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Effects of extreme high and low environmental temperature in Bangladesh perspective on clinical parameters in goats

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Abstract

In this study, Black Bengal (BB) goats' physiological characteristics were examined in relation to high and low ambient temperatures. The investigation was carried out throughout the winter months (November- February) and the summer months (April- July). Twelve experimental Black Bengal goats of either sex was used in this experiment and were aged between 2-3 years old with a body weight of 18 to 23 kg. A digital hygrometer and thermometer installed in the animal shed were used to record the daily temperature in the surrounding air and relative humidity to compute the temperature-humidity index (THI). Physiological parameters (respiratory rate, heart rate and rectal temperature) of the animals were noted daily during the experimental period. According to this study, all of the animals endured extremely high levels of heat and cold stress in the summer and winter, with the temperature humidity index (THI) recorded in the summer was 30.5 ± 0.51 and the winter was 16.37 ± 1.51. Throughout the summer and winter, all BB goats showed significant alterations in their clinical parameters. The results of the study indicated that seasonal and recording-time differences in rectal temperature, heart rate, and respiration rate were statistically ($P<0.05$) substantial. It has been found that THI in Black Bengal goats is more influenced by ambient temperature than relative humidity and is a sensitive indication of both heat and cold stress. Therefore, heat stress is associated with certain physiological effects in Black Bengal goats.

Keywords: Summer; Winter; Heat stress; Physiology; Goats

1. Introduction

Livestock are exposed to various forms of stress, including chemical, nutritional, psychological, physical, and thermal stress [1] and are well-adapted to a variety of environmental circumstances, including severe and harsh climates [2, 3]. Animal survival is most seriously threatened by heat stress among other climatic stresses [3]. Changes in rectal temperature, heart rate, and respiration rate have all been used extensively to identify physiological adaptation to heat stress in small ruminants [4]. Goats are more suited to thrive in difficult environments than other household ruminants since they can adapt to a variety of agroclimatic scenarios [3]. Climate stress divides the body's resources, such as protein and energy, at the expense of a decline in development, reproduction, output, and overall well-being. Environmental elements that affect animal performance directly or indirectly include humidity, sunlight radiation, and ambient temperature [5]. The most crucial indicators of thermal stress in goats are elevated body temperature and respiration rate [6, 7]. Black Bengal goats make an important contribution to most families in Bangladesh because they are drought-tolerant and most disease-resistant [8]. They must have developed signaling pathways that allow them to survive at very high temperatures of 48-500 [9]. Therefore, goats are an ideal species for studying the effect of heat stress and to investigate the factors affecting heat tolerance. For this, the present work aimed to determine the effect of heat stress on physiological parameters in Black Bengal goats in different seasons (summer and winter).

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2. Materials and methods

2.1. Location

The experiment was carried out at the Research Animal Farm (RAF), Department of Surgery and Obstetrics, Bangladesh Agricultural University.

2.2. Experimental Animals

Twelve experimental goats used in this experiment were aged between 2-3 years old with body weight between 18 to 23 kg. Animals were kept in a semi-intensive housing system under a well-ventilated animal shed and proper hygienic conditions and they were allowed to graze for 6 hours and were supplemented with a concentrate mixture and green fodder daily.

2.3. Climatological Measurements

The ambient temperature and relative humidity data of the experimental days were collected from a digital hydrometer installed in the animal shed of RAF, Department of Surgery and Obstetrics, BAU. The experiments were conducted during two distinct phases that coincided in two seasons of the year viz. summer season (April – July) and winter season (November – February). The environmental parameters were recorded twice daily in the morning and afternoon.

2.4. Calculation of Temperature Humidity Index

Based on ambient temperature and relative humidity, Temperature Humidity Index (THI) was calculated with the formula Marai et al. [10]:

$$THI = tm^0 c - \{(0.31- 0.31 \times RH) \times (tm^0 c - 14.4)\}$$

Where,
tm^0 c = Temperature in Celsius
RH = Relative humidity percentage/100.

The THI values are classified as follows: <27.8= absence of heat stress, 27.8 - < 28.9= moderate heat stress, 28.9 - <30.0 = severe heat stress, and 30.0 and more = very severe heat stress [10].

2.5. Clinical Examination

Clinical parameters (rectal temperature, respiratory rate, and heart rate) of the animals were recorded daily during the summer and winter seasons. Rectal temperature (RT) was recorded by a clinical thermometer. Respiratory rate (RR) was determined by means of visual observation of chest movement. Heart rate (HR) was recorded by auscultation of the heart with a flexible stethoscope.

2.6. Statistical Analysis

All the data were expressed as Mean ± SEM (Standard Error of Mean). The Statistical Package for the Social Science (SPSS) version 20.0 was used to run an independent sample t-test to compare the data between the groups. Probability $P<0.05$ was regarded as statistically significant.

