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Long term cyclic heat stress influences physiological responses and blood characteristics in indigenous sheep

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Abstract

The present study was designed to elucidate changes in physiological and blood parameters of indigenous sheep during cyclic heat exposure. Twelve 2-4 year-old sheep with an average body weight of 10.5±0.5 kg were randomly allocated to one of three experimental heat treatments: control (21°C, stall feeding), short term (21°C to 32°C; 32°C for 4 h/d, grazing), and long term (21°C to 32°; 32°C for 8 h/d, grazing).The results have shown that sheep exposed to cyclic heat treatments exhibited higher (P=0.05) rectal temperature, body temperature, and respiratory rate compared to the control group. Cyclic heat treatments significantly decreased heart rate of sheep. There was a sharp reduction in rumination and an increase in time spent by sheep in eating during cyclic heat treatments. Long term heat treatment significantly increased RBC and WBC counts, PCV values, and hemoglobin level than that of the control and short term heat treatments. Similar responses were also observed in plasma glucose, uric acid, aspartate aminotransferase, and blood urea nitrogen levels. These results suggest that short term heat stress is tolerable but long term is physiologically detrimental to them to indigenous sheep.

Key words: Blood characteristics, cyclic heat stress, indigenous sheep, physiological responses

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Introduction

Heat stress is an important determinant in the intensive animal production system, particularly in tropical and sub-tropical countries. Productivity and animal welfare significantly compromised due to heat stress in the animal agriculture in many regions of the world. Heat stress not only causes physiological dysfunctions leading to suffering and death in the animals but also reduces performance and profitability. Generally, three categories of heat stress such as chronic, acute and cyclic are prevailed in hotter regions of the world. Chronic one is a non-lethal stress that can be applied for long period of time. However, acute one results in hyperthermia and can lead to death if animals are exposed to the heat stress during long period. Cyclic nature of heat stress is generally practiced to animals because of their short duration of thermal load and way of adaptation to thermoneutral temperature.

Sheep are important farm animals in tropic and sub-tropic regions. High temperature with high or low humidity lasted at least 6-8 months in the tropic and sub-tropic regions, resulting in the increased body temperature and severe heat stress (Ali et al. 1999). The rectal temperature generally provides a good indication of deep body temperature. The higher magnitude of increase in rectal temperature in small ruminants during the period of heat stress suggests that these animals can store body heat during the periods of heat stress. Under physiological conditions, their deep body core temperatures are fully remained constant by an increment in sensible heat loss (convection, conduction and radiation) and/or thermal gradient between animal and the surrounding environment. However, under stressful conditions, the above mechanism is less effective. Therefore, animals must rely on evaporative cooling mechanisms from the skin and the respiratory tract.

The relationship between heat stress and growth or reproductive performance is well documented (Abouheif and Alsobayel 1983). Heat stress markedly depressed feed intake, average body

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weight gain, and increased sudden death in sheep, particularly in summer times (Abdel-Hafez 2002). Heat-stressed sheep exhibited higher body temperature and respiration rate (Al-Haidary 2004). Several findings also showed that high temperatures or stressed conditions could alter the blood characteristics especially RBC counts (Zeidan and Abbas 2004), WBC counts (Bhattacharya and Uwayjan 1975), PCV values (Aatish et al. 2007), and hemoglobin level (Al-Haidary 2004) in sheep. Moreover, it was reported that heat stress altered glucose, blood urea nitrogen, potassium, chloride, and aspartate aminotransferase levels of sheep (Bhattacharya and Uwayjan 1975; Nazifi et al. 2003).

Indigenous breeds particularly in tropical environment are considered to have some levels of resistance to high ambient temperature (Srikandakumar et al. 2003, Soleimani et al. 2011). However, it is not clear yet what is their physiological threshold for heat stress perception. Therefore, the current study aimed to investigate the effects of different heat exposure magnitude on some physiological and behavioral response of indigenous sheep.

Materials and Methods

Experimental materials: Experiments were performed in sheep and goat farm of the Department of Animal Science, Bangladesh Agricultural University, Bangladesh during July of the year 2011. Twelve castrated male indigenous sheep 2-4 years old, weighing 10-11 kg were used in this experiment. The animals were housed in individual wooden pens (1.0 m × 1.2 m) with concrete floors in an open-sided barn for a 14-d adaptation period with experimental barn at ambient temperature 21°C and relative humidity 68%.

