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Physiological Responses of Baladi Goats undergoing Water Deprivation during Summer Condition

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ABSTRACT

This study was assigned to evaluate the effect of water deprivation on physiological responses, liver and kidney functions, hematological parameters, serum metabolites, electrolytes and hormonal profiles of Baladi goats during summer months. A total of 12 healthy, non-pregnant and non-lactating does (1.5-2 years old) were divided into 2 groups (average body weight of 23.35 ± 1.16 and 23.15 ± 1.13 kg for control and the treated group (exposed to water deprivation cycles 24h, 48h and 72h /week for 3 months. Temperature-humidity index (THI) was determined. Rectal temperature (RT) and respiration rate (RR) were measured. Haematological parameters, serum hormones, metabolites and electrolytes were assayed. Results showed that RT was higher ($P \leq 0.05$) in deprived does for 48h and 72h, but 24h did not affect RT compared with control. RR reduced insignificantly, but BW decreased ($P \leq 0.05$) in deprived does. Water deprivation had no effect ($P > 0.05$) on haematological parameters, liver and kidney functions (ALT, AST, urea, creatinine). Each of total proteins, globulin, cholesterol and triglycerides increased ($P \leq 0.05$), while albumin insignificantly increased in deprived does. Serum glucose had reduced ($P \leq 0.05$) as water deprivation progressed. Serum electrolytes differed ($P \leq 0.05$), except for Cl^- . Content of Na^+ and Cl^- increased, while K^+ decreased in deprived does ($P \leq 0.05$). Serum Aldosterone and IgG levels increased ($P < 0.05$) in deprived does, however, no significant effect on thyroid hormones. It is concluded that Baladi goats could be adapted for unsuitable conditions of water insufficiency or drought without having harmful effects.

Keywords: Goat, water deprivation, haematology, metabolites, hormones, immunity

INTRODUCTION

There is no doubt that the world is suffering from water scarcity and that the coming conflicts around the world will be over water resources. One-third of the world population may be without suitable water for consumption by 2025 (UNESCO, 2006). Many factors have limited the amount of fresh water available to most areas around the world such as irregularities in rainfall manners as a result of global warming and vagaries in weather conditions (Kurylyk and MacQuarrie, 2013) as well as constructing dams.

Water is considered as an essential nutrient and the simplest constituent of feeds yet. An animal's first response to water stress is a reduction of voluntary feed intake. The existence of adequate water in body tissues is an essential prerequisite to maintain the normal life, and it is a principal constituent of all living cells. Aganga *et al.* (1986) pointed out that the body water of ruminants is not fresh water since it contains salts in solution. The basic importance of water in animal nutrition includes its role in nutrient solution and absorption. Other uses of water include removal of harmful metabolic products through urinary and alimentary tracts and the maintenance of body temperature. Water is a basic constituent of all living cells, and hence it is concerned with the maintenance of normal osmotic pressures and turgidity of the cells in the various organs of the body (Choshniak and Shkolnik 1978; Brosh *et al.* 1986; Dahlborn and Holtenius 1990).

The increase in water need is a result of the insensible water loss being more pronounced through respiration, perspiration and evaporation (More and Sahni 1981). The water scarcity often experienced by animals in the tropical and or semi-arid environment led to the acclimatization and survival

of desert species such as camels and Bedouin goats (More and Sahni, 1981). Goats are known to be well adapted for survival than sheep because of a lower water turnover rate than in sheep suggests that goats are more suitable in dry or poor regions. The fact that the water turnover rate of Sahel goats was the lowest suggests that, under conditions where supplies of drinking-water are limited, they would be the more suitable breed for production (Aganga, 1992). Although adaptation can be enhanced following sustainable exposure by livestock, studies have noted huge differences in response by different breeds (Habibu *et al.*, 2017). Desert goats raised under traditional systems may be watered once every 3–6 d during water scarcity. Barmer and Black Bedouin goats, as adapted breeds, can manage and still alive on a watering regime of once every 4 days (Silanikove, 1994). Despite this efficient water use in adaptable breeds, disturbances of water balance portend a stressful stimulus and have been shown to impede feed intake and body weight, and influence the body heat balance, as well as the composition of the body fluids (Akinmoladun *et al.*, 2019). In addition to the marked decrease in feed intake under water deprivation that could have influenced the energy budget, rectal temperature in dehydrated goats was 0.5 - 0.9°C higher than the hydrated ones to reduce evaporative heat loss (Jessen *et al.*, 1998) as noticed in three local Saudi Arabia goat breeds. Respiratory activity was noted to be reduced during periods of water deprivation in goats (Alamer, 2006). Dehydration (72 hours water deprivation) in goats significantly increased overall means of packed cell volume (PCV), blood osmolality, electrolytes, total proteins, albumin, globulin and glucose (Samara *et al.*, 2012). In other studies, hypoglycemia or hypokalemia was observed as a result of water stress (El-Nouty

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et al. 1990; Duncan *et al.* 1994; Jaber *et al.* 2004; Abdoun *et al.* 2010; Samara *et al.*, 2012).

In Egypt and many countries suffering water insufficiency, especially in arid or semi-arid areas during higher temperatures (summer) consequently, we need animals which have to adapt to little water at certain times of the year. Small ruminants adapt to severe water scarcity by recouping as much water as possible in the rumen during rehydration to counteract weight loss induced by water deprivation (Akinmoladun *et al.*, 2019).

The present study aimed to evaluate the effect of water deprivation on Baladi goat performance by following up thermoregulatory response, blood metabolites, hormones, and liver and kidney functions.

MATERIALS AND METHODS

The current experiment was conducted at the Research Station of Animal Production Department, Demo region, a semi-arid desert about 15 km far from the city, belonging to Faculty of Agriculture, Fayoum University, Fayoum Province, Egypt. The study was conducted during the summer season (July- September)

A total of 12 healthy, non-pregnant and non-lactating Baladi does, 1-1.5 years old, were divided into 2 groups with an average body weight of 23.35 ± 1.16 and 23.15 ± 1.13 kg for control and deprived does. The 1st group was freely watering twice a day while the other was exposed to deprivation cycles 24h, 48h or 72h/week for 3 months. The deprived does received water once a day every three days' cycle per week. The does were deprived for the first three consecutive days /week and then weekly repeated in terms of there were three stages of water deprivation (24h, 48h and 72h). After water deprivation, rehydration of animals was occurred gradually. All does were raised under the same managerial and environmental conditions in individual semi-open pen. Does were depended on a ration contains concentrate feed mixture (CFM) and wheat straw according to NRC (2007).

