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Nutritional and Physiological Responses of Sudan Desert Sheep and Nubian Goats to Water Restriction

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Abstract: This study was conducted to compare the nutrient utilization, concentration of some rumen metabolites, blood urea nitrogen and some physiological responses to water restriction in Sudan desert sheep and Nubian goats. Three yearling uncastrated intact males from each species, averaging 18.37 kg (for sheep) and 13.21 kg (for goats), were randomly allotted to four treatments in a completely randomized block design with a 2 x 2 factorial arrangement of treatments to determine the effects of animal species and water restriction. Both species were offered either *ad libitum* feed and water or water restricted to 50% of *ad libitum* level with *ad libitum* feed. Animal species resulted in a significant ($P<0.01$) increase in dry matter intake, water intake, faecal dry matter and respiration rate and a decrease ($P<0.01$) in water intake: dry matter intake ratio in sheep compared with goats. Sheep showed also higher ($P<0.05$) urine volume value than goats. Rectal temperature was not affected by animal species. Dry matter intake, faecal dry matter and urine volume decreased insignificantly with water restriction. However, water intake and water intake: dry matter intake ratio decreased significantly ($P<0.01$) with treatment. Rectal temperature and respiration rate values were almost similar at the two levels of water intake. Species x treatment interaction showed a significant ($P<0.01$) increase in water intake in sheep compared with goats given water *ad libitum*. Water intake, however, decreased in both species as a result of water restriction. Animal species induced a significant effect on the apparent digestibility coefficients of dry matter, organic matter, crude protein, crude fibre, nitrogen free extract and total digestible nutrients. Ether extract digestibility did not differ between species. Goats had lower digestibility coefficients and total digestible nutrients compared with sheep. Except for ether extract digestibility, the digestibility coefficients of nutrients as well as total digestible nutrients increased with water restriction. Sheep had the highest nitrogen balance value. Nitrogen balance showed similar trend whether it is expressed as a percentage of nitrogen intake or digested nitrogen. Species x treatment interactions were not found for digestibility and nitrogen balance data. Rumen pH and ammonia nitrogen were not affected significantly by species. Water restriction did not induce a significant effect on rumen pH and blood urea nitrogen. A significant species and treatment effect on blood urea nitrogen and ammonia nitrogen, respectively, was recorded.

Key words: Goats; sheep; water restriction; utilization of nutrients

INTRODUCTION

Limitations of water intake occur through infrequent drinking, water restriction and heat load. These limitations reduce appetite and increase feed utilization. The reduction in rumen motility, rumination activity and saliva secretion reduce passage rate, and hence increase the digestibility of structural carbohydrates (Silanikove 1992).

The amount of water intake (WI) by animals depends on body size, milk yield, quantity of dry matter (DM) consumed, temperature and relative humidity of the environment, temperature of water, quality and availability of water, and amount of moisture in the food (Looper and Waldner 2002).
Breeds of ruminants which are well adapted to arid environments demonstrate a greater capability than non-desert breeds to ameliorate the stressful effects induced by water deprivation and heat load and thereby maintain higher feed intake and productivity (Silanikove 1992).

A number of reports have documented the capability of goats to tolerate dehydration (Silanikove 2000). During periods of water shortage, goats activate several water saving mechanisms that result in minimizing their water losses and, therefore, increasing their capability to withstand water deficit. Desert sheep do not seem to be quite as tolerant as goats to dehydration, but the desert adapted breeds have large capacity to withstand dehydration than breeds native to temperate climate. Indigenous sheep breeds of Sudan can survive drought and malnutrition during the dry season (Ahmed and Abdelatif 1994). Goats exhibit poor insulation capacity, while sheep exhibit the opposite (Silanikove 1992).When shade is provided, goats appear to consume less water than sheep but when shade is absent, goats appear to drink more water than sheep (McGregor 2004). A comparative study between Angora goats and Merino sheep grazing dry un-shaded summer pasture revealed that WI of goats was 36% greater than sheep (McGregor 1986).

