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Effects of Water Stress on Zootechnical Physiological and Blood Parameters of Ouled Djellal Ewes in Algeria

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THIS study evaluates the effects of water stress on zootechnical, physiological and certain blood variables (biochemical and hematology parameters) parameters of Ouled Djellal ewes. The experiment was carried out on 40 ewes divided into 4 groups of 10 animals in each: control lot A, lots B and C were drinking water containing 1 and 1.6% Nacl, respectively, and lot D drinking only one day out of 3. All ewes were fed alfalfa hay and concentrate. Lower forage consumption with higher water consumption in the water-stressed females compared to the control group was observed, as well as weight loss in lots B and D and weight maintenance in lot C. The results showed that water salinity causes a decrease in heart and respiratory rates, while water restriction causes a decrease in respiratory rate due to decreased ingestion. While water stress does not appear to affect hematological parameters in ewes, it was appear to increase serum protein and blood glucose levels. Water restriction increases creatinine and urea in the blood, while water salinity decreases creatinine and urea. These findings highlight the important role of water quality as a limiting factor for animal husbandry in saline and/or low water resource environments.

Keywords: Algeria, Ouled djellal ewes, Water salinity, Blood metabolites.

Introduction

The sheep stock is very widespread in Algeria and is distributed throughout the northern part of the country, with a higher number in the steppe and the high semi-arid cereal plains (80% of the total number) [1]. Populations also exist in the Sahara, exploiting the resources of oases and desert pastures [2]. These animals are among the main livestock resources that sustain human life in difficult arid and semi-arid regions where water and food are the most deficient elements, in addition to the high salinity of drinking water at water points, which further aggravates this situation, especially during the long dry season, thus constituting a major constraint affecting the efficiency and sustainability of livestock systems.

Livestock and agriculture are two inseparable parts of each other. Livestock use a variety of medicinal plants in pastures when grazing, and these herbs can be part of their diet [3-8] in recent decades, medicinal plants have attracted much attention due to their special properties [9-12], as an alternative to growth stimulants and part of the treatment of diseases [13-16] in animal nutrition.

Daws and Squires [17] mentioned that water consumption by animals can be altered if the distance from water sources changes. This is

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the case in the desert and semi-desert areas of Algeria, where livestock farmers suffer from the remoteness of water sources in the face of drought, which can last from June to October [18] and their scarcity, forcing them to restrict watering for up to three days to avoid the arduous movement of livestock. This situation is particularly alarming since Mediterranean countries are more exposed to climate change, which will tend to further affect their productive performance, given the importance of water on the digestive and metabolic profile and the health of the animal [19].Given this context and due to the lack of studies in Algeria on the effect of water stress on zootechnical performance, physiological variables and blood parameters in the local OuledDjellal sheep breed, that this study aims to assess the deleterious effects of water stress, particularly in hot and arid regions where water is often a limiting factor in livestock production and assessing the effectiveness of appropriate watering strategies to improve livestock performance while maintaining healthy livestock. In addition, the study determines the degree of tolerance of the Ouled Djellal breed to water stress.

Materials and Methods

Ethical approval

All procedures used in this study were approved by Chadli Bendjedid University's Animal Ethics Committee (Algeria).

Description of the study area

The test was conducted in the commune of Cheria in the Wilaya of Tébessa (35° 28' north latitude, 08° 07' longitude) in north-eastern Algeria. It is bounded to the north by the wilaya of Souk-Ahras, to the south by the wilaya of El-Oued, to the east by Tunisia and to the west by the wilayas of Khenchela and Oum El Bouaghi. Its surface area is 13.878 km^2 [20].This region is part of the Algerian steppe characterized by a cool semi-arid climate on its northern part and temperate arid climate in the south [21]. The average minimum temperature of the coldest month is between – 2°C and 4°C and the average maximum temperature of the hottest month varies from 33°C to 38°C. Rainfall varies from 100 to 400mm/year and the average rainfall during the dry season is 250mm [22].

Animals, food and water consumption and experimental protocol

Forty (40) adult ewes of the OuledDjellal breed of the same age (4 to 5 years old), of approximately the same weight (50 kg), Non pregnant and Cyclic ewes, were dewormed and then identified using curling tongs. The choice of this breed was dictated by the size of its population in the region and its resistance to difficult environmental conditions [23-25]. Age was determined by examination of the dentition, and pregnancy was diagnosed by exploration using a WELLD-3100 ultrasound scanner equipped with a linear abdominal probe with a frequency of 5.5 MHz.

The females were separated into four batches of 10 ewes each, of which two batches were subjected to a salt stress test (B and C). Lot A, considered a control, received only spring water at will, while lots B and C received the same spring water as lot A, *adlibitum*, but at 1 and 1.6% salinity, respectively, while the last lot (lot D) was water-restricted by having access to spring water on only one day out of three. The 24day experimental period was preceded by a seven-day pre-experimental period. The females of the four batches received the same diet: alfalfa hay, at a rate of 1.5 kg per ewe per day, and a commercial concentrate (50% barley and 50% wheat bran) distributed at a rate of 400 g per ewe per day. Water and feed refusals were quantified each day and for each batch (at the end of the day) using an electronic scale and a 500ml graduated beaker.

