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Water restriction periods affect growth performance and nutritional status of Santa Inês sheep in the Brazilian Semi-arid

Períodos de restrição hídrica afetam o desempenho produtivo e o estado nutricional de ovinos Santa Inês no Semiárido Brasileiro

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Highlights

Small ruminants vary in the ability to conserve water.
One method for assessing this ability is the intermittent supply of water.
Water restriction for up to 72h00 is recommended only in extreme water shortage.

Abstract

This study aimed to assess the growth performance and nutritional status of sheep under intermittent water supply by means of performance, intake, apparent digestibility of nutrients, water balance and nitrogen. Thirty-two intact male sheep (20.7 ± 2.63 kg, 8 months of age) were distributed in a completely randomized design with 4 water supply intervals via drinking trough (0h00, 24h00, 48h00, and 72h00), with 8 replicates. The extension in the water restriction period caused a reduction in the intake of dry matter, crude protein,

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neutral detergent fiber, digestible energy, and metabolizable energy (P < 0.05). The digestibility coefficients of dry matter, crude protein, and neutral detergent fiber showed a linear decrease with increasing periods of water restriction (P < 0.05). Water intake via food, total water intake, and water excretion via feces showed a linear increase in response to an increase in the water supply interval (P < 0.05). Water intake via drinking, metabolic water, total water excretion and water balance presented a linear decrease, with increasing periods of water restriction (P < 0.05). Nitrogen intake and absorbed nitrogen were influenced by water restriction, presenting a linear decreasing trend according to water supply periods (P < 0.05). Final weight, daily weight gain, and total weight gain, were influenced by the periods of water restriction, showing a linear reduction (P < 0.05). Feed conversion increased as the water restriction period increased (P=0.004). Intermittent water supply at intervals of up to 72h00 reduced nutrient intake and digestibility, resulting in a decrease in weight gain of the studied animals.
Key words: Intermittent water supply. Metabolic water. Small ruminant. Weight gain.

Resumo

Objetivou-se avaliar o desempenho produtivo e o estado nutricional de ovinos de ovinos submetidos à oferta intermitente de água, através do desempenho, consumo, digestibilidade aparente dos nutrientes, balanço hídrico e balanço de nitrogênio. Trinta e dois ovinos machos inteiros (20,7 ± 2,63 kg e idade de 8 meses) foram distribuídos em delineamento inteiramente casualizado com 4 intervalos de abastecimento de água via bebedouro (0h00, 24h00, 48h00 e 72h00), com 8 repetições. O aumento do período de restrição hídrica proporcionou redução nos consumos de matéria seca, proteína bruta, fibra em detergente neutro, energia digestível e energia metabilizável (P < 0,05). Os coeficientes de digestibilidade da matéria seca, proteína bruta e fibra em detergente neutro reduziram linearmente (P < 0,05) com o aumento do período de restrição hídrica. A ingestão de água via alimento, a ingestão total de água e a excreção de água pelas fezes apresentaram um aumento linear em resposta ao aumento do intervalo de fornecimento de água (P < 0,05). A ingestão de água via bebedouro, água metabólica, excreção total de água e balanço hídrico apresentaram decréscimo linear, com o aumento do período de restrição hídrica (P < 0,05). O consumo de nitrogênio e o nitrogênio absorvido foram influenciados pela restrição hídrica, apresentando comportamento linear decrescente de acordo com os períodos de abastecimento de água (P < 0,05). O peso final, ganho de peso diário e ganho de peso total, foram influenciados pelos períodos de restrição hídrica, decrescendo linearmente (P < 0.05). A conversão alimentar aumentou com o aumento do período de restrição hídrica (P=0,004). O fornecimento intermitente de água em intervalos de até 72h reduziu a ingestão e a digestibilidade de nutrientes, promovendo diminuição no ganho de peso dos animais estudados.
Palavras-chave: Água metabólica. Ganho de peso. Oferta intermitente de água. Pequenos ruminantes.

Introduction

Nutritional success depends on supplying enough water for the animal to meet the water demand by ingestion (Albuquerque et al., 2020a; Al-Khaza'leh, Abdelqader, Abuajamieh, & Hayajneh, 2020). This, as well as the use of water, is related to factors such as dry matter intake, energy consumption, body weight, temperature, species, water quality, and physiological stage of animals. Animals suffering from water stress tend to show a decrease in their performance since water is required for several processes in the body, such as food digestion (Rojas-Downing, Nejadhashemi, Harrigan, & Woznicki, 2017).