Rectal temperature (RT, °C) and respiration rate (RR, breaths/min) were recorded for 3 days/week at 10 a.m. before feeding. Rectal temperature was estimated using digital thermometer, while RR was recorded by counting flank movements in one minute. Blood sampling were weekly collected from the jugular vein of deprived does into two containers, one of them was heparinized to prevent clotting for haematological parameters and another one was used to collect the serum. The collected serum was stored at -20°C for further investigation of metabolites, electrolytes and hormones.

Does health were monitored by determining the activity of liver enzymes [Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT)] colorimetrically by commercial kits (Diamond Diagnostics) at 546 nm wave length, while kidney function markers included concentration of creatinine and urea determined in blood serum by applying enzymatic-coloremetric test (Berthot) using a kit (Spinreact, S.A., Spain).

Serum metabolites such as total proteins (TP), albumin (Alb) and cholesterol (Chol) concentrations were determined by using commercial kits (Diamond Diagnostics, Stanbio laboratory, Boeme) with wave length of 546 nm, Meanwhile, serum globulin (Glob) was calculated by subtracting serum Alb from TP. Serum glucose (Glu) and triglycerides (TG) concentrations were also detected by using Stanbio

enzymatic- colorimetric kits with wave length of 500 nm. In addition, Serum electrolytes (Na^+ , K^+ and Cl^-) were spectrophotometrically measured at wave length of 545, 420 and 480 nm, respectively by using commercial kits (Biodiagnostic). Blood serum hormones, including aldosterone (Ald), thyroid hormones (T3, T4), estradiol (E2) and progesterone (P_4) in serum were also assayed by commercial radioimmunoassay (RIA) kits (Diagnostic products corporation (DPC) Los Angeles, USA.), while immunological indicator in terms of immunoglobulin G (IgG) was assayed by enzyme-linked immunosorbent assay (ELISA). Finally, haematological parameters, in term of complete blood picture (CBC) were estimated in fresh blood samples according to Hawk *et al.* (1974).

Thermal-humidity index (THI) was calculated by measuring ambient temperature (AT, °C) and relative humidity (RH%) by using a developed equation for estimating THI under the Egyptian climatic conditions by the following formula:

$$THI = 32.783 + 1.478 \times AT + 0.056 \times RH$$

Where: 32.783 is the intercept, 1.478 is the regression of THI on AT, 0.056 is the regression of THI on RH, AT is the average of air temperature (°C) and RH is the average of relative humidity (%). The accuracy of this equation (R^2) is 0.995 (Sadek *et al.*, 2015). Where measurements refer to THI throughout current study were 87.55 which was a dangerous area.

The statistical analysis was carried out using SPSS software program, version 23, (SPSS, 2015, IBM, Chicago). Level of statistical significance was set at $P \leq 0.05$. The model used for the present experiment was as follows:

$$Y_{ijk} = \mu + WD_i + M_j + (WD_i \times M_j) + e_{ijk}$$

Where, Y_{ijk} is dependent variable in the study, μ is overall mean, WD_i is the effect of water deprivation ($i=24, 48$, and $72h$), M_j is the effect of moth ($j=1, 2, 3$), $WD_i \times M_j$: Effect of interaction of water deprivation with month, and e_{ijk} is the error.

RESULTS AND DISCUSSION

Thermoregulatory responses and body weight

As shown in Table 1, the results proved an elevation in overall mean of RT consequent water deprivation but remained within the normal range which suggested by Degen (1977). This tendency of RT to remain within a particular range has been reported at different environmental conditions (Lucena *et al.*, 2013). Generally, an increase ($P \leq 0.05$) in RT is often attributed to the advances of water deprivation, especially for 48h and 72h, since RT were 38.89, 39.08 and 39.09°C for 24h, 48h and 72h as compared to the control does (38.86°C) as previously noted by Alamer (2006). Regard month effect, RT decreased ($P \leq 0.05$) with advancing experimental periods from the 1st month to 3rd month. Goats were able to elevate their body temperature, which may indicate their thermolabile capability (Al-Haidary 2005; Samara *et al.*, 2012). Values of RR recorded in this study were slightly decreased as the water deprivation period increased from 24h to 72h. This effect of water deprivation on RR of goat was not significant. No effect of month was recoded on RR. The reduced RR of water deprived does may be adaptive role or attempt of goat to decline the excessive loss of water through the pulmonary evaporation by decreasing their respiratory activities (Casamassima *et al.*, 2016; akinmoladun *et al.*, 2020a). Our results are in agreement with that of Baker (1989), who stated that respiratory frequency was higher after drinking than in dehydrated animals which were not allowed to drink.

Body weight (BW) also decreased ($P \leq 0.05$) in does as a result of water deprivation (WD) where the average body weight was 22.98 and 24.71 kg for water deprived and control does' group, respectively. In similar studies, the body weights fall in deprived Saudi Arabia goats for 3 days (Alamer, 2006) or in a 75-d water-restriction study in Xhosa goats (Akinmoladun *et al.* 2020 b). The significant reduction in BW of water deprived does may be refers to fat mobilization from adipose tissues, as a result of suboptimal water supply, as an

attempt to maintain energy needs normally in order to face energy production compromising under water stress (Jaber *et al.* 2013). The progressive decrease in body weight to a prolonged water deprivation in this study could be attributed to reduced feed and water intake as well as body water loss (Mpendulo *et al.*, 2020). No effects for month or its interaction with water deprivation (WD x month) were found in concern with RR and/or BW, however, the interaction of (WD x month) was significant regard RT.