Physico-chemical analyses of drinking water and food supplies

Physico-chemical analyses of the different sources of drinking water were carried out, including the determination of pH with an electronic pH meter, conductivity and salinity with an electrode conductivity meter. The hydrotimetric titer (HT) was determined according to ISO standards [26]. Chlorides were assessed by the Mohr method by silverrimetric titration, while the photometric method was adopted using stabilized Barium chloride for the determination of sulphates. Samples of forage and concentrate were analysed by the AOAC [27] method to determine dry matter, ash, total nitrogen and fibre.

Experimental measurements

Zootechnical and physiological parameters

The ewes of each batch were weighed individually in the morning after 15 hours of fasting, at the beginning and end of the experimental period, using a suspended scale. The feed (forage and separate concentrate) and drinking water distributed and waste were measured daily to estimate the quantity of forage

(QIF), quantity of ingested concentrate (QIC) and quantity of drunk water (QDW).A daily check at 8 a.m. of each ewe was performed on the following physiological parameters: body temperature taken rectally with a thermometer, heart rate, measured by cardiac auscultation with a stethoscope and finally a double measurement of the respiratory frequency with the stethoscope, supported by visual observation of the respiratory movements of the rib cage laterally at 45° to the animal's back.

Hematological and biochemical analyses

Blood samples from the jugular vein were taken on an empty stomach prior to the start of the experiment, at 12 and 24 days of the experiment (d0, d12, d24) at 7am. The blood collected from each ewe was separated into two tubes, one containing EDTA for hematology and the other heparinized for biochemical analysis. The analyses included the determination of: glucose, total protein, aspartate aminotransferases (ASAT), alanine aminotransferases (ALAT), creatinine, urea and cholesterol for biochemistry. White (WBC) and red (RBC) blood cells, hemoglobin (Hb), hematocrit (Ht), mean blood cell volume (MBCV) and mean corpuscular hemoglobin concentration (MCHC) for hematology. The RESPONS-920 analyzer was used for biochemical parameters while the MINDRAY BC-30s analyzer was used for hematological parameters.

Statistical analysis

The results obtained were subjected to an analysis of variance (Anova) using the generalized linear model (GLM) procedure of the SAS software (2004) to compare the batches as a function of sampling times and to compare the different samples taken from the same batch. The initial live weight was used as a covariance factor to eliminate its influence on the different zootechnical parameters studied. The differences between the means were tested using the LSMEANS procedure. The S.N.K. (Student-Newman- Keuls) test was used for the multiple comparison of the means.

Results

Physico-chemical analyses of drinking water and food

The results in Table 1 show that there are wide variations between treated and control waters and between treated waters, with large simultaneous increases in chloride, sodium, TDS, salinity and electrical conductivity relative to NaCl treatment of the water. On the other hand, slight increases characterise certain parameters such as sodium and sulphates; with values ranging from 38.5 to 5850 mg/l and 200 to 298 mg/l respectively for the above-mentioned elements.

However, contrary to all the observations made previously, bicarbonate concentrations decreased from 122 to 73.2 mg/l following water treatment. Bicarbonate concentrations remained stable, regardless of the dose of treatment used in this experiment, i.e. 73.2 mg/l. Table 2 reports the results of the feed consumed by the animals. The results showed that the forage is rich in total nitrogenous matter (15.48%DM) and crude fiber compared to the concentrate.

Effect of water stress on zootechnical parameters

Table 3 reports the effect of water restriction and saline stress on zootechnical parameters. The results show that water stress has a very highly significant effect ($P < 0.0001$) both on the quantity of water drunk, the quantity of forage ingested and the final weight of the ewes. Thus, the quantity of water drunk was increased by 1.76 l and 6.08 l respectively for females that drank water with

TABLE 1. Physico-chemical quality of drinking water

Parameters	pH	WH (°F)	TS(g/l)	CE (ms/cm)	Cl^-(mg/l)	Na^+(mg/l)	HCO_3 (mg/l)	SO_4^{-2} (mg/l)
Control	7,8	31	0,02	0,353	35,5	38,5	122	200
Water at 10 (g/l Nacl)	8,6	66	7,5	16,99	1775	2925	73,2	290
Water at 16 (g/l Nacl)	8,8	69	12,2	26,1	3550	5850	73,2	298
Standards (WHO)	6,5-9,2	15<TH<30	-	<2,1	<250	<200	-	<500

pH: potential of Hydrogen; WH: water hardness; TS: total salinity; HCO_3: bicarbonate; SO_4^{-2}: sulfate

TABLE 2. Food chemical composition

	Dry matter (%)	Ash	Crude fiber	Total nitrogenous matter
		% DM		
Forage	83,72	8,01	40,85	15,48
Concentrate	88,89	2,64	14,56	4,74