The search for more efficient ways of using water in animal production systems is becoming increasingly necessary, as this important nutrient has become increasingly scarce. Although small ruminants in semi-arid regions can survive up to a week with little or no water, it is proven that water deficiency affects the physiological homeostasis of animals, leading to body weight loss, low reproductive rate, and decrease in resistance to diseases (Albuquerque et al., 2020b). However, little attention has been given to water supply in production systems. Similarly, studies on the importance and influence of water on animal production systems in the Brazilian semi-arid region are recent and scarce (Cordova-Torres et al., 2017; Nobre et al., 2018; Albuquerque et al., 2020b; Souza et al., 2020).

Tolerance to water restriction varies according to species and breed, sheep differ in their ability to support water limitation. One possible alternative to minimize water demand in an animal production system is the change in the way water is supplied to animals. Thus, researchers have been conducting studies assessing the intermittent water supply, partial restriction of drinking water, and even the use of salt water for ruminants (Kumar et al., 2016; Mdletshe, Chimonyo, Marufu, & Nsahlai, 2017; Mpendulo, Chimonyo, & Zindove, 2017; Sun et al., 2017; Yirga et al., 2018).

Periods of intermittent water supply can represent an alternative management to minimize the effects of water deficit in feedlot systems, in regions with water shortage. Thus, we hypothesized that periods of restricted water supply affect the growth performance of sheep in the Brazilian semi-arid. This study evaluated the effect of intermittent water supply on growth performance and nutritional status of Santa Inês sheep.

Material and Methods

Experiment location and ethical aspects

The experiment was conducted in the experimental field of the Animal Metabolism Unit of Embrapa Semi-arid. This area is located in the Caatinga biome, in the municipality of Petrolina, state of Pernambuco, Brazil. The mean annual maximum and minimum temperatures are 33.8 and 21.5 °C, respectively, with relative air humidity of 60.52% and total rainfall of 22.2 mm. This study was assessed and approved by the Ethics and Deontology Committee on Studies and Research of the Federal University of the São Francisco Valley, UNIVASF, under the protocol number 0007/131014.

Animals, treatments and experimental diets

Thirty-two intact male Santa Inês sheep (20.7 kg ± 2.63 kg body weight) were distributed in individual stalls (0.80 × 1.20 m) with feeding and drinking troughs. The experimental design was a completely randomized design with four treatments and eight animals per treatment. The experiment lasted 77 days, preceded by 10 days for adaptation to the water restriction intervals. At the beginning of the adaptation period, animals were identified, weighed, treated against endo- and ectoparasites, and randomly assigned to stalls previously identified according to the treatment. Treatments consisted of four water supply periods: T1= without water restriction (daily water supply); T2= 24h00 of restriction and then water supply for 24h00; T3= 48h00 of restriction and then water supply for 24h00 and T4= 72h00 of restriction and then water supply for 24h00.

Diet consisted of Tifton grass hay (Cynodon dactylon cv. Tifton 85) and concentrate based on ground corn, soybean meal, and mineral nucleus (Table 1). Diet was formulated with a 50:50 roughage: concentrate ratio on a dry matter basis and balanced to allow a mean weight gain of 200 g day-1, according to the National Research Council [NRC] (2007) recommendations. The diet was offered twice a day at 08h30 and 15h30 and leftovers were weighed to determine the intake and adjustment of dry matter intake in order to allow for 10% leftovers in the trough. Samples of the supplied diet and leftovers were collected weekly for further laboratory analysis.

Table 1
Chemical composition of ingredients offered in the experimental diets

	Ingredients		
Fraction in % DM	Tifton-grass hay	Concentrate	Total Diet
Dry matter[1]	87.17	86.37	86.77
Organic matter	91.10	97.04	94.07
Mineral matter	8.90	2.96	5.93
Ether extract	1.33	2.42	1.87
Crude protein	12.56	20.48	16.52
NDFap[2]	68.86	9.72	39.29
Acid detergent fiber	39.85	6.23	23.04
Total carbohydrates	77.21	74.14	75.68
Non-fibrous carbohydrates	8.34	63.69	36.01
Lignin	9.09	1.45	5.27
Total digestible nutrients	59.93	83.89	71.91

[1]In % fresh matter; [2]NDFap = neutral detergent fiber corrected for ash and protein.

Intake and digestibility of nutrients

Daily dry matter intake (DMI) was obtained by the difference between the total DM of the consumed feed and the total DM in leftovers. The nutrient intake was determined as the difference between the total nutrients present in the consumed food and the total nutrients in leftovers, on a total DM basis.