Treatments: Twelve sheep were divided at a uniform body weights into three groups. Four animals for each group were subjected to short term (21°C to 32°C; 32°C for 4 h/d, 10 AM to 2 PM, grazing) and to long term (21°C to 32°C; 32°C for 8 h/d, 9 AM to 5 PM, grazing) heat exposure. The control sheep were maintained at 21°C and 68%. Ambient temperature and relative humidity for the heat exposed groups were 32°C and 87%, respectively. Both temperature and relative humidity for all treatments were recorded throughout the study. The animal was returned to individual pen just after end of each heat protocol and also moved out for heat treatment. Similar protocol was applied for a period of 21-d. Feed offered twice a day at 7 AM and 7 PM, and water was supplied *ad libitum*.

Blood collection and measurements: Blood was collected through jugular into EDTA tubes, placed in ice and analyzed shortly after collection for RBC, PCV, Hb using the coulter count. Blood samples were centrifuged at 3000 rpm for 10 min to separate plasma. Blood tests for albumin, glucose, triacylglycerols, sodium, potassium, chloride, blood urea nitrogen, uric acid, and aspartate aminotransferase were conducted using standard assays in an accredited Shodesh hospital laboratory.

Physiological parameters assessment: Digital thermometer was used for measuring rectal temperature in sheep exposed to different thermal load. Body skin temperatures were measured using non-contact infrared thermometer. Respiration rate was recorded by observing the flank movement of sheep. Heart rate was measured using a stethoscope. Rumination time and bolus time were determined with stop watch.

Statistical analysis

Values are given as means ± standard error of mean. Duncan's multiple-range tests were applied to assess the significance of differences between means. All analyses were performed with the aid of the GLM procedure of SAS software (SAS, 1985).

Results

Table 1 showed the effect of heat stress on physiological traits in sheep . Sheep exposed to short and long term cyclic heat stress significantly ($p<0.05$) increased rectal temperatures, body temperature, and respiratory rate when compared to the control group. On the other hand, both short and long term cyclic heat treatments significantly ($p<0.05$) decreased heart rate as compared to their counterpart.

Table 1. Heat stress induced changes in physiological parameters

Parameters	Control	Heat stress	
		Short term	Long term
RT (°C)	38.2 ^{b}±0.5	40.3^{a}±0.2	40.8^{a}±0.1
BST (°C)	34.9^{c}±0.8	38.7^{b}±0.4	40.5^{a}±0.4
RR (breath /min)	19.5^{c}±1.9	122.8^{b}±1.0	131.5^{a}±1.2
HR (beat /min)	108.3^{a}±2.5	99.8^{b}±1.1	95.5^{b}±0.8

RT, rectal temperature; BST, body skin temperature; RR, respiratory rate; HR, heart rate; Means with different superscript within a row differed significantly (p<0.05)

The results of time in eating and rumination are presented in Table 2. Eating time was significantly (p<0.05) increased in sheep when exposed to cyclic heat treatments compared to the sheep kept at control temperature. Cyclic heat treatments caused significant (p<0.05) reduction in rumination time in sheep.

Table 2. Changes in eating and ruminating time due to heat treatments

Measurements	Control	Heat stress	
		Short term	Long term
Eating time (min)	283.3^{b}±2.5	325.6^{a}±5.4	335.5^{a}±3.4
Ruminating time (min/h)	11.3^{a}±0.4	9.8 ^{b}±0.5	8.5^{b}±0.3

Means with different superscript within a row differed significantly (p<0.05)

Changes in blood constituents are presented in Table 3. Blood cellular components such as RBC count, WBC count, PCV value, and hemoglobin level were higher (p≤0.05) in long term cyclic heat treatment than that of the control and short term heat treatment. Short term cyclic heat treatment did not show any change in blood constituents compared to the control group.

The plasma glucose, uric acid, aspartate aminotransferase, and blood urea nitrogen levels after long term cyclic heat treatment were significantly higher (p≤0.05) compared with control and short term heat treatment. Plasma potassium concentrations were decreased by long term heat stress. In contrast, there were no such changes occurred to any plasma parameters between control and short term heat-exposed sheep (Table 4).