DM: Dry matter

TABLE 3. Effect of water restriction and saline stress on the zootechnical parameters of Ouled Djellal ewes (Mean ± Standard error)

Salinity effect						
Lots	**QDW (L)**	**QIF (Kg)**	**QIC (Kg)**	**IW(kg)**	**FW(kg)**	**Diff.(kg)**
Lot A	5.43 ^{a}±0.11	1.5^{a}±0.05	0.4^{a}±0.01	51.8±4.94	52.9^{a}±3.13	1.10^{a}±1.14
Lot B	7.19 ^{b}±0.25	1.48^{b}±0.04	0.4^{a}±0.01	51.31±3.70	48.63^{b}±3.19	- 2.68^{b}±2.04
Lot C	11.51^{c}±1.75	1.38^{c}±0.02	0.4^{a}±0.01	52.65±5.00	52.8^{a}±4.46	0.15^{a}±0.33
P	0.0001	0.0001	0.09	/	0.0001	0.029
Restriction effect						
Lot D	10.25^{b}±1.25	1.2^{d}±0.01	0.398^{a}±0.01	47.77±3.04	49.69^{b}±3.71	1.92^{b}±1.73
P	0.0001	0.0001	0.0001	/	0.0001	0.694

Lot A: control batch; Lot B: low salinity (10 g/l Nacl); Lot C: high salinity (16g/l Nacl) and Lot D: water restriction. QDW: quantity of drunk water (/animal/day); QIF: quantity of ingested fourage (/animal/day); QIC: quantity of ingested concentrate (/animal/day). IW: initial weight; FW: final weight; Diff.: weight difference (FW-IW).^{a,b,c}: the different letters in the same column indicate the difference between the measured parameters of the lots.

low and high salinity. Females given high salinity water decreased forage intake by 0.12 Kg, while the decrease was less significant (0.02 Kg) for females given low salinity water.

On the other hand, water salinity did not have a significant effect on the consumption of the concentrate, which was the same for all females (0.4 kg). The low salinity of the water consumed had a very highly significant effect on the final weight of the ewes ($P<0.0001$), which was reduced by 2.68 kg, in contrast to the females that received high salinity water, which maintained a final weight statistically identical to that of the control lot (lot A). Furthermore, it can be observed that the water restriction had a significant effect on all zootechnical parameters, other than the quantity of ingested concentrate (QIC), with a highly significant increase in the quantity of water drunk (+ 4.82 l), a decrease of 0.3 Kg of forage ingested and a significant weight gain estimated at 1.92Kg.

Effect of water stress on physiological parameters

The results summarized in Table 4 show that the rectal temperature of water-stressed females is statistically identical to that of females in the control lot. The heart and respiratory rates of ewes undergoing high salinity stress and water deprivation were decreased compared to females in the control lot (-3.76 beats/min and -10.61 movements/min for lot C and -7.27 beats/min and -3.15 movements/min for lot D, respectively). The same is true for females in the low salinity stressed lot (-0.92 beats/min and -0.99 movements/min respectively), although the differences are not significant with the control lot.

Effect of water stress on biochemical parameters

Table 5 indicates that water stress has no significant effect on the cholesterol, ALT and AST of OuledDjellal sheep and that only water restriction influencescreatinine, which was increased at the last sampling (9.75 g/l). Blood glucose levels increases as females drink saline water and the same is true for those under water restriction.Blood urea varies significantly with the degree of salinity of the drinking water and is increased in water-restricted females (mean 0.43 vs. 0.34 g/l). While protein levels do not appear to be statistically affected by water restriction, high salinity appears to increase it. Indeed, protein levels increased by 7 and 6 g/l, respectively, during the last two samples in females drinking high salinity water.

TABLE 4. Effect of water restriction and saline stress on the physiological parameters of *OuledDjellal* ewes (Mean/animal/day ± Standard error)

Lot	T	HR	RF
Salinity effect			
Lot A	38.55^{a}±0.21	70.97^{a}±1.21	35.13^{a}±1.39
Lot B	38.68^{a}±0.36	71.89^{a}±0.99	34.14^{a}±0.65
Lot C	38.56^{a}±0.27	67.21^{b}±1.09	24.52^{b}±0.55
P	0.09	0.0001	0.0001
Restriction effect			
Lot D	38.7^{a}±0.29	78.24^{c}±1.97	31.98^{c}±0.30
P	0.09	0.0001	0.0001

T: rectal temperature (°C); HR: heart rate (beat/min); RF: respiratory frequency (motion/min);
Lot A: control lot; Lot B: low salinity (1% Nacl); Lot C: high salinity (1.6% Nacl) and Lot D: water restriction

Effect of water stress on hematological parameters

Water stress has no significant effect on the hematological parameters of OuledDjellal ewes, which are statistically identical to those of the control lot like watched in Table 6.