Dietary nutrient digestibility was determined by a digestibility test in the final third of the experimental period, with a duration of 5 days of collection preceded by 3 days of adaptation. For this, animals were housed in metabolic cages with feeding and drinking troughs arranged in a covered area. Feces of each animal were sampled using collection bags, which were fixed to the animals two days before the sampling period. Bags were weighed and emptied twice daily, and a sub-sample of 10% of the total amount was collected to form a composite sample for each treatment, which was stored at −20 °C.

Nitrogen balance

Urine was collected once daily in plastic buckets containing 100 mL 2N hydrochloric acid to prevent nitrogen volatilization and sampled for nitrogen content determination. The apparent nitrogen balance (NB) was calculated according Silva and Leão (1979).

Water intake assessment

Water intake (WI) was assessed daily. Water was supplied in buckets and weighed before supply and again 24h00 later. Buckets containing water were distributed close to animal cages in the shed and monitored in order to determine daily evaporation, so that after weighing, this loss (evaporation) was added to the calculation of the WI per animal. Water intake was obtained by multiplying water intake by the number of days with access to water during the experimental period: T1= 67 days; T2= 34 days; T3= 23 days; T4= 17 days. Water intake via drinking (WID) was estimated by the difference between the amount of water supplied and the surplus plus the daily evaporation of water:

$$\text{WID (kg day}^{-1}\text{)} = \text{water supplied} - (\text{surplus} + \text{evaporation})$$

Production of metabolic water (MW) was estimated from chemical analysis of the diets and calculated by multiplying the consumption of digestible carbohydrate, protein and ether extract by 0.60; 0.42 and 1.10, respectively (Church, 1993). Water balance (WB) was assessed using the equations described by Church (1993).

Growth performance

Sheep were weighed at the beginning and end of the experimental period after fasting for solids for 12h00 (with access to water). The following equations were used to assess the total weight gain (TWG), daily weight gain (DWG), and feed conversion:

$$\text{TWG (kg)} = \text{fasting final body weight} - \text{fasting initial body weight}$$

$$\text{DWG (g day}^{-1}\text{)} = \text{TWG/confinement days}$$

$$\text{FC} = \text{DMI/DWG}$$

Laboratory analysis

Samples of the offered food, leftovers, and feces were collected weekly and stored in a freezer at −20 °C. After thawing, these samples were pre-dried in an oven at 55 °C for 72h00 and ground to 1-mm particles (Wiley mill, Marconi, MA-580, Piracicaba, Brazil). All chemical analyses were carried out using the procedures described by the Association of Official Analytical Chemists [AOAC] (2016) for dry matter (DM, method 967.03), mineral matter (MM, method 942.05), crude protein (CP, method 981.10), and ether extract (EE, method 920.29). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined as described by Van Soest, Robertson and Lewis (1991). Neutral detergent fiber corrected for ash and protein (NDFap; thermostable alpha-amylase without sodium sulfite) was determined according to Licitra, Hernandez and Van Soest (1996) and

Mertens (2002) and lignin was determined by treating the acid detergent fiber residue with 72% sulfuric acid (Silva & Queiroz, 2006). Total carbohydrates (TC) were calculated using the equation proposed by Sniffen, O'Connor and Van Soest (1992):

$$TC\ (g\ kg^{-1}) = 100 - (CP + EE + MM)$$

Non-fiber carbohydrate (NFC) contents were calculated as proposed by Hall (2003):

$$NFCap\ (g\ kg^{-1}) = TC - NDFap$$

Apparent digestibility coefficient (ADC) of nutrients was measured as described by Silva and Leão (1979), in which:

$$ADC = \{[\text{nutrient intake (kg)} - \text{nutrient excreted in feces (kg)}]/\text{nutrient intake (kg)}\} \times 100$$

Total digestible nutrients (TDN) of the diet were estimated using the equation of Harlan, Holter and Hayes (1991):

$$TDN\ (g\ kg^{-1}) = 82.75 - (0.704 \times ADF)$$

TDN of the diet was converted into digestible energy (DE) and metabolizable energy (ME) using the following equations proposed by the NRC (2001).

Statistical analysis

All the analyzed variables were subjected to analysis of variance (ANOVA), followed by a regression model, considering the periods of water restriction. Data were analyzed by the GLM procedure of SAS 9.1 software, considering as significant probability values lower than 5%. The following statistical model was adopted: $Y = \mu + Bi + Tj + eij$, where: Y = observed value of the variable; μ = overall mean; Bi = effect of block i; Tj = effect of water supply level j; eij = residual error.

