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Impact of Water Deprivation on Serum Hormonal and Biochemical Profile, and Haematology in Ossimi Ewes

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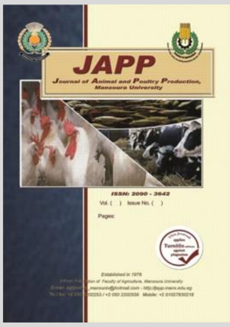

ABSTRACT

This work was conducted to evaluate the impact of water deprivation on physiological responses, serum hormones, metabolites, electrolytes, haematology and thermoregulatory parameters of Ossimi ewes during summer months. Total of 12 healthy, non-pregnant and non-lactating Ossimi ewes (2-2.5 years of age and average BW of 43.44 ±1.14 kg) were divided into 2 groups, control and ewes exposed to water deprivation cycles 24h, 48h and 72h /week for 3 months. Temperature-humidity index (THI) was calculated. Thermoregulatory response, rectal temperature (RT) and respiration rate (RR) were determined. Serum hormones [aldosterone, thyroid hormones (T3&T4), estradiol (E2), and progesterone (P4)], IgG, total proteins (TP), albumin (Alb), globulin (Glb), triglycerides (TG), cholesterol (Chol), glucose (Glu), creatinine (Creat), urea, Na+, Cl^-, K+, and liver enzymes (ALT, AST) were assayed. Haematological parameters (CBC) in blood were measured. Results showed that RR and RT were higher (P≤0.05) in deprived ewes after 24h, while their values of 48h and 72h were the same as compared to the control. No changes in serum hormones were observed in deprived ewes, except aldosterone level which increased (P≤0.05) in deprived ewes. There were no variations in serum TP, Glob, Creat, urea and liver enzymes (ALT, AST) while Alb, TG, Chol, Na^+, and Cl^- were elevated (P≤0.05), while Glu and K^+ declined (P≤0.05) by water deprivation. Haematological parameters sustained unaffected after deprivation. It is concluded that Ossimi ewes could easily maintained under the conditions of water scarcity or drought without adverse influences.

***Keywords**: Sheep, water deprivation, metabolites, hormones, haematology.*

INTRODUCTION

Water is a nutrient of a huge importance for animals and must be considered as key nutrient in any phase. This importance increases with the increasing of scarcity of water resources in Egypt and many other countries which directs these regions' society to find solutions for this problem. Sheep and goats have social and economic importance due to their great ability in adapting to adverse environmental conditions and using water efficiently. Many researches and new technologies for water use in livestock production are examined to save water. One-third of the world population may be without suitable water for consumption by 2025 (UNESCO, 2006).

Several techniques or methods have been adopted in various sheep or goat herds to minimize water consumption such as using water restriction and /or drinking salty water. Water deprivation is one of these techniques to deal with water scarcity problem. Water is distributed within the body including both extra and intracellular fluids, which represents from 31 to 38% and from 62 to 69% of the overall body water respectively. Many studies concerning water quality are available, clarifying that water deprivation leads to various variations in physiological traits, including body weight loss, hematology, blood metabolites, and feed intake (Qinisa *et al.* 2011;, Mpendulo *et al.* 2016; Akinmoladun *et al.*, 2019). The well adapted ruminants to desert environment showed high ability to ameliorate the stressful effect induced by water deprivation (Silanikove, 2000). A drop in feed intake and weight reduced respiratory rate and increased concentration of blood metabolites are the general effects and/or observations that are encountered by small ruminants during the period of water stress (Akinmoladun *et al.*, 2019). The increase in the concentration of blood metabolites (cholesterol, urea, creatinine, total proteins and electrolytes) was also confirmed in several studies in different sheep (Jaber *et al.*,2004; Nejad *et al.*, 2014) and goat (Alamer, 2006) breeds that were subjected to water stress. High blood urea concentration following water restriction was as a result of the kidney taking up much water and with reduced blood flow towards the urinary system (Casamassima *et al.*, 2008). Furthermore, water imbalance (restriction/deprivation) imposes stressful conditions on animal and negatively impact on their productivity and changes blood metabolites (Hamadeh *et al.*, 2006).

This study was conducted to evaluate the impact of progressive water deprivation on physiological, metabolic and hormonal parameters of Ossimi ewes.

MATERIALS AND METHODS

This study was conducted in Animal Production Research Station belongs to Faculty of Agriculture, Fayoum University during summer months (June- August), to evaluate the effect of progressive water deprivation on the thermoregulatory response, blood metabolites, hormones, liver and kidney functions, and hematological parameters of Ossimi ewes.

To achieve this aim, 12 healthy ewes, 2-2.5 years of age were divided into 2 groups with 43.51±1.16 and 43.36±1.13 kg bodyweight for control and deprived ewes' groups, respectively. The 1st group free access to water twice a day, while the 2-nd one was exposed to deprivation cycles 24h, 48h and 72h/week for 3 months (summer). The deprived ewes received water once a

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day every three days' cycle per week. Ewes were deprived for the first three consecutive days /week and then weekly repeated in term of three stages of water deprivation (24, 48 and 72 h). After water deprivation, rehydration of animals was occurring gradually. All Animals were raised under the same managerial and environmental condition and kept in individual semi-open pen. Animals were fed concentrate feed mixture (CFM) and wheat straw according to NRC (2007).

Rectal temperature (^oC) and respiration rate (breaths/min) were measured 3 days/week at 10 a.m. before feeding. Rectal temperature was measured using digital thermometer while respiration rate (breaths/min) was measured by counting the flank movements using stopwatch.