In Sudan, most livestock (ca. 90%) are owned by nomadic people and raised under arid and semi-arid conditions where water and feed are not available in most parts of the year, because of a long dry season. Consequently, the animals have to adapt to water shortage at certain times of the year. The present work was conducted to study the effects of water restriction on dry matter intake (DMI), WI, digestibility of nutrients, N balance, some rumen fermentation products, blood urea nitrogen (BUN), rectal temperature (RT) and respiration rate (RR) in Sudan Desert sheep and Nubian goats.

MATERIALS AND METHODS

Experimental animals

Six yearling uncastrated males of Sudan Desert sheep averaging 18.37 kg and six yearling uncastrated males of Sudan Nubian goats averaging 13.21 kg were used in this study. The animals were purchased from a local market. On arrival at the experimental farm, they were ear-tagged, dewormed with Ivomec against endo-parasites, sprayed with Gamatox to control the ecto-parasites and given a prophylactic dose of Oxytetracycline. The animals were left to acclimatize for 14 days, during which they were randomly assigned to one of four treatments (3 animals/ treatment).

Experimental procedure

The animals (sheep and goats) were assigned to one of the two watering regimes (*ad libitum* or restricted to 50% of *ad libitum* intake) with three animals per treatment following the completely randomized design with a 2x2 factorial arrangement of treatments. The treatments will be referred to as follows:

GT_1: Goats given *ad libitum* feed and water

GT_2: Goats given *ad libitum* feed and water restricted to 50% of the *ad libitum* intake

ShT_1: Sheep given *ad libitum* feed and water

ShT_2: Sheep given *ad libitum* feed and water restricted to 50% of the *ad libitum* intake

During the experiment, the animals were provided with chopped Abu Sabeen (a local forage variety of sorghum; *Sorghum vulgare*). Prior to the experiment, fresh Abu Sabeen was prepared by drying into hay and then chopped and thoroughly mixed before feeding. The chemical composition of Abu Sabeen hay on DM basis was as follows: 92.72% OM, 4.9% CP, 1.21% EE, 33.46% CF and 53.15% NFE. Metabolizable energy (ME) was calculated after MAFF (1975) using the following equation: ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE. It amounted to 10.01 MJ/kg DM.

Water was served in metal buckets tied on securely to the crates. Water consumed by each animal was determined by measurement of depletion in the bucket and correcting for evaporation.

The experiment was conducted during early summer (May). The mean air temperature was 43.5ºC. The parameters investigated were DMI, WI, faecal DM output, urine volume, RT, RR, digestibility coefficients of the various nutrients, N balance, some rumen fermentation products and BUN.

Digestibility trial

A digestibility trial was conducted with 12 animals (6 sheep and 6 goats) in a completely randomized block design with a 2x2 factorial arrangement of treatments to determine the effects of animal species and treatment (water restriction) on diet digestibility.

The animals were harnessed and kept in metabolism cages to allow the collection of faeces and urine separately. After 14 days adjustment period, DMI was recorded for 5 days and DM digestibility and N balance measured during a 5-days collection period. Daily faecal excretions were collected quantitatively in canvas bags. Urine collected passed between the wooden slats of the crates and drained to zinc urinary trays (required frequent cleaning) and into Winchester (glass) bottles. Five millilitre of concentrated sulphuric acid was placed in each bottle to acidify and preserve each animal's urine output.

Each sheep's and goat's daily urine output was agitated vigorously to ensure a good blend and measured volumetrically. At least, 10% of aliquot of the well- mixed urine was added to the sample of the previous days which was then refrigerated and sub- sampled at the end of the collection period for N analysis. Ten percent of each animal's faecal output was dried daily at 105ºC for 24 hours for DM determinations, and the remaining quantity was bulked and refrigerated. At the end of the collection period, the composited faecal samples were mixed well, sub-sampled, dried at 60ºC for 24 hours, ground and used for chemical analysis.

Samples of feeds offered were taken daily and bulked at the end of the collection period. The collected composites were divided into two portions: one dried at 60ºC and the other at 105ºC for chemical analysis and DM determinations, respectively. Digestion coefficients were calculated according to standard procedures (Schneider and Flatt 1975). The samples of feed and faeces were analyzed for their proximate chemical components as described by AOAC (1980). Urine nitrogen was determined as described by El-Shazly (1958). RT was recorded with a telethermometer and RR by counting the flank movements (Ahmed 1989). All the observations were recorded when the animals were in resting state under shade at 8:00 am.

