water-restricted and then regained 13 -14 % of their dehydrated body weight.Boer goats lost 2.44 kg while Tswana goats lost 2.6 kg. After a day of rehydration, Boer goats regained 2.91 kg while the Tswana goats regained 2.98 kg. On teff, they lost 7-9 % of their body weight when water restricted and regained 10 % of their dehydrated body weight when rehydrated. Boer goats lost 2.17 kg whileTswana goats lost 1.85 kg. After a day of rehydration, Boer-goats regained 2.14 kg while the Tswana goats regained 2.27 kg while eating teff.

**Table 2:** Effect of 50% water restriction on body weights (kg) of Boer goats (n = 6) and Tswana goats (n = 6) fed *Eragrostis teff* and *Medicago sativa* hay

| Feed type | Goat breed | Day 0 | Day 7 | Day 8 | LSD |
|---|---|---|---|---|---|
| | Boer | $23.08^{ab}$ | $20.64^{b}$ | $23.55^{a}$ | 2.66 |
| **Lucerne** | Tswana | $25.55^{a}$ | $22.95^{a}$ | $25.93^{a}$ | 3.69 |
| | Boer | $24.23^{a}$ | $22.06^{a}$ | $24.20^{a}$ | 3.07 |
| **Teff** | Tswana | $25.75^{a}$ | $23.90^{a}$ | $26.17^{a}$ | 4.55 |

[a,b] Means within same row with different superscript are significantly different at $p< 0.05$.

**3.2 Dehydration and health status**

For both the Boer and Tswana goats, the haematocrit and total plasma proteins were not affected by water restriction. Heart rate and rectal temperature values were also not affected by water restriction. Temperature values were higher in goats fed on lucerne hay. Respiration rate increased in both breeds during water restriction (Table 3). When fed lucerne, the urine: plasma osmolar ratio stayed at 7.2:1 at day 4 and 7 of water restriction in both Boer and

Tswana goats. On teff, the urine: plasma osmolar ratio of rose from 6.6:1 and 5.9:1on day 4 to 7.8:1 and 7.4:1 on the last day of water restriction for Boer and Tswana goats respectively. On the average, the urine: plasma osmolar ratio for both breeds is about 7:1 (Table 4).

**Table 3:** Effect of 50% water restriction on blood parameters, heart and respiration rates, and rectal temperature in Boer goats (n=6) and Tswana goats (n=6) fed *Eragrostis teff* and *Medicago sativa* hay

| Feed | Breed | Day | HT | TPP | OSM(P) | Urea | HR | RR | TEMP |
|---|---|---|---|---|---|---|---|---|---|
| **Lucerne** | Boer | 0 | 23.17$^{a}$ | 6.34$^{a}$ | 316.25$^{a}$ | 9.37$^{b}$ | 80.25$^{b}$ | 56.33$^{a}$ | 39.00$^{b}$ |
| | Tswana | | 25.50$^{a}$ | 6.88$^{b}$ | 318.17$^{a}$ | 9.15$^{b}$ | 74.33$^{a}$ | 56.42$^{ab}$ | 38.85$^{b}$ |
| | Boer | | 27.17$^{b}$ | 6.83$^{ab}$ | 334.50$^{b}$ | 9.98$^{b}$ | - | - | - |
| | Tswana | 4 | 27.42$^{b}$ | 7.39$^{bc}$ | 330.33$^{b}$ | 10.33$^{b}$ | - | - | - |
| | Boer | | 26.75$^{a}$ | 7.13$^{b}$ | 339.42$^{b}$ | 11.53$^{b}$ | 86.75$^{c}$ | 60.75$^{b}$ | 39.00$^{b}$ |
| | Tswana | 7 | 27.58$^{b}$ | 7.73$^{c}$ | 333.00$^{b}$ | 10.60$^{b}$ | 81.75$^{bc}$ | 62.42$^{b}$ | 38.94$^{b}$ |
| **Teff** | Boer | 0 | 26.58$^{a}$ | 6.23$^{a}$ | 312.58$^{a}$ | 5.48$^{a}$ | 71.75$^{a}$ | 52.91$^{a}$ | 38.40$^{b}$ |
| | Tswana | | 27.92$^{b}$ | 6.87$^{b}$ | 316.17$^{a}$ | 4.78$^{a}$ | 76.17$^{ab}$ | 53.83$^{a}$ | 38.20$^{a}$ |
| | Boer | | 27.67$^{b}$ | 6.90$^{b}$ | 327.67$^{b}$ | 6.73$^{b}$ | - | - | - |
| | Tswana | 4 | 27.92$^{b}$ | 7.58$^{c}$ | 327.00$^{b}$ | 6.19$^{a}$ | - | - | - |
| | Boer | | 26.92$^{a}$ | 6.76$^{a}$ | 325.33$^{b}$ | 7.28$^{b}$ | 74.25$^{a}$ | 62.83$^{b}$ | 38.58$^{b}$ |
| | Tswana | 7 | 29.08$^{b}$ | 7.61$^{c}$ | 325.50$^{b}$ | 6.61$^{ab}$ | 70.17$^{a}$ | 61.33$^{b}$ | 38.16$^{a}$ |
| **S. E.** | | | 1.32 | 0.22 | 2.15 | 0.55 | 2.71 | 2.35 | 0.05 |