Blood samples were weekly withdrawn from the jugular vein of fasted ewes and blood serum was obtained for metabolites and hormonal analysis. Blood serum hormones including aldosterone (Ald), thyroid hormones (T3, T4), and estradiol (E2) and progesterone (P_4) were also assayed by commercial radioimmunoassay (RIA) kits (Diagnostic products corporation (DPC) Los Angeles, USA), while immunological indicator in term of immunoglobulin G (IgG) was assayed by Enzyme- linked Immunosorbent Assay (ELISA). Serum metabolites such as total proteins (TP), albumin (Alb) and cholesterol (Chol) were determined by using test kits combination provided by Diamond Diagnostics, Stanbio laboratory, Boeme (with wave length 546nm), while serum globulin (Glob) was calculated by subtracting serum Alb from TP. Serum glucose (Glu) and triglycerides (TG) were also detected by using Stanbio enzymeatic- colorimetric kits with wave length 500 nm. In addition, Serum electrolytes Na^+, K^+ and chloride Cl^- were spectrophotometerically measured at wave length of 545, 420 and 480 nm, respectively, by using test kits combination provided by Biodiagnostic.

Ewes health were detected by determining liver enzymes [Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT)] calorimetrically by commercial kits (Diamond Diagnostics) at 546 nm wave length, while kidney function in term of creatinine and urea concentrations was determined by applying enzymatic- coloremtric test (Berthot) by using a kit (Spinreact, S.A., Spain). Additionally, haematological parameters in terms of complete blood picture CBC was estimated in fresh blood samples according to Hawk *et al*. (1974).

Temperature humidity index (THI) was calculated from the averages of measured ambient temperature (AT, °C) and relative humidity (RT%). Ambient temperature was measured inside the pens and under the sun at 10 a.m. and 2 p.m. A developed equation for estimating THI under the Egyptian climatic conditions (Sadek *et al*., 2015) was applied as follows:

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

Where: 32.783 is the intercept, 1.478 is the regression of THI on AT, 0.056 is the regression of THI on RH and 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. The calculated THI throughout the experimental period was 87.42 which was a danger area.

Statistical analysis was carried out using SPSS software program, version 23, (SPSS, 2015) IBM, Chicago. Level of statistical significance was set at P ≤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, 72h), M_j is the effect of month (j=1, 2, 3), ($WD_i \times M_j$)is the effect of interaction of water deprivation with month, and e_{ijk} is the error.

RESULTS AND DISCUSSION

Thermoregulatory responses:

Table 1 showed that water deprivation led to increases (P≤0.05) in both respiratory rate (RR) and rectal temperature (RT) especially after 24h for RR and 24h and 72h for RT in deprived ewes in comparing with control ewes. However, 48 h and 72h returned to the level near the control group. Regard to month effect, RT was higher in the 1st month (P≤0.05) than other months, but month effect on RR was insignificant. Imbalance in water intake can precipitate an increase in body heat and rectal temperature **(**Rahardja *et al*., 2011**,** Nejad and Sung, 2017**)** which might be due to a decrease in metabolic rate in animal exposed to water insufficiency (Choshniak *et al*., 1995; Davis and DeNardo, 2007)**.** The reduced RR in deprived ewes after 72h may due to the reduction in respiratory activities to prevent water loss and dehydration via pulmonary evaporation (Casamassima *et al*., 2016). Additionally, panting rate (breathe/min) declined in water restricted and dehydrated sheep which suffer elevated temperature (Nejad and Sung, 2017).

Table 1. Effect of water deprivation on thermoregulatory responses of Ossimi ewes

Item	Control	Treatment			Overall mean
		24h	48h	72h	
RR (bpm)					
Month 1	49.00 ±3.038	51.33 ±2.652	48.92 ±2.529	43.63 ±2.529	48.22 ±1.357
Month 2	41.79 ±1.703	47.75 ±1.525	42.33 ±1.63	44.01 ±1.589	43.97 ±0.832
Month 3	47.92 ±1.454	49.92 ±1.560	51.33 ±1.429	40.20 ±1.333	48.59 ±0.728
Overall mean	46.24^{b} ±1.313	49.67^{a} ±1.262	47.53^{ab} ±1.184	44.28^{b} ±1.082	46.93 ±0.628
RT (°C)					
Month 1	38.86^{abc} ±0.058	39.01^{a} ±0.052	38.77^{bcd} ±0.036	39.23^{a} ±0.035	38.97^{A} ±0.02
Month 2	38.63^{def} ±0.119	38.95^{ab} ±0.063	38.63^{def} ±0.063	38.81^{cd} ±0.046	38.76^{B} ±0.058
Month 3	38.54^{ef} ±0.045	38.49^{f} ±0.055	38.74^{cde} ±0.056	38.62^{def} ±0.036	38.60^{C} ±0.119
Overall mean	38.67^{bc} ±0.045	38.82^{a} ±0.045	38.71^{b} ±0.038	38.89^{a} ±0.024	38.77 ±0.045

RR= Respiration rate (breath/min) RT= Rectal temperature (C°) h= hours

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

Elevation in RT induced by water insufficiency (dehydration) might be adaptive in conserving water, where it elevates the temperature at which animals switch from thermoregulation through convection and radiation to evaporation via cooling (Mitchell *et al*., 2002). The obseved RT in three local Saudi Arabia goat breeds under water deprivation was due to that water deprivation increases body temperature as a result of the reduction in thermoregulatory evaporation (Alamer, 2009). This reduction of skin evaporation may stimulate the water conservation mechanism (Mckinley *et al*., 2007), with an increase in RT during the water deprivation period.