Rumen liquor and blood samples

At the end of the digestibility trials, the animals were fasted for 24 hours, then samples of rumen liquor were obtained using a stomach tube immediately before feeding, 3hrs, and 6hrs after feeding. The samples were strained by means of a cheese -cloth and used for the determination of pH and ammonia nitrogen (NH_3-N). The rumen pH was measured using electronic pH meter (Model 41600), and the ruminal NH_3-N was determined as described by Conway (1957). Blood samples were withdrawn from jugular vein immediately before feeding, 3hrs and 6hrs post feeding. The blood samples were allowed to clot, and the serum was separated by centrifugation and stored at –20ºC until assayed for blood urea as described by Conway (1957).

Statistical analysis
Data from the digestibility trial were subjected to the analysis of variance (ANOVA) as a completely randomized block design with a 2x2 factorial arrangement of treatments to test the effects of treatment, animal species and interactions. The ruminal pH and NH_3-N and BUN data were analyzed as a completely randomized block design with a 2x2x3 factorial arrangement of treatments to test treatment, animal species, sampling time and interaction effects. All data were subjected to ANOVA according to Steel and Torrie (1980). The least significant difference (LSD) test was used for mean seperation at $P < 0.05$.

RESULTS AND DISCUSSION

Effect of water restriction on DMI, WI, the ratio of WI: DMI, faecal DM output, urine volume, rectal temperature and respiration rate
DMI, WI, the ratio of WI: DMI, faecal DM output, and RR were significantly ($P< 0.01$) affected by animal species (Table1). RT was not significantly affected by both animal species and treatment. There was a significant ($P<0.05$) difference between sheep and goats in urine volume. WI and the ratio of WI: DMI were significantly ($P<0.01$) affected by treatment. The treatment, however, failed to induce a significant effect on DMI, faecal DM output, urine volume, RT and RR. The data suggest that water restriction reduced DMI, WI, the ratio of WI: DMI, faecal DM output and urine volume but no effect on RT and RR was observed when water was restricted. In addition, the species appears to interact significantly ($P< 0.01$) with treatment on WI.

Table 1. Effect of water restriction on dry matter intake (DMI) , water intake, faecal DM output, urine volume, rectal temperature and respiration rate in Sudan desert sheep and Nubian goats

Source main effect		Parameter						
		DMI (kg/day)	Water intake (kg/day)	Water intake: DMI	Faecal DM (kg)	Urine volume (ml)	Recta temperature (°C)	Respiration rate (min^{-1})
Species (Sp.)	Goat (G)	0.62^{B}	1.63^{B}	2.61^{A}	0.15^{B}	63.75^{B}	38.64	32.70^{B}
	Sheep (Sh)	0.97^{A}	2.01^{A}	2.06^{B}	0.20^{A}	114.40^{a}	38.60	43.47^{A}
	SEM	0.18	0.19	0.28	0.002	25.33	0.001	5.39
Treatment (T)	*Ad lib*. water (T_1)	0.81	2.28^{A}	2.88^{A}	0.36	101.93	38.54	37.73
	50% water (T_2)	0.78	1.35^{B}	1.79^{B}	0.16	76.22	38.76	38.43
	SEM	0.002	0.47	0.55	0.01	12.86	0.11	0.35
Sp. x T interaction	GT_1	0.62	1.95^{B}	3.13	0.16	76.73	38.59	31.47
	GT_2	0.62	1.30^{C}	2.09	0.14	50.77	38.68	33.93
	ShT_1	0.99	2.61^{A}	2.63	0.21	127.13	38.49	44.00
	ShT_2	0.94	1.40^{C}	1.49	0.19	101.67	38.84	42.93
	SEM	0.10	0.30	0.35	0.001	16.40	7.43	3.16

