

Original Research Article

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Water Restriction and Its Effect on Blood Hormones, Minerals and Metabolite in Baladi Goats

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ABSTRACT

The aim of this study was to investigate the effect of 50 % water restriction on blood hormones, minerals and metabolite in baladi goats during summer months (June – August). Ten non-pregnant and non-lactating balididoes (1.5-2 years old and average BW = 23.4 ± 1.3 kg), divided equally into two groups of 5 does each. The first group (treated) received 50% of water requirements (G1) while the other assumed as control (G2) (ad libitum water). Temperature – humidity index (THI) was calculated. Body weight (BW) and thermoregulatory response, rectal temperature (RT) and respiration rate (RR) were recorded. Blood serum metabolites and mineral (total protein (TP), albumin (Alb), globulin (Glb), triglycerides (TG), cholesterol (Chol), glucose (Glu), Na⁺, Cl⁻ and K⁺) were determined. Kidney (creatinine and urea) and liver (ALT, AST) function and serum hormones (Triiodothyronine (T₃), thyroxin (T₄), aldosterone (Ald), progesterone (P₄) and estradiol E₂) were measured and Haematological parameters (CBC) were assayed. Blood biochemical analysis indicated that the blood serum albumin, cholesterol, triglycerides, Na⁺, K⁺, Cl⁻, ALT, AST, Creatinine and urea were not affected by water restriction. It was also, no changes in serum hormones were observed in water restricted does. Although, serum total protein and globulin were higher (P<0.05), serum glucose was significantly reduced (P<0.05) in treated goats. Blood picture as affected by treatment showed an increase (P<0.05) in MCHC and decrease in HT, MCV and Platelets while Hb, MCH, WBCs and RBCs were not affected. It is concluded that baladi goats can easily survive under semi-arid areas.

Keywords

Water restriction, goat,
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Introduction

Water is considered one of the most important substances or nutrients, which consume in larger quantity than other nutrients by livestock (Mustafa *et al.*, 2010) it covers almost 98% of the molecules in the animal organism (NRC, 2001). Water is already scarce for more than a billion people on the

planet. If urgent measures are not adopted, one-third of the population may be without suitable water for consumption by 2025 (UNESCO, 2006). By 2055, 64% of the world's population will be living in water-stressed basins and 33% in areas of absolute water scarcity (Schlink *et al.*, 2010 and Steinfeld *et al.*, 2006). Water rarity is growing in progress problem in arid and semiarid

regions with global warming and changes patterns of rainfall, which affect water resources, feed quality and quantity in addition to increase of heat stress. These challenges cause abroad range of physiological responses in sheep leading to adverse effects on production, immunity and welfare (Jaber *et al.*, 2011).

Electrolyte and osmolality are affected by water stress. During water deprivation, hyperosmolality occurs as plasma volume reduces. Na⁺ and Cl⁻ electrolyte concentration mainly increased in water stress (Qinisa *et al.*, 2011). To maintain Na⁺ balance in the body, animal increased their retention of Na⁺. Some workers reported that higher renal retention is because of aldosterone (Ashour and Benlamlih 2001), whereas others stated the effect of vasopressin (McKinley *et al.*, 2000). These reports suggested that vasopressin increased in dehydrated state.

Small ruminants, especially sheep and goats, have social and economic importance in the entire world. Information about feeding habits and nutrient requirements of these animals is essential for managing their welfare and for contributing to the livelihoods of people that depend on them. Adequate nutrition and management of these small ruminants are important for their maintenance to different ecosystems from the Arctic Circle to the Sahara desert (NRC 2007).

Water sources to goats include drinking water, dietary water (feed), and metabolic water from catabolism of nutrients (Araújo *et al.*, 2010), where water is taken by goats intermittently and lost continuously in sweat, transpiration, urination and defecation.

This study aim to investigate if baladi goats can survive living in restricted water areas without being physiologically (hormones, minerals and others) affected.

Materials and Methods

This study was conducted at Demo area (semi-arid desert), Experimental station belongs to Animal Production Farm, Faculty of Agriculture, Fayoum University, EL-Fayoum governorate, Egypt.

Ten healthy non-pregnant and non-lactating does (1.5-2 years old and 23 ± 1.3 kg body weight) were equally divided in two groups, water restriction 50% (G1) and control (G2). Goats were maintained in semi-open pens and feed concentrate mixture and Wheat straw. 60: 40% according to NRC (1985) during summer months (June –August).