Serum hormonal profiles:

As presented in Table 2, aldosterone (Ald) levels in deprived sheep showed a significant increase (P≤0.05) for all deprivation periods (24h, 48h and 72h) as compared to the control ewes. Serum Ald also elevated (P≤0.05) in 1st monthas compared to 2nd and 3rd months regarding the effect of month. The interaction effect between deprivation and month was significant (P≤0.05) with respect to serum aldosterone concentrations. These findings agreed with that of Vosooghi-Postindoz *et al.* (2018), who pointed out that water deprivation and rising the amount of total dissolved salts (TDS) elevated the concentration of aldosterone significantly for water deprivation (p≤0.05) and insignificantly for salinity.

Furthermore, there were no significant (P≤0.05) changes in serum T_3, T_4 and T_3/T_4 ratio with respect to water deprivation or month effect. Slight increases in both serum T_3 and T_4 and declines in T_3/T_4 ratio were observed as a result of water deprivation. Regarding the effect of month, T_3 and T_4 insignificantly reduced from 1st month to 3rd month, while T_3/T_4 ratio was increased from the 1st to the 3rd month. These results suggest that sheep might ameliorate the impact of water deprivation by enhancing thyroid status to some extent. Our results are in contrast to other reports, founding that water restriction (Jaber *et al*., 2011) and nutrient limitation (Ward *et al*., 2008) were found to lower the levels of T3 and T4 in dry Awassi ewes and pregnant Whiteface Western ewes, respectively. Similarly, Caldeira *et al.* (2007) noticed a decrease in these hormones with decreasing body score of ewes.

Table 2. Effect of water deprivation on serum aldosterone and thyroid hormones of Ossimi ewes

Item	Control	Treatment 24h	Treatment 48h	Treatment 72h	Overall mean
Ald (pg/l)					
Month 1	76.48^{de} ± 4.30	155.23^{a}±16.00	160.27^{a}±43.72	111.84^{bcd}±11.66	125.96^{A}±17.84
Month 2	79.04^{d}±8.93	112.83^{bcd}±2.49	125.82^{b}±9.26	109.31^{bcd}±16.28	106.75^{B}±6.04
Month 3	110.81^{bcd}±8.02	119.44^{bc}±15.74	93,41^{cd}±2.97	116.52.^{bc}±9.03	110.05^{B}±5.89
Overall mean	88.78^{b}±5.90	129.17^{a} ±7.24	126.50^{a}±16.07	112.56^{a}±8.97	114.25 ±5.79
T3 (ng/dl)					
Month 1	93.82 ±16.532	121.35 ±27.382	93.42 ±12.927	116.47 ±66.330	106.27±16.954
Month 2	89.12 ±5.524	123.21 ±20.514	119.84±20.172	91.22 ±9.030	105.85 ±8.609
Month 3	118.29±27.398	83.43±6.690	90.36 ±7.936	127.99 ±27.254	105.02±10.380
Overall mean	100.41±14.901	109.33 ±10.138	101.21 ±7.653	111.89 ±20.008	105.71 ±6.899
T4 (µg/dl)					
Month 1	5.32 ±0.230	6.37 ±0.721	5.43 ±1.33	6.45 ±1.892	5.89 ±0.550
Month 2	4.92 ±0.260	6.10 ±1.331	6.27.003	5.15 ±0.811	5.61 ±0.493
Month 3	5.01 ±0.640	5.98 ±0.425	4.93 ±0.760	6.08 ±0.545	5.50 ±0.298
Overall mean	5.08 ±0.375	6.15 ±0.384	5.54 ±0.533	5.89 ±0.525	5.67 ±0.232
T3/T4					
Month 1	17.64 ±2.454	19.05 ±2.182	17.20 ±2.780	18.06 ±4.011	17.99 ±1.266
Month 2	18.11 ±0.807	20.20 ±2.366	19.11 ±0.571	17.71 ±1.048	18.78 ±0.805
Month 3	23.61 ±2.550	13.95 ±1.471	18.33 ±1.495	21.05 ±2.844	19.24 ±1.210
Overall mean	19.79 ±1.455	17.73 ±1.364	18.22 ±0.942	18.94 ±1.659	18.67 ±0.705

Ald = aldosterone T_3 = triiodothyronine T_4 = thyroxine h= hours Means having different superscripts a,b,c… in the same rows are significantly differ while that having superscripts A, B, C… in the same column are significantly differ (p≤0.05).

Immune response and reproductive hormones

Serum immune response, in the figure of immunoglobulin G, (IgG), and reproductive hormones (E_2 and P_4) levels of Ossimi ewes was illustrated in Table 3. Water deprivation had no significant effect on serum IgG, however, IgG statistically augmented (P≤0.05) with the progression of treatment month. Regarding month effect, IgG level in 1st month (0.014 g/l) was significantly lower (P≤0.05) than 2nd month (0.033 g/l) and 3rd month (0.026 g/l). Environmental or temperature related stresses have the ability to change immune parameters (Akinmoladun *et al*., 2019). Immunoglobulins (IgG), white blood cells including the differential counts are often used as the indices of immune status and stress levels in animals (Davis *et al*., 2008].

