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# Water Metabolism and Nutrition in Animals Exposed to Water Scarcity and Hot Environment

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**ABSTRACT:** The water metabolism and feed utilization of domestic animals exposed to harsh environmental conditions were investigated. Three groups consisting of eight indigenous goats each were used for the study. One group was deprived of water for 3 days; another group had water deprivation for 5 days; while the control group had free access to water on a daily basis. They were fed *ad libitum* with a mixture of lucerne *(Medicago sativa)* and Eragrostis hay *(Eragrostis curvula)* blended with molasses. There was a significant difference between the different treatments with regard to water consumption on a daily basis. The feed intake of the goats dropped as the water consumption decreased. Reduced urine and faecal water loss accompanied prolonged intervals between water intakes. Unmeasured water (metabolism, respiration and evaporation) was significantly less in water deprived animals. Providing water once in three or five days for animals under adverse environmental conditions can streamline their metabolic activities vis-à-vis their nutritional status without constituting any threat to their physiological demands.
**Keywords:** *nutrition, metabolism, water scarcity, animals, hot environment.*

## INTRODUCTION

Water is of great importance in animal nutrition. Aganga et al. (1990) stressed the economic importance of a regular and frequent water supply to animals for maintenance, pregnancy and lactation. In temperate zones, the water requirement of ruminant animals is met by an adequate supply of water as well water available from lush pastures (More and Sahni, 1981). Ruminants in the tropical areas are faced with high temperatures, drought and water scarcity (Payne, 1996). Farm animals, especially those managed nomadically, often depend on streams that may be dry or have limited available water (Aganga *et al*., 1990). Most of the studies on small ruminants have not taken their water requirement into consideration (Silanikove and Tadmor, 1989; Schoeman and Visser, 1995). The information on indigenous ruminants is also limited (More and Sahni, 1981; Qinisa and Boomker, 1998). The temptation to extrapolate from information on Bedouin goats also exists (Silanikove, 1993), especially as they are known to tolerate water deprivation (Choshniak *et al*., 1984; Silanikove, 1987; Brosh *et al*., 1988). Indigenous goats were therefore used in this trial to investigate the effects of different water regimens.

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## MATERIALS AND METHODS

Twenty - four South African Pedi goats aged between twenty-four and forty-eight months were used in a 30-day study conducted at Onderstepoort, South Africa. The body mass of the goats ranged from 16.2 to 41.6 kg, with an average of 29.1 kg. They were housed in individual metabolic crates in an environment simulating natural hot dry conditions. The goats were fed a mixture of lucerne *(Medicago sativa)* and Eragrostis hay *(Eragrostis curvula)* blended with molasses. This diet had a crude protein (CP) content of 10.47%, a crude fibre content of 38% (39.2% ADF and 71% NDF) and an energy level of 17.5 $MJkg^{-1}$.

The animals were randomly divided into three groups of eight goats each. One group (control), was allowed free access to water while the other was restricted to water for a period of four hours every third day. The 3rd group of animals had water deprivation for 5 days, and on that 5th day, they were allowed to drink water for only four hours like group 2. The goats were weighed weekly during the trial.

The neck of each goat was shaved and a blood sample was collected asceptically twice during each treatment. The heamatocrit and total plasma proteins were determined from the blood samples. These values assisted in estimating the hydration status of the goats. Daily feed refusals and water left overnight were measured to determine intake. Faeces and urine outputs were also measured and samples collected and stored at -20°C for later analysis. The samples were later thawed and analyzed according to AOAC (1984) methods. The Student's t-test was used for statistical analysis.

## RESULTS

The average water intake of the control group (free access to water) was measured directly, while the values for daily water consumption of the water deprived goats were calculated from total consumed on the third or fifth day, to estimate average daily water intake (table 1). The volume of water intake and average water consumed (litre per kg feed consumed) by the groups of animals on water deprivation were significantly different (P<0.05) from the values obtained for those animals that were given water free choice. The goats receiving *ad libitum* water consumed more feed than those that were restricted in their water consumption.