Daily ambient temperature and relative humidity (RH %) were measured to calculate Temperature Humidity index (THI) according to Hahn (1997) formula where

$$THI = [0.81 \text{ db}^{\circ}\text{C} + RH (\text{db}^{\circ}\text{C} - 14.4) + 46.4]$$

Where: db. - dry bulb temp (⁰C), RH: relative humidity (RH, %) /100.

Which refer to THI through experiment were 90.52

Body weight (BW), rectal temperature and respiration rate were recorded weekly at 10.00 a.m. before the distribution of the meal. Rectal temperature was measured using digital thermometer and respiration rate (breaths/min) was measured by counting the flank movements using stopwatch.

Blood samples were weekly withdrawn from a jugular vein of fasted does and blood serum were obtained and stored at -20⁰C for hormonal and biochemical analysis. Serum metabolites, total protein (TP), albumin (Alb), glucose (Glu), cholesterol (chol), triglycerides (TG) were determined according to (Cannon, 1974), (Beng and Lim, 1973), (Howanitz and

Howantiz 1984), (Burtis *et al.*, 2006), (Scheleter and Nussel 1975) respectively, while globulin (glob) were calculated by subtracting serum Alb from TP. Where serum minerals (Na^+ , K^+ and Cl^-), liver and kidney function were measured according to (Trinder, 1951), (Sunderman and Sunderman 1958), (Burtis, 1999) and (Reitman *et al.*, 1957) respectively. Hormonal profile (Ald, T3, T4, E2 and P4) by commercial radioimmunoassay (RIA) kit of Diagnostic products corporation (DPC) Los Angeles, USA. According to Mayes, (1970). Another blood samples were collected to haematological parameters which estimated according to Hawk *et al.*, (1974).

The statistical analysis was carried out using SPSS software program, version 21 (IBM, Chicago). Level of statistical significance was set at $P < 0.05$. The model used for the present experiment was as follows:

$$Y_i = \mu + W_i + e_i$$

Where, Y_i is dependent variables in the study

μ is overall mean

W_i is the effect of water mood (treatment) ($i=1, 2$)

e_i is the error

Results and Discussion

Thermoregulatory parameters and body weight

Insignificant differences were noticed in rectal temperature of water restricted group compared to control group, where the average of RT were 38.93 and 38.98°C respectively Table 1. The slightly changes in RT of restricted goats due to the adaptive response of Baladi goats to the breeding environment that serves to reduce water loss through

mechanisms of thermoregulation for the defence from heat (Ghanem *et al.*, 2008). Furthermore, water restriction caused a decrease ($P < 0.05$) in respiration rate by 6% compared with ad libitum water intake (Table 1). Moreover, the reduction of respiratory acts under water restriction is one of many defence mechanisms which the animal employs to prevent the loss of water and dehydration through pulmonary evaporation (El- Khashab, 2002).

Analysis of the results in (Table 1) indicated that there was body weight loss due to water restriction. Where water restriction caused a decrease significantly in body weight by 7.54% (1.86kg) compared with control group. The weight loss may be due to body water loss and consequent mobilization of fat (and possibly muscle) used for energy metabolism (Jaber *et al.*, 2004). These results agreed with Kumar *et al.*, (2016) who found the final body weight was lower in water-restricted animals.

Blood serum metabolites

Insignificant increase in Chol, Alb and TG were noticed in water restricted does (Table 2). Water restriction caused an increase in serum total protein and globulin by 13% and 14.12% respectively compared with ad libitum water intake. The observed significant increase in serum total proteins in this study might be due to reduction in plasma volume caused by dehydration (Khalil *et al.*, 1990). The increase in serum total proteins might cause an increase in plasma colloid osmotic pressure (Cole, 2000). Moreover, the increase in globulin due to water deprivation might be due to either mobilization of proteins from the lymphatics to the blood circulation or to the activation of the lymphoid tissue to produce antibodies (Shoukry, 1981).

Water restriction caused a decrease in serum glucose concentration by 10.90% compared

with control group. This result agreed with Kumar *et al.*, (2016) found that the glucose and cholesterol levels were lower ($P < 0.05$) in 20% less than ad libitum water intake compared with control ad libitum water. Some reports stated that glucose metabolism decreases because of decreased propionate production in the rumen as feed intake reduces following water restriction.

An insignificant increase of 1.09, 10.89 and 17.37% in water restricted does in Alb, Chol and TG respectively. The increase in serum TG and Chol in this study might be due to reduction in plasma volume caused by dehydration (Khalil *et al.*, 1990). The increase in cholesterol level after water restriction is mainly due to fat metabolism because of low energy intake (Jaber *et al.*, 2013).