Table 1. Effect of water deprivation on thermoregulatory responses and body weight of Baladi goats

Item	Control	Treatment			Overall mean
		24h	48h	72h	
RT (°C)					
Month 1	39.11 ^{bc} ±0.059	39.23 ^{ab} ±0.148	39.30 ^a ±0.128	39.23 ^a ±0.072	39.22 ^A ±0.055
Month 2	38.74 ^{def} ±0.060	39.00 ^{cd} ±0.082	38.94 ^{cde} ±0.057	39.12 ^{bc} ±1.955	38.95 ^B ±0.488
Month 3	38.72 ^{def} ±0.062	38.72 ^{ef} ±0.039	38.99 ^{cd} ±0.265	38.93 ^{ef} ±0.038	38.84 ^C ±0.026
Overall mean	38.86 ^b ±0.022	38.98 ^{ab} ±0.460	39.08 ^a ±0.461	39.09 ^a ±0.652	39.00 ±0.164
RR (bpm)					
Month 1	34.89 ±2.009	34.00 ±2.703	37.40 ±2.703	36.21 ±1.914	35.63 ±1.333
Month 2	36.215 ±1.584	33.50 ±1.866	37.58 ±1.866	33.49 ±1.439	35.18 ±1.256
Month 3	39.66 ±0.924	36.80 ±1.132	35.40 ±1.132	38.80 ±1.887	37.67 ±0.661
Overall mean	36.90 ±0.842	34.77 ±1.142	36.87 ±1.132	36.17 ±1.201	36.16 ±0.651
BW (kg)					
Month 1	23.79 ±0.486		23.19 ±0.548		23.49 ±0.367
Month 2	24.72 ±0.489		22.95 ±0.553		23.84 ±0.386
Month 3	25.62 ±0.485		22.80 ±0.530		24.21 ±0.402
Overall mean	24.71 ^a ±0.286		22.98 ^b ±0.509		23.85 ±0.222

RR= Respiration rate RT= Rectal temperature BW= body weight bpm = breaths/min

Means having different superscript a,b,c... are significantly differ in the same rows while that having superscript A, B, C... are significantly differ ($p \leq 0.05$) in the same column.

Blood haematology

The result of haematological responses of Baladi goats is presented in Table (2). Water deprivation had no significant ($P > 0.05$) effect on haematological parameters tested [hemoglobin (Hb), red blood cell counts (RBCs) and hematocrite (Ht)]. the effect of month was insignificant ($P > 0.05$) on Hb and platelets (PLT), while a significant variation was observed in RBCs, PCV and WBCs regard month effect, since 3rd month (m3) has the least mean as compared to other months for these parameters. On the other hand, a slight decrease in WBCs and PLT.

Additionally, there was no significant ($P > 0.05$) interaction between water deprivation and month for the all blood parameters measured. The slightly increase in some parameters might be attributed to a reduction in plasma volume due to water loss (Li *et al.*, 2000; Ghanem 2005; Hamadeh *et al.*, 2006) since some authors agreed with the increase in PCV, RBC and Hb as well as a decrease in WBC concentrations in deprived goats and considered that's as good indicators of dehydration (Hassan 1989; Ghanem 2005; Khanvilker *et al.*, 2017).

Table 2. Effect of water deprivation on blood haematological parameters of Baladi goats.

Item	Control	Treatment			Overall mean
		24h	48h	72h	
Hb (g/dl)					
Month 1	9.33 ±0.277	9.49 ±0.298	9.78 ±0.322	9.10 ±0.270	9.43 ±0.146
Month 2	9.22 ±0.097	9.26 ±0.536	9.88 ±0.599	9.80 ±0.420	9.54 ±0.220
Month 3	8.70 ±0.476	9.76 ±0.437	9.36 ±0.465	9.30 ±0.404	9.28 ±0.222
overall mean	9.08 ±0.185	9.50 ±0.219	9.67 ±0.239	9.40 ±0.199	9.42 ±0.106
RBCs ($\times 10^6/\mu\text{l}$)					
Month 1	5.49 ± 0.105	5.68 ± 0.177	5.79 ± 0.109	5.53 ± 0.099	5.62 ^A ± 0.064
Month 2	5.41 ± 0.120	5.86 ± 0.221	5.54 ± 0.196	5.58 ± 0.123	5.60 ^A ± 0.087
Month 3	5.01 ±0.119	5.30 ± 0.301	5.25 ± 0.112	5.19 ± 0.116	5.19 ^B ± 0.087
Overall mean	5.30 ± 0.079	5.61 ± 0.130	5.53 ± 0.090	5.43 ± 0.071	5.47 ± 0.048
Ht %					
Month 1	21.16 ±0.609	22.40 ±1.236	22.11 ±0.950	21.26 ±0.511	21.73 ^{AB} ±0.429
Month 2	24.78 ±1.122	22.30 ±1.260	23.38 ±2.311	21.64 ±1.620	23.03 ^A ±0.864
Month 3	19.12 ±0.913	20.70 ±0.563	19.90 ±0.286	21.83 ±0.474	20.39 ^B ±0.360
Overall mean	21.69 ±0.546	21.80 ±0.700	21.80 ±0.763	21.58 ±0.565	21.72 ±0.330
WBCs ($\times 10^3/\mu\text{l}$)					
Month 1	10.31 ±0.296	10.42 ±0.771	11.01 ±0.892	10.88 ±0.942	10.66 ^A ±0.373
Month 2	10.74 ±0.507	8.58 ±0.933	9.50 ±0.730	10.94 ±0.765	9.94 ^{AB} ±0.408
Month 3	10.22 ±0.198	8.44 ±0.402	8.30 ±0.421	8.68 ±0.630	8.91 ^B ±0.381
Overall mean	10.42 ±0.335	9.15 ±0.493	9.60 ±0.542	10.17 ±0.757	9.84 ±0.244
PLT ($\times 10^3/\mu\text{l}$)					
Month 1	304.40 ±4.507	274.20 ±9.160	283.90 ±10.708	266.90 ±6.775	282.35 ±4.513
Month 2	303.00 ±3.578	299.20 ±5.589	270.00 ±17.666	303.60 ±26.771	293.95 ±8.166
Month 3	290.80 ±7.276	279.20 ±10.219	308.20 ±27.516	270.40 ±22.697	287.15 ±9.261
Overall mean	299.40 ±6.161	284.20 ±5.710	287.37 ±9.663	280.30 ±9.395	287.82 ±3.805

Hb= Hemoglobin RBCs= Red blood cells counts Ht %= Hematocrite WBCs= White blood cells count PLT= platelets h= hours

Means having different superscript A, B, C... are significantly differ ($p \leq 0.05$) in the same column.