3. Results

Table 1 contains data on the meteorological conditions during the experimental days. During the experiment, the average ambient temperature was 31.52 ± 1.63 (°C) and 16.35 ± 1.53 (°C) in the summer and winter seasons respectively. The average relative humidity was approximately 80.61± 3.15 in summer and 98.35 ± 1 in the winter season. Based on data on ambient temperature (AT) and relative humidity (RH), the calculated THI was 30.5± 0.516 during the summer season and 98.35 ± 1 in the winter season. Hence, the THI value was 30.5± 0.51 which indicates that the animals in the summer season were in heat stress condition.

Table 1 Ambient temperature, relative humidity, and temperature-humidity index (THI) of the summer and winter seasons

Season	**Ambient Temperature (AT)** (°C)	**Relative Humidity (RH)**	**THI**
Summer	31.52 ± 1.63	80.61± 3.15	30.5± 0.51
Winter	16.35 ±1.53	98.35 ±1.0	16. 37 ± 1.51

Physiological data of Black Bengal (BB) goats indicates body temperature, respiratory rate, and heart rate, and the seasonal variations in the physiological parameters of BB goats are compiled in Table 2. The findings revealed that there were statistically significant ($P<0.05$) differences in rectal temperature, heart rate, and respiration rate between seasons and recording periods. There was a statistically significant ($P< 0.05$) variation found in the rectal temperature of BB goats during the summer and winter seasons. The respiration in Black Bengal goats changed significantly between the summer and winter seasons. The variation in mean heart rate of Black Bengal goats was altered in different seasons and the changes were statistically significant ($P< 0.05$). However, In the morning, there was a substantial ($P<0.05$) decrease in the recorded values of temperature, heart rate, and respiration rate compared to the afternoon values.

Table 2 Physiological data of Black Bengal goats during summer and winter seasons

Season	**Time**	**BT** (°F)	**RR (/min)**	**HR (/min)**
Summer	Morning	101.43 ± 0.92^{ax}	34.3 ± 8.15^{ax}	85.8 ± 10.10^{ax}
	Afternoon	102.93± 0.98^{bx}	44.43± 12.30^{bx}	99.23 ± 9.74^{bx}
Winter	Morning	100.27 ± .23^{ay}	23.34 ± 1.00^{ay}	76.00 ± 3.760^{ay}
	Afternoon	101.89 ± .23^{by}	41.45 ± 2.28^{by}	102.66± 3.32^{by}

$^{a, b, x,y}$ Mean (± SE) within a column showing different superscripts are significantly different ($P<0.05$).

4. Discussion

Temperature humidity index (THI) is used to quantify the degree of heat and cold stress in various livestock animals since it is difficult to measure the degree of heat stress in animals using a single environmental variable. The temperature humidity index (THI), which combines relative humidity and ambient temperature, was introduced as a method of assessing the intensity of heat stress [10]. During this study, During the summer, each experimental animal were having severe heat stress; however, during the winter, the THI values showed that each animal was comfortable. There was no heat stress during this period which is agreed with the score of Marai et al. [10].

The degree of stress experienced by animals is reflected in physiological reactions such as rectal temperature, respiration rate, and heart rate [11]. Rectal temperature is an accurate indicator of deep body temperature that depicts thermal balance, therefore it can be used to evaluate the consequences of heat stress [12]. In this study, body temperature rises more in the afternoon and the significant increase in rectal temperature is attributed to the increased ambient temperature and these results coincide with those of Al-Hidary et al. [13] and Marai et al. [14].

In physiological responses, respiratory rate is the first observation during heat stress. The goats' increased rate of respiration is caused by the fact that they mostly depend on their respiratory activity to dissipate heat and regulate their body temperature in hot weather [15]. Respiration rate (RR) has been used to evaluate the level of heat stress in goats [16]. In the present study, the RR of Black Bengal goats during the winter season changes significantly as compared to the summer seasons. During winter or thermoneutral season, RR of adult goats remains low [17] which is similar to this study. In BB goat breeds, the RR during the summer season i.e., during high THI, increased which indicated that animals were stressed [15].

In this study, heart rate during the winter season was found significantly higher in Black Bengal goats as compared to the summer season at different times of recording which was contrary to the other findings Sejian et al. [3]. A higher heart rate during the summer season suggests active participation in the thermoregulatory protective mechanism of goats.

5. Conclusion

It can be concluded that the physiological parameters of BB goats were significantly altered by heat stress in both the summer and winter. Higher THI is associated with significantly increased levels of rectal temperature, heart rate, and respiratory rate. Therefore, further study should be taken to investigate the blood biochemical parameters under heat stress conditions in summer and winter seasons in BB goats.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no conflict of interest to declare.

Statement of ethical approval

The study has been performed with the approval and guidelines of the Animal Welfare Experiment and Ethics Committee (AWEEC) of the Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh (permission Number: AWEEC/BAU/2022/08

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