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RESEARCH ARTICLE

COLD OR WARM WATER AWASSI SHEEP PREFER UNDER HEAT STRESS?

*Diya AL-Ramamneh

Department of Biology, University College of Tayma, Tabuk University, Tabuk, PO Box 741, Tabuk 71491 Kingdom of Saudi Arabia

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ABSTRACT

The aim of this investigation to verify the effect of providing either cold or warm water on feed intake, physiological parameters, and behavioral responses in sheep under heat stress condition. Twelve Awassi sheep were randomly allocated to two treatment groups with three hours drinking interval and ad libitumfeeding. The first group (N=6) animals were watered warm water coming from water tanks exposed to sun and the second group watered with cold water with a temperature less than 10º C. Individual feed and water intake were measured daily, respiratory rate was measured three times a day, while rectal temperature and body weight were measured once a weekFurthermore, animal behavior by using scan sampling were noticed three times a week. Results showed that water and feed intake per metabolic body weight showed significant differences in both groups, with a higher amount of warm water intake and lower amount of feed intake in the same group. Respiratory rate and rectal temperature were significantly higher in a warm water group. Furthermore, animal behavior confirmed these differences. However, these results suggest that providing of cold water to sheep under heat stresswould dissipate heat better and promote greater animal comfortably.

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INTRODUCTION

In arid environments, livestock is forced to walk long distance seeking feed and water and forced to drink the available water which is influenced by climatic conditions. That is led to increase or decrease in body heat content beyond the animal's normal physiological range, and its ability to cope with an increase or decrease core body temperature (Silanikove, 2000 and Marai, 2007). Water availability is considered as the crucial factor in sustainable animal production, especially in arid and semi-arid areas. Water is an important component of animal nutrition because it fulfills a wide range of physiological and chemical functions inside the animal body for internal metabolism and heat dissipation. The only variation that exists among sources of pure, clean water beside intake by and availability to livestock is its temperature. However, few data concerning effects of water temperature under heat stress condition on the physiological and behavioral reaction of sheephave been reported (Butcher, 1966 and Brod, 1982). Water temperature available to animals may affect water consumption and animal performance (Araújo, 2010). The temperature of the water ingested is also an important factor affecting water intake because water may become a thermal buffer in the rumen-reticulum protecting or changing the fermentation capacity and therefore affecting the microbial function (Araújo, 2010). Several research studies investigate the effects of drinking water temperature on rumination rate (Brod, 1982) ruminal temperatureand recovery to normal ruminal temperature (Bewley, 2008), body temperature (Stermer, 1986), digestibility of the dietary constituents and ruminal fermentation (Brod, 1982) feed consumption (Brod, 1982), milk yield and composition (Andersson, 1985), and live weight change (Savage, 2006), Studies are indicating that cattle prefer warm water between 20 and 28 ºC (10). Other studies indicate that water temperature between 7 and 16 ºC reduces tympanic temperature and respiratory frequency in dairy cattle (Stermer, 1986 and Milam, 1986), other studies indicating that the animals do not prefer water temperature (Milam, 1986; Wilks, 1990; Beck, 2000). Andersson (Andersson, 1985), suggested that warming the drinking water of highproducing dairy cows will improve milk yield. On the other hand, Stermer et al., (Stermer, 1986), found that chilled water (10, 16, 22 °C) was effective in reducing body temperature in dairy cattle by 32 %at milking time. In other studies, Beck et al. (Beck, 2000), did not find any significant differences in milk production when cows consumed water at 17 and 24 ° C. Nevertheless, to our knowledge, no studies have been published on the effect of drinking water temperature on sheep performance and behavior under heat stress condition. Here, we hypothesized that sheep under heat stress condition will drink more cold water to eliminate heat load on their body,

*Corresponding author: **Diya AL-Ramamneh,**
Department of Biology, University College of Tayma, Tabuk University, Tabuk, PO Box 741, Tabuk 71491 Kingdom of Saudi Arabia

therefore, our investigation aimed to verify the effect of providing either cold or warm water on feed intake, physiological parameters, and behavioral responses in sheep under heat stress.

MATERIALS AND METHODS

Animals and Management: The experiment was conducted at the mean maximum environmental temperature was 28.1 ± 0.5 °C, and relative humidity 15.0 ±0.4 % (mean±SD). The investigation was carried out on Twelve healthy adult female sheep of an Awassi breed with an average age of 1.8 ±0.1 years (mean±SD) in individual pens (2.0 X 2.0 m) at the Alghaith Farming Station, Tayma, Tabuk region, Saudi Arabia. All the animals were fed alfa (Medicago sativa L.) ad libitum and water 3 hours aday (10-13 h) during all the experimental period that lasted for three weeks.Housing condition represented by75% shading metal roof with 3 m height and concrete walls surrounding the pens 1 m height with sands bedding. Animals were randomly assigned to two treatment groups of 6 animals each. In the first group, the animals were watered 3 hours warm water coming from water tanks exposed to sun and the second group watered 3 hours a day with cold water with atemperature less than 10°C during all the experimental period.