Liver and kidney functions

As illustrated in Table 3, goat health indices in this study includes concentration of ALT and AST, and concentration of urea and creatinine. Slight elevations were noticed in some health items (ALT, AST, urea and Creatinine) but still significantly unaffected ($p \leq 0.05$). In addition, month effect showed significant differences for ALT, AST and creatinine while that of urea was unaffected since the 2nd and 3rd months were higher ($P \leq 0.05$) than the 1st month with respect to ALT and AST, however, the 2nd month was higher than the 1st and 3rd months for creatinine. No significant interaction was detected for all items of health indicators under study. Small increase in both serum urea and creatinine was detected in water deprived goats. Serum urea

was not significantly affected ($P > 0.05$) by level of water deprivation as observed by Mpendulo *et al.* (2020) which may refer that the kidney functions were not compromised which almost occur in cases of prolonged dehydration and increased concentrations of blood metabolites. The increased level of urea may be due to increasing water and urea reabsorption by nephrons or to urea renal retention under water limitation level in goat (Abdelatif *et al.* 2010). The raised levels of creatinine with the increase in water deprivation periods may be related to slow glomerular filtration as a result of water stress on the kidney as shown in similar studies (Abdelatif *et al.* 2010; Kaliber *et al.* 2015). Neither month effect nor its interaction with WD showed any significance level on serum urea and creatinine.

Table 3. Effect of water deprivation on serum kidney and liver functions of Baladi goats.

Item	Control	Treatment			Overall mean
		24h	48h	72h	
ALT (U/L)					
Month 1	21.81 ±1.563	19.16 ±0.516	20.33 ±0.421	21.33 ±0.843	20.66 ^B ±0.492
Month 2	21.21 ±1.289	23.67 ±1.452	23.33 ±1.452	24.00 ±1.537	23.05 ^A ±0.722
Month 3	22.30 ±1.284	22.67 ±1.706	23.67 ±1.520	24.27 ±1.542	23.23 ^A ±0.731
Overall mean	21.77 ±0.963	21.83 ±0.893	22.44 ±0.771	23.20 ±0.735	22.31 ±0.412
AST (U/L)					
Month 1	53.06 ±3.627	53.00 ±1.825	55.67 ±2.512	58.50 ±2.645	55.06 ^B ±1.357
Month 2	89.61 ±3.523	91.00 ±10.21	93.00 ±9.814	92.39 ±7.786	91.50 ^A ±3.548
Month 3	85.03 ±5.919	82.83 ±3.239	88.00 ±2.955	89.67 ±2.894	86.40 ^A ±1.914
Overall mean	75.90 ±4.736	75.61 ±4.874	78.89 ±4.995	80.22 ±4.483	77.65 ±2.479
Urea (mg/dl)					
Month 1	54.07 ±2.600	51.17 ±1.851	52.67 ±2.679	54.10 ±2.753	53.00 ±1.209
Month 2	50.04 ±4.409	56.00 ±3.214	57.67 ±3.179	58.83 ±2.728	55.64 ±1.876
Month 3	51.99 ±3.363	55.67 ±2.472	58.67 ±1.837	61.98 ±2.929	57.08 ±1.474
Overall mean	52.03 ±1.83	54.28 ±1.422	56.34 ±1.535	58.30 ±1.697	55.24 ±0.867
Creatinine (mg/dl)					
Month 1	1.38 ±0.113	1.25 ±0.060	1.30 ±0.067	1.43 ±0.090	1.34 ^B ±0.041
Month 2	1.39 ±0.206	1.67 ±0.437	1.72 ±0.407	1.68 ±0.217	1.62 ^A ±0.175
Month 3	1.31 ±0.079	1.35 ±0.078	1.41 ±0.058	1.44 ±0.063	1.38 ^B ±0.037
Overall mean	1.36 ±0.062	1.42 ±0.092	1.47 ±0.087	1.52 ±0.081	1.44 ±0.043

ALT= Alanine aminotransferase

AST= Aspartate aminotransferase

h= hour

Means having different superscript a,b for each item are significantly differ in the same rows while that having superscript A, B, C... for each item are significantly differ ($P \leq 0.05$) in the same column.

Serum metabolites

As presented in Table 4, water deprivation significantly ($P \leq 0.05$) raised serum total proteins (TP), globulin (Glob), while the increase in serum albumin (Alb) was insignificant. The increases in TP, Alb and Glob were attributed to the advancing or increasing dehydration periods where the highest values were recorded after 72h as compared to control and/or other deprivation periods, 24h and 48h. The significant differences in TP, Alb and Glob levels, regard to month effect, were observed between different months where the 3rd month has higher values than other months. No significant effects for interactions of deprivation with month were detected on TP, Alb and Glob. These results were similar to that of Samara *et al.* (2012). Increasing TP mostly contributed to the maintenance of blood volume by stimulating water movement into the vascular system (Alamer 2006). The resultant hyperalbuminemia could refer to an adjustable mechanism to survive blood hydrostatic pressure in goat (Samara *et al.*, 2012). As well as, this response is mainly related to blood hemoconcentration (Ayoub and Saleh, 1998). On another view scope, hyperalbuminemia may result from the action of liver as an attempt for maintaining a suitable blood volume during dehydration (Samara *et al.*, 2012). Ratio of Alb/Glob slightly

decreased as a result of increasing Glob more than albumin (Table 4).