**Table 1:** Water and feed intake of experimental goats (Means ± SEM).

| | ***Ad libitum* water** | **Water every 3 days** | **Water every 5 days** |
|---|---|---|---|
| Water intake ($Ld^{-1}$) | $1.47 \pm 0.34^{a}$ | $0.84 \pm 0.20^{b}$ | $0.54 \pm 0.13^{b}$ |
| Feed intake ($Kgd^{-1}$) | $0.93 \pm 0.12^{a}$ | $0.80 \pm 0.14^{ab}$ | $0.78 \pm 0.13^{b}$ |
| *Water consumed ($Lkg^{-1}$ feed intake)* | $1.58 \pm 0.27^{a}$ | $1.05 \pm 0.17^{b}$ | $0.69 \pm 0.04^{b}$ |

*Superscripts that differ on the horizontal lines are significantly different (P<0.05).*

**Table 2:** Water intake and output of experimental goats (Means ± SEM).

| | ***Ad libitum* water** | **Water every 3 days** | **Water every 5 days** |
|---|---|---|---|
| ***Intake*** | | | |
| Free water ($Ld^{-1}$) | $1.47 \pm 0.34^{a}$ | $0.84 \pm 0.20^{b}$ | $0.54 \pm 0.13^{b}$ |
| % of total intake | 95.5 | 93.3 | 90.0 |
| Feed water ($Ld^{-1}$) | 0.07 ± 0.009 | 0.06 ± 0.014 | 0.06 ± 0.013 |
| % of total intake | 4.5 | 6.7 | 10.0 |
| Total water intake ($Ld^{-1}$) | $1.54 \pm 0.37^{a}$ | $0.90 \pm 0.21^{b}$ | $0.60 \pm 0.15^{b}$ |
| ***Output*** | | | |
| Faecal water ($Ld^{-1}$) | 0.45 ± 0.10 | 0.33 ± 0.20 | 0.23 ± 0.08 |
| % of total intake | 29.2 | 36.7 | 38.3 |
| Urine ($Ld^{-1}$) | $0.42 \pm 0.12^{a}$ | $0.24 \pm 0.11^{b}$ | $0.23 \pm 0.08^{b}$ |
| % of total intake | 27.3 | 26.7 | 38.3 |
| Unmeasured water ($Ld^{-1}$) | $0.68 \pm 0.31^{a}$ | $0.33 \pm 0.12^{b}$ | $0.15 \pm 0.07^{b}$ |
| % of total intake | 43.5 | 36.7 | 23.3 |
| *Total water loss ($Ld^{-1}$)* | 1.55 ± 0.37 | 0.90 ± 0.21 | 0.61 ± 0.15 |

*Superscripts that differ on the horizontal lines are significantly different (P<0.05).*

**Table 3:** Water efficiency of experimental goats (Means ± SEM).

| | ***Ad libitum* water** | **Water every 3 days** | **Water every 5 days** |
|---|---|---|---|
| Body weight (Kg) | 29.8 ± 8.9 | 28.7 ± 6.7 | 28.8 ± 9.4 |
| Water intake ($Ld^{-1}$) | 1.47 ± 0.34[a] | 0.84 ± 0.20[b] | 0.54 ± 0.13[b] |
| *Water efficiency ($mlkg^{-0.75}d^{-1}$)* | 118.5 ± 25.7[a] | 68.7 ± 16.2[b] | 44.6 ± 0.13[b] |

*Superscripts that differ on the horizontal lines are significantly different (P<0.05).*

**Table 4:** Daily water intake of Experimental goats, Blackhead Persian sheep, Dorper sheep and Mutton Merino sheep (Means ± SEM).

| | **Experimental goats** | **Blackhead Persian*** | **Dorper*** | **Mutton Merino*** |
|---|---|---|---|---|
| Body weight (Kg) | 29.8 ± 9.8 | 34.0 ± 0.79 | 53.0 ± 1. 55 | 50.0 ±1.57 |
| Water intake ($Ld^{-1}$) | 1.47 ± 0.34 | 2.3 ± 0.28 | 4.8 ± 0.58 | 5.6 ± 0.85 |
| Water consumption ($Lkg^{-1}$feed intake) | 1.58 ± 0.27 | 1.82 ± 0.22 | 2.56 ± 0.19 | 5.6 ± 0.41 |
| *Water efficiency ($mlkg^{-0.75}d^{-1}$)* | 118.5 ± 25.7 | 163.4± 19.6 | 246. 1± 19.8 | 311.6± 45.6 |

*Adapted from Schoeman and Visser (1995).*

Water intake, output and unmeasured water are listed in table 2. The total water intake (from feed and water) by goats on daily water regimen was higher than those on water deprivation. Goats receiving water *ad libitum* produced a significantly higher volume of urine per day than those deprived of water. It is interesting that three and five days of water deprivation led to similar amounts of urine being voided. Goats with free access to water used a significantly higher volume of water for metabolism (unmeasured water) than animals deprived of water.