Table 1. Average body weight, water drunk, dry matter intake, water intake to dry matter intake ratio, respiratory rate, and rectal temperature in Awassi sheep in treatments groups (warm and cold water. Values are means ± SE

Trait	Warm water (N=6)	Cold water (N=6)	SEM*	P-value
Body weight (kg)	59.15^a	59.62^a	3.77	0.929
Metabolic body weight (kg$^{-0.75}$)	21.29^a	21.41^a	1.02	0.931
Water drunk (l d^{-1})	3.65^a	3.00^a	0.30	0.106
Water drunk (g kg BW)	61.66^a	49.19^b	2.57	0.001
Water drunk (g kg BM$^{-0.75}$)	170.66^a	136.81^b	8.37	0.005
Dry matter intake (kg d^{-1})	1.30^a	1.50^a	0.08	0.063
Dry matter intake (kg BW^{-1})	22.08^b	25.31^a	0.73	0.001
Dry matter intake (g kg BM$^{-0.75}$)	7.76^b	11.33^a	0.34	<0.001
WD / DMI*1	3.01^a	2.05^b	0.14	<0.001
Respiratory rate (breath min^{-1})	46.48 ± 1.14^a	36.79 ± 1.14^b	1.14	<0.001
Rectal temperature (° C)	39.27 ± 0.09^a	33.80 ± 0.09^b	0.09	0.001

*1WD/DMI: Water drunk per dry matter intake a, b: values in raws with different letters differ significantly ($P \leq 0.05$)

Water drunk by individuals was recorded daily (24h) by weighing and re-weighing water bucketsbefore and after water administration. Corrections forwater evaporation were made by placing a separate bucket containingwater in an adjacent area to measure the amount of water lost by evaporation. The actual amount of water consumed by the animals was calculated bysubtracting the evaporated amount from the total water intake.Alfa hay with an average DM content of 85.0 ± 1.2% was offered ad libitum daily at 10.00 h,and individual daily feed consumption was measured. About one week adjustment period was provided for all sheep to habituate drinking water in abucket and to standardize watering restriction regime.

Physiological Reactions

Respiratory rate was measured three times a day at 8, 14, and 20 h by counting the rate of flank movement for one minute. Rectal temperature was measured to the nearest 0.1 °C once per week. Individual body weight was recorded to the nearest 10 g at weekly intervals.

Animal behaviors

Behavioral data werecollected by counting the number of animals eating, drinking, standing,and lyingby using scan sampling at 15 minutes intervals per hour three times a week during water offering period. Standing was considered to be when an inactive upright posture (no locomotion), whereas lying down was defined when body contact with the ground. Feeding was defined when head over or in the trough and drinking as the head over or in the water trough.

Statistical Analysis

Analysis of variance was performed using the PROC MIXED procedure of the software package Statistical Analysis System version 9.01 (14). The model included the fixed effect of treatments, (warm vs. cold) and the random effect of animals.

$$Yij = \mu + Ti + Aj + eij$$

where Yij = observation value; μ = overall mean; Ti = water temperature; Aj = random effect of animals; and eij = random error.

The Tukey-Kramer test was used to partition any significant differences among means due to treatments main effect. Significant statistical differences werereported when $P< 0.05$.

RESULTS

Feed and water intake

Water temperature either warm or cold had no significant effect on feed and water intakes per day for both groups. However, when we expressed the feed and water intakes on a whole body weight basis or a metabolic weight basis feed and water intakes showed significant differences either we offered warm or cold water to each group (Table 1). With a higher amount of water intake in sheep offered warm water compared to cold water group. On the other hand, sheep that's received cold water had the significantly higher amount of feed intake compared to warm water group as shown in Table 1. when we expressed ratio water intake / dry matter intake (WI/DMI), we found that sheep that drunk warm water had significantly higher water intake to dry matter intake ratio compared to sheep drunk cold water (Table 1).

Physiological reactions

Water temperature did not significantly influence body weight, and water restriction regime (Table 1) either expressed as a whole body weight or metabolic body weight. Sheep had significantly higher respiratory rates and rectal temperatures in a warm water group than sheep watered cold water (Table 1).

Animal behavior

Live observation confirmed the higher amount of water intake by sheep when they offered warm water three hours a day; sheep visited warm water buckets more often than cold water bucket (P<0.001). While on the other hand, sheep that drunk cold water visited feed bucket more often than sheep drunk warm water as shown in table 2. Standing and laying down behavior did not show any significant differences in both groups.

