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WATER BALANCE AND SOME BLOOD PARAMETERS IN WATER-RESTRICTED GOATS DURING HOT-DRY SEASON

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ABSTRACT

Six West African Dwarf (WAD) and 6 Red Sokoto (RS) dry female goats were subjected to volumetric water restriction (WR). The experiment was arranged in a modified cross-over design with 3 treatment periods (TPs) of 1 week each and 2-week wash-out (WO) period. The goats were subjected to 3 graded levels of WR daily: *ad libitum* (0 %), 33 % and 67 %. Blood samples on day 1 and day 7 of each TP were collected. Daily urine and faeces were collected for 3 days each TP. Combining data for the two breeds, WR had no significant (P>0.05) effect on initial value, final value or differences in the values of the packed cell volume (PCV), red blood cells (RBC), haemoglobin (Hb) concentration, plasma urea, plasma osmolality, blood glucose, total serum protein, albumin and globulin. No significant (P>0.05) effect of water restriction on urine volume, fresh faeces, faecal DM and volume of water in faeces was recorded. However, based on metabolic weight, water loss in faeces was significantly (P<0.05) higher in 0 % WR grade level than in 33 % and 67 % WR grade level groups. Similarly, water intake-urine ratio was higher in 0 % and 33 % than in 67 % group. Taking each breed separately, there was significant (P<0.05) effect of WR on faecal output and faecal water content (FWC). RS goats voided more faeces (DM) than WAD goats at 0 % but not at 33 % and 67 % restriction levels. FWC per metabolic weight was higher in RS than in WAD goats at all WR levels. In RS goats, there was a gradual decrease in FWC with increase in water restriction level, whilst there was no significant difference in WAD goats. WR did not affect the blood parameters, however WAD goats proved superior to RS in regulating amount of water losses in faeces, thereby showing a higher capacity to cope with water shortage.

Key words: water restriction; goat; water balance; haematology

INTRODUCTION

Water is one of the most important nutrients, consumed in larger quantity than other nutrients by livestock (Mustafa *et al.*, 2010) and being the most abundant molecule in all living cells (NRC, 2007). It is involved in virtually all physiological functions of the animals (Wilson and Brigstocke, 1981). The significance of water in ruminant livestock production was reviewed by Aganga *et al.* (1986) and more recently by Araújo *et al.* (2010). Water is widely distributed in the body of animals covering both intra and extracellular spaces. Positive balance of water in tissues is an essential pre-requisite for the normal maintenance of life (Aganga *et al.*, 1989). Sources of water to goats include drinking water, dietary water in feed ingested and metabolic water from catabolism of nutrients (Araújo *et al.*, 2010). Water is taken by goats intermittently, however its loss from body system is continuous in sweat, in transpiration, in urination and in defaecation. Water is lost in milk production and neonates during parturition. Therefore, goat farmers

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need to pay attention to the supply of adequate and clean water for the animals. Sometimes however, goats are exposed to varying degrees of water deprivation especially during dry season. The first physical response of an animal to the restriction of water intake is restriction of voluntary feed intake, which has profound negative effect on productivity of the animals (Abioja *et al.*, 2010).

In Nigeria, it is generally known that animals in the Guinean and Sahelian savannah zones experience water deprivation almost throughout the year. Consequently, the animals that will survive there, must have ability to cope with little water. The assumption is that ruminant animals reared in the humid forest zone of the southern Nigeria do not experience such situation. This is not totally correct, especially during the hot-dry season (February-April) when the available pastures are dried and fibrous in south-western Nigeria. At such a time, the ambient temperature is usually above 30 °C. Goats, therefore, experience varying degrees of water deprivation. The effects which these conditions may have on body water balance and on the haematological picture have not been fully studied in goats reared in the region.

West African Dwarf (WAD) goats are of importance in the humid tropics of South-Western Nigeria because of their relative trypanotolerance (Akusu, 1994). On the other hand, Red Sokoto (RS) goats are more adapted to the drier condition of the Northern Nigeria. RS goats are being introduced into the south and can serve as a good breed for comparison with WAD goats that are common in the south on the effects of water deprivation. It has been reported that when WAD and RS goats were subjected to water restriction up to two-third of normal intake during hot-dry season, they exhibited higher respiratory and pulse rates and reduced voluntary feed intake and loss of weight (Abioja *et al.*, 2010) compared to the unrestricted group. Changes in drinking behaviour and water intake, as affected by water restriction in German black-head mutton sheep and Boer goats, had also been reported by Al-Ramamneh *et al.* (2012). Alamer (2009) has earlier reported that water restriction had effect on lactation performance of Aardi goats under heat stress conditions. Togashi and Tanaka (1979) reported that water restriction has effect on haematocrit, haemoglobin and serum protein in fattening beef cattle. Adogla-Bessa and Aganga (2000) however reported that Tswana goats can survive water deprivation without severe dehydration even when watered once in 72 hours. This tolerance in Tswana goats to water deprivation was attributed to the animals' ability to limit urine and faecal water excretion. This has not been confirmed in WAD and RS goats. Therefore, the present study is aimed at determining the effect of water restriction on haematological and water balance responses of WAD and RS goats.