Table 3. Effect of water deprivation on serum IgG and reproductive hormones (E_2 and P_4) levels of Ossimi ewes

Item	Control	Treatment 24h	Treatment 48h	Treatment 72h	Overall mean
IgG (g/l)					
Month 1	0.018 ±0.007	0.008 ±0.001	0.010 ±0000	0.018 ±0.007	0.014^{B} ±0.002
Month 2	0.022 ±0.003	0.033 ±0.018	0.053 ±0.013	0.023 ±0.003	0.033^{A} ±0.006
Month 3	0.030 ±0.003	0.025 ±0.005	0.028 ±0.009	0.022 ±0.004	0.026^{A} ±0.002
Overall mean	0.023 ±0.004	0.022 ±0.005	0.030 ±0.007	0.021 ±0.002	0.024 ±0.002
E_2 (pg/ml)					
Month 1	10.59 ±1.201	11.01 ±3.055	11.07 ±4.255	9.71 ±0.001	10.60 ±1.373
Month 2	9.80 ±0.822	9.45 ±1.882	9.53 ±2.058	8.98 ±2.073	9.44 ±0.917
Month 3	11.00 ±1.154	9.33 ±1.333	9.59 ±2.309	11.01 ±3.179	10.23 ±0.946
Overall mean	10.46 ±1.306	9.93 ±1.331	10.06 ±1.702	9.90 ±1.201	10.09 ±0.699
P_4 (ng/ml)					
Month 1	1.59 ±0.260	1.44 ±0.066	1.62 ±0.088	1.56 ±0.233	1.55 ±0.233
Month 2	1.80 ±0.8208	1.64 ±0.448	1.41 ±0.402	1.87 ±0.910	1.68 ±0.910
Month 3	1.45 ±0.173	1.83 ±0.835	2.03 ±1.334	1.70 ±1.334	1.75 ±1.334
Overall mean	1.61 ±0.294	1.64 ±0.293	1.69 ±0.398	1.71 ±0.445	1.66 ±0.545

IgG= immunoglobulin G E_2 = estradiol P_4 = progesterone h= hours
Means having superscripts A, B, C… in the same column are significantly differ (p≤0.05).

Insignificant slight decline in serum E_2 and slight increase in P_4 were observed in ewes undergo water deprivation after 24h, 48h and 72h as compared to control group. Levels of E_2 and P_4 still unaffected in concern to month effect. The effect of interaction of deprivation with month on E_2 and P4 levels was not significant. The decreased level of E_2 in ewes 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, 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 may be related to the metabolic clearance rate of P_4 rather than differences in secretion levels (Lozano *et al*., 1998). Feed intake and plasma P_4 level are inversely related and this might be due to the differences in the metabolic clearance rate of P_4 rather than differences in secretion levels (Lozano *et al*., 1998) since they reported a marked increase in plasma P_4 in water restricted ewes and linked this status to reduced feed intake (Kumar *et al*., 2016) as inversely relationship.

Serum metabolites

Results in Table 4 revealed increases in serum total proteins (TP), albumin (Alb), globulin (Glob) and Alb/Glob ratio of different deprivation periods. These increases were significant only for serum Alb, being higher ($P \leq 0.05$) in deprived ewes than in control ewes. Moreover, Alb level was significantly ($P<0.05$) higher after 48h and 72h than 24h of the deprivation. The effect of month remained statistically unaffected for all previous parameters. Many researchers stated an increase in blood albumin and globulin in sheep under water insufficiency (Jaber *et al.*, 2004; Ghanem 2005, Alamer 2005; Casamassima *et al.,* 2008**;** Hamadeh *et al.,* 2009**;** El-Khashab *et al*, 2018). Increasing protein concentration may be due to the reduction in plasma volume as a result of dehydration (Cork and Halliwell 2002; El-Khashab 2002; El-Khashab *et al*, 2018). Serum albumin is a major protein reservoir, since it has a great importance in maintaining osmoregulation. Therefore, some variations in serum albumin concentrations can observe, but returning to normal levels has to be re-established as soon as amino acids from other sources like the skeletal muscle are available (Moorby *et al*., 2002).