Table 2. Average daily eating, drinking, standing and lyingdown behavior in Awassi sheep in treatments groups (warm and cold water. Values are means ± SE

Trait	Warm water N=6	Cold water N=6	SEM*	P-value
Eating (N d^{-1})	2.07^{b}	2.75^{a}	0.18	<0.001
Drinking (N d^{-1})	2.79^{a}	1.95^{b}	0.30	<0.001
Standing (N d^{-1})	4.86^{a}	4.70^{a}	0.14	0.258
Lying down (N d^{-1})	1.14^{a}	1.30^{a}	0.14	0.258

*SEM: Standard error of the mean

a, b: values in raws with different letters differ significantly (P≤ 0.05)

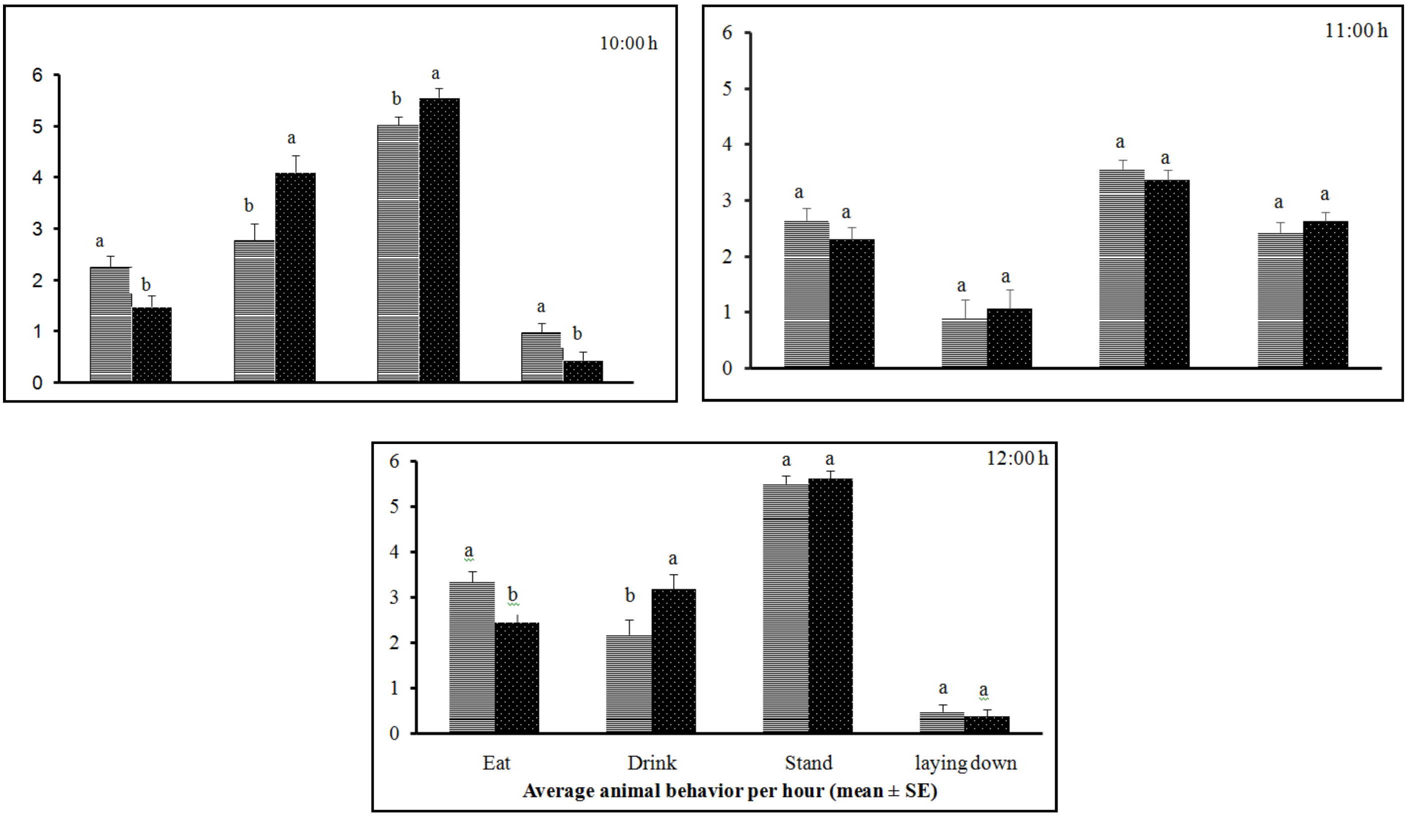

Figure 1. Average animal behaviors areeating, drinking, standing and layingin Awassi sheep watering either warm (black columns) or cold water (gray columns)for three hours (10-13 h) per a day. Values are presented in (Mean ± SE)