MATERIAL AND METHODS

Experimental animals and management

Twelve non-pregnant (6 WAD and 6 RS) does used for this study were managed intensively in an open-sided slatted-floor individual pens at the Small Ruminant Unit of the University Teaching and Research Farms, Federal University of Agriculture, Abeokuta, Nigeria. They were allotted randomly to treatments in a modified cross-over design with 3 treatment periods. The three treatments were: *ad libitum* water supply (A), 33 % reduction (B) and 67 % reduction (C) from average water intake. A preliminary period of 7 days was

Table 1: Average weather conditions during the experimental period

Climatic factor	Mean	Diurnal variation		Treatment period			
	± sem	08.00 h	14.00 h	1	2	3	sem
Minimum temperature (°C)	26.5 ± 0.45			27.1	25.9	26.4	0.78
Maximum temperature (°C)	36.3 ± 0.58			37.9	34.9	36.0	0.92
Mean temperature (°C)	31.4 ± 0.45			32.5	30.4	31.2	0.74
Relative humidity (%)	81.1 ± 1.58	92.1 ± 1.23	70.1 ± 2.40	76.4	83.2	83.7	2.55
Temperature-humidity index	98.0 ± 1.81	88.6 ± 1.81	107.4 ± 2.13	100.3	94.6	99.2	3.14
Dry-bulb temperature (°C)	29.2 ± 0.44	27.1 ± 0.39	32.7 ± 0.55	30.8	29.0	30.0	0.75
Wet-bulb temperature (°C)	26.7 ± 0.25	26.0 ± 0.29	27.5 ± 0.30	26.7	26.2	27.3	0.43

sem- standard error of mean

allowed for determination of the average water intake of the experimental animals. This was followed by three treatment periods (TPs) of one week each. Between each TP there was a two-week period (wash-out period, WP) during which the effects of earlier treatment were expected to wear off before the next treatment.

The daily minimum and maximum temperatures, relative humidity, wet- and dry-bulb temperatures at 0800 h and 1400 h were monitored using suitable thermometers. The temperature-humidity index (THI) was calculated as described by Palmer (2000). The composition of the feed given to the animals was wheat offal (54 %), brewer's dried grain (20 %), rice bran (24 %), common salt (1 %) and bone meal (1 %). They were fed on 4 % body weight basis.

Haematological and blood biochemical studies

On the first and the last day of each of the three TPs, blood samples were obtained by jugular vein puncture at 07.00 h before feeding. Plasma from EDTA-supplemented bottles and serum from clotted blood, collected into hypodermic syringes, were harvested. The packed cell volume (PCV), red blood cell count (RBC), haemoglobin concentration (Hb), plasma urea (URE), plasma osmolality (OSM), blood glucose level (GLU), total serum protein (TSP), serum albumin (ALB) and serum globulin (GLO) were determined using standard analytical methods. The blood samples in the EDTA-supplemented bottles were centrifuged and the plasma was stored at -20 °C until analyses. Wintrobes microhaematocrit and colorimetric methods (Lamb, 1991) were used to determine packed cell volume (PCV), haemoglobin concentration (Hb) and red blood cell count (RBC). Blood samples collected into labelled EDTA-supplemented bottles were placed into the microhaematocrit centrifuge and spun for 5 minutes at a speed of 11000 rpm. The PCV values were subsequently determined by measuring the height of the red blood cell column and expressing this as a ratio of the height to the total blood column using microhaematocrit reader. RBC count was done by diluting the blood sample with 0.9 % NaCl and shaking well. The diluted blood was placed on a haemocytometer and the number of erythrocytes was counted under a microscope. Serum biochemical indices, plasma urea (URE), plasma osmolality (OSM), total serum protein (TSP), serum albumin (ALB) and serum globulin (GLO) were determined using spectrophotometer, as described by Werner *et al.* (1976). Blood glucose level (GLU) was measured by enzymatic colorimetric test (GOD-POD). The values of blood parameters on the first day were subtracted from those of the day 7 to reveal changes in blood picture as a result of water restriction.