Discussion

Physico-chemical quality of drinking water

Water remains the most important nutrient for sheep [28]. In general, water contains 99.2% of the molecules that make up the body of ruminants. In addition, water contributes to the homeothermal balance by retaining body heat in cold weather, while facilitating its dispersal in warm weather. At the same time, this nutrient participates in the digestion of ingested food, the metabolism of absorbed nutrients, the hydrolysis of various molecules such as lipids, proteins and carbohydrates, and the elimination of waste products. Water also serves as a natural support for the nervous system, helps to lubricate joints, transports sound to the ear and vision [29].

Like the quantitative aspect, the qualitative aspect is so important in animal nutrition [28]. The chemical elements that contribute to the quality of drinking water are of particular importance. These include pH, hardness, salinity and various toxic elements. Nevertheless, the consequences of poor water quality on the health of animals, especially ruminants, and on their production are numerous, whether it is a chemical or bacteriological anomaly. The pH measures the quantity of hydrogen ions present in the liquid. The pH of treated and controlled water is not a problem for sheep (7.8 to 8.8). However, Beede and Myers [30] indicated that water with a pH above 8.5 is potentially dangerous to livestock. Furthermore, according to Olkowski [31], risks of metabolic acidosis or alkalosis are observed with extreme pH values of drinking water.

The total hardness of water is the result of its concentrations of calcium and magnesium [32]. However, these two elements in excess can also give water an unpleasant taste [33, 34,35]. The results indicate that the water analyzed is hard (hydrotimetric titer [HT] < 30°F). These findings are probably related to the lithological nature of the underlying soil formation. High hardness can, however, cause anemia [36].

Sodium and chlorine are generally found in association and are used to maintain the acid-base balance. Abnormally high levels are due to treatment with NaCl, since water from the public water system has normal concentrations according to the international standards of the WHO. In addition, according to Cinq-Mars [28], high sulphate concentrations can also lead to reduced water consumption, cause mild diarrhea and impair the assimilation of certain trace elements such as copper, zinc, manganese, selenium, iron and vitamin E. However, the concentrations of sulphate ions in all samples do not present any risk to the ewes.

The control water from the public network is also moderately mineralized according to the electrical conductivity value obtained, i.e. 0.353 ms/cm, and therefore presents no risk for the sheep. Nevertheless, the treated samples are characterized by high conductivity values, i.e.

TABLE 5. Effect of water restriction and saline stress on the biochemical parameters of OuledDjellal ewes (Mean ± Standard Error)

