Small Ruminant Research 133 (2015) 123–127

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Resilience of Malpura ewes on water restriction and rehydration during summer under semi-arid tropical climatic conditions

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ARTICLE INFO

Article history:
Received 16 April 2015
Received in revised form 23 August 2015
Accepted 8 September 2015
Available online 11 September 2015

Keywords:
Sheep
Hot environment
Water stress
Blood biochemical
Thermoregulation

ABSTRACT

Fourteen adult Malpura ewes of 2–4 years of age were randomly and equally divided into two groups, including G1 and G2 in order to determine the resilience of Malpura ewes on water restriction and rehydration during summer under semi-arid tropical climatic conditions. The experimental period was divided into three parts, i.e., ad libitum water intake period for one week (first week) then a four week water restricted period and last week rehydration period. During the water restricted period animals in G1 were restricted to 20% and in G2 to 40% of their water requirement. Feed intake increased significantly ($P < 0.05$) in both groups during the rehydration period as compared to restricted periods. Rectal temperature at morning decreased significantly ($P < 0.05$) during the rehydration period in both groups. Hemoglobin (Hb) and packed cell volume (PCV) were higher in G2 during the water restricted period. Cortisol level was significantly ($P < 0.05$) higher during the restricted period as compared to the rehydration period. The results reveal that restriction of water consumption up to 40% during summer leads to physiological and plasma biochemical changes in Malpura ewes. But they can overcome these stressful conditions and recoup their normal physiological conditions by the ad libitum supply of water.

1. Introduction

Scarcity of drinking water for animals is a characteristic feature in the semi-arid tropical region of western India, especially during summer months with high air temperature. In such adverse climatic condition of semi-arid region, livestock production is a challenge and productivity is often compromised (Alamer, 2009).

Small ruminants are an integral part of the farming system, especially sheep is embedded deep in the culture of resource poor small and marginal farmers of semi-arid western India, and it is the major livelihood for them. They mostly follow the pastoral system for sheep rearing (Sejian et al., 2010). Often, the sheep has to walk kilometers as the availability of drinking water in grazing areas are very limited, particularly in summer months. Therefore, the animals need to endure stressful conditions due to high temperature, low feed and water scarcity enroute of grazing on dry barren land (Casamassima et al., 2008). In such conditions, most of the mammals die, if their body water loss exceeds 15% (Shkolnik et al., 1980). However, sheep can survive during drought and malnutrition in the dry season and can tolerate a water loss of up to 20% (Al-Ramamneh et al., 2012). Limited water availability affects feed intake and consequently reduces body weight (Chedid et al., 2014). Although different breeds have a different level of adaptive capability, animals can adapt to some degree to withstand the water scarcity (Kay, 1997). Adaptive capability of animals is assessed through disturbances of normal physiological parameters like thermoregulation, endocrine profile and hematic parameter under stressful condition or under scarcity period. Previous studies indicated that water restriction in sheep increased haemoglobin (Li et al., 2000), blood concentration of hematocrite (Hamadeh et al., 2006), blood concentration of total protein, albumin, cholesterol (Jaber et al., 2004; Casamassima et al., 2008) and plasma cortisol concentration (Li et al., 2000; Kataria and Kataria, 2007). The production loss caused by water stress is similar to that of heat stress and most of the time these two stresses act together and exacerbate the intensity of stress in semi-arid environments (Chedid et al., 2014). The experimental breed of sheep in our study is Malpura breed which is indigenous to the semi-arid region and have evolved to successfully thrive in the environment with limited vegetation and water availability of semi-arid region of western India. Studies have already described the significant effect of water stress

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http://dx.doi.org/10.1016/j.smallrumres.2015.09.004
0921-4488/

Table 1
Meteorological data during experimental period.

	Max temp (°C)	Min temp (°C)	DBT (°C)	WBT (°C)	RH (%)	THI
Morning (0700 h)	37.15 ± 0.70	29.84 ± 0.62	32.01 ± 0.41	26.00 ± 0.12	34.00 ± 4.40	27.97 ± 0.28
Afternoon (1400 h)	41.45 ± 0.598	30.32 ± 0.58	39.28 ± 0.58	27.12 ± 0.16	28.42 ± 2.99	33.29 ± 0.42

Max Temp, Maximum temperature; Min Temp, minimum temperature; DBT, dry bulb temperature; WBT, wet bulb temperature RH, relative humidity; THI, temperature–humidity index. THI was measured by formula given by Marai et al. (2007).

on sheep production and husbandry (Nejad et al., 2014a,b). The changes in various blood biochemical profiles are a characteristic feature in diagnosing various physiological conditions (Padmaja et al., 2006). Therefore, blood biochemical parameters may used a litmus test to predict the adaptability in response to stress conditions.

It is a pertinent question to investigate the effect of water restriction in controlled environment conditions and also to determine the extent of tolerance to water restriction. There is tendency for animals to quickly rejuvenate their body water as soon as a good availability of water is ensured. The adaptive capability in arid and semi-arid environment depends upon both tolerances to water restriction as well as quick rejuvenation. Therefore, the present study was planned to investigate the effect of water restriction on Malpura sheep breed in terms of both tolerance as well as rejuvenation following availability of ad libitum water after water restriction.