Faecal and urine output

Six (3 WAD and 3 RS) does were transferred into metabolism cages where the daily (24 h) faeces and urine samples were collected for three days for each TP. Faeces collected were weighed before being transferred into an oven for faecal dry matter and water content determination. The samples were dried to constant weight. Faecal water content was taken as the difference

Table 2: Effect of water restriction on the change in blood constituents and chemistry (final values minus initial values) in goats

Parameter	Water restriction 0 %	33 %	67 %	sem
Water intake (ml)	1489[a]	1436[a]	841[b]	128.80
PCV (%)	2.7	3.2	2.7	0.85
Hb concentration (g.dL)	0.9	1.0	0.9	0.29
RBC ($x10^6.mm^3$)	0.27	0.29	0.33	0.101
Urea (mg.dL)	-0.1	1.2	0.1	1.67
Glucose (mg.dL)	5.8	7.1	5.2	1.94
Osmolality (mOsmo.kg)	17.9	24.0	21.0	7.15
Serum total protein (g.dL)	3.3	7.6	5.3	2.10
Serum albumin (g.dL)	2.9	5.3	3.2	1.29
Serum globulin (g.dL)	0.3	2.3	2.1	1.09

[a,b]Row means with different superscripts differ significantly ($P<0.05$)

between weights of fresh faeces and the dry matter. The volume of the daily urine output for individual goat was also measured.

Statistical analyses

The data obtained were subjected to analysis of variance using a modified cross-over design. The daily mean temperature and relative humidity were included as covariates. All analyses were done with SYSTAT analytical computer package version 5.0 (Systat Inc., 1992). Means with probability value less than or equal to 0.05 were considered to be significantly different and were separated using Duncan multiple range test.

RESULTS

Meteorological conditions

The summary of climatic data during the experimental period is shown in Table 1. The minimum, maximum and mean temperatures averaged 26.5 ± 0.45, 36.3 ± 0.58 and 31.4 ± 0.45 °C, respectively. The relative humidity averaged 81.1 % during the experimental period while the temperature-humidity index was 98.

Haematology and biochemistry

The result of haematological responses and serum biochemical indices in the goats is shown in Table 2. Water restriction had no significant (P>0.05) effect on all the haematological and blood biochemical parameters examined. As well, there was

Table 3: Effect of water restriction on water losses in urine and faeces in goats

Parameter	Water restriction 0 %	33 %	67 %	sem
Live weight (kg)	17.3	17.5	17.1	0.80
Metabolic weight(kgW$^{0.75}$)	8.4	8.5	8.4	0.29
Urine output (ml)	621.3	616.3	503.8	48.73
Urine output (ml.kgW$^{0.75}$)	74.2	72.4	60.1	5.18
Fresh faecal output (g)	606.6	513.5	537.7	52.80
Faecal output (g.DM)	182.3	211.9	243.8	20.94
Water in faeces (ml)	424.2	301.6	294.0	36.28

Table 4: Effects of water restriction on water losses in urine and faeces of WAD and RS goats

Parameter	Water restriction 0 %		33 %		67 %		sem
Breed	WAD	RS	WAD	RS	WAD	RS	
Live weight (kg)	17.7	16.9	18.4	16.5	17.3	16.9	1.13
Metabolic weight(kgW$^{0.75}$)	8.6	8.3	8.8	8.2	8.4	8.3	0.42
Urine output (ml)	629.1	613.4	654.3	578.3	532.1	475.6	68.91
Urine output (ml.kgW$^{0.75}$)	73.3	75.1	74.1	70.6	63.0	57.3	7.33
Fresh faecal output (g)	439.1^{ab}	774.0^{a}	373.8^{b}	653.2^{a}	422.6^{b}	652.9^{a}	74.67
Faecal output (g.DM)	144.3^{b}	220.3^{a}	179.3^{ab}	244.5^{a}	193.1^{ab}	294.5^{a}	29.61
Water in faeces (ml)	294.8^{b}	553.7^{a}	194.5^{b}	408.7^{a}	229.5^{b}	358.4^{ab}	51.30
Water intake : urine output	2.3	2.4	2.2	2.8	1.7	1.8	0.29

^{a,b}Row means with different superscripts differ significantly (P<0.05) no significant (P>0.05) change in these parameters before and after 7 days of water restriction. There was no significant (P>0.05) interaction between water restriction and breed in the blood parameters (data not shown).