	Lot A	Lot B	Lot C	Salinity effect (P)	Lot A	Lot D	Restriction effect (p)
Blood glucose (g/l)							
D0	0.51$^{a.1}$±0.01	0.55$^{a.1}$±0.04	0.56$^{a.1}$±0.02	0.10	0.51$^{a.1}$±0.01	0.57$^{b.1}$±0.01	0.74
D12	0.51$^{a.1}$±0.01	0.54$^{a.1}$±0.03	0.53$^{b.1}$±0.02	0.32	0.51$^{a.1}$±0.01	0.55$^{b.1}$±0.02	0.19
D24	0.52$^{a.1}$±0.02	0.60$^{a.1}$±0.04	0.60$^{c.1}$±0.03	0.30	0.52$^{a.1}$±0.02	0.61$^{a.1}$±0.03	0.32
P	0.09	0.07	0.0009		0.09	0.02	
Urea (g/l)							
D0	0.34$^{a.1}$±0.02	0.28$^{a.2}$±0.02	0.27$^{a.2}$±0.02	0.004	0.34$^{a.1}$±0.02	0.52$^{a.2}$±0.03	0.001
D12	0.32$^{a.1}$±0.01	0.26$^{a.1}$±0.01	0.25$^{a.1}$±0.01	0.06	0.32$^{a.1}$±0.01	0.38$^{b.2}$±0.02	0.0001
D24	0.34$^{a.1}$±0.02	0.25$^{a.2}$±0.01	0.26$^{a.2}$±0.01	0.005	0.34$^{a.1}$±0.02	0.40$^{b.2}$±0.02	0.0003
P	0.41	0.55	0.83		0.41	0.001	
Creatinine (g/l)							
D0	7.99$^{a.1}$±0.21	7.84$^{a.1}$±0.21	7.59$^{a.1}$±0.21	0.54	7.99$^{a.1}$±0.21	8.89$^{a.2}$±0.21	0.0006
D12	8.60$^{a.1}$±0.25	8.27$^{a.1}$±0.26	8.11$^{a.1}$±0.25	0.49	8.60$^{a.1}$±0.25	9.08$^{ab.2}$±0.27	0.04
D24	9.09$^{a.1}$±0.31	8.09$^{a.1}$±0.22	7.96$^{a.1}$±0.22	0.09	9.09$^{a.1}$±0.31	9.75$^{b.1}$±0.38	0.0003
P	0.15	0.41	0.48		0.15	0.04	
Cholesterol (g/l)							
D0	0.52$^{a.1}$±0.02	0.46$^{a.1}$±0.01	0.53$^{a.1}$±0.02	0.07	0.52$^{a.1}$±0.02	0.50$^{a.1}$±0.02	0.46
D12	0.51$^{a.1}$±0.01	0.46$^{a.1}$±0.01	0.51$^{a.1}$±0.01	0.25	0.51$^{a.1}$±0.01	0.43$^{a.1}$±0.02	0.07
D24	0.56$^{a.1}$±0.02	0.49$^{a.2}$±0.02	0.50$^{a.2}$±0.01	0.05	0.56$^{a.1}$±0.02	0.48$^{a.1}$±0.01	0.71
P	0.05	0.43	0.73		0.05	0.11	
ASAT (UI/I)							
D0	87.01$^{a.1}$±5.15	98.01$^{a.1}$±6.78	89.36$^{a.1}$±6.29	0.29	87.01$^{a.1}$±5.15	96.63$^{a.1}$±6.36	0.39
D12	94.18$^{a.1}$±7.19	91.72$^{a.1}$±7.36	97.47$^{a.1}$±6.89	0.89	94.18$^{a.1}$±7.19	91.49$^{a.1}$±6.19	0.69
D24	90.37$^{a.1}$±7.76	94.55$^{a.1}$±6.98	84.82$^{a.1}$±5.87	0.52	90.37$^{a.1}$±7.76	111.54$^{a.1}$±8.88	0.22
P	0.70	0.71	0.56		0.70	0.54	
ALAT (UI/l)							
D0	26.59$^{a.1}$±1.21	26.80$^{a.1}$±1.50	25.96$^{a.1}$±1.48	0.91	26.59$^{a.1}$±1.21	28.24$^{a.1}$±2.67	0.37
D12	21.61$^{a.1}$±1.36	19.60$^{b.1}$±1.22	22.39$^{a.1}$±1.38	0.54	21.61$^{a.1}$±1.36	17.66$^{a.1}$±1.45	0.11
D24	21.87$^{a.1}$±1.78	21.51$^{b.1}$±1.36	19.27$^{a.1}$±1.21	0.36	21.87$^{a.1}$±1.78	22.37$^{a.1}$±2.37	0.54
P	0.05	0.0001	0.08		0.05	0.06	
Total protein (g/l)							
D0	71.21$^{a.2}$±1.34	73.01$^{b.2}$±1.43	78.34$^{a.2}$±1.59	0.01	71.21$^{a.2}$±1.34	82.02$^{a.1}$±1.44	0.14
D12	80.29$^{b.1}$±1.90	77.38$^{ab.12}$±1.54	87.36$^{b.1}$±1.60	0.007	80.29$^{b.1}$±1.90	83.02$^{a.1}$±1.80	0.29
D24	80.88$^{b.1}$±1.91	80.38$^{b.1}$±1.64	86.88$^{b.1}$±1.57	0.04	80.88$^{b.1}$±1.91	84.88$^{a.1}$±1.92	0.58
P	0.0001	0.02	0.01		0.0001	0.65	

[a. b. c]Different letters in the same column indicate the difference between the blood metabolites of the lots according to the samples

[1. 2.3]Different letters on the same line indicate the difference in blood metabolites between lots. Lot A: control lot; Lot B: low salinity (1% Nacl); Lot C: high salinity (1.6% Nacl) and Lot D: water restriction; P: level of significance.

TABLE 6. Effect of salinity and water restriction on the hematological parameters of OuledDjellal ewes (Mean ± Standard error)

	Lot A	Lot B	Lot C	Salinity effect (p)	Lot A	Lot D	Restriction effect (p)
WBC (×10⁹/L)							
D0							
D12	4.36±0.14	4.19±0.89	4.68±0.14	0.06	4.36±0.14	4.06±0.56	0.07
D24	4.15±0.13	3.88±0.78	4.59±0.12	0.46	4.15±0.13	3.81 ±0.06	0.44
P	4.51±0.15	4.32±0.90	4.77±0.15	0.61	4.51±0.15	4.11±0.88	0.42
	0.09	0.52	0.36		0.09	0.08	
RBC (×10¹²/L)							
D0	9.16±0.58	9.35±0.62	9.43±0.76	0.56	9.16±0.58	9.25±0.59	0.88
D12	9.95±0.60	9.13±0.61	8.83±0.70	0.88	9.95±0.60	9.11±0.82	0.60
D24	9.32±0.59	9.57±0.66	9.47±0.66	0.63	9.32±0.59	9.47±0.76	0.61
P	0.11	0.76	0.20		0.11	0.09	
Hb (g/dl)							
D0	9.52±0.21	9.16±0.81	9.03±0.44	0.10	9.52±0.21	9.27±0.19	0.01
D12	8.82±0.19	8.98±0.77	8.83±0.40	0.95	8.82±0.19	8.94±0.56	0.63
D24	9.31±0.20	9.46±0.88	9.45±0.43	0.86	9.31±0.20	9.40±0.45	0.78
P	0.06	0.17	0.17		0.06	0.08	
Ht (%)							
D0	31.24±1.37	31.03±1.89	31.37±2.41	0.54	31.24±1.37	30.71±0.99	0.90
D12	30.45±1.33	30.65±1.97	31.07±2.40	0.95	30.45±1.33	30.30±1.17	0.85
D24	32.01±1.35	32.07±2.03	32.57±2.41		32.01±1.35	31.48±1.66	0.51
P	0.80	0.17	0.55	0.86	0.80	0.11	
MBCV (fL)							
D0	34.33±1.91	33.37±1.93	33.35±1.91	0.61	34.33±1.91	33.33±2.01	0.92
D12	34.06±1.92	33.59±1.89	33.44±2.03	0.79	34.06±1.92	33.81±2.34	0.22
D24	33.83±1.87	33.10±1.87	32.81±1.95	0.49	33.83±1.87	32.81±1.99	0.19
P	0.91	0.14	0.22		0.91	0.10	
MCHC(g/l)							
D0	304.7±4.13	295±4.37	287.8±7.32	0.80	304.7±4.13	301.8±6.51	0.91
D12	290±4.10	292.9±4.05	284.1±6.65	0.66	290±4.10	295±4.45	0.16
D24	291±4.25	295±4.37	290.1±7.45	0.20	291±4.25	298.6±5.46	0.12
P	0.99	0.10	0.45		0.99	0.11	