Our outcomes proved a significant decrease in serum glucose concentration as a result of water deprivation through all deprivation periods. Additionally, month also showed a significant effect where the 3rd month was higher ($P \leq 0.05$) than other months. No interaction effects were recorded between (month x WD) on serum glucose levels. The decreased glucose level with a limited water intake may be due to a reduction in feed intake as adaptive response in small ruminants and such feed intake depression may affect blood concentration of glucose (Akinmoladun *et al.*, 2019) which is in agreement with the significant drop observed in sheep (Li *et al.* 2000) during water deprivation. However, hyperglycemia was observed throughout dehydration in some studies on goats (Duncan *et al.* 1994).

A highly significant elevation in serum cholesterol (Chol) concentration was observed with increasing the deprivation periods, as well as water deprivation led to significant rises in concentration of triglycerides (TG) in deprived does especially after 48h and 72h. Concerning month effect, Chol level contradicts TG trend where the 1st month showed the highest ($P \leq 0.05$) Chol and the lowest TG (Table 4). Serum cholesterol increased with increasing water

deprivation period which was similar to that of Mpendulo *et.al.* (2020). The elevated Chol and TG levels may result from haemoconcentration of blood constituents with limited water intakes (Akinmoladun *et al.* 2020b) in goat or by fat

mobilization from adipose tissues in response to increased energy demand associated with higher respiratory rate in Aardi goats (Jaber *et al.*, 2013). Moreover, a significant interaction was detected for Chol but not for TG (Table 4).

Table 4. Effect of water deprivation on serum metabolites of Baladi goats,

Item	Control	Treatment			Overall mean
		24h	48h	72h	
TP (g/dl)					
Month 1	8.22 ±0.186	8.92 ±0.054	9.17 ±0.117	9.32 ±0.294	8.91 ^B ±0.140
Month 2	7.91 ±0.118	9.37 ±0.417	9.70 ±0.305	10.00 ±0.418	9.25 ^{AB} ±0.267
Month 3	8.28 ±0.490	9.72 ±0.244	10.12 ±0.427	10.12 ±0.423	9.56 ^A ±0.233
Overall mean	8.14 ^c ±0.179	9.34 ^b ±0.151	9.66 ^{ab} ±0.221	9.81 ^a ±0.280	9.24 ±0.128
Alb (g/dl)					
Month 1	3.01 ±0.090	3.18 ±0.147	3.37 ±0.135	3.38 ±0.135	3.24 ^A ±0.071
Month 2	2.82 ±0.116	2.63 ±0.185	2.73 ±0.185	3.04 ±0.319	2.81 ^B ±0.125
Month 3	3.17 ±0.324	3.47 ±0.247	3.62 ±0.252	3.76 ±0.215	3.51 ^A ±0.127
Overall mean	3.00 ±0.164	3.09 ±0.139	3.24 ±0.142	3.39 ±0.126	3.18 ±0.072
Glob (g/dl)					
Month 1	5.21 ±0.186	5.74 ±0.158	5.80 ±0.161	6.17 ±0.226	5.73 ^B ±0.112
Month 2	5.09 ±0.202	6.74 ±0.504	6.97 ±0.433	6.87 ±0.196	6.42 ^A ±0.258
Month 3	5.11 ±0.290	6.25 ±0.272	6.68 ±0.222	6.60 ±0.309	6.16 ^A ±0.165
Overall mean	5.14 ^b ±0.129	6.24 ^a ±0.177	6.48 ^a ±0.182	6.55 ^a ±0.196	6.10 ±0.101
Alb/Glob					
Month 1	0.58 ±0.031	0.55 ±0.047	0.58 ±0.030	0.56 ±0.025	0.57 ^A ±0.016
Month 2	0.55 ±0.032	0.39 ±0.052	0.39 ±0.051	0.46 ±0.079	0.45 ^B ±0.027
Month 3	0.57 ±0.059	0.56 ±0.058	0.54 ±0.028	0.58 ±0.037	0.56 ^A ±0.023
Overall mean	0.57 ±0.028	0.50 ±0.034	0.50 ±0.026	0.53 ±0.025	0.53 ±0.014
Glu (mg/dl)					
Month 1	57.20 ±2.232	52.33 ±1.626	51.50 ±1.258	50.39 ±1.256	52.86 ^B ±0.897
Month 2	59.50 ±0.399	52.67 ±4.409	50.67 ±2.185	48.00 ±1.979	52.96 ^B ±1.765
Month 3	65.50 ±1.979	57.17 ±2.535	55.33 ±1.926	51.03 ±1.815	57.26 ^A ±1.476
Overall mean	60.73 ^a ±1.365	54.06 ^b ±1.494	52.50 ^b ±1.090	50.14 ^b ±1.002	54.36 ±0.827
Chol (mg/dl)					
Month 1	92.02 ^{abcd} ±3.759	93.00 ^{abc} ±4.343	95.83 ^{ab} ±4.308	99.96 ^a ±3.373	95.20 ^A ±2.022
Month 2	65.30 ^e ±3.061	89.67 ^{abcd} ±8.569	90.00 ^{abcd} ±4.999	92.89 ^{abc} ±2.230	84.47 ^B ±4.447
Month 3	79.51 ^d ±3.556	81.67 ^{cd} ±2.170	83.33 ^{bcd} ±1.855	87.30 ^{bcd} ±1.875	82.95 ^B ±1.214
Overall mean	78.94 ^b ±3.022	88.11 ^a ±2.713	89.72 ^a ±2.468	93.38 ^a ±2.259	87.54 ±1.486
TG (mg/dl)					
Month 1	52.36 ±2.455	57.00 ±1.983	59.17 ±1.777	64.89 ±2.039	58.36 ^C ±1.259
Month 2	65.06 ±7.668	84.00 ±4.932	86.00 ±5.859	89.00 ±5.002	81.02 ^B ±4.152
Month 3	101.03 ±7.864	109.00 ±6.623	111.17 ±6.209	113.87 ±6.209	108.77 ^A ±3.316
Overall mean	72.82 ^b ±4.170	83.33 ^{ab} ±6.794	85.45 ^a ±6.751	89.25 ^a ±4.552	82.71 ±3.340

TP = total protein Alb = albumin Glob = globulin Glu = glucose
 Chol = cholesterol TG = triglycerides H = hour
 Means having different superscript a,b,c...for each item are significantly differ in the same rows while that having superscript A, B, C... for each item are significantly differ ($p \leq 0.05$) in the same column.