Water metabolism

The effect of water restriction on water losses in faeces and urine in goats (data combined) is shown in Table 3 and in Figures 1 and 2. Daily urine volume and amount of faeces voided by goats (fresh or dried) were not significantly (P>0.05) affected by water restriction. Water content of faeces was however significantly (P<0.01) lowered by water restriction. 0 % goats had the higher water loss in faeces than 33 % and 67 % goats; moreover the latter groups were not different from each other (Figure 1). Ratio of water

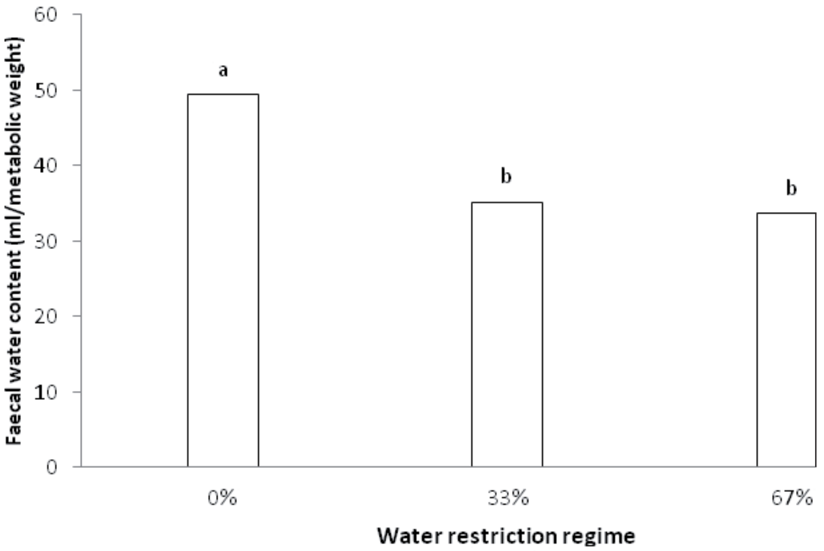

Fig. 1: Effect of water restriction level on faecal water content in goats

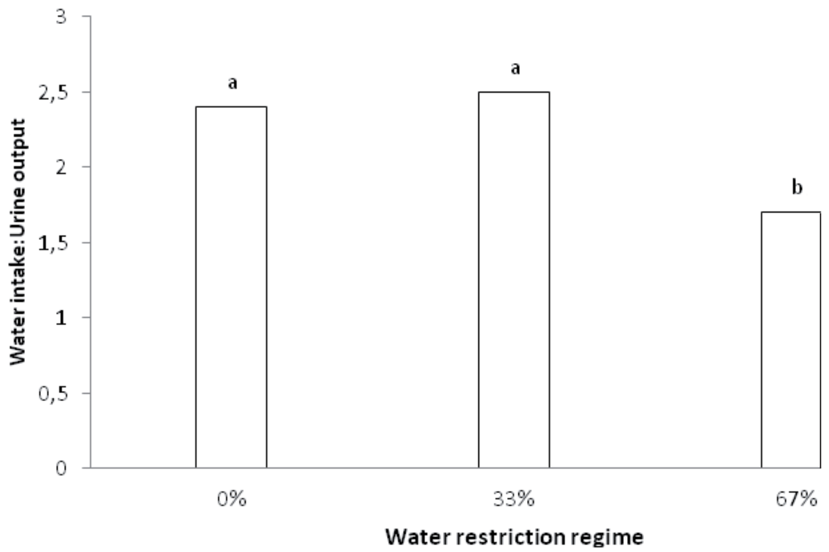

Fig. 2: Effect of water restriction level on water intake : urine output ratio in goats