Lot A: control lot; Lot B: low salinity (1% Nacl); Lot C: high salinity (1.6% Nacl) and Lot D: water restriction.
P: level of significance; WBC: white blood cells; RBC: red blood cells; Hb: hemoglobin; Ht: hematocrit; MBCV: mean blood cell volume; MCHC: mean corpuscular hemoglobin concentration.1 μm^3 = 1 fL; P: level of significanc

16.99 and 21.1 ms/cm, proportional to the doses of treatment with NaCl, i.e. 10 and 16g/l of water respectively, so treated samples received water with high salinity levels, even reaching brine levels.

Moreover, several authors have confirmed that the increase in NaCl concentration leads to an increase in TDS, resulting from a large quantity of salts in solution [37, 38]. Nevertheless, the results of all the treated waters indicate salt, conductivity and TDS concentrations above the WHO standards for sheep watering and are considered unacceptable for such use. Magnesium contributes to the proper functioning of the skeletal, enzymatic and nervous systems in sheep [28]. In spring, low magnesium levels in lush pastures can cause hypomagnesemia or grass tetany in sheep [31]. Treated samples had magnesium concentrations above the WHO standards for sheep watering, which are considered by Beede and Myers [30] as dangerous for animals.

Effect of water stress on zootechnical parameters

The salt level in the drinking water in lots B and C increased the quantity of water drunk, while the quantity of forage ingested decreased by 3% and 8%, respectively. The same finding was reported by Yousfi and Salem [19] in Barbary rams. The ewes, subject to water deprivation, drank twice (10.25 l/ewe) the volume drunk by the control group (5.43 l/ewe), probably due to intense thirst, which is consistent with the observations of Singh et al. [39] after 48 h of water deprivation of Chokla ewes. The total quantity of water consumed increased in parallel with the increase in water salinity in lots B and C. This response to high salt intake was also observed in sheep and goats by Runa et al.[40].

Although water stress had no effect on the quantity of concentrate consumed as reported by Casamassima et al. [41], the quantity of forage consumed was reduced in saline stressed lots B and C, also so in lot D, which was subject to water deprivation, with the exception of ewes in lot C, and was accompanied by a decrease in weight performance;this is perhaps because of reduction of energy intake. This decrease in forage consumption was 2, 8 and 20% in the ewes that received 1 and 1.6% Nacl and water-restricted ewes, respectively.

Other authors [41,42] have also reported the depressive effect of water restriction on food consumption, contrary to the results obtained by Muna and Ammar[43]. The authors did not report any effect of water restriction on this parameter. Adogla-Bessa and Aganga [44] even suggested that food consumption per kilogram of metabolic weight increased when the water deprivation interval is 72 h in Tswana goats. These discrepancies could be explained by the nature of the feed distributed on the one hand and animal variability on the other.

Nevertheless, low feed consumption has been described as partially compensated by reduced intestinal peristalsis, leading to an increase in the duration of exposure of feed to the intestinal microflora, with beneficial effects on digestibility and feed utilization [43,45, 46]. While the ewes in Lot D of this study were able to compensate for their water consumption, they were unable to do so for forage due to the limited capacity of their stomachs. This confirms the concept of Crampton and Harris in the work of Singh et al. [39] that the first response of an animal to water deprivation is a decrease in consumption. While in the present study the decrease in forage consumption in the saline stressed animal groups is attributed to an increase in water consumption, Runa et al. [40] reported that feed consumption is not affected by salt water concentrations of 1.5% in goats and sheep. According to Runa et al. [40], dry matter consumption even tends to increase gradually when goats have access to salt and fresh water alternately.