The water efficiency was calculated in $mlkg^{-0.75}d^{-1}$ (table 3). There was a decrease in efficiency with increase in water deprivation. When comparing the water consumption of the goats that had free access to water with the amount of water consumed by certain breeds of sheep, the goats were found to have consumed small amount of water. From table 4, it can be seen that goats are more efficient in water metabolism than sheep.

## DISCUSSION

Water can be a limiting factor to optimal performance of metabolic functions by any living creature. According to Aganga *et al* (1990) and French (1986), temporary water shortages are detrimental to life and production. Where water is naturally scarce, metabolic activities can be effective in animals that utilize water efficiently. The potential of goats is yet to be fully exploited in this regard. Intermittent drinking is well tolerated by goats as indicated by this study. There were no visible signs of stress in the animals as shown by the physiological parameters obtained. The haematocrit and total plasma proteins were within the normal ranges of 22 to 38% and 6.0 to $7.5gdl^{-1}$ respectively (Duncan and Prasse, 1986).

As expected the total amount of water consumed by the goats on daily water regimen was more than that of the animals that were deprived of water. Previous studies have shown that goats drink small volumes of water (Devendra, 1980; More and Sahni, 1981). When the water consumption of the goats was calculated relative to the amount of feed intake, it was discovered that the treatment groups consumed small volume of water, even when allowed free access to water after the deprivation period. French (1986) observed that water deprived cattle when fed dry herbage and also exposed to stressful long walks in search of water, patiently took their turn to drink, and did not consume large quantities when drinking.

It is interesting that these animals on water deprivation differ significantly ($p<0.05$) from those given water free choice in the use of water for metabolism, respiration and insensitive loss (table 2). Since the animals were subjected to the same environmental conditions, one would have expected the values of the unmeasured water to be similar. Hence, it can be deduced that the water deprived animals were able to adjust their metabolic activities proportionately to the volume of water consumed and probably conserve more fluid within their body systems.

Animals exposed to dehydration conserve water loss through various excretory routes by endocrine means (Choshniak *et. al.,* 1984; More and Sahni, 1981). One of these mechanisms is the reduced production of urine by the kidneys. The goats on *ad libitum* daily water regimen lost more water via the urine and faeces than the deprived groups during the three and five days water deprivation periods. This observation was confirmed by English (1996) that limiting the water intake of ruminants will lead to the conservation of water loss via the hormonal mechanisms.

The efficiency of water consumption was calculated as 118.5$mlkg^{-0.75}d^{-1}$ for daily group, and 68.7 and 44.6 $mlkg^{-0.75}d^{-1}$ for 3-day and 5-day groups respectively. The animals whose water consumption was restricted to the third day show a better ratio of water to feed consumption than those animals given water *ad libitum.* The goats deprived of water for five days were also found to have higher, albeit insignificant water efficiency than goats deprived of water for three days. Goats are known to have a lower water requirement than most ruminants (Gihad *et. al.,* 1980). Qinisa and Boomker (1998) confirmed this in a table of summary showing the water consumption of some breeds of sheep and that of indigenous goats. When comparing the water efficiency for different breeds of sheep to that of the goats (table 4), it was found that the goats were very efficient. One other source contributing to the water metabolism of ruminant animals is the fluid found within the rumen. Goats have large water reservoirs in the rumen to meet potential deficit (Silanikove and Tadmor, 1989). This might be a contributing factor to the water efficiency of the goats used for this study.

The limited supply of water decreased feed intake, but enhanced feed utilization by the goats without any adverse physiological consequences. In view of these results, one might propose a strategy of providing water for ruminant animals once in either three or five days. This is not only economical but also beneficial, as it would facilitate the adaptation of the animals' metabolic activities along with their nutritional status without any adverse physiological consequences. It is also helpful as areas far from sources of water can be utilized efficiently by ruminant animals and could also prevent erosion from occurring around water areas. This is relevant in areas of tropical Africa where water is scarce and grazing pressure high.

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