Table 4. Effect of water deprivation on blood serum metabolites in Ossimi ewes

Item	Control	Treatment 24h	Treatment 48h	Treatment 72h	Overall mean
TP (g/dl)					
Month 1	8.29 ±0.378	8.48 ±0.557	8.73 ±0.669	9.04 ±0.943	8.64 ±0.318
Month 2	8.70 ±0.669	9.00 ±1.096	9.50 ±1.150	10.45 ±0.450	9.41 ±0.437
Month 3	8.66 ±0.402	9.08 ±0.551	9.23 ±0.663	10.17 ±0.416	9.29 ±0.272
Overall mean	8.55 ±0.204	8.85 ±0.357	9.15 ±0.413	9.89 ±0.306	9.11 ±0.190
Alb (g/dl)					
Month 1	3.12 ±0.051	3.57 ±0.138	3.85 ±0.042	4.10 ±0.055	3.66 ±0.075
Month 2	3.38 ±0.384	3.70 ±0.152	3.93 ±0.033	3.99 ±0.023	3.75 ±0.120
Month 3	3.47 ±0.244	3.75 ±0.067	3.88 ±0.065	4.10 ±0.061	3.80 ±0.077
Overall mean	3.32^{c} ±0.107	3.67^{b} ±0.067	3.89^{a} ±0.031	4.06^{a} ±0.101	3.74 ±0.049
Glob (g/dl)					
Month 1	5.17 ±0.347	4.91 ±0.484	4.88 ±0.632	4.94 ±0.887	4.98 ±0.290
Month 2	5.32 ±1.051	5.30 ±1.101	5.5 7 ±1.183	6.46 ±0.863	5.66 ±0.449
Month 3	5.19±0.617	5.33 ±0.570	5.35 ±0.715	6.07 ±0.416	5.49 ±0.288
Overall mean	5.23 ±0.351	5.18 ±0.342	5.27 ±0.419	5.82 ±0.383	5.37 ±0.187
Alb/Glob					
Month 1	0.60 ±0.037	0.73 ±0.072	0.79 ±0.093	0.83 ±0.128	0.74 ±0.046
Month 2	0.64 ±0.244	0.70 ±0.173	0.71 ±0.224	0.62 ±0.087	0.66 ±0.083
Month 3	0.67 ±0.156	0.70 ±0.089	0.73 ±0.147	0.68 ±0.040	0.69 ±0.056
Overall mean	0.64 ±0.074	0.71 ±0.052	0.74 ±0.076	0.71 ±0.062	0.70 ±0.033
TG (mg/dl)					
Month 1	50.32 ±1.477	51.17 ±1.275	52.33 ±0.988	55.36 ±1.176	52.30^{B} ±0.656
Month 2	51.40 ±0.387	63.00 ±12.767	65.67 ±13.370	67.62 ±1.545	61.92^{A} ±4.543
Month 3	51.29 ±0.421	62.67 ±7.596	65.33 ±8.305	69.21 ±0.945	62.13^{A} ±3.073
Overall mean	51.00^{b} ±0.990	58.95^{a} ±3.930	61.11^{a} ±4.248	64.06^{a} ±2.780	58.78 ±1.657
Chol (mg/dl)					
Month 1	85.91 ±5.319	89.17 ±6.117	92.50 ±6.601	94.01 ±5.765	90.40 ±2.858
Month 2	84.95 ±4.151	87.00 ±3.605	88.00 ±3.055	90.76 ±3.241	87.68 ±1.670
Month 3	86.69 ±1.855	87.17 ±1.701	88.00 ±1.612	92.49 ±1.720	88.59 ±0.890
Overall mean	85.85^{b} ±2.002	87.78^{ab} ±2.508	89.50^{a} ±2.685	92.42^{a} ±2.178	88.89 ±1.240
Glu (mg/dl)					
Month 1	62.39 ±1.979	52.33 ±1.744	51.67 ±1.801	51.09 ±2.286	54.37^{A} ±1.594
Month 2	63.08 ±2.007	50.00 ±1.154	49.00 ±2.309	48.26 ±2.027	52.59^{AB} ±2.266
Month 3	61.98 ±1.429	50.50 ±1.945	48.67 ±1.429	46.93 ±1.085	52.02^{B} ±1.451
Overall mean	62.48^{a} ±1.602	50.94^{b} ±1.041	49.78^{b} ±1.025	48.76^{b} ±1.897	52.99 ±0.978

Tp = total protein Alb = albumin Glob = globulin Glu = glucose Chol = cholesterol TG= triglycerides h= hours
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.

Additionally, the current outcomes suggested that ewes suffering water deprivation had higher ($P \leq 0.05$) serum triglycerides (TG) and cholesterol (Chol) compared with control. The observed increase in the concentration of blood metabolites (cholesterol, urea, creatinine, total proteins and electrolytes) was also confirmed in several studies in sheep (Nejad *et al.,* 2014; Jaber *et al.,* 2004) and goat (Alamer, 2006) breeds that were subjected to water stress. Nevertheless, glucose levels were statically lower ($P \leq 0.05$) in deprived ewes in comparison to control group. These observations agreed with that of Vosooghi-postendoz *et al.* (2018) for Chol and TG and disagreed with glucose level. The increased serum lipid profile might be due to fat mobilization occurring as a result of stress. Due to low feed intake following water restriction, plasma glucose in sheep drops (Li *et al.,* 2000) below the normal range of 48–75 mg/dl (Kramer 2000). Plasma glucose concentration in response to water restriction in goats remains unchanged as reported by Alamer (2006). However, other studies reported a decline of 13% in the plasma glucose level in Sudanese desert sheep watered every 72 h (Abdelatif and Ahmed, 1994) and in Baladi goat (ElKhashab *et al.,* 2018).

Serum electrolytes

As shown in Table 5, serum electrolytes of Ossimi ewes (Na^+ and Cl^-) tended to increase significantly by water deprivation periods, but K^+ significantly ($P \leq 0.05$) reduced due to water deprivation compared to control ewes. Water deprivation led to a rise in serum levels of Na^+ by 9.14, 10.81 and 12.39% and of Cl^- by 2.00, 3.63 and 5.53% and a reduction in serum K^+ by -16.19, -16.41 and -21.29% in 24h, 48h, 72h deprived ewes ($P \leq 0.05$) comparing with control, respectively. In addition, the effect of month was significant ($P \leq 0.05$) where the 1st month showed the lowest Na^+ and Cl^- and the highest K^+ levels in comparing with other months. The effect of interaction between WD and month was significant only on serum Na^+ level (Table 5).

It has been stated that water deprivation caused a reduction in plasma volume consequently elevate electrolytes level and osmolality specially Na^+ and Cl^- (Qinisa *et al.*, 2011). Moreover, the increased ions level as a response to water deprivation may be due to the rise in renal retention of Na^+ to maintain sodium balance under the effect of increasing aldosterone level (Ashour and Benlemlih, 2001) or vasopressin (ADH, McKinley *et al.*, 2000), since dehydration causes an increase in plasma vasopressin levels which is directly related to urinary osmolality and inversely related to urine flow rate (Yesberg *et al.*, 1970). This may explain why dehydrated goats and sheep decrease their urine volume while the osmolality and vasopressin levels augment.