Table 3. Changes in blood constituents due to cyclic heat treatments

Measure-ments	Control	Heat stress	
		Short term	Long term
RBC (million/m^{3})	9.18^{b}±0.34	9.75^{b}±0.13	10.75^{a}±0.10
WBC (thousan/mm^{3})	7.10^{b}±0.64	7.75^{ab}±0.30	8.85^{a}±0.17
PCV (%)	25.93^{b}±1.03	27.80^{ab}±1.0	29.28^{a}±0.47
Hb (g %)	8.83^{b}±0.24	9.20^{ab}±0.16	10.10^{a}±0.43

RBC, red blood cell; WBC, white blood cell; PCV, packed cell volume; Hb, hemoglobin; Means with different superscript within a row differed significantly (p<0.05)

Table 4. Changes in blood parameters due to cyclic heat stress

Measure-ments	Control	Heat stress	
		Short term	Long term
Albumin mmol/L	127.5^{a}±4.8	132.5^{a}±11.0	152.3^{a}±10.3
Glucose mmol/L	2.46^{b}±0.10	2.62^{a}±0.04	2.99^{a}±0.14
TGC mmol/L	0.37^{a}±0.14	0.36^{a}±0.05	0.28^{a}±0.07
BUN mmol/L	5.18^{a}±0.54	4.05^{ab}±0.52	3.45^{b}±0.39
Uric acid mmol/L	51.50^{b}±5.74	73.75^{b}±3.12	107.2^{a}±12.3
Sodium mEq/L	151.8±1.44^{a}	148.5^{ab}±0.98	146.3^{a}±1.1
Potassium mEq/L	6.10^{a}±0.25	5.10^{ab}±0.14	5.13^{b}±0.11^{b}
Chloride mEq/L	112.0^{a}±3.4	108.5^{a}±2.8	105.5^{a}±2.3
AAT IU/L	220.3^{b}±14.2	278.8^{ab}±44.6	352.3^{a}±26.5

BUN, Blood urea nitrogen; TGC, Triacylglycerols; AAT, Aspartate aminotransferase; Means with different superscript within a row differed significantly (p<0.05)

Discussion

In mammals, respiration is directed at the elimination of CO_2 from the tissues of the body and the provision of O_2 under thermo-neutral conditions, and evaporation of moisture from the respiratory tract and prevention of hypothermia under high ambient temperatures. Heat stress generally increased rectal temperature to irrespective of species, suggesting that animals have the ability to store body heat upon exposure to heat stress. Moreover, exposure to heat stress, animals' skin temperature significantly increased and the increase in body temperature may be responsible for the alteration in blood circulation system. Therefore, respiratory rate and rectal temperature might be useful tools to assess the adversity of the thermal environment. As expected, exposure to short or long term cyclic heat stress resulted in the elevation of rectal temperature (RT), skin temperature (ST) and respiratory rate (RR) (Table I). These results confirmed previous observations that heat stress augmented the RT, ST and RR in sheep (Ashutosh and Kundu 2000; Sudarman and Ito 2000; Srikandakumar et al. 2003; Al-Haidary 2004).

Some novel findings reported that heart rate decreased in ruminant animals at stressful conditions, and there is a strong positive correlation between heart rate and metabolic heat production (Holmes et al. 1976; Barkai et al. 2002). Animals strive to keep reduced metabolic heat production to minimize the heat load for maintaining normal body temperature. Therefore, the present findings showed that heart rate was decreased due to heat stress time dependently (Table 1). It was postulated that heart rate decreased because the general effort of animal to decrease heat production. This reduction could be achieved by the animal either by intake reduction or by activity reduction or both (Aharoni et al. 2003).

Slight changes in the thermal environment could induce specific physiological responses in the digestive system, such as a decrease in blood flow to rumen (76% under severe stress and 32% under moderate stress), reduction of ruminal motility and reduction of rumination (Christopherson 1985). The present study shows that eating time was significantly ($p<0.05$) increased in sheep when exposed to cyclic heat treatments compared to the sheep kept at control temperature. Cyclic heat treatments significantly decreased rumination time in sheep (Table 2). Similar results were reported by Mateus et al. (1992).

Blood cellular components such as RBC counts, WBC count, PCV value, and hemoglobin level were higher ($p<0.05$) in long term cyclic heat treatment than that of the control and short term heat treatments. Short term cyclic heat treatment did not show any change in blood constituents compared to the control group. Long term cyclic heat treatment showed higher stress-responsive alteration in blood constituents compared to short term group, due to severity of heat treatment. These results are consistent with those of Zeidan and Abbas (2004), Bhattacharya and Uwayjan (1975), Aatish et al. (2007) and Al-Haidary (2004) who reported that high temperatures or stressed conditions could alter the blood characteristics especially RBC counts, WBC counts, PCV values and hemoglobin level in sheep.