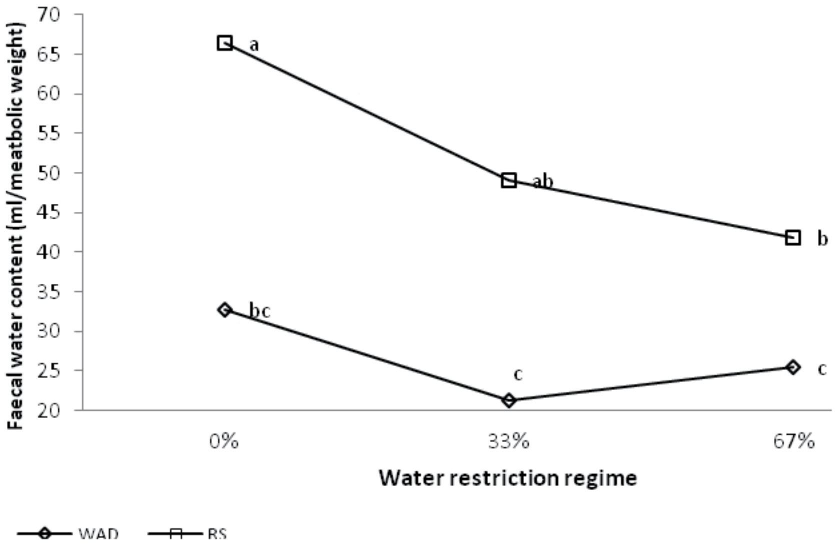

Fig. 3: Effect of water restriction on faecal water content in WAD and RS goats

intake to daily urine voided was significantly (P<0.05) affected by water restriction (Figure 2). There was no difference between 0 % (2.4 ± 0.17) and 33 % (2.5 ± 0.17) restriction level in water intake-urine ratio, but these values were higher than those of the 67 % group (1.7 ± 0.17).

The result of water losses by WAD and RS goats, as affected by water restriction, is presented in Table 4. In both WAD and RS goats, the daily volume of urine (in millilitre and millilitre per metabolic weight) was not different (P>0.05) among the three water restriction groups. However, both fresh (P<0.05) and dry matter (P<0.01) faecal material voided daily were significantly affected by water restriction. Considering fresh faecal weight, RS goats had higher weight than WAD goats at 33 % and 67 % water restriction level. However, the dried faecal weight in RS goats was only higher than that of WAD goats at 0 % restriction level. Faecal water content (FWC) per metabolic weight was higher for RS than WAD goats at all water restriction levels (Figure 3). In RS goats, there was a gradual decrease in FWC with increase in water restriction level, whilst there was no significant difference in FWC of WAD goats.

DISCUSSION

The non-significant effect on water restriction observed in the present study on haematological and biochemical results of analyses of goats is opposite to the reports of various previous studies in ruminant animals (Togashi and Tanaka, 1979; Abdelatif and Ahmed, 1994; Adogla-Bessa and Aganga, 2000). Water deprivation causes a shift in the dynamic water balance, which results in certain responses from the body systems. The initial response to a negative water balance is the withdrawal of fluid from tissues to maintain the normal blood volume (Radostits *et al.*, 2000). During dehydration, water is reabsorbed to accompany sodium absorption in the colon, which results in the return of water to the blood. It means the animals in this study were able to maintain the blood components by drawing water from other tissues into the blood system. The absence of a significant effect observed here might also be due to goat´s superior adaptability to water shortage (Devendra and McLeroy (1982) and the shortness of the treatment period. However, in agreement with this study, Qinisa (2010) reported that though blood urea concentration increased as the level of water restriction increased, the values were not significantly different for the animals on *ad libitum*, half *ad libitum* or quarter *ad libitum* water supply.

In this present study, water restriction had no effect on daily urine volume. In contrast, Adogla-Bessa and Aganga (2000) reported a decrease in urine volume in Tswana goats as the period of water deprivation lengthened. The reason for the differences in results may be adduced to higher capacity to withstand water shortage in WAD and RS goats, used in the present study, than in Tswana goats used in the previous study. Moreover, the present study dwelt on volumetric water restriction, as against 0, 24, 48, 72 and 98 hour water restriction regimes, applied by Adogla-Bessa and

Aganga (2000). Ahmed and El Kheir (2004) reported that whether Sudanese desert goats were offered good or bad quality feed, water restriction decreased faecal water losses and increased water losses in urine. In the same vein, Dahlborn and Karlberg (1986) reported that a decrease in water intake even for a single day gradually reduced secretion of urine in goats. However, result similar to the present one was observed by Little *et al*. (1976) in cattle, where 40 % reduction in WI resulted in no significant reduction in urine output, though there was evidence for the reduction in total body water. The weights of fresh faecal and faecal dry matter from goats, subjected to different regimes, were not different but RS goats voided more faeces than WAD goats. In the other study, water deprivation decreased faecal output in Tswana goats (Adogla-Bessa and Aganga, 2000). The result of the present study might be due to a decrease in the number of rumen bacteria and protozoa following water deprivation, as suggested by Fluharty *et al*. (1996). Water loss in faeces was lower in goats subjected to 67 % water restriction, showing that the animals were able to reduce water loss during the short period of water deprivation. WAD goats have greater ability to conserve water and reduce water loss in faeces than RS goats, as they voided drier faeces. This is in contrary to the expectation from RS goats, as they are adapted to drier conditions of the Northern Nigeria.

CONCLUSION

WAD goats proved superior to RS in regulating amount of water losses in faeces, thereby showing a higher capacity to cope with water shortage under conditions prevalent in the southern Nigeria during hot-dry season.

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