The first hour of water offering warm water sheep drunk more water compared than cold water group (P<0.001). While in the second hour both groups did not show any significant differences (P=0.975). In the third hour of offering water sheep drunk more warm water in compared to cold water group (P<0.001). Eating behavior showed that during the first and last hour of water offering sheep that drunk cold water had higher feed intake than sheep drunk warm water as shown in figure 1, while the intermediate watering hour both groups did not show any significant differences in their feed intake (P=0.632).Standing and laying down behavior showed significant differences during the first hour of offering water, while in the second and third hours of water offering did not show any significant differences (Figure1), with higher standing in warm water sheep group and less laying down compared to sheep that drunk cold water.

DISCUSSION

Our investigation showed that under the present water restriction regime and temperate climatic conditions, sheep were not significantly reduced their body weight, indicating that animals were able to adjust to the water deficit during the day.Water restriction also did not affect feed intake and body mass in our study, which is in agreement with results obtained under different environmental conditions (15, 16, 17) in adult goats and sheep.When animals are faced with water shortage, they activate several water-saving mechanisms to minimize water losses and keep essential physiological systems unimpaired (1). In arid environments, solar radiation effects on the behavioral, thermoregulatory, and physiological responses of livestock(18, 19, 20, 21). When animals are subjected to heat stress, they employ several thermoregulatory mechanisms to reduce heat gain by an equivalent loss, maintain their core body temperature, and reach thermal equilibrium (1).Sheep under heat stress performed several physiological reactions include an increase in respiratory and cutaneous evaporative cooling (1, 2), an increase in peripheral blood flow and the suppression of thermogenic hormone production (1, 2). In our investigation sheep had higher respiratory rate and rectal temperature, with lower dry matter intake per metabolic body weight this observation may indicate increased endogenous metabolic heat production that required sheep to be drunk more water per metabolic body weight to dissipate excessive heat load for evaporative cooling. On the other hand, sheep that drunk cold water had lower water intake per metabolic body weight, lower respiratory and rectal temperature with increases their dry matter intake per metabolic body weight. Similar results were obtained where sheep preferred to drink more water at 30 °C than at 20 °C in warm climatic conditions (9). Furthermore, Wilks et al., (12) found that cows offered colder water (10 °C) consumed more feed (3%), drunk more water (7.7%) and had reduced respiration rates and rectal temperature. Several reports have documented the capability of desert sheep to withstand water shortage by reducing their feed intake and therefore endogenous heat production and subsequent water requirement for evaporative cooling (1). In addition, multiple behavioral adaptive mechanisms play themajor role, including, but not limited to, the seeking of shade and more cooling surfaces, change in posture and reduced muscular activity in addition to changing the pattern of feed and water intake (1, 2). However, the capability and speed of fluid replacement in arid adapted animals appear to be higher incomparable to other species. Silanikove (22) reported that ruminants could withstand dehydration and replenish the entire water loss in one drinking bout by storing the ingested water in the rumen, that act as a water reservoir. Our observation of animal behavior revealed that higher frequency of drinking events in sheep drunk warm water might be related to their evaporative cooling mechanisms because sheep panted more frequently. It is proposed that sheep require more water to regulate their body temperature due to their higher rectal temperature, which indicates their endogenous heat production. The behavioral pattern at the time of water offering revealed that sheep visited feed and water bucket significantly during the first and last hour more frequently compared to the intermediate hour (11:00 h) that didn't show any significant differences between both groups. In general, ruminants can substitute 15-20% of their body weight at the first drinking bout and 20-25% within 1 to 2.5 hours (23). In Northern Nigeria, for example, Yankasa ewes have been observed to drink an equivalent of up to 30 % of their body weight within 2 to 3 minutes during the dry season with ambient temperatures ranging from 19-30 °C (24).

Conclusion

A better understanding of the animal x environment interactions shouldcontributeto the estimate of animal needed and types of environmental adjustment for various livestock production systems requirements (25). On atheoretical basis, providing fresh, clean, sufficient, accessible water supply to all animals is obligatory. However, on the reality, this is not always the case. On the other hand, watering points are exposed to direct sunlight and placed too far away from the shadedanimal, wheres animals prefer to stay under shade rather than walking under the sun to get warm water. During this time animals use much of their available body water to dissipate heat through evaporation. Therefore, water trough should be placed in the shade near animals, provide shelter to animals during hot weather, insulate water tanks. If animals are not aperformance to prospects, one of the first factors that should be considered and observed is the drinking water. However, these results suggest that providing of cold water (10 °C) to sheep under heat stresscircumstance, despite not being preferred by the animals, would dissipate heat better and promote greater animal comfort in hot weather.

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