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Physiological Responses of Naimey Sheep to Heat Stress Challenge under Semi-Arid Environments

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ABSTRACT

Eight Naimey sheep were used in this study to determine the effect of heat stress on body temperature, heart rate and some blood constituents. The results show that exposure to heat stress challenge resulted in a significant increase in RT, RR, and skin temperature sites. Heart rate rhythm exhibit a circadian rhythm and exposure to heat stress reduce the heart rate mainly during the hottest part of the day. The effect of heat stress was also observed on total serum thyroxin and triiodothyronine.

Key Words: Heat stress; Heart rate; Sheep; Rectal temperature; Thyroxin; Triiodothyronine

INTRODUCTION

Sheep are very important farm animals in Saudi Arabia, especially the Naimey breed. One of the major problems facing the Naimey sheep is the heat stress and the high ambient temperature that remains above the thermoneutral zone for at least 8 months (Ali *et al.*, 1999). The thermal environment is a major factor that can negatively affect sheep performance. Increased body temperature and respiration rate are the most important signs for heat stress in sheep. The increase in body temperature is associated with marked reduction in feed intake, redistribution in blood flow and changes in endocrine functions that will affect negatively the productive and reproductive performance of the sheep (Abouheif & Alsobayel, 1982, 1983: Eltawill & Narendran, 1990). These physiological adjustments are essential to maintain normal body temperature and to prevent hyperthermia (Bhattacharya & Uwayjan 1975; Al-Haidary, 2000; Lowe *et al.*, 2001). Moreover, under these conditions the animal's productivity severely affected that result in a tremendous economic loss for the sheep industry. There is a limited data dealing with the effect of heat stress challenge on the thermoregulatory system of sheep. Therefore, the objective of this trail was to determine the effect of heat stress on sheep and to gain better understanding of the thermoregulatory system of heat stressed sheep.

MATERIALS AND METHODS

Eight Naimey sheep (51.0±2.66 kg average body weight) were used in this study to determine the effect of heat stress on body temperature, heart rate rhythm and for red blood cell (RBC) counts, packed cell volume (PCV), hemoglobin (Hb) concentration , mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC). Animal were housed in semi-environmental chamber in the Animal production department farm, King Saud University, Riyadh. One room was assigned as control (average room temperature 23.6^{o}C & 50% relative humidity) and the other room was served as heat stress room (ambient temperature was cycling reaching maximum during middle of the day (1100-1700 h). The study lasted for five weeks, the first two weeks were adaptation period in which both rooms were maintain at 23.6^{o}C followed by three weeks experimental period whereas room temperature (Fig. 1) increased gradually until it reached the heat stress level (33-38.5^{o}C). Feed offered twice a day at 0700 and 1600 h, water was available *ad libtium*. Ambient temperature (Ta), and relative humidity (RH) were recorded throughout the study. Blood samples were collected from the jugular vein, on a weekly basis. Blood was then analyzed shortly after collection for RBC, PCV , Hb, MCV, MCH, and MCHC using the coulter count. Serum was separated and stored at -20^{o}C until analyzed for the thyroxin (T_4), triiodothyronine and (T_3) concentrations. Thyroxin and triiodothyronine were determined by radioimmunoassy, solid phase technique from Diagnostic Products Corporation, Los Angles, CA, USA. Rectal temperature (RT) was measured by thermistor probe (VWR Scientific Digital Thermometer). Skin temperatures were measured in four different locations (neck, back, right hip and left hip) in shaved, cleaned sites using non-contact infrared thermometer (VMR Scientific Horiba). Heart rate was monitored by Mini-Logger 2000 (Mini-Mitter Co, Bend OR, USA). Respiratory frequency (RR) was measured by counting the flank movement and was expressed as number of breath per minute. All of these measurements along with the heart rate rhythm were repeated during exposure to heat stress. Data were statically analyzed using SAS (Goodnight *et al.*, 1985). The mean response data were analyzed with an ANOVA using the general linear model proceeding in SAS. The responses differences were considered to be significant when the probabilities were less than 0.05.