Studies on different sheep breeds (Mojabi *et al.*, 2000; Eshratkhah *et al.*, 2008) showed a negative correlation between Na^+ and K^+ in plasma. Concurrently, blood K^+ was reported to decrease in water-deprived sheep (Jaber *et al.*, 2004) probably due to the intra-erythrocytic diffusion of K^+ or loss of these ions in urine in exchange of Na^+ re-absorption (Igbokwe, 1993). However, others observed an elevation in plasma K^+ under water restriction (Mengistu *et al.*, 2007), while Hamadeh *et al.* (2006) did not report a variation in K^+ levels in Yankasa and Awassi sheep.

Serum chloride increased in parallel pattern to Na^+ concentration in dehydrated ewes as previously noticed by Hamadeh *et al.* (2006) and Casamassima *et al.* (2008) since Cl^- is passively distributed according to electrical gradients established by active Na+ transport (Olsson, 2005). This rise may be associated with many phenomena such as the hemoconcentration results from a reduced blood water level (Casamassima *et al.*, 2008), along with the increased level of aldosterone and vasopressin (Ashour and Benlamlih, 2001) leading to increased renal retention.

Table 5. Effect of water deprivation on serum electrolytes in Ossimi ewe

Item	Control	Treatment			Overall mean
		24h	48h	72h	
Na^+ (mmol/l)					
Month 1	$143.42^{cd} \pm 5.908$	$147.67^{cd} \pm 2.691$	$150.33^{cd} \pm 2.691$	$152.39^{bc} \pm 1.282$	$148.45^{B} \pm 1.756$
Month 2	$143.19^{cd} \pm 3.127$	$160.00^{ab} \pm 1.732$	$162.67^{a} \pm 1.201$	$163.98^{a} \pm 3.552$	$157.46^{A} \pm 2.890$
Month 3	$142.07^{d} \pm 1.382$	$160.17^{ab} \pm 0.945$	$162.00^{a} \pm 0.730$	$165.43^{a} \pm 2.444$	$157.42^{A} \pm 2.062$
Overall mean	$142.89^{b} \pm 3.648$	$155.95^{a} \pm 1.975$	$158.33^{a} \pm 1.892$	$160.60^{a} \pm 3.294$	154.44 ± 1.330
K^+ (mmol/l)					
Month 1	4.49 ± 0.366	4.42 ± 0.256	4.35 ± 0.296	4.32 ± 0.292	$4.40^{A} \pm 0.144$
Month 2	4.60 ± 0.193	3.53 ± 0.240	3.47 ± 0.218	3.15 ± 0.059	$3.69^{B} \pm 0.173$
Month 3	4.45 ± 0.146	3.38 ± 0.142	3.48 ± 0.132	3.18 ± 0.062	$3.62^{B} \pm 0.127$
Overall mean	$4.51^{a} \pm 0.175$	$3.78^{b} \pm 0.175$	$3.77^{b} \pm 0.172$	$3.55^{b} \pm 0.206$	3.90 ± 0.095
Cl^- (mmol/l)					
Month 1	102.58 ± 0.641	105.23 ± 1.447	106.67 ± 1.115	110.11 ± 1.179	$106.15^{B} \pm 0.614$
Month 2	106.91 ± 1.27	109.40 ± 3.124	111.67 ± 2.185	113.60 ± 1.710	$110.40^{A} \pm 1.057$
Month 3	108.97 ± 0.760	110.17 ± 1.536	111.67 ± 1.085	112.36 ± 0.703	$110.79^{A} \pm 0.709$
Overall mean	$106.15^{c} \pm 1.514$	$108.27^{bc} \pm 1.138$	$110.00^{ab} \pm 0.954$	$112.02^{a} \pm 1.329$	109.11 ± 0.503

Na^+= sodium Cl^-= chloride K^+= potassium h= hours

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.

Liver and kidney functions:

Data in Table 6 showed that creatinine (Creat) and urea concentrations were statistically unaffected ($P \leq 0.05$) by water deprivation. Slight reductions in the average serum Creat and slight increases in urea were recorded in deprived groups in comparing with the control group. The creatinine level is influenced by proteolysis and endogenous N-sources (Caldeira *et al.*, 2007), and/or higher retention rate of kidney due to decreased glomerular filtration rate (Kataria and Kataria 2007). These factors are related to the level of dehydration. Moreover, these observations were in coincidence with those of Vosooghi-postindoz *et al.* (2018), who reported insignificant increases in serum creatinine and urea of water restricted sheep. The increase in blood urea concentration during water deprivation would enhance the transport of urea from blood stream into the rumen. Increasing of blood urea as a result of water deprivation was not sustained since it declined in plasma as a result of urea recycling (Igbokwe, 1993). Also, Mpendulo *et al.* (2020) found that glucose and creatinine increased ($P \leq .05$) with increasing the period of water deprivation in Nguni goats.

The transfer role of the kidney is modified under water stress (Kataria and Kataria, 2007) by reducing glomerular filtration and increase urea re-absorption (Silanikove 2000). Urine volume decreased by 75% and fecal water output was 37% lower in desert sheep subjected to 5 days of water restriction. Consequently, urea reabsorption by the kidney is also expected to rise as reflected by elevated concentration in the blood (Marini *et al.*, 2004). Furthermore, high blood urea concentration following water restriction was due to the kidney taking up much water and with reduced blood flow towards the urinary system (Casamassima *et al.*, 2008) while elevated creatinine was attributed to changes in the clearance rate of endogenous creatinine (Baxmann *et al.*, 2008).