Serum Alanine amino transferase (ALT) and Aspartate aminotransferase (AST) concentration were not affected by water restriction where the average mean showed the same.

Serum mineral profile

The current results indicated that slightly increase of Na^+ and Cl^- and decrease in K^+ level in water restricted does but the differences in both case are insignificant (Table 3). This increase might be due to sweating rate and excretory pattern. Also the ability of goat's kidney to concentrate urine and conserve water caused variations in blood volume as proposed by Ashmawy and Ibrahim (1999).

In addition this increase in Na^+ and Cl^- in restricted goat may be accompanied by an increase of blood osmolality and osmosis balance as result of dehydration as previously noticed in 72 h water deprivation, which is preceded by losses from intracellular pool and decrease in extracellular water volume (Cole

2000). The increase in Na^+ when sheep deprived from water might be due to adrenal response to this stress in an attempt to maintain plasma volume or probably due to a decrease in extracellular fluid volume (more and sahani, 1980). The slight decrease in serum K^+ in goats might be due to K^+ elimination in the urine.

Serum Urea and Creatinine of water restricted and control of goats presented in Table 3 the average concentration of serum urea and create was insignificantly higher (55 and 53 mg/dl) for urea and (1.42 and 1.33 mg/dl) for create in water restricted and control group respectively. Water deficiency leads to increased water reabsorption at the nephron level; consequently, increased urea reabsorption is expected as it is a highly permeable molecule. The increase in serum urea level may also be related partially to increase in secretion of the hormone arginine vasopressin (AVP).

It has been reported that water deprivation increased (AVP) level in goats (Olsson and Dahlborn, 1989) and this would have opposed loss of urea as (AVP) promotes urea reabsorption in the kidney (Meintjes and Engelbrecht, 2004). The rise in urea level could also be associated with catabolism of body proteins during dehydration (Haupt, 2004).

Osbaldiston (1971) reported that hypovolaemia due to water insufficiency is expected to cause a decrease in renal blood flow, thus leading to a decreased filtration rate; in fact, 95% of creatinine, the final metabolite of create, is of muscular origin and it is excreted by the kidneys in proportion to the muscle mass and to its rate of proteolysis. When kidney water stress leading to slower glomerular filtration and reabsorption of urea excretion affects kidney excretion function (Kataria and Kataria, 2007).

Table.1 Rectal temperature, respiration rate and body weight of Baladi goats under ad libitum water and restriction 50%

Parameters	Control	Restricted water	sig
RT(°C)	38.93±0.04	38.98±0.05	0.15
RR(rpm)	36.97±0.95	34.77±0.82	0.02
BW(kg)	24.66±0.34	22.80±0.29	0.000

R: rectal temperature BW: body weight

RR: respiration raterpm: Revolution per minute

Table.2 Peripheral blood serum metabolites and liver function of Baladi goats under ad libitum water and restriction 50%.

Parameters	Control	Restricted water	sig
TP(g/dl)	8.38±0.22	9.47±0.24	0.002
Alb (g/dl)	3.07±0.15	3.38±0.15	0.15
Glb(g/dl)	5.31±0.14	6.06±0.36	0.002
Glu(mg/dl)	61.20±1.65	54.53±1.40	0.005
Chol (mg/dl)	80.20±3.43	88.93±3.82	0.10
TG (mg/dl)	73.67±6.81	86.47±10.13	0.30
AITU/L	21.93±0.81	21.33±0.95	0.64
AstU/L	72.67±5.44	73.33±5.63	0.93

TP: Total protein Alb: Albumin Chol: Cholesterol

Glb: globulin Glu: Glucose TG: Triglyceride

ALT: Alanine amino transferase Ast: Aspartate amino transferase

Table.3 Peripheral blood serum mineral profile and kidney function of Baladi goats under ad libitum water and water restriction 50%

Parameters	Control	Restricted water	sig
Na ⁺ (mEq/L)	150.80±2.79	155.67±2.70	0.22
CL ⁻ (mEq/L)	108.06±1.25	110.01±1.41	0.31
K ⁺ (mEq/L)	4.14±0.18	4.01±0.21	0.66
urea(mg/dl)	53.00±1.86	55.00±1.85	0.45
Creat(mg/dl)	1.33±0.08	1.42±0.11	0.49