RESULTS AND DISCUSSION

Sheep are homoeothermic animal, they can maintain near constant body temperature under wide range of environmental conditions. Under thermoneutral condition they can keep their body temperature in a normal ranges utilizing sensible heat loss (Convection, conduction and radiation) to dissipate body heat to the surrounding environment. The hyperthermia during exposure to heat stress is the result of decreased thermal gradient between animal and the surrounding environment, and as a result sensible heat loss becomes less effective. Under these conditions animal must relay on evaporative cooling mechanisms from the skin and the respiratory tract. In the present study exposure to heat stress results in a significant (P<0.01) increase in rectal temperature (RT) (Table I), this was associated with a significant increase in respiratory frequency (RR) and skin temperature sites (P<0.05). The increased in RR is an attempt to increase respiratory evaporization and the higher skin temperature can be attributed to the partially to the fact that exposure to heat stress alter the blood flow and redistribution of blood flow and increase blood flow to the surfaces. Similar finding was recently reported by Al-Haidary (2000), Ashutosh and Kundu (2000), Sudarman and Ito (2000), Sunagawa *et al.* (2002) and Srikandakumar *et al.* (2003). Respiratory rate and RT have been shown to be good indicators of the thermal stress and may be used to assess the adversity of the thermal environment.

Values for heart rate in the present study fall well within the range of recently published data for heart rate determined direct in sheep using a stethoscope (Sleiman & Abi Saab, 1995), ECG (Mir *et al.*, 2000) and data logger (Ariel *et al.*, 2002). Heart rate exhibits a diurnal rhythm (Fig. 2) reaching maximum (160 beat/min) at middle of the day (1300-1700 h) and minimum (70 beat/min) during early morning (0600-0800) with a daily average of 115.7±.1. Recent study has showed that heart rate of sheep exhibited circadian rhythm reaching maximum during the middle of day (Lowe *et al.*, 2001). Barkai *et al.* (2002) working with sheep found heart rate of sheep show a clear diurnal pattern, the lowest value occurred at night and the highest value were recorded during the middle of the day.

Exposure to heat stress reduced (P<0.01) the daily average of heart rate (115.7 and 85.8±.11 beat /min for the control and heat stress group, respectively). The heart rate rhythm of heat stressed group also exhibited a circadian rhythm reaching maximum earlier (1000-1200 h) than the control ones. Several investigators have reported that there is a correlation between heart rate and metabolic heat production (Holmes, 1976; Fukuhara *et al.*, 1983; Yamamoto & Ogura 1985; Barkai *et al.*, 2002). On the other hand exposure to heat stress is well known to reduce the metabolic heat production to minimize the heat load and maintain normal body temperature. Therefore, the results from the present study show that heat stress challenges reduce heart rate, and the mark reduction of heart rate occurred during the hottest part of the daily cycle (1200-1700 h). Aharoni *et al.* (2003) have suggested that heart rate decreased because the general effort of the animal to decrease heat production. This reduction could be achieved by the animal either by intake reduction of by activity reduction or both. Others (Bhattacharya & Uwayjan 1975; Sunagawa *et al.* 2002) did not detect any significant changes in hear rate when animals exposed to heat stress. Ghosh and Pan (1994) and Bhattacharya and Hussain (1974) found significant increased in heart rate.

Exposure to heat stress resulted in a significant (P<0.05) increase (Table II) in Packed cell Volume (PCV). The higher PCV Values has been reported to be an adapted mechanism to provide water necessary for evaporative cooling process. In the contrary, El-Nouty *et al.* (1990) and Singh (1983) have reported a significant depression in PCV for the heat stressed cattle and they attributed that to the hemodilution effect where more water is transported in the circulatory system for evaporative cooling. There was no effect of heat stress on hemoglobin in agreement with Srikandakumar *et al.* (2003).