The present results in Table 6 indicated insignificant variations ($P \leq 0.05$) in activity of both serum ALT, and AST enzymes as a result of water deprivation in comparison with the ewes which had free access to water (control). On the other side, regardless the treatment, ALT, and AST activities were significantly higher in the 2nd and 3rd months comparing to the 1st month. The effect of interaction between WD and month on ALT and AST activity and kidney Creat and urea levels was not significant.

Table 6. Effect of water deprivation on kidney and liver functions in Ossimi ewes

Item	Control	Treatment			Overall mean
		24h	48h	72h	
Creatinine (mg/dl)					
Month 1	1.32 ±0.038	1.29 ±0.098	1.38 ±0.094	1.49 ±0.145	1.37 ±0.052
Month 2	1.41 ±0.158	1.41 ±0.257	1.47 ±0.270	1.49 ±0.247	1.45 ±0.118
Month 3	1.94 ±0.760	1.41 ±0.142	1.41 ±0.133	1.62 ±0.228	1.60 ±0.197
Overall mean	1.56 ±0.289	1.37 ±0.080	1.42 ±0.077	1.53 ±0.103	1.47 ±0.085
Urea (mg/dl)					
Month 1	52.90 ±2.565	54.83 ±3.070	56.50 ±3.191	59.12 ±1.382	55.84 ±1.292
Month 2	55.37 ±3.181	55.33 ±3.480	57.00 ±3.214	57.19 ±2.054	56.22 ±1.320
Month 3	53.97 ±1.498	55.83 ±1.759	56.33 ±1.909	58.41 ±1.887	56.14 ±0.884
Overall mean	54.08 ±2.003	55.33 ±1.466	56.61 ±1.508	58.24 ±1.196	56.07 ±0.669
ALT (µ/l)					
Month 1	21.10 ±1.211	20.67 ±0.988	21.67 ±1.256	22.27 ±1.134	21.43^{B} ±0.600
Month 2	27.03 ±1.851	28.00 ±5.567	29.33 ±5.456	32.84 ±3.009	29.30^{A} ±2.068
Month 3	26.95 ±2.108	29.00 ±2.569	29.50 ±2.729	32.89 ±2.155	29.59^{A} ±1.176
Overall mean	25.03 ±1.284	25.89 ±1.753	26.83 ±1.782	29.33 ±1.307	26.77 ±0.841
AST (µ/l)					
Month 1	59.91 ±2.155	59.50 ±1.454	59.00 ±1.843	61.07 ±1.720	59.87^{B} ±0.902
Month 2	67.02 ±2.977	66.33 ±8.1921	72.67 ±13.345	74.69±3.510	70.18^{A} ±3.688
Month 3	68.07 ±1.725	68.33 ±4.247	70.83 ±7.409	75.72 ±1.641	70.74^{A} ±2.181
Overall mean	65.00 ±2.032	64.72 ±2.570	67.50 ±4.012	70.49 ±3.171	66.93 ±1.367

ALT= Alanine aminotransferase (µ/l) AST= Aspartate aminotransferase (µ/l) h= hour
Means having different superscript A, B, C… in the same column for each item are significantly differ (p≤0.05).

Hematological parameters:

As presented in Table 7, the current results showed that blood hemoglobin (Hb), red blood cell counts (RBCs), hematocrit (Ht), platelets (PLt) were insignificantly increased with the progression of deprivation stages (24h, 48h to 72 h) as compared to control group. Regarding the effect of month, Hb, RBCs and Ht increased in 2nd month followed by significant decreases to normal or more in 3rd month of deprivation which may be an indication that adapted sheep can maintain plasma volume (Sneddon, 1993). White blood cell counts (WBCs) were significantly reduced with advancing stages 2nd and/or 3rd month. Although there were some variations in blood components, it was still insignificant different (P≤0.05). In general, insignificant changes in haematological parameters of ewes were observed with advancing the deprivation cycle or due to its interaction with the month.