[A, B, C] Within the same column, means with different superscripts differ significantly at $P < 0.01$.
[a, b, c] Within the same column, means with different superscripts differ significantly at $P < 0.05$.
SEM: Standard error of the mean

Animal species resulted in a significant (P<0.01) increase in DMI and WI and a decrease in WI (kg): kg DMI in sheep compared with goats. Aganga (1992) indicated that Yankasa rams consumed more feed and water, and therefore gained more weight, than the Maradi bucks. This finding agrees with the report of Gihad (1976), who noted that goats fed tropical natural grass hay had a lower intake of water than sheep. Regarding WI: DMI ratio, Ferreira *et al.* (2002) reported a different finding. They found that Boer goat kids have lower WI per kg of feed intake than Merino lambs. Alamer (2009) demonstrated also that during water restriction, goats consumed less feed than that during control period. In general, when goats are water stressed, they will eat less food so reducing their intake of water within the food than other domestic species (McGregor 2004). DMI was not affected by treatment. The insignificant reduction in DMI due to water restriction was obtained by other research workers (Ahmed and El Shafei 2001; Casamassima *et al.* 2008) who found that imposing a restriction ranging between 40% and 80% in WI for sheep and goats has no effect on DMI.

Eating less during water restriction helps to maintain osmotic balance, because smaller meals reduce the impact of an osmotic load (food) not balanced by adequate WI. If ruminants failed to decrease food intake during dehydration, it might even compromise the osmotic buffer function of the rumen, because it might increase rumen fluid osmolality so much as to prevent the use of rumen water to alleviate the systemic hypertoncity of dehydration (Burgos *et al.* 2001).

WI and the ratio of WI, kg: kg DMI was significantly (P< 0.01) higher when animals had *ad libitum* access to water. This is in accord with the results obtained by Ajibola (2006) in goats subjected to water restriction (30%, 50% and 100% of the *ad libitum* WI). Similar results were reported by Alamer (2009) who found a significant decrease in total WI with 50% and 25% water restriction in goats. Species x treatment interaction showed a significant (P<0.01) increase in WI in sheep compared with goats given water *ad libitum*. WI, however, decreased in both species as a result of water restriction. Similarly, Aganga (1992) found that WI by sheep was higher (P<0.01) than goats.

Faecal M output and urine volume were lower in goats compared with sheep. This is in agreement with the results obtained by Aganga (1992) who found that the Maradi goats drank less water and produced drier faeces than the Yankasa sheep. Moreover, there was a reduction in urine excretion in goats compared with sheep, indicating a better water conservation mechanism.

Sheep showed significantly ($P < 0.01$) higher RR than goats. Sevi *et al.* (2009) noted that water restriction causes an increase in RT and breathing rate in sheep. This confirms the findings obtained in this study.

Apparent digestibility coefficients

Animal species induced a significant effect on the apparent digestibility coefficients of DM, OM, CP, CF, NFE and TDN (Table 2). However, animal species failed to induce a significant effect on EE digestibility. Except for EE digestibility, the digestibility coefficients of nutrients as well as TDN increased with water restriction. Similar trend was observed by Lutfi and Ahmed (2010). Their results revealed, however, that water restriction had no significant effect on the digestibility coefficients of the various proximate components and TDN in Sudan Nubian goats. In the present study, a significant ($P<0.05$) effect was observed in DM, OM, CF, NFE and TDN digestibility. No significant ($P>0.05$) difference, however, could be detected for CP and EE digestibility.

Goats had lower digestibility coefficients and TDN than sheep. Maloiy (1974) found no differences in digestibility between East African desert goats and haired sheep fed hay with 6% CP, *ad libitum*. In a comparative study between goats, sheep, cows and buffaloes fed a poor quality roughage *ad libitum* (Sharma and Rajora 1977), goats were superior to the other species in the digestibility of all nutrients. In another study, El Hag (1976) stated that in case of a good quality roughage such as berseem hay there was no difference at all between goat and sheep in digesting the nutrients present in such a feed. This is not in accord with the present results. No significant species x treatment interactions were noted for the variables studied.