$^{abc}$ Means within same column with different superscript are significantly different at $p< 0.05$.

HT = haematocrit in percent; TPP = total plasma protein in g/100ml; OSM (P) = Plasma osmolarity in mOsmol/l; UREA = Blood urea in mMol/l; HR = heart rate in beat/minute; RR = respiration rate in breaths/minute; TEMP = rectal temperature in °C.

**Table 4:** The urine: plasma osmolar ratio of water restricted Boer goats (n=6) and Tswana goats (n=6) fed either *Eragrostis teff* or *Medicago sativa* hay

| Feed | Breed | DAY | OSM(U) | OSM(P) | $U/P_{osmol}$ |
|---|---|---|---|---|---|
| **Lucerne** | Boer | 4 | 2416.00$^{a}$ | 334.50 | 7.2 : 1$^{b}$ |
| | Tswana | | 2369.00$^{b}$ | 330.33 | 7.2 :1$^{b}$ |
| | Boer | 7 | 2454.83$^{ab}$ | 339.42 | 7.2: 1$^{b}$ |
| | Tswana | | 2476.17$^{b}$ | 333.00 | 7.4: 1$^{b}$ |
| **Teff** | Boer | 4 | 2163.17$^{a}$ | 327.67 | 6.6: 1$^{a}$ |
| | Tswana | | 1926.00$^{a}$ | 327.00 | 5.9 : 1$^{a}$ |
| | Boer | 7 | 2539.83$^{b}$ | 325.33 | 7.8: 1$^{c}$ |
| | Tswana | | 2409.50$^{b}$ | 325.50 | 7.4: 1$^{c}$ |
| **S. E.** | | | 113.49 | 2.15 | 0.35 |

$^{abc}$ Means within same column with different superscript are significantly different at $p< 0.05$.

## 4. Discussion

Loss of body weight during water restriction trials is usually a result of loss of water content from the gastro-intestinal tract (rumen) and other body water. This is highlighted by the almost instant return to normal body weight during rehydration after such trials. Body weight losses were regained within 24 hrs in Saudi Arabia indigenous goats deprived of water for 3 days. The goats were able to take in a volume of water accounting for 23.5 % of their dehydrated body weights (Alamer, 2006). El–Nouty *et al.*, (1990), reported similar findings where Aardi goats regained 20 % of their dehydrated body weights after being deprived of water for 4 days. Water – deprived Bedouin goats' body weight loss was fully compensated for during one short drinking bout (Brosh *et al.*, 1987). The black Bedouin goats are also able to gulp an amount of water that exceeded the losses in their body weights (Maltz *et al.*, 1984). Some of the goats in this study regained more than their original body weight .Tswana and Boer goats have the capacity of rapid rehydration which can match that of the Bedouin goats as illustrated by their ability to regain the lost body weights within 24 hrs of rehydration. Moderate water restriction seems to lead mainly to loss of body water and not tissue mass, and this has no deleterious effects on the production or growth of the goats.