Heat stress markedly increased glucose, blood urea nitrogen, potassium, chloride, and aspartate aminotransferase levels of sheep (Srikandakumar et al. 2003; Bhattacharya and Uwayjan 1975; Nazifi et al. 2003). The present study also showed that the plasma glucose, uric acid, aspartate aminotransferase, and blood urea nitrogen levels increased significantly ($p<0.05$) after long term cyclic heat treatment compared with control and short term heat treatments. Plasma potassium concentrations were decreased by long term heat stress. In contrast, plasma parameters did not differ between control and short term heat-exposed sheep (Table 4). These results suggest that the experimental conditions employed here are suitable for the identification of physiological and biochemical characteristics of sheep under heat stress conditions.

Our results show that cyclic heat treatments either short or long term in nature induce changes in physiological and behavioral traits. Blood parameters are significantly altered in sheep when exposed to long term cyclic heat treatment compared to control and 4h heat treatments. These results suggest that short term heat stress is tolerable but long term is physiologically detrimental to indigenous sheep.

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References

Aatish HU, Sindhu Z, Iqbal Z, Jabbar A, Tasawar Z (2007). Prevalence of sheep Mange in different Dera Ghazi Khan (Pakistan) and associated hematological/ biochemical disturbances. International Journal of Agricultural Biology. 9: 917-920.

Abdel-Hafez MAM (2002). Studies on the reproductive performance in sheep. PhD Thesis. Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Abouheif MA, Alsobyal AA (1983). Environmental and genetic factors influencing birth weight of black Najdi lambs. World Review of Animal Production. 19: 51.

Aharoni Y, Brosh A, Kourilov P, Arieli A (2003). The variability of the ratio of oxygen consumption to heart rate in cattle and sheep at different hours of the day and under different heat load conditions. Livestock Production Science, 79: 107-117.

Al-Haidary A (2004). Physiological responses of Naimey sheep to heat stress challenge under Semi-Arid environments. International Journal of Agricultural Biology, 6: 307-316.

Ali K, Al-Haidary AA, Alshaikh M, Hayes E (1999). The effect of evaporative cooling in alleviating seasonal differences in milk production of Almarai dairy farms in the Kingdom of Saudi Arabia. Asian-Australasian Journal of Animal Sciences, 12: 590-596.

Ashutosh D, Kundu R (2000). Physiological responses of native and crossbred sheep to climate stress under semi-arid conditions. Indian Journal of Animal Science, 8: 857-861.

Barkai D, Landau S, Brosh A, Baram H, Molle G (2002). Estimation of energy intake from heart rate and energy expenditure in sheep under confinement or grazing condition. Livestock Production Science, 73: 237-246.

Bhattacharya AN, Uwayjan M (1975). Effect of high ambient temperature and low humidity on nutrient utilization and some physiological responses in Awasi sheep fed different level of roughage. Journal of Animal Science, 5: 320-328.

Christopherson RJ (1985). The thermal environment and the ruminant digestive system. In: Yousef MK (ed) Stress physiology in Livestock. Vol 1. CRC Press, Boca Raton,

Holmes C, Stephens S, Toner J (1976). Heart rate as a possible indicator of the energy metabolism of calves kept out-of doors. Livestock Production Science, 3: 333-341.

Mateus JR, Paranhos da Costa, Roberto Gomez da Silva, Roberto Carlos de Souza (1992). Effect of air temperature and humidity on ingestive behavior of sheep. International Journal of Biometerology, 36: 218-222.

Nazifi S, Saed M, Rowhagni E, Kaveh K (2003). The influence of thermal stress on serum biochemical parameters of Iranian fat-tailed sheep and their correlation with triiodothyronine (T_3) and thyroxine (T_4) and cholesterol levels. Comparative Clinical Pathology, 12: 135-139.

SAS (Statistical Analysis Systems) (1985). User's Guide: Statistics. 5th edition. Carry, NC, SAS institute. Inc.

Soleimani AF, Zulkifli I, Omar AR, Raha AR (2011). Physiological responses of 3 chicken breeds to acute heat stress. Poultry Science, 90: 1435-1440.

Srikandakumar A, Johnson EH, Mahgoub O (2003). Effect of heat stress on respiratory rate, rectal temperature and blood chemistry in Omani and Australian Merino sheep. Small Ruminant Research, 49: 193-198.

Sudarman A, Ito T (2000). Heat production and thermoregulatory responses of sheep fed different roughage proportion diets and intake levels when exposed to a high ambient temperature. Asian-Australasian Journal of Animal Science, 13: 625-629.

Zeidan AEB, Abbas HE (2004).Physiological and biochemical changes in the ewe during breeding and non-breeding seasons. Zagazig Veterinary Journal, 32: 37-48.