Table 2. Apparent digestibility coefficients of Sudan desert sheep and Nubian goats as affected by water restriction

Source main effect		Parameter						
		DM	OM	CP	EE	CF	NFE	TDN
Species (Sp.)	Goat (G)	76.03[B]	76.33[B]	68.31[B]	53.87	79.56[B]	75.50[b]	71.56[B]
	Sheep (Sh)	79.54[A]	79.93[A]	73.94[A]	64.27	83.29[A]	78.83[a]	75.14[A]
	SEM	1.76	1.80	2.82	5.20	1.87	1.67	1.79
Treatment (T)	*Ad lib.* water (T_1)	76.80[b]	77.00[b]	70.68	59.92	80.23[b]	76.01[b]	72.34[b]
	50% water (T_2)	78.77[a]	79.26[a]	71.57	58.22	82.62[a]	78.32[a]	74.36[a]
	SEM	0.99	1.13	0.45	0.85	1.20	1.16	1.01
Sp. x T interaction	GT_1	74.66	74.69	67.39	55.95	77.65	73.93	70.10
	GT_2	77.39	77.97	69.23	51.79	81.46	77.07	73.02
	ShT_1	78.93	79.31	73.97	63.89	82.81	78.09	74.58
	ShT_2	80.15	80.55	73.92	64.65	83.77	79.56	75.70
	SEM	1.18	1.26	1.67	3.12	1.34	1.19	1.21

DM: dry matter; OM: organic matter; CP: crude protein; EE: ether extract; CF: crude fibre; NFE: nitrogen free extract; TDN: total digestible nutrients

[A, B] Within the same column, means with different superscripts differ significantly at $P < 0.01$.

[a, b] Within the same column, means with different superscripts differ significantly at $P < 0.05$.

SEM: Standard error of the mean

Contrary to the findings obtained in this study, several studies found no significant increase in nutrient digestibility with water restriction as in sheep (Ahmed and Abdelatif 1994; Hadjigeorgiou *et al.* 2000) and goats (Silanikove 1987; Lutfi and Ahmed 2010). Ghosh *et al.* (1983) stated that the increased digestibility with reduced free drinking water may possibly be explained in terms of decreased rate of passage of ingesta in the alimentary tract. Bohra and Ghosh (1983) postulated that improvement in the efficiency of digestion in water restricted sheep may not be due to enhanced microbial activity in the rumen, but may possibly be due to an increased absorption of feed nutrients in the hindgut of these animals. Choshniak *et al.* (1988) attributed the better digestibility during water restriction to a longer mean retention time of the digesta in gastro-intestinal tract, in addition to a decrease in the size of particulate matter in the rumen.

N-balance

The effects of water restriction, animal species and water restriction x animal species interaction on nitrogen balance are shown in Table 3. The total N intake was significantly ($P<0.01$) higher in sheep than in goats. El Hag (1976) reported a similar trend in sheep and goats fed on alfalfa (*Medicago sativa* L.) hay, but the difference between the two species was not significant. It has been previously demonstrated that goats drink small volumes of water (More and Sahni 1981). This is accompanied by a reduction in voluntary feed intake (VFI) and consequently decreased N intake by the goats. This confirms the findings of Ajibola (2006) in goats subjected to varying levels of water restriction (30%, 50% and 100%).There was a significant ($P<0.01$) difference in N balance between sheep and goats. The higher N balance value was obtained for sheep. This could be related to the significant increase in N intake in sheep as compared with goats. On the contrary, El Hag (1976) found that goats show non-significantly higher N retention than sheep fed on alfalfa hay.