Fig. 1. Ambient temperature in the control and heat stress rooms

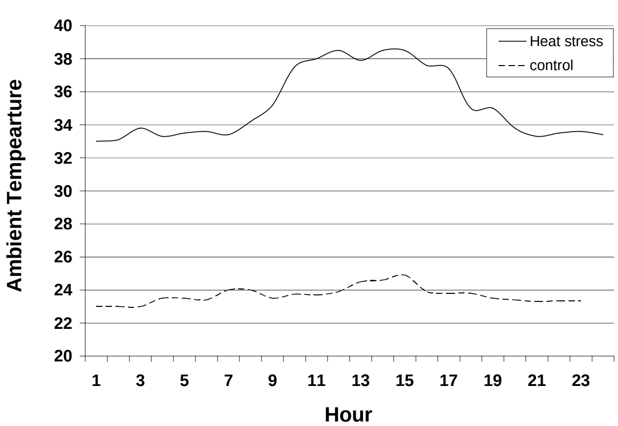
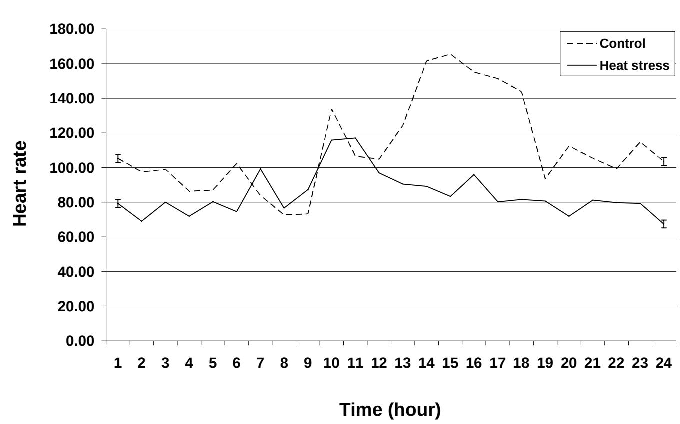


Fig 2. Heart rate rhythm of the control and the heat stressed sheep



Many investigators have reported that the higher body temperature during exposure to heat stress is associated with significant depression in thyroid gland activity resulting in a lowering of thyroid hormones level (Ross *et al.*, 1985). Other investigators did not detect any significant changes in thyroid hormones level. In the present study, exposure to heat stress challenge did not result in significant changes in the thyroid hormones concentrations (Table II).

Table I. Effect of heat stress challenge on body temperature and heart rate of Naimey sheep

Parameters	Treatment		SE
	Control	Heat stress	
Rectal temperature (°C)	39.3[b]	39.7[a]	0.08
Respiratory rate (no/min)	61[b]	80[a]	3.40
Skin temperature of the neck (°C)	32.5[b]	33.4[a]	0.31
SK2 Skin temperature of the back (°C)	32.2[b]	33.5[a]	0.35
Skin temperature of the right hip (°C)	31.8[b]	33.7[a]	0.60
Skin temperature of the left hip (°C)	32.6[b]	33.6[a]	0.30
Heart rate (beat/min)	115.17[a]	85.77[b]	0.70

Table II. Effect of heat stress challenge on some blood constitutes of Naimey sheep

Parameteres	Treatment		SE
	Control	Heat stress	
Red blood cell counts	7.9	8.4	0.24
Hemoglobin	11.05	11.4	0.21
Packed cell volume	27.3[b]	29.2[a]	0.60
Mean cell volume	34.7	34.9	0.50
Mean cell hemoglobin	14.1	13.6	0.30
Mean cell hemoglobin concentration	40.7[a]	38.9[b]	0.63
Platelets	361.5	415.4	19.10
Thyroxine	.63	.57	0.04
Triiodothyronine	1.15	1.05	0.04

Values in the same row with different superscript differ ($P<0.05$)

Our results show that exposure to heat stress challenge resulted in a significant increase in RT, RR, skin temperature sites. The heart rate rhythm exhibit a circadian rhythm and the exposure to heat stress reduce the heart rate mainly during the hottest part of the day. Therefore, protecting animals from the heat stress during this time is highly recommended.

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