Na⁺: Sodium ion CL⁻: Chloride ion

K⁺: Potassium ion create: creatinine

Table.4 Peripheral blood hormonal of Baladi goats under ad libitum water intake and water restriction 50%

Parameters	Control	Restricted water	sig
Ald(pg/l)	75.44±10.94	78.13±7.99	0.84
T3(ng/dl)	112.17±7.021	107.85±10.521	0.75
T4(ug/dl)	5.93 ±0.58	6.083±0.44	0.83
E2(pg/ml)	9.71±1.50	10.83±1.85	0.64
P4ng/ml)	3.18±0.92	2.33±0.77	0.84

Ald: Aldosterone T3: Triiodothyronine T4: Thyroxine

E2: Estradiol P4: Progesterone

Table.5 Complete blood picture CBCs of Baladi goats under ad libitum water intake and water restriction 50%

Parameters	Control	Restricted water	Sig
HT%	21.05±0.94	18.72±0.46	0.03
Hb(g/dl)	9.55±0.27	9.71±0.26	0.67
RBCs(x10 ⁶ /µl)	5.45±0.17	5.23±0.11	0.28
MCH (pg)	17.78±0.73	19.70±1.25	0.19
MCV(um ³)	38.43±0.97	35.92±0.70	0.04
MCHC%	46.39±2.15	53.68±1.74	0.01
Platelet (x10 ³ / µl)	323.65±9.94	287.20±9.58	0.01
WBC(x10 ³ /µl))	12.67±1.80	13.23±0.96	0.65
Neutrophil	15.46±1.31	15.09±1.47	0.85
lymphocyte	73.77±1.54	73.64±1.89	0.96
monocyte	6.45±0.40	6.69±0.49	0.71
Eosinophil	4.28±0.21	4.54±0.23	0.41

Hb: Haemoglobin HT: Haematocrit

RBCs: Red Blood Cells WBCs: White Blood Cells

MCH: Mean corpuscular hemoglobin MCV: Mean corpuscular volume

MCHC: Mean corpuscular hemoglobin concentration

Blood hormones

Table 4 shows that insignificant differences were noticed in T₃ and T₄ level of water restriction group compared to control group, where the average of T₃ and T₄ were (112.17 and 107.85ng/dl) and (5.93 and 6.08ug/dl) These results agreed with (Jaber *et al.*, 2011) who found T₃ and T₄ level decreases in water-restricted animals.

The reason of reduced T₃ in case of water stress refers lower metabolic state due to dehydration and decreased feed intake (Jaber *et al.*, 2013). The possible reason behind decreased thyroid hormone activity is attributed to the animals' attempt to minimize water loss by decreasing metabolism (Olsson 2005).

Analysis of the results in Table 4 indicated that water restriction has barely affected serum aldosterone concentration in goats. These results agreed with Li (2000) who

found plasma aldosterone was not affected by restricted group. Also, water restriction did not significantly increase plasma osmolality in the warm environment (Silanikove and Tadmor 1989).

It was obviously observed that there is insignificant increase and decrease in E₂ and P₄ in goats due to water restriction in this study Table 4. However, in another research estrogen and progesterone showed a reverse trend for the effect of water restriction (Kumar *et al.*, 2016).

It is well known that endocrine responses to stress, in general, work toward suppressing productive functions, such as growth and reproduction, in favor of maintenance and survival (Rivest and Rivier, 1995). The last research referred the serum estradiol in the water-restricted groups may be attributed to the diminished ovarian follicular development caused by suppressed peripheral level of gonadotropins (Lechner-Doll *et al.*, 1995).

Haematological parameters

Water restriction caused a decrease in hematocrit (HT) This decrease in hematocrit values during the water restriction is partially due to a decrease in circulating erythrocytes (Nejad *et al.*, 2014), MCV and Platelets by 11, 6.53 and 11.26% respectively compared with control group (Table 5). While, an increase of 15.7% in MCHC of treated goat was noticed compared with ad libitum water intake may be due to a decrease in Ht value.

The present results indicated that water restriction has barely affected Hb, MCH and RBCs count in goats. This result agreed with Nejad *et al.*, (2014) who found that RBCs values remained unchanged under goes water restriction regime. Moreover, insignificant differences were noticed in WBCs count and it differential of water restriction group compared to control group, which in parallel to Nejad *et al.*, (2014) who reported concentrations of white blood cell were not different among treatment groups.

It could be concluded that blood serum hormones, mineral profile, metabolites and liver kidney function were not affected by water restriction in goats so goat may survive at 50% restriction of water without affecting physiological indices and then their production.

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