Table 3. N-balance of Sudan desert Sheep and Nubian goats as affected by water restriction

Source main effect		Parameter					
		N-intake (g/day)	Faecal-N (g/day)	Urinary-N (g/day)	N-balance (g/day)	N-balance as a percentage of N intake	N-balance as a percentage of digested N
Species (Sp.)	Goat (G)	4.89[B]	1.69	0.37	2.83[B]	57.93[b]	88.22
	Sheep (Sh)	7.56[A]	2.00	0.47	5.09[A]	67.28[a]	91.46
	SEM	1.34	0.16	0.005	1.13	4.68	1.62
Treatment (T)	*Ad lib*. water (T_1)	6.33	1.99	0.45	3.88	59.88	88.91
	50% water (T_2)	6.13	1.69	0.40	4.04	65.34	90.77
	SEM	0.10	0.15	0.003	0.008	2.73	0.93
Sp. x T interaction	GT_1	4.89	1.91	0.36	2.61	53.48	87.35
	GT_2	4.89	1.46	0.38	3.05	62.38	89.08
	ShT_1	7.77	2.08	0.54	5.15	66.28	90.48
	ShT_2	7.36	1.92	0.41	5.03	68.29	92.45
	SEM	0.78	0.13	0.004	0.66	3.28	1.08

[A, B] Within the same column, means with different superscripts differ significantly at $P < 0.01$.

[a ,b] Within the same column, means with different superscripts differ significantly at $P < 0.05$.

SEM: Standard error of the mean

N balance, as a percentage of N intake, differed significantly ($P<0.05$) between species. No significant ($P>0.05$) difference, however, was detected when N balance was expressed as a percentage of digested N. Sheep recorded higher values in both cases. The positive N balance observed with both species indicated that N was sufficient to meet the requirements of the animal

The amount of N excreted in the faeces and urine were not affected significantly ($P>0.05$) by animal species. Sheep showed also higher values than goats. This would reflect the higher intake in sheep compared with goats.

No significant treatment and species x treatment interactions were noted for the studied variables. It is worth mentioning that N-balance increased with water restriction. The reverse was true with faecal and urinary N and N intake. These observations are in accord with earlier reports from van der Walt *et al.* (1999) that inadequate drinking leads to decreased N excretion and improved N retention. Ahmed and El Shafei (2001) found also an increase in N retention with water restriction. Yagil (1985) demonstrated that the positive N retention with water restriction in animals on good quality roughage might reflect adaptation to desert conditions whereby animals would acquire the ability to recycle N through the ruminal wall and saliva for microbial synthesis.

Ruminal NH_3-N and pH and BUN

The ruminal NH_3-N and pH and BUN, as affected by water restriction, are presented in Table 4. No significant species x treatment x time interactions were found for rumen fermentation products studied, therefore, main effects are presented and discussed.

The pH values of the rumen fluid were lower ($P>0.05$) in goats than sheep. Lower rumen pH values in goats compared to sheep were also reported by El Hag (1976), who correlated these values with a high concentration of volatile fatty acids (VFA) resulting from a faster turn-over in the goat's rumen. The treatment effect on this variable is, however, not significant. This is not in accord with the results obtained by

Ahmed and Abdelatif (1994) who reported that water restriction significantly decreased the pH. They attributed this reduction to reduction in rumen volume and reduced salivary secretion and the increase in the concentration of VFA. In sheep, the dietary protein is probably better utilized in the body by being converted into amino acids and tissue proteins. The lower potential for protein utilization by goats compared to sheep may explain the higher NH_3-N content in the rumen fluid which is eventually converted to urea and excreted (Allison 1978). Contradicting result was obtained by El Hag (1976) who found that goats make better use of its protein than sheep. Rumen pH is a function of metabolite concentrations. Kannan *et al.* (2007) stated that the higher NH_3 levels may have a lowering effect on rumen pH. Water restriction, however, induced a significant ($P<0.05$) effect on rumen pH before feeding and 3hours post feeding compared with 6 hours post feeding.

NH_3-N decreased significantly ($P<0.01$) with water restriction. This is in contrast to the results of Toha *et al.* (1987a) and Ahmed and Abdelatif (1994) who found that rumen NH_3-N concentrations are not affected significantly ($P>0.05$) by the level of WI.

The NH_3-N concentrations tended to increase ($P<0.01$) three hours after feeding compared with the fasting or six hours after feeding. Lutfi and Ahmed (2010) observed similar trend, however, the NH_3-N concentrations obtained in their study were not affected by sampling time. Toha *et al.* (1987b) found that rumen NH_3-N concentrations 6 hours after feeding were not affected by water restriction. They noticed also a decrease in NH_3-N at 2 hours post feeding in lambs consuming the normal sodium diet subjected to water restriction.