Serum electrolytes

Serum electrolytes were varied as a result of water deprivation. These variations were statistically significant ($P \leq 0.05$) for Na^+ and K^+ but not for Cl^- levels (Table 5). The current results assumed that the significant effect on Na^+ concentration was obviously appeared as the level of deprivation period increased since only 72hr of deprivation showed the significant increase ($P \leq 0.05$). On the other hand, serum K^+ was significantly declined with the increase in deprivation period where 48h and 72h were significantly elevated ($p \leq 0.05$) as compared to control group. Level of Cl^- had the same trend of Na^+ where a slight increase in serum Cl^- was observed with the advance of deprivation period. Average changing percent was +4.48, +6.02 and +7.26% for Na^+ and -12.14, -16.75 and -21.12% for K^+ and +1.49, +2.70 and +4.17% for Cl^- for the periods of 24h, 48h and 72h of deprivation cycles as compared to control, respectively. No significant effect of month for the current electrolytes except for Cl^- levels, where the 3rd month was higher ($P \leq 0.05$) as

compared to other months. Interactions of WD x month were not significant for these electrolytes. A higher Na^+ as well as a lower K^+ levels could be explained through the activation of Renin-Angiotensin-Aldosterone systems as a first reaction to water deprivation (Wittenberg *et al.* 1986; Duncan *et al.* 1994; Abdoun *et al.* 2010), however, Samara *et al.* (2012) found a contradict results for K^+ in goat. Furthermore, the increased levels of Na^+ and Cl^- may be related to the increased renal retention which occurs under the influence of higher aldosterone Ashour and Benlemlih (2001), or to the effect of vasopressin secretion (McKinley *et al.*, 2000) which noted to be increased under dehydration conditions in both lactating goats (Maltz *et al.*, 1984; Mengistu *et al.*, 2007) and non-lactating ones (Maltz *et al.*, 1984; Shaham *et al.*, 1994) or haemoconcentration consequent water deprivation. However, the declined serum K^+ concentration might be due to the K^+ diffusion to-erythrocyte cells or losing it in urine through exchange process of Na^+ re-absorption (Igbokwe 1993).

Table 5. Effect of water deprivation on serum electrolytes of Baladi goats

Item	Control	Treatment			Overall mean
		24h	48h	72h	
Na ⁺ (mmol/l)					
Month 1	150.07 ±1.108	157.17 ±3.771	157.83 ±4.110	159.50 ±4.022	156.14 ±1.734
Month 2	149.82 ±1.201	159.00 ±1.154	162.67 ±2.333	165.10 ±2.109	159.15 ±2.037
Month 3	151.78 ±7.254	157.83 ±5.516	160.48 ±4.484	161.99 ±4.286	158.52 ±2.719
Overall mean	151.22 ^b ±2.534	158.00 ^{ab} ±2.539	160.33 ^{ab} ±2.385	162.20 ^a ±2.235	157.94 ±1.342
K ⁺ (mmol/l)					
Month 1	4.21 ±0.364	3.68 ±0.147	3.73 ±0.168	3.23 ±0.192	3.71 ±0.121
Month 2	4.01 ±0.210	3.40 ±0.251	3.27 ±0.272	3.44 ±0.178	3.53 ±0.141
Month 3	4.15 ±0.265	3.77 ±0.302	3.30 ±0.118	3.07 ±0.084	3.57 ±0.122
Overall mean	4.12 ^a ±0.121	3.62 ^b ±0.138	3.43 ^b ±0.107	3.25 ^b ±0.102	3.61 ±0.076
Cl ⁻ (mmol/l)					
Month 1	105.05 ±2.279	106.93 ±1.743	107.38 ±2.018	109.08 ±1.876	107.11 ^B ±1.023
Month 2	106.99 ±2.391	108.67 ±3.529	110.00 ±2.886	111.01 ±2.633	109.17 ^{AB} ±1.178
Month 3	111.00 ±1.520	112.23 ±2.666	114.38 ±2.427	116.42 ±2.045	113.51 ^A ±1.109
Overall mean	107.68 ±1.373	109.28 ±1.488	110.59 ±1.539	112.17 ±1.150	109.93 ±0.717

Na⁺= sodiumCl⁻= chlorideK⁺= potassium

h= hour

Means having different superscript a,b,c...for each item are significantly differ in the same rows while that having superscript A, B, C... for each item are significantly differ (p<0.05) in the same column.

Serum hormones and immunoglobulin G (IgG)

As illustrated in Table 6, serum aldosterone (Ald) concentrations increased (P<0.05) in does under all stages of water deprivation as compared to control does which freely accessed water. These results agreed with findings of Vosoghi-Postindoz *et al.* (2018) which indicated that water deprivation raised (P<0.05) the concentration of aldosterone as a result of water deprivation in lambs and ewes, respectively.

No significant differences were observed between the various months. The interaction between water deprivation and month was significant on aldosterone levels. Moreover, water deprivation (WD) had no significant (P<0.05) impact on T3, T4 and T3/T4 ratio in Baladi goats. The overall means of T3, T4 and T3/T4 were slightly lower in goats exposed to

water deprivation. Regarding month effect, T3 and T3/T4 have the same significance trend where the 3rd month had the highest means for each. No significant interaction (WD x month) was observed on the previous thyroid hormones. Thyroid hormones play a principal role in different physiological functions such as thermoregulation and metabolic homeostasis of energy and proteins (Huszenicza *et al.*, 2002). The lower thyroid hormones activity under dehydration conditions might be a reflection of the decreasing metabolic state due to dehydration and decreased feed intake while the small reduction in T4 level was probably a response to heat stress condition (Nazifi *et al.*, 1999). In addition, this decrease in thyroid hormone may present an attempt of experimental does to minimize water losses by decreasing general metabolism (Nazifi *et al.*, 2003).