Results and Discussion

The intakes of DM (p=0.004), CP (p=0.036), NDF (p=0.005), DE (p=0.004), and ME (p=0.004), decreased linearly as the period of water restriction increased (Table 2). Dry matter intake decreased with water restriction indicating that this probably imposed stress on animals. This was probably due to the lower water availability in the rumen-reticulum to transport the gastrointestinal tract content, removal of undigested residues, excretion of metabolic residues, and less dilution of the available ruminal content (Benatallah, Ghozlane, & Marie, 2019). In addition, rumination, absorption and excretion generate heat production, so animals reduce dry matter intake in an attempt to reduce endogenous heat production because water reaching their body is insufficient for these mechanisms (Conte et al., 2018). This behavior is consistent with studies on the effect of water restriction on small ruminants (El Khashab, Semaida, & ABD El-Ghany, 2018; Jaber, Duvaux-Ponter, Hamadeh, & Giger-Reverdin, 2019; Santos et al., 2019).

Table 2
Daily intake of nutritional components, apparent digestibility, and productive performance of nutrients in sheep submitted to intermittent water supply

Fraction in % DM	Water restriction (hours)				SEM	*P value*	
	0	24	48	72		L	Q
			Intake (g day^{-1})				
Dry matter[1]	935.45	917.45	710.55	682.02	0.06	0.004	0.741
Crude protein[2]	180.39	178.83	169.68	169.04	0.01	0.036	0.633
Neutral detergent fiber[3]	538.90	488.01	437.12	386.23	0.03	0.005	0.382
Digestible energy[4], Kcal day^{-1}	2.95	2.89	2.37	2.15	0.002	0.004	0.718
Metabolizable energy[5], Kcal day^{-1}	2.41	2.36	1.95	1.76	0.001	0.004	0.697
			Digestibility (g kg^{-1})				
Dry matter[6]	738.2	729.6	678.4	627.4	1.94	<0.001	0.286
Crude protein[7]	810.8	799.1	777.9	735.1	1.51	0.001	0.356
Neutral detergent fiber[8]	716.8	718.2	649.2	591.6	2.17	0.001	0.193
			Performance				
Final weight[9], kg	32.62	32.29	26.77	25.88	0.89	0.001	0.808
Daily weight gain[10], g day^{-1}	0.178	0.172	0.093	0.074	0.01	0.001	0.678
Total weight gain[11], kg	11.91	11.50	6.24	4.99	1.09	0.001	0.684
Feed conversion[12]	5.26	5.33	7.64	9.22	1.15	0.004	0.511

SEM = Standard error of the mean; L= Linear Effect; Q= Quadratic Effect; Significant at the 5% probability level.
Equations: Y^1= -96.719x + 1053.2, R^2= 0.87; Y^2= -4.32x + 185.29, R^2= 0.88; Y^3= -50.89x + 589.79, R^2= 0.99; Y^4= -0.292x + 3.32, R^2= 0.92; Y^5= -0.236x + 2.71, R^2 = 0.93; Y^6= -3.836x + 78.93, R^2 = 0.93; Y^7= -2.483x + 84.28, R^2 = 0.92; Y^8= 73.42 - 0.18x; R^2= 0.45; $\hat{Y}^9$= -2.574x + 35.825, R^2 = 0.87; Y^{10}= -0.0391x + 0.227, R^2 = 0.89; Y^{11}= -2.602x + 15.165, R^2 = 0.89; Y^{12}= 1.419x + 3.315, R^2 = 0.91.

During water stress, small ruminants respond by reducing their feed intake culminating in weight reduction as a result of body mass and water loss. Water losses amounting to 20% body weight can be tolerated by sheep and goat. Although such an imbalance in water and energy metabolism produces a negative impact on general health and productivity, small ruminants have evolved adaptive mechanisms to successfully thrive and breed in water-limited and arid lands (Akinmoladun, Muchenje, Fon, & Mpendulo, 2019).

Protein intake values were higher than those recommended by the NRC (2007), which are 117 g day^{-1} for animals with 20 kg of live weight. However, this increase in intake was not enough for the animals to reach the expected weight gain. In relation to voluntary intake of NDF was regulated by water restriction, being associated with a lower amount of water for the wetting processes of the bolus and by the physical limitation of the gastrointestinal tract, which restricts rumen distension, thus ceasing intake (Hussein et al., 2020).