2. Materials and methods

2.1. Location of experiment

This experiment was conducted at Central Sheep and Wool Research Institute, Avikanagar, Rajasthan, India. The area is geographically located at longitude 75°28′E and latitude 26°26′N and at an altitude of 320 m above mean sea level. This area is under semi-arid tropical climate with very hot and dry summer season. The average annual temperature and relative humidity of this area ranges from 4 °C (minimum) to 46 °C (maximum) and 10% (minimum) to 85% (maximum), respectively. The annual rainfall in this area ranges from 200 to 500 mm with an erratic distribution throughout the year. The experiment was carried out in the hot summer months (June–July). Average temperature–humidity index (THI) was calculated using the formula given by Marai et al. (2007) in Table 1.

2.2. Experimental animals

The experiment was carried out on Malpura sheep which is well adapted native breed of semi-arid tropical region, reared for its mutton, wool and skin. Fourteen 2–4 years old cyclic Malpura ewes were selected for the study and average body weight of the ewes at selection was 38.86 ± 1.28 kg. The animals were housed in well ventilated asbestos roofed and mud floored shed. The animals were maintained under proper hygienic conditions throughout the experimental period. The prophylactic measures were taken against sheep pox, peste des petits ruminants (PPR), enterotoxaemia, endo parasitic and ecto parasitic infestations as per the schedule of the Institute Animal Health Division. The experiment was conducted after taking approval from the institutional animal ethics committee for subjecting the animals to water restriction.

2.3. Experimental procedure

Fourteen sheep were randomly allotted to two groups viz., G1 and G2, seven animals in each. The whole experiment was carried out in a six week period. In the first week of experiment, ad libitum water was provided to sheep both in G1 and G2 individually in a bucket with 5 l of water from 0730 h to 1830 h and the residue was measured. Daily individual animals ad libitum water consumption was recorded for 7 days on residual basis. Average ad libitum water (Odour, Unobjectionable; Turbidity, nil; pH, 8.29; Total dissolved solids, 280 mg/l, Total hardness as $CaCO_3$, 170.15 mg/l; Calcium hardness as Ca, 36.07 mg/l; magnesium hardness as Mg, 19.44 mg/l; chloride Cl, 28.07 mg/l; alkalinity to (P) as $CaCO_3$, 5.50 mg/l; alkalinity to (M) as $CaCO_3$, 154.12 mg/l; nitrate as NO_3, 19.17 mg/l; sulphate SO_3, 3.25 mg/l; iron as Fe, BDL (<0.01) mg/l; fluoride as F, 0.19 mg/l; sodium as Na, 58.01 mg/l) intake per day per animal for each individual animal for the 7 day period was estimated. After estimating the ad libitum water intake in the first week, the ewes of G1 and G2 were provided with 20% less and 40% less than their ad libitum water intake for next four weeks. After four weeks of water restriction period ewes were again provided with ad libitum water for one week period to assess the resilience and rehydration capability. During this one week period procedure of water offering and measuring water intake was similar to that of the first week (Table 2). All the animals were individually stall fed from 0730 h to 0630 h. The diet consisted of 70% roughage (*Cenchrus ciliaris*) and 30% concentrate (barley, 650 g/kg; groundnut cake, 320 g/kg; minerals 30 g/kg including 10 g/kg NaCl, with crude protein 180 g/kg and total digestible nutrients 650 g/kg). Daily feed intake was estimated on an individual basis. Initial body weight was recorded and thereafter at the end of each week on individual basis early in the morning before offering feed and water. Rectal temperature (RT) was recorded on weekly basis once at 0700 h and again at 1400 h. Blood samples were collected weekly once.

Table 2
Effect of rehydration to water restricted Malpura ewes on water intake, feed intake and body weight.

	Water intake (ml)				Feed intake (DMI g/$W^{0.75}$/day)				Body weight (kg)			
	G1	G2	SE	*P* value	G1	G2	SE	*P* value	G1	G2	SE	*P* value
Ad libitum	3549^{x}	3578^{x}	190.51	0.915	57.58^{xy}	54.70^{xy}	2.64	0.455	38.87	38.86	1.88	0.996
Restriction	2839^{ay}	2147^{by}	132.91	0.003	54.13^{y}	51.54^{y}	1.97	0.37	38.43	37.56	1.57	0.703
Rehydration	3084^{axy}	2727^{bz}	93.49	0.019	62.62^{x}	60.40^{x}	2.10	0.468	38.86	38.91	1.76	0.982
P value	0.008	0.001			0.038	0.048			0.961	0.878		

G1, 20% water restricted; G2, 40% water restriction. DMI, dry matter intake. Mean value of same parameters having different superscript (a,b) within a row differ significantly ($P < 0.05$) between the groups (G1 and G2) of different stage of watering (ad libitum, restriction and rehydration). Mean value of same parameters having different superscript (x,y) within a column differ significantly ($P < 0.05$) between the different watering stages (ad libitum, restriction and rehydration) with in a group.