In this study, a decrease in intake in ewes consuming 1% water resulted in a decrease in body weight. Attia-ismail et al. [47] and Mdletshe et al. [48] explained this phenomenon by the fact that salinity negatively affects feed intake and digestive metabolism by inhibiting parotid saliva, a decrease in microbial flora and proteolytic activity which could be responsible for a decrease in ewe weight. In contrast to the females that consumed 1.6% water and those that were deprived of water, weight gain was even observed (+0.15 and +1.92 kg, respectively). The excessive increase in drinking water consumption (11.51 and 10.25 l, respectively) due to the high salt concentration in the water and water deprivation, respectively in both cases, leads to an increase in the volume of water in the body that is transported to the interstitial space [49].

Effect of water stress on physiological parameters

Water stress had no significant influence on the rectal temperatures of the ewes as they were maintained within the standard range of 38-39.5°C. Casamassima et al. [41] and Adogla-Bessa and Aganga [44] also found the same result in Lacaune ewes and Tswana goats, respectively. El-gawad [50] and Jaber et al. [34] reported the same result for Nubian goats and Awassi ewes, respectively, which suffered from salinity stress. The high salinity of drinking water seems to negatively influence heart rate by decreasing it, which does not seem to be the case in Ouled Djellal ewes that have experienced a 3day water restriction, as it is maintained within the standards advanced by Meyer [51] for sheep (70-80 bt/min). This result is in contrast to the Tswana goats, which were deprived of water for 72 hours and had a reduced heart rate [44].

The heart rate of ewes subjected to high saline stress (lot C) showed bradycardia (67.21 bt/min) due to the associated marked decrease in respiratory rate (24.52 m/min). This decrease in heart rate, also observed in ewes from lot D, is parallel to a decrease in intake, which, according to Abdelatif and Ahmed [42], decreases the metabolic activity of the animals and thus reduces their oxygen requirements, resulting in a decrease in respiratory rate. These results are consistent with those of Eltayeb[52] who deprived Nubian goats of drinking water for 2 days, for which an RF of 28 movements/min was recorded, but contradict those of Adogla-Bessa and Aganga[44] who recorded an increase in RF in Tswana goats deprived of water for 72 hours.

Effect of water stress on biochemical parameters

In this study, water stress affected the blood sugar level of sheep in OuledDjellal. Although statistically, the blood sugar values of the water-stressed females were not statistically different from those of the control lot. Nevertheless, numerically, these values are higher than the standards proposed by Dubreuil et al. (0.52 g/l) [53]. Yousfi and Salem [19] reported the same result and recorded an increase in blood glucose levels in Barbary sheep subjected to saline water stress. The authors attributed this increase to a decrease in insulin levels due to a decrease in the quantity of feed ingested. While Bengoumi and Faye [54] and Rasooli*et al.* [55], explain it with the increase of temperature. Casamassima et al. [41] and Abdelatif et al. [56] reported no influence of water restriction on blood glucose levels in Lacaune ewes. In the other hand, high temperature increases the respiratory muscular activity so glucose demand increases too, and automatically insulin levels decrease [57].

Creatinine and serum urea, which are indicators of renal function [19] are increased by water restriction. The increase in serum urea, relative to the control females, could be attributed to the water restriction which resulted in a state of dehydration associated with a hematic concentration of metabolites, preventing the kidney from fulfilling its function [41],Tubular reabsorption of urea is under hormonal influence (DHA) [58].

The results of this study are consistent with those of Jaber et al.[34] who also found an increase in blood urea in response to two and four days of water restriction in Awassi ewes. Osbaldistonin in Casamassima et al. [41] reported that hypovolemia due to water deficiency should result in decreased renal blood flow, resulting in decreased filtration rate. Thus, in this study, water-restricted conditions led to slower glomerular filtration, affecting renal excretion function [41].

The salinity of drinking water would cause the opposite effect by increasing glomerular filtration according to Godwin and Williams[59] and Engelbrecht and Meintjes[60], thus making urea available in quantity for the renal tubules, which will accelerate its excretion in the urine and thus contribute to a decrease in blood concentration. Engelbrecht and Meintjes [60] reported that increasing salt in the rumen, either by artificial introduction or in drinking water, will increase the concentration of urea in the rumen, which will automatically lead to a decrease in the concentration of urea in the blood.

Although it meets the standards recommended by Dubreuil et al.[53], blood creatinine levels appear to be statistically increased by water restriction. This phenomenon has also been reported in similar experiments in sheep [44, 61] and Nubian goats [56]. Referring to Rasooli et al. [55] and Titaouine and Meziane [11] ,We can explain creatinine increase with the amplification of muscle protein catabolism caused by lower concentration of thyroid hormones which in turn refers to the depression of thyroid activity resulting from the exposure of animals to high ambient temperature.

The total protein levels of the water-restricted females were statistically identical to those of the females in the control batch, but were numerically higher than the standards proposed by Brugère-Picoux [62] 60-79 g/l. The same phenomenon was observed in Lacaune ewes under water restriction and by Casamassima et al. [41] who deprived the goats of water for 4 days. According to Khan et al. in Casamassima et al. [41], increasing serum protein concentration would help to maintain colloidal blood pressure in water-restricted animals, as lack of water leads to overconcentration in a lower blood volume [41].