The hydration status of an animal can be monitored using the Pack Cell Volume (PCV), which should increase when dehydration is significant. PCV results showed no significant variation in Yankasa sheep deprived of water for up to 5 days (Aganga *et al*., 1989; Igbokwe, 1993). In goats, Ajibola (2000), found no significant variation in PCV values of goats which were restricted to 50 % and 30 % of their free choice water intake. In this study PCV and TPP values did not deviate from the 22 – 38 % and 6.0 to 7.5 g/dl respectively (Duncan & Prasse, 1991). In both breeds, PCV and TPP values were therefore not affected by water restriction in this study.

The normal plasma osmolarity ranges from 280 – 300 mOsmol/l. Values above 300 mOsmol/l indicate hypertonicity (dehydration) while those below 260 mOsmol/l indicate hypotonicity (overhydration) (Blood & Radostis, 1989). The recorded increase in plasma osmolarity following water restriction in this study has also been reported in other studies on goats (Hassan, 1989; El –Nouty et. al., 1990) and sheep (Igbokwe, 1993; Meintjies & Engelbrecht, 1994). The rise in plasma osmolarity was likely to have been caused by an increase in plasma sodium. The rise in plasma osmolarity during water restriction contributes largely to the maintenance of the plasma volume, by inducing water movement into the vascular system (Alamer, 2006; Mengistu *et al*., 2007). The increase in blood urea is due to the greater water uptake from the kidneys and to the decreased blood flow towards the urinary apparatus that causes a reduction of urine and the increase of blood urea concentration (Casamassima, 2008). Water restriction may cause a reduction in urinary nitrogen excretion (Brosh *et al*., 1986) as a result of a reduced filtration in the glomerulus of the kidney (Wittenberg *et al*., 1986).

When checking the health status of an animal the most commonly used measurements are the heart and respiration rate as well as rectal temperature. Daily measurement of heart rate and rectal temperature of dairy cows restricted to 60 % of their daily water intake showed that the health of cows was not affected by the magnitude of the restriction (Balch *et al*., 1953). Degen (1977), working with Awassi male lambs found that even during dehydration, sheep remained thermostable. Similar results were also obtained in Awassi sheep (Jaber *et al*., 2004: Hamaden *et al*., 2006). Both Boer and Tswana goats remained thermostable and showed no significant changes in heart rate during this trial.

In goats, the excessive solar heat load due to solar radiation exposure during water restriction resulted in a 50 % increase in respiration rate (Dmi'el, 1986). Goats restricted to 40 % of their daily *ad libitum* water intake showed increased respiration rates (Ahmed & El Kheir, 2004). In this study respiration rates were also elevated by water restriction. However, the contrary was shown by Aganga *et al*., (1990), who reported that respiration rates decreased with increased water deprivation - possibly as a result of a reduction in metabolic activities of the water-deprived ewes. This is also an adaptive mechanism to survive water deficiency by limiting evaporation from the respiratory surfaces.

Concentration of the urine during water deprivation helps to keep plasma fluid levels stable. This results in changes in the ratio of solutes in the urine to that in the plasma. The maximum urinary: plasma osmolar ratio achievable by cattle is about 4:1. Goats and sheep have the ability to achieve urinary: plasma osmolar ratios ($U/P_{osm}$) in the range of 6:1 to 8:1 (Maloiy, 1973, cited by Wilson (1989)). Owen (1975) found significantly greater $U/P_{osm}$ ratios in sheep during dehydration when fed a high, rather than a low, protein diet. There seems to be no major difference in the $U/P_{osm}$ ratios when both Boer and Tswana goats were fed either *eragrostis teff* or lucerne hay. The ratio (average of 7: 1) obtained in this study when compared with those in desert-adapted ruminants after periods of dehydration i.e. 8:1 for the camel (Maloiy, 1972), 7: 1 for the Bedouin goat (Maloiy *et al*., 1979), and 11: 1 for the dik-dik (Maloiy, 1973), illustrate that the Boer and Tswana goats are normally capable of a high degree of urine concentration and are, in this respect, also well adapted to living in arid regions.

## 5. Conclusion

Tswana and Boer goats could be classified as rapid recoverers as they were able to regain the lost body weight within a very short space of time (24hrs), after rehydration. Restricting the water intake of goats to 50 % of their average daily water intake did not affect their maximum physiological capabilities as shown by lack of change in their heart rate and rectal temperature. The urine: plasma osmolar ratios indicated that these goats can easily survive under arid conditions.

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