According to the NRC (2007), adequate levels of energy intake are required by young sheep to develop and execute their potential. These animals can be kept with lower intake levels compared to heavier animals and aiming at higher gain. For this, the diet should be balanced, not only based on quality standards, but also on the amount of supplied nutrients. The results for ME intake in the present study are higher than recommended by Cabral et al. (2008), who suggested a daily intake of 1.38 kcal kg^{-1} DM for sheep under the Brazilian conditions. Therefore, water restriction did not completely limit the ME demand, although the diet and its intake were not enough to achieve the expected gains.

The digestibility coefficients of DM (p<0.001), CP (p=0.001), and NDF (p=0.001), showed a linear decrease, as the water restriction period increased (Table 2). Water restriction can result in an increase in diet digestibility, which is due to the increased time of digesta in the rumen, providing more time for degradation and microbial synthesis (Nejad, Lohakare, West, & Sung, 2014; Vosooghi-Postindoz, Tahmasbi, Naserian, Valizade, & Ebrahimi, 2018). This was not evidenced in the present study, in which water restriction negatively affected digestibility, i.e. nutrient digestibility reduced as the water restriction period increased. Misra and Singh (2002) subjected goats to water restriction in the semiarid regions for 0, 24h00 and 48h00, and observed that water deprivation for up to 48h00 did not affect nutrient digestibility, but animals of the 48h00 treatment showed higher digestibility values compared to the other treatments. The authors associated this increased digestibility with decreased food intake and increased mean retention time of particles in the ruminal fluid and throughout the intestine.

In relation to animal performance, final weight (p=0.001), daily weight gain (p=0.001), and total weight gain (p=0.001), were influenced by the water restriction period, with a linear decrease. Feed conversion increased as the water restriction period increased (p=0.004) (Table 2). The reduction in final body weight according to water restriction is in agreement with the reduction in DMI, showing a direct relationship between water and feed intake and, consequently, a reduction in daily and total average gain, since animals were not able to reach the expected daily gain of 200 g. The lower weight gain can also be attributed to body water losses. In addition, in order to produce metabolic water, there is an increase in fat, carbohydrate and protein oxidation, resulting in less weight gain. From these results, we can observe a large influence of water intake/availability on animal performance, showing decreased performance as the water supply interval increased.

Animals submitted to longer periods of water restriction had lower efficiency in converting the diet into animal product, presenting lower DMI and in return a higher feed conversion index. That is, the absence of water requires a greater effort for the utilization of food.

Water intake via food (p=0.043), total water intake (p<0.001), and water excretion via feces (p=0.029) showed a linear increase in response to an increase in the water supply interval (Table 3). Water intake via drinking (p<0.001), metabolic water (p=0.002), total water excretion (p=0.016) and water balance (p=0.035) presented a linear reduction, with a higher water intake for those animals submitted to water restriction for 72h00 (Table 3).

Table 3
Water balance in sheep submitted to intermittent water supply

Fraction in % DM	Water restriction (hours)				SEM	*P value*	
	0	24	48	72		L	Q
Water intake via food[1], kg day^{-1}	2.15	5.14	5.74	7.18	10.76	0.043	0.480
Water intake via drinker[2], kg day^{-1}	0.14	0.14	0.10	0.11	395.40	<0.001	0.120
Metabolic water[3], g day^{-1}	51.46	50.06	39.12	38.39	0.03	0.002	0.729
Total water intake[4], kg day^{-1}	2.29	5.28	5.84	7.29	401.28	<0.001	0.136
Water use efficiency, kg water kg^{-1} DM	3.00	3.06	3.00	2.92	534.37	0.299	0.391
Water excretion via feces[5], kg day^{-1}	723.47	572.53	360.76	317.10	723.47	0.029	0.470
Water excretion via urine, g day^{-1}	367.96	524.52	387.14	461.68	367.96	0.700	0.361
Total water excretion[6], g day^{-1}	1091.43	1097.05	747.90	778.78	1091.43	0.016	0.984
Water balance[7], kg day^{-1}	1.70	1.80	1.32	1.14	402.82	0.035	0.113
Nitrogen intake[8], g day^{-1}	28.86	28.13	23.24	20.64	2.34	0.003	0.065
N feces, g day^{-1}	5.83	6.01	5.65	5.72	0.47	0.716	0.737
N urine, g day^{-1}	7.93	9.30	10.64	14.22	2.79	0.062	0.7876
Absorbed nitrogen[9], g day^{-1}	23.32	24.41	16.15	16.87	1.72	0.003	0.920