Table 6. Effect of water deprivation on serum hormones and IgG levels of Baladi goats

Item	Control	Treatment			Overall mean
		24h	48h	72h	
Ald (pg/dl)					
Month 1	40.74 ^d ±3.82	136.47 ^a ±18.92	86.61 ^{bc} ±6.00	75.87 ^{bcd} ±32.36	84.92 ±13.16
Month 2	68.08 ^{bcd} ±6.30	59.87 ^{cd} ±10.43	73.84 ^{bcd} ±12.90	96.37 ^{bc} ±6.71	74.54 ± 5.25
Month 3	75.52 ^{bcd} ±6.46	105.46 ^{ab} ±14.16	90.00 ^{bc} ±4.04	82.44 ^{bcd} ±4.36	88.36 ±4.88
Overall mean	61.45 ^b ±5.27	100.60 ^a ±12.07	83.48 ^a ±6.71	84.89 ^a ±8.12	82.61 ±4.37
T3 (ng/dl)					
Month 1	124.17 ±10.886	113.01 ±2.312	119.87 ±3.441	119.09 ±12.023	119.04 ^{AB} ±3.765
Month 2	127.37 ±3.386	113.15 ±5.834	100.71 ±15.161	92.38 ±0.032	108.40 ^B ±5.327
Month 3	122.07 ±8.503	121.14 ±3.841	127.71 ±5.470	122.55 ±5.781	123.37 ^A ±2.908
Overall mean	124.54 ±4.771	115.77 ±2.573	116.10 ±5.372	111.34 ±5.357	116.94 ±2.314
T4 (µg/dl)					
Month 1	6.27 ±0.513	5.85 ±0.129	5.96 ±0.075	5.89 ±0.229	5.99 ±0.112
Month 2	6.03 ±0.635	5.90 ±0.058	5.72 ±0.049	5.87 ±0.367	5.88 ±0.198
Month 3	5.70 ±0.274	5.93 ±0.195	6.03 ±0.236	5.85 ±0.286	5.87 ±0.120
Overall mean	6.00 ±0.230	5.89 ±0.098	5.90 ±0.120	5.87 ±0.189	5.92 ±0.081
T3/T4					
Month 1	19.80 ±1.794	19.32 ±0.354	20.11 ±0.327	20.22 ±2.268	19.86 ^{AB} ±0.640
Month 2	21.12 ±2.593	19.18 ±0.801	17.61 ±2.657	15.74 ±1.411	18.41 ^B ±0.997
Month 3	21.42 ±1.263	20.43 ±0.922	21.18 ±1.455	20.95 ±0.628	20.99 ^A ±0.527
Overall mean	20.78 ±0.920	19.64 ±0.517	19.63 ±1.012	19.97 ±0.898	19.76 ±0.423
IgG (g/l)					
Month 1	0.013 ±0.002	0.010 ±0.001	0.010 ±0.001	0.009 ±0.001	0.011 ^B ±0.001
Month 2	0.016 ±0.004	0.037 ±0.014	0.053 ±0.008	0.021 ±0.006	0.032 ^A ±0.006
Month 3	0.019 ±0.004	0.033 ±0.003	0.028 ±0.006	0.023 ±0.005	0.026 ^A ±0.002
Overall mean	0.016 ^b ±0.002	0.026 ^a ±0.004	0.030 ^a ±0.005	0.018 ^b ±0.004	0.023 ±0.002

Ald = aldosterone

T₃ = triiodothyronineT₄ = thyroxine

IgG = immunoglobulin G

h= hour

Means having different superscript a,b,c...for each item are significantly differ in the same rows while that having superscript A, B, C... for each item are significantly differ (p<0.05) in the same column.

Immunoglobulin (IgG) and white blood cells and their fractions are often used as the indices of immune status and stress levels in animals (Davis *et al.*, 2008). Serum IgG increased ($P \leq 0.05$) in both 24h and 48h of water deprivation while 72h was not affected in comparison to control group. Regarding the month effect, IgG levels were statistically enhanced ($P \leq 0.05$) with the progression of the experimental periods where the 2nd and 3rd months showed higher ($P \leq 0.05$) IgG than the 1st month. The interaction effect of WD x month on IgG was not significant. An increase in goat serum IgG may indicate the ability of goats to change immune parameters as a reaction to face environmental or temperature related stresses (Akinmoladun *et al.*, 2019). However, plasma IgG levels and white blood cells of 2 and 3h water deprived

Corriedale ewes after feeding were not altered (Davis *et al.*, 2008).

Insignificant decrease in serum E₂ and an increase in P₄ were noted in does impact-prone water deprivation after 24h, 48h and 72h of deprivation cycle comparing to the control group. The average values of serum E₂ were 10.67, 11.01, 10.90 and 11.03 pg/ml while those values of P₄ were 3.23, 3.09, 3.10, and 3.04 ng/ml for deprivation periods of 24h, 48h, 72h and control does respectively. E₂/P₄ ratio also gradually increased in deprived does from 24h to 72h as compared to control group however these increases were not significant ($p \leq 0.05$). The average E₂/P₄ was 9.19, 9.30, 9.42 and 7.43 for 24h, 48h, 72h of deprived does and control one respectively.