Protein levels also appear to increase with water salinity as the duration of treatment increases, which was not the case in barbarian ewes under saline water stress [19], but in Nubian goats under 0.8-2% saline water stress during the winter season [49]. This significant increase may be related to the role of sodium Na in the absorption of amino acids in the gut and their subsequent use in plasma protein formation [63], the total protein in plasma generates a colloid osmotic pressure which controls the flow of water between blood and tissue fluids [64]. Cholesterol levels remain within the norms cited by Bouzenzana [65] 0.43-0.79 g/l in the OuledDjellal breed, as well as by

Brugère-Picoux [62] 0.52-0.76 g/l. The values of the enzymatic activity of ASAT also remain within the physiological limits 71-209 cited by Ramos et al.[66] and those of Radostits et al.[67] 60-280 as well as those of Dubreuil et al. 72-101 [53]. The same applies to ALAT, whose standards are between 10 and 30 according to Brugère-Pioux [62].

Effect of water stress on hematological parameters

The salinity of the drinking water had no significant effect on hematological parameters(RBC, WBC, Hb,Ht, MBCV, MCHC), whichis consistent with the results of Assad et al.[68] who exposed Barki ewes to two concentrations of salt (7.7 g/l and 13.5 g/l). However, this result contradicts those of Casamassima et al. [41] who reported increases in hemoglobin and mean corpuscular hemoglobin concentration (MCHC), red blood cells and water-restricted ovine hematocrit. The results of these parameters remain within the standards indicated by Greenwood and Blunt [1,69] for sheep, with the exception of the MCHC which appears to be below these standards (310-380 g/l), for both control and experimental lots. It seems like the MCHC is a racial variable.

Conclusion

It can be concluded that both water salinity and water restriction lead to a significant reduction in forage consumption. The reduction in respiratory and heart rate is caused by saline stress at 16 g NaCl/l, while water deprivation decreases respiratory rate. Water stress increases the values of certain biochemical parameters (blood sugar and protein levels). The increase in urea and creatinine in water-deprived ewes would suggest impaired renal function.

These results show the primordial role of water as a limiting factor for small ruminants reared in the desert areas of Algeria where water scarcity and salinity are a limiting factor for the development of the livestock sector, for which watering strategies should be seriously implemented by the authorities, at the risk of threatening the sustainability of these livestock systems.

However, further studies are required to complete this study, including the identification of endocrine parameters, micro-minerals.

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Competing interest statement

The authors state that there is no competing interest in this research.

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آثار الإجهاد المائي على المعايير التقنية الفسيولوجية ومعايير الدم لدى نعاج أولاد جلال في الجزائر

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[١] مخبر المراقبة الوبائية ، الصحة ، الإنتاج والتكاثر ، التجارب والعلاج الخلوي للحيوانات الأليفة والبرية - قسم العلوم الزراعية - جامعة الشاذلي بن جديد - ص.ب ٣٧، ٣٦٠٠٠- الطارف - الجزائر.
[٢] مخبر الزراعة وعمل النظم البيئية - ص.ب ٣٧، ٣٦٠٠٠- الطارف - الجزائر.

تقيّم هذه الدراسة آثار الإجهاد المائي على المتغيرات التقنية الحيوانية و الفسيولوجية وبعض متغيرات الدم لنعاج أولاد جلال. أجريت التجربة على ٤٠ نعجة مقسمة إلى ٤ مجموعات من ١٠حيوانات في كل منها: مجموعة شاهدة (أ)، ومجموعة (ب) و(س) مع العلم أن مياه الشرب تحتوي على التوالي ١ و ١.٦٪ من كلورير الصوديوم (ملح الطعام) ، والدفعة (د) تشرب يومًا واحدًا فقط من أصل ٣.

قمنا بتغذية جميع النعاج على البرسيم والعلف المركز. لوحظ انخفاض استهلاك الأعلاف مع ارتفاع استهلاك المياه لدى النعاج المجهدة بالماء مقارنة بالمجموعة الشاهدة ، بالإضافة إلى فقدان الوزن لدى المجموعة (ب) و (د) والحفاظ على الوزن في الدفعة (س). وأظهرت النتائج أن ملوحة الماء تؤدي إلى انخفاض في معدل ضربات القلب و التنفس ، بينما يؤدي تقييد المياه إلى انخفاض معدل التنفس بسبب انخفاض القدرة على الأكل. يبدو أن الإجهاد المائي لا يؤثر على متغيرات الدم لدى النعاج ، إلا أنه يزيد من مستويات بروتين المصل والجلوكوز في الدم. يؤدي تقييد الماء إلى زيادة الكرياتينين واليوريا في الدم ، بينما ملوحة الماء تقلل منهما .

تسلط هذه النتائج الضوء على الدور المهم لنوعية المياه كعامل مقيد لتربية الحيوانات في البيئات المالحة و / أو البيئات التي تتميز بموارد المياه المنخفضة.