The NH_3-N concentration was higher than rumen NH_3-N concentration of 5 mg/ 100 ml reported by Satter and Slyter (1974) as being necessary for maximal protein synthesis. Owens and Bergen (1983) reported that concentrations varying from 0.35 to 29 mg/100 ml promote maximal microbial growth.

Table 4. . Effect of water restriction and sampling time on rumen pH, ammonia nitrogen (NH_3-N) and blood urea nitrogen (BUN) in Sudan desert sheep and Nubian goats

Source main effect		Parameter		
		Rumen pH	NH_3 –N (mg/100ml rumen fluid)	BUN (mg/ 100 ml blood
Species (Sp.)	Goat (G)	6.76	12.45	28.55^{A}
	Sheep (Sh)	6.89	11.54	21.64^{B}
	SEM	0.007	0.46	3.46
Treatment (T)	*Ad lib*. water (T1)	6.86	13.46^{A}	24.26
	50% water (T2)	6.79	10.53^{B}	25.92
	SEM	0.004	1.47	0.83
Time	BF[1]	6.87^{a}	8.97^{C}	24.12
	3hrs PF[2]	6.92^{a}	14.30^{A}	27.12
	6hrs PF[2]	6.68^{b}	12.72^{B}	24.05
	SEM	0.007	1.58	1.01
Sp. x T interaction	G T_1	6.80	13.92	30.60^{a}
	G T_2	6.72	10.98	26.49^{ab}
	Sh T_1	6.92	13.01	17.92^{c}
	Sh T_2	6.85	10.08	25.36^{b}
	SEM	0.004	0.89	2.64
Sp. x Time interaction	G BF[1]	6.84	8.60	27.48
	G 3hrs PF[2]	6.89	14.76	31.00
	G 6hrs PF	6.55	13.99	27.16
	Sh BF[1]	6.90	9.30	20.75
	Sh 3hrs PF[2]	6.96	13.84	23.23
	Sh 6hrs PF[2]	6.80	11.45	20.93
	SEM	0.006	1.06	1.68
T x Time interaction	T_1 BF[1]	6.94	9.94	23.64
	T_1 3hrs PF[2]	6.92	16.08	26.17
	T_1 6hrs PF[2]	6.72	14.37	22.59
	T_2 BF[1]	6.81	7.99	24.59
	T_2 3hrs PF[2]	6.93	12.52	28.06
	T_2 6hrs PF[2]	6.63	11.07	25.12
	SEM	0.005	1.21	0.75

[1]Before feeding [2] Post feeding

[A, B,C] Within the same column, means with different superscripts differ significantly at P <0.01.

[a, b, c] Within the same column, means with different superscripts differ significantly at P < 0.05.

SEM: Standard error of the mean

Goats showed higher ($P<0.01$) BUN compared with sheep. BUN was affected significantly ($P<0.05$) by species x treatment interaction. Water restriction did not affect ($P>0.05$) BUN in this study. This confirms the results obtained by several research workers (e.g. Ghosh *et al*. 1983; Lutfi and Ahmed 2010). In agreement with previous studies (Ahmed and Abdelatif 1994; Burgos *et al.* 2001) BUN increased with water restriction, suggesting an increase in tissue protein catabolism and (or) a reduction in tissue protein synthesis (Cole *et al.* 1986). The increase in BUN is due to the greater water uptake to kidney and to the decreased blood flow towards the urinary apparatus that causes a reduction of urine and the increase of BUN concentration (Casamassima *et al*. 2008). BUN increased ($P>0.05$) 3hrs after feeding compared with before feeding and 6hrs after feeding values.