DM = Dry matter; SEM = Standard error of the mean; L= Linear Effect; Q= Quadratic Effect; Significant at the 5% probability level.
Equations: Y^1=-102.76x+1387.2, R^2=0.78; Y^2=1117.8x+2991.8, R^2=0.80; Y^3=-5.015x+57.295, R^2=0.86; Y^4=1107.5x+3130.5, R^2=0.79; Y^5=-177.64x+1420.6, R^2=0.89; Y^6=1285.2x+1709.9, R^2=0.83. Y^7= 1.80-0.009x; R^2=0.35; Y^8=30.81-0.13x; R^2=0.37; Y^9=24.22-0.11x; R^2=0.37.

Rumen plays an important role in maintaining homeostasis under dehydration in ruminants adapted to the semiarid. Due to its relatively large volume, it acts as an important water reservoir providing most of the water lost during prolonged dehydration to maintain blood volume (Gebreyohanes & Assen, 2017). It also allows the intake of large volumes of water upon rehydration, which is temporarily sequestered in the rumen. Through efficient and well-coordinated mechanisms of saliva recycling and high water and Na+ retention in the kidneys, slow rehydration is achieved without causing water toxicity and with minimal water losses (Jaber, Chedid, & Hamadeh, 2013).

Ruminants, especially sheep, can survive dehydration of up to 20% due to the rumen ability to store water that can be used in low availability of this nutrient (Gebreyohanes & Assen, 2017). In all the treatments, the animals ingested a total amount of water higher than that recommended by international committees, which suggest 0.800 kg water day-1 for sheep (NRC, 2007). This may be related to environmental conditions, diet, and water restriction imposed to animals. The decreasing linear behavior for water intake via food followed the behavior of DMI, i.e. water intake via food decreased as food intake decreased. On the other hand, the results for water intake via drinking troughs showed that animals undergoing longer periods of water restriction, when they had a water supply, consumed more than they consumed the food. This higher intake could be for maintenance of their metabolism.

Metabolic water is produced by cells during oxidation of hydrogen molecules contained in the main nutrients. Thus, 1 g protein, carbohydrate, and fat produce 0.42, 0.60, and 1.10 g water for each nutrient, respectively (Church, 1993). Considering that crude protein intake was influenced by water supply intervals, metabolic water production accompanied this result, with a decreased participation of water ingested by animals according to the increased water restriction.

The observed behavior for water excretion via feces and total water excretion is related to water intake by animals, i.e. those consuming a lower amount consequently had lower water excretions. This behavior may have been used by animals as a water retention or saving mechanism, aiming at a reduction of water losses in response to water restriction. Animals subjected to longer periods of water restriction had lower values of water balance, indicating a mechanism of water conservation. For proper animal production, it is necessary a stable or positive water balance between its body fluids. In addition, WB of this study does not consider losses through sweat, which represents about 70% total losses (Albuquerque et al., 2020a).

Water use efficiency and water excretion via urine were not affected by intermittent water supply (p>0.05) (Table 3).

Nitrogen intake (p=0.003) and absorbed nitrogen (p=0.003) were influenced by water restriction, presenting a linear decreasing behavior according to the periods of intermittent water supply (Table 3). Nitrogen intake values were above that recommended by the NRC (2007), 19.7 g nitrogen intake for sheep in this weight range, with daily gains of 200 g day-1. Nitrogen intake above requirements promotes higher nitrogen losses via feces and urine, showing that excess nitrogen is eliminated by the animal (Van Soest, 1994). This was also observed in the present study.

Nitrogen excretion via urine showed that animals ingesting more nitrogen excreted less. Thus, there was a higher nitrogen uptake by these animals. This can be explained by the intake and digestibility of CP, which were higher in these treatments, corroborating Nejad et al. (2014), who stated that animals subjected to water restriction with lower nitrogen excretion in feces and urine would present a higher CP digestibility. The results observed in this study showed that losses of protein or nitrogen compounds occurred due to water restriction, demonstrating that the dietary protein fraction may not have been used efficiently by these animals, thus resulting in weight loss.

Nitrogen in feces and urine was not influenced by the intermittent water supply (p>0.05) (Table 3).

Conclusions

Under experimental conditions, intermittent water supply at intervals of up to 72h00 reduced nutrient intake and digestibility, promoting a decrease in weight gain of the studied animals.

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