Table 7. Effect of water deprivation on blood haematology and CBC of Ossimi ewes

Item	Control	Treatment			Overall mean
		24h	48h	72h	
Hb (g/dl)					
Month1	10.33 ±0.262	9.96 ±0.396	10.38 ±0.382	10.23 ±0.422	10.23^{AB}±0.181
Month 2	10.57 ±0.582	10.93 ±0.324	10.58 ±0.240	10.85 ±0.281	10.73^{A} ±0.180
Month 3	9.50 ±0.453	9.58 ±0.279	9.85 ±0.252	10.10 ±0.342	9.76^{B} ±0.166
Overall mean	10.13 ±0.337	10.16 ±0.241	10.27 ±0.212	10.39 ±0.318	10.24 ±0.114
RBCs ($x10^6$/µl)					
Month 1	6.70 ±0.207	6.94 ±0.204	7.06 ±0.276	7.09 ±0.280	6.95^{B} ±0.120
Month 2	7.44 ±0.400	7.58 ±0.185	7.29 ±0.259	7.87 ±0.299	7.55^{A} ±0.145
Month 3	6.59 ±0.311	6.78 ±0.188	7.01 ±0.142	7.09 ±0.150	6.87^{B} ±0.105
Overall mean	6.91 ±0.254	7.10 ±0.133	7.12 ±0.153	7.35 ±0.207	7.12 ±0.079
Ht %					
Month 1	27.48 ±0.638	28.26 ±1.186	31.06 ±0.739	29.63 ±0.971	29.11^{AB}±0.482
Month 2	30.27 ±1.661	30.12 ±0.944	30.17 ±0.769	32.12 ±1.468	30.67^{A} ±0.615
Month 3	27.58 ±1.480	27.22 ±1.487	28.93 ±1.129	26.88 ±0.826	27.65^{B} ±0.610
Overall mean	28.44 ±0.593	28.53 ±0.743	30.05 ±0.515	29.54 ±0.818	29.14 ±0.339
WBCs ($x10^3$/µl)					
Month 1	18.56 ±2.376	16.44 ±1.494	17.98 ±1.527	21.08 ±1.926	18.52^{A} ±0.934
Month 2	12.42 ±1.773	12.98 ±1.570	11.82 ±0.962	12.43 ±1.231	12.41^{B} ±0.667
Month 3	10.12 ±1.219	10.37 ±0.931	10.72 ±1.002	10.58 ±1.005	10.45^{B} ±0.489
Overall mean	13.70 ±1.294	13.26 ±0.999	13.51 ±1.076	14.70 ±1.623	13.79 ±0.628
PLT ($x10^3$/µl)					
Month 1	262.45±26.527	334.58±48.112	343.25±52.461	350.17±46.225	322.61±22.113
Month 2	314.00±73.229	373.67±67.078	323.83±72.802	397.67±95.234	352.29±37.000
Month 3	212.33±36.275	392.17±87.642	356.00±84.258	315.00±84.207	318.88±38.172
Overall mean	262.93±24.236	366.81±35.253	341.03±36.575	354.28±35.004	331.26±17.144

Hb= Hemoglobin RBCs= Red blood cells counts Ht %= Hematocrite WBCs= White blood cells count PLT= platelets h= hours BW= body weight
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 sams columns.

Some authors pointed out that the increases in PCV and Hb concentration are good indicators of dehydration (Abdelatif and Ahmed 1994; Ghanem 2005). Even though levels of hematocrit were found to increase in Awassi (Ghanem *et al*., 2008). Similar contradictory results were reported regarding hemoglobin, whilst an elevation of hemoglobin level was attributed to a decrease in plasma volume due to water loss (Li *et al*., 2000; Ghanem 2005; Hamadeh *et al*., 2006), others did not report any variation (Aganga *et al*., 1989; Igbokwe, 1993; Jaber *et al*., 2004). The confliction in these results may be an indication that adapted sheep can maintain plasma volume (Sneddon, 1993) and redistribute body water after a long water deprivation period (Ashour and Benlamlih, 2001).

It was concluded that, Ossimi ewes could be easily maintained under the conditions of water scarcity or drought without adverse influences on health, blood metabolites and hormonal profiles.

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تأثير التعطيش على مستويات سيرم الدم من الهرمونات والمركبات التمثيلية وصورة الدم في الاغنام الأوسيمي

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أجري هذا البحث لتقييم تأثير التعطيش على الاستجابات الفسيولوجية والمستوى الهرموني ومكونات الدم التمثيلية والالكتروليتات وصورة الدم ومقاييس التنظيم الحراري لنعاج الاوسيمي. خلال فترة الصيف. أستخدمت في هذه التجربة 12 نعجة أسيمي بحالة صحية جيدة جافة وغير عشار وعمرها 2- 2,5 عام ومتوسط وزنها 43,44 ±1,14 كجم والتي قسمت الى مجموعتين أولاهما المجموعة الحاكمة (كونترول) أما الأخرى فقد تعرضت لدورات تعطيش 24, 48, 72 ساعة/اسبوع والتي استمرت 3 شهور). وقد حسب دليل الحرارة والرطوبة THI أثناء فترات التجربة, كما قيست درجة حرارة المستقيم ومعدل التنفس وتم تقدير مستوى سيرم الدم من الهرمونات (الالدوستيرون, الثيروكسين, الثيرونين ثلاثي اليود, الاستراديول, البروجستيرون, الجلوبيولين المناعي IgG), والبروتينات الكلية, الالبيومين والجلوبيولين, الجلسريدات الثلاثية, الكلوستيرول, الجلوكوز, الكرياتينين, اليوريا, الصوديوم, الكلوريد, البوتاسيوم). كما قدرت انزيمات الكبد (ALT, AST), كما قيست مكونات الدم (صورة الدم). واظهرت النتائج أن درجات حرارة المستقيم ومعدل التنفس كانت أعلى معنويا (p≤0.05)في مجموعة التعطيش بعد 24 ساعة في حين كانت بعد 48, 72 ساعة مماثلة للكونترول. وأشارت النتائج الحالية الى عدم وجود أي تغييرات معنوية في مستوى الهرمونات بسيرم النعاج المعطشة فيما عدا مستوى هرمون الالدوستيرون والذي ارتفع معنويا (p≤0.05) في النعاج المعرضة للتعطيش. بالاضافة الى انه لم يكن هناك اختلافات معنوية في محتوى السيرم من البروتينات الكلية, الجلوبيولين, الكرياتينين, اليوريا, وانزيمات الكبد بينما ارتفعت تركيزات الالبيومين, والجليسريدات الثلاثية, الكولستيرول , الصوديوم والكلوريد معنويا (p≤0.05)مع انخفاض مستوى الجلوكوز والبوتاسيوم معنويا (p≤0.05) نتيجة للتعطيش. بينما ظلت صورة الدم دون تأثر عقب التعطيش. والخلاصة أن النعاج الأسيمي يمكن الحفاظ عليها بسهولة في ظل ظروف ندرة المياه أو الجفاف دون تأثيرات سلبية.