In conclusion, during water restriction of 50% of *ad libitum* level efficient water economy is achieved by reducing DMI, urinary and faecal water losses (resulting from a reduction in the ratio of WI:DMI). Generally, water restriction resulted in increased nutrient digestibility (except for EE digestibility which tended to decrease slightly in response to water restriction), TDN and a slight improvement in N retention (resulting from increased N intake and decreased N excretion in urine and faeces). This would indicate adaptation to arid and semi-arid conditions in water restricted animals when DMI is depressed due to water restriction and when low N diet is fed. The results also indicated that the rumen function is more influenced by water restriction rather than by the animal species although CF digestion is markedly improved when considering both species and treatment effects. The results obtained in this study support research data suggesting that direct comparisons between sheep and goats have often produced conflicting results and it is, therefore, difficult to draw clear conclusions especially with respect to the influence of water restriction on the nutritional and physiological parameters investigated in this study.

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الإستجابة الغذائية والفسيولوجية للضأن الصحراوي السوداني والماعز النوبي لتقليل ماء الشرب

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المستخلص: أجريت هذه الدراسة لمقارنة الإستفادة من المادة الغذائية، وتركيز بعض نواتج التمثيل الثانوية في الكرش، ويوريا الدم، والإستجابات الفسيولوجية، لتقليل ماء الشرب في الضأن الصحراوي السوداني والماعز النوبي. وزعت عشوائيا ثلاثة ذكور من كل نوع (غير مخصية وتبلغ من العمر سنة ومتوسط وزن 18.37 كجم للضأن و13.21 كجم للماعز) علي أربع معاملات في تصميم قطاعي كامل العشوائية بتنظيم عاملي 2 x 2 لتقدير تأثيرات نوع الحيوان وتقليل الماء. أعطي كلا النوعين إما علف حتى الشبع وماء حتي الإرتواء أو ماء تم تقليله إلي 50% من مستوي الإرتواء مع علف حتى الشبع. نتج عن نوع الحيوان زيادة معنوية في المادة الجافة المأكولة و ماء الشرب المستهلك والمادة الجافة للروث ومعدل التنفس، ونقص معنوي في نسبة ماء الشرب المستهلك إلي المادة الجافة المأكولة في الضأن مقارنة بالماعز. أظهر الضأن أيضاً قيمة حجم بول أعلي من الماعز. لم تتأثر درجة حرارة المستقيم بنوع الحيوان. نقصت المادة الجافة المأكولة والمادة الجافة للروث وحجم البول نقصاً غير معنوي بتقليل الماء. من ناحية أخرى، نقص ماء الشرب المستهلك ونسبة ماء الشرب المستهلك إلي المادة الجافة المأكولة نقصاً معنوياً بالمعاملة. قيم درجة حرارة المستقيم ومعدل التنفس كانت تقريباً متماثلة عند كلا المستويين لماء الشرب المستهلك. أظهر تفاعل النوع x المعاملة زيادة معنوية في ماء الشرب المستهلك في الضأن مقارنة بالماعز الذي أعطي الماء حتي الإرتواء. نقص ماء الشرب المستهلك في كلا النوعين نتيجة لتقليل الماء. أحدث نوع الحيوان تأثيراً معنوياً علي معاملات الهضم الظاهري للمادة الجافة والمادة العضوية والبروتين الخام والألياف الخام والمستخلص الخالي من النيتروجين والمواد الكلية المهضومة. لم تختلف

هضمية مستخلص الإيثر بين النوعين، وكان للماعز أقل معاملات هضم ظاهري ومواد كلية مهضومة مقارنة بالضأن. بإستثناء هضمية مستخلص الإيثر، فقد زادت معاملات الهضم الظاهري للمواد الغذائية والمواد الكلية المهضومة بتقليل الماء. سجل الضأن أعلي قيمة ميزان نيتروجين وأظهر ميزان النيتروجين نمطاً مماثلاً سواء تم التعبير عنه كنسبة مئوية من النيتروجين المأكول أو النيتروجين المهضوم. لم تلاحظ تفاعلات للنوع x المعاملة في بيانات الهضمية وميزان النيتروجين. ولم يتأثر الرقم الهيدروجيني (pH) والأمونيا- نيتروجين معنوياً بنوع الحيوان. لم يحدث تقليل الماء أي تأثير معنوي علي الرقم الهيدروجيني ويوريا الدم. سجل تأثير معنوي لنوع الحيوان والمعاملة علي يوريا الدم و الأمونيا- نيتروجين، علي التوالي.