Table 7. Effect of water deprivation on serum sex hormones levels of Baladi goats

Item	Control	Treatment			Overall mean
		24h	48h	72h	
E ₂ (pg/ml)					
Month 1	12.84 ±1.154	10.33 ±0.333	11.00 ±2.309	11.33 ±0.667	11.42 ±0.890
Month 2	7.75 ±1.143	9.01 ±1.721	13.03 ±1.335	10.04 ±1.712	9.96 ±1.059
Month 3	12.33 ±3.179	12.67 ±2.185	9.00 ±2.645	11.29 ±0.881	11.33 ±1.232
Overall mean	11.03 ±1.305	10.67 ±1.252	11.01 ±1.194	10.90 ±1.119	10.90 ±0.667
P ₄ (ng/ml)					
Month 1	0.73 ^{de} ±0.307	0.70 ^{de} ±0.550	0.90 ^{de} ±0.799	0.73 ^{de} ±0.166	0.77 ^B ±0.235
Month 2	3.49 ^{cd} ±1.001	0.80 ^{de} ±0.251	0.90 ^{de} ±0.498	0.89 ^{de} ±0.333	1.52 ^B ±0.399
Month 3	4.98 ^{bc} ±1.985	8.20 ^a ±0.500	7.47 ^{ab} ±0.856	7.67 ^{ab} ±0.933	7.06 ^A ±0.743
Overall mean	3.04 ±0.813	3.23 ±0.990	3.09 ±0.887	3.10 ±0.791	3.12 ±0.450
E ₂ /P ₄					
Month 1	17.59 ±5.879	14.76 ±3.261	12.22 ±3.266	15.52 ±8.794	15.02 ^A ±5.784
Month 2	2.22 ±0.407	11.26 ±2.871	14.48 ±4.732	11.28 ±2.507	9.81 ^{AB} ±1.099
Month 3	2.48 ±0.267	1.55 ±0.402	1.20 ±0.507	1.47 ±0.152	1.67 ^B ±0.360
Overamean	7.43 ±1.638	9.19 ±1.976	9.30 ±1.684	9.42 ±1.466	8.84 ±0.508

E₂ = Estradiol P₄ = progesterone E₂/P₄ = Estradiol/ progesterone ratio h= hour
Means having different superscript a,b,c...for each item are significantly differ in the same rows while that having superscript A, B, C... for each item are significantly differ ($p \leq 0.05$) in the same column.

Moreover, general means of E₂ was not affected throughout deferent months, while that of P₄ was higher ($P < 0.05$) in the 3rd month as compared to 1st and 2nd months which may be due to reproductive cycles. On the other hand, the 3rd month was the lowest E₂/P₄ ratio comparing to 1st and 2nd months due to the increased P₄ level in the 3rd month. No significant variations were detected for the interaction of (deprivation x month) regarding E₂ and E₂/P₄ but not for P₄. The little low level of E₂ in does under water stress may be due to the diminished development in ovarian follicles as a result of the repression in peripheral gonadotropins levels (Roth *et al.*, 2000) which was very obvious in Malpura ewes under water restriction (Kumar *et al.*, 2016). During periods of water scarcity or deprivation, the hormones are mobilized, giving their critical roles, to ensure that the energy needs are satisfied and water losses minimized. However, the increased level of P₄ might be related to the metabolic clearance rate of progesterone rather than differences in secretion levels (Lozano *et al.*, 1998) since they reported a marked increase in plasma P₄ in water restricted ewes and linked this status to reduced feed intake as inversely relationship (Kumar *et al.*, 2016).

CONCLUSION

It could be concluded that goat have the ability to adapt water deprivation and can survive without deleterious impacts on health, or performance under the condition of water scarcity or drought.

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الاستجابات الفسيولوجية للماعز البلدي تحت ظروف التعطيش أثناء الصيف

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صممت هذه التجربة لتقييم تأثير التعطيش على الاستجابات الفسيولوجية للماعز البلدي في صورة المؤشرات الصحية (وظائف الكلى والكبد وصورة الدم)، مقاييس التنظيم الحراري، ومستوى سيرم الدم من المكونات التمثيلية والالكتروليتات والمستوى الهرموني أثناء فترات الصيف (يونيه- أغسطس). ولهذا الغرض خصصت 12 أنثى ماعز جافة وغير عشار وبحالة صحية جيدة عمرها 1.5- 2 عام والتي قسمت إلى مجموعتين متوسط وزنها 1.16 ± 23.35 و 1.13 ± 23.15 كجم للمجموعة الحاكمة والمعاملة (والتي تعرضت لدورات تعطيش 24، 48، 72 ساعة/اسبوع لمدة 3 شهور). وقد حسب دليل الحرارة والرطوبة THI أثناء فترات التجربة، كما قيست درجة حرارة المستقيم ومعدل التنفس وتم تقدير مكونات الدم في شكل صورة الدم ومستويات سيرم الدم من الهرمونات، المكونات التمثيلية والالكتروليتات كما قدرت انزيمات الكبد (ALT, AST) والجلوبيولين المناعي IgG. وظهرت النتائج ارتفاع درجات حرارة المستقيم معنويًا في مجموعة التعطيش خاصة بعد 48، 72 ساعة بينما كان 24 ساعة مثل الكونترول بينما انخفض معدل التنفس بصورة غير معنوية في حين كان الانخفاض في وزن الجسم معنويًا ($p \leq 0.05$) في الماعز المعطشة. لم يكن للتعطيش تأثير معنوي على المؤشرات الصحية في صورة مكونات الدم (صورة الدم)، وظائف الكبد والكلى (انزيمات الكبد واليوريا والكرياتينين). كما أظهرت النتائج زيادات معنوية في مستويات سيرم الدم من البروتينات الكلية والجلوبيولين والكلوستيرول والجليسريدات الثلاثية بينما كانت الزيادة في مستوى الألبومين غير معنوية في المجموعة المعطشة. بينما اتخذت مستويات الجلوكوز نتائج معاكسة فقد انخفضت معنويًا ($p \leq 0.05$) مع التقدم في التعطيش. كما اختلفت مستويات الألكتروليتات بالسيرم معنويًا فيما عدا الكلوريد حيث لوحظ ارتفاع مستويات الصوديوم والكلوريد بينما انخفض مستوى البوتاسيوم معنويًا ($p \leq 0.05$) نتيجة للتعطيش. إضافة إلى ذلك أثبتت النتائج ارتفاع مستوى السيرم من الألدسترون والجلوبيولين المناعي IgG في الماعز المعرضة للتعطيش ومع ذلك لم تلاحظ أي اختلافات معنوية في مستوى هرمونات الدرقية (الثيروكسين والثيرونين ثلاثي اليود). ويمكن الوصول إلى خلاصة أن الماعز البلدي يمكنه التأقلم مع الظروف غير المناسبة من عدم كفاية الماء أو الجفاف بدون ظهور تأثيرات ضارة عليها.