

Thermal imaging and physiological responses of crossbred goats under different housing system during hot humid season

SV Singh*, AK Misra¹, Gaurav Kumar and Apeksha Ukey

Received: 20 February 2023 / Accepted: 20 April 2023 / Published online: 23 June 2023

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Abstract: In order to observe the effect of hot humid (July-August) season on physiological responses and skin surface temperature, eighteen adult female crossbred goats were selected divided equally into three groups i.e. Group I (control), Group II (modified shed) and Group III (open environment) based on their body weight. These animals were fed as per the standard feeding schedule followed at NDRI, Karnal. The average respiration rate of group I, II and III was 76.11 ± 1.03 , 67.22 ± 0.06 and 70.49 ± 0.61 per minute respectively during morning hours. The RR increased significantly during afternoon over morning values in all the groups due to increase of THI. The rectal temperature of goats during morning hours was 38.73 ± 0.02 , 38.57 ± 0.03 and $38.68 \pm 0.03^\circ\text{C}$ in group I, II and III respectively and no significant change in RT was observed during the afternoon. The overall lowest and highest skin temperature were recorded at the lower part of legs and ears respectively in group I and II, whereas in group III the highest skin temperatures was found to be at dorsal and lowest at ventral region of the body. The information generated may serve as normal reference values for crossbred goats under different housing conditions and may be useful for predicting the animal welfare and prognosis of diseases.

Keywords: Heat stress, Infrared thermography, Physiological responses

Heat stress is one of the limiting factors worldwide for livestock production under changing climatic scenario. Goats are considered the best-suited animal among the farm animals to survive under tropical climatic conditions. It is well known fact that thermal stress negatively affects the productive and reproductive performance of goats by reducing feed intake, growth performance, milk production, immunity, reproductive efficiency and quality meat production. Hence, the efforts should be made for enhancing the adaptive capacity of goats to reproduce and perform better under extreme weather conditions. Tropical breeds of goat are well adapted to the different agro-climatic conditions where they have evolved and are thriving well on low quality roughages and extreme stressful conditions where high yielding exotic and crossbred animals succumb (Akinyi 2008). Therefore selection of goat breeds that are best suited to a broad range of environmental conditions is needed. Compared to another livestock species, goats acquire several unique morphological and physiological adaptive traits. Welfare of goats could be examined based on several indicators including behavioral, physiological, reproductive and productive responses. In order to understand the adaptive mechanisms of crossbred goats to heat stress, the present study was planned under different housing system during most stress period of the year i.e. hot humid season.

Eighteen adult crossbred (Alpine x Beetal) goats were selected from the Livestock Research Centre of ICAR-National Dairy Research Institute, Karnal (Haryana) and further divided equally (6 in each group) into three groups. Group-I animals were kept under existing housing system, group-II was kept under modified shed with fan and group-III were kept in open environment. Karnal is situated at an altitude of 250 meter above mean sea level at latitude of ($29^\circ 42' \text{N}$) and longitude of ($79^\circ 54' \text{E}$). The maximum ambient temperature during summer goes up to 45°C and minimum temperature in winter comes down to 0°C with a diurnal variation of $15\text{-}20^\circ\text{C}$. The experiment was conducted during hot humid season (July and August) and physiological parameters viz. respiration rate (RR) and rectal temperature (RT) was recorded in morning (09.45- 10.15AM) and in afternoon (2.15-2.30PM). Physiological parameters were recorded using standard methods i.e. respiration rate by counting the flank movement and rectal temperature by using digital thermometer. Thermograph of

Animal Physiology Division
ICAR-National Dairy Research Institute, Karnal (Haryana)-132001

¹LPM, ICAR-NDRI, Karnal

SV Singh (✉)
Email: sohanvir2004@yahoo.com

different group of animals were also taken using non contact infrared camera and body surface temperature were recorded from thermographs at different anatomical sites viz. head, dorsal and ventral region, ear, lower and upper leg of goats. The data was analyzed for mean, standard error and their significance. The environmental parameters in terms of dry and wet bulb temperature were recorded for calculation of temperature humidity index (THI) using the following formula.

$$THI=0.72 (Dbt+Wbt) + 40.6$$

Where: Dbt = dry bulb temperature in °C and Wbt = wet bulb temperature in °C

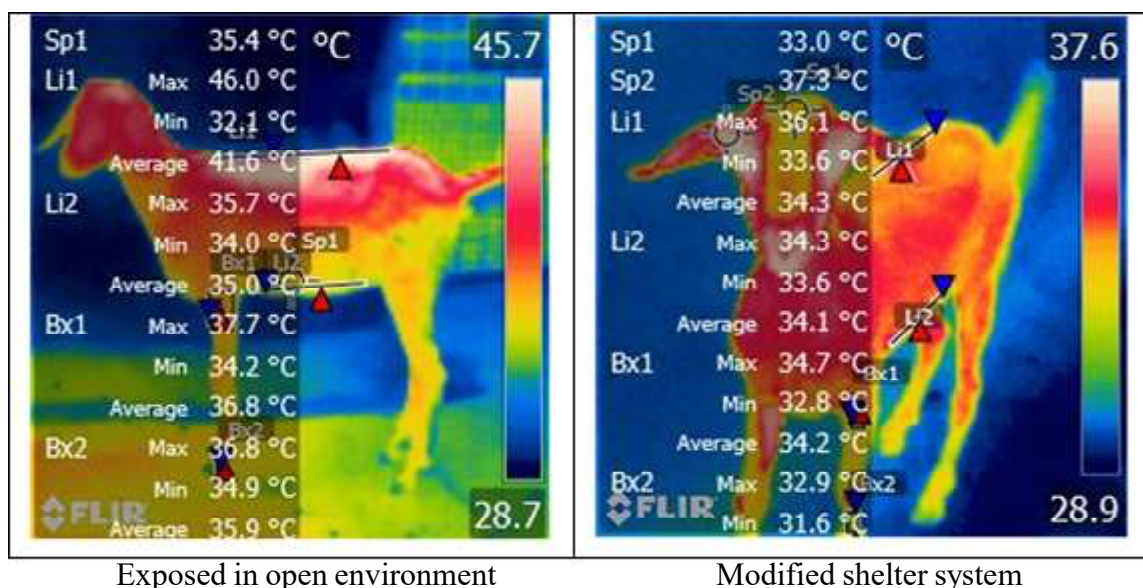
The average morning THI was lowest in modified shed (81.86) followed by control (83.53) and outside (85.28). Vaidya et al. (2017) also reported the almost similar values during July and August months. The mean ambient temperature and relative humidity recorded during the present study was higher than the thermoneutral zone established for sheep and goats by Ayo et al. (1998) and Silanikove (2000). THI is commonly used to measure the level of heat stress in dairy animals (Armstrong 1994).

Heat stress affects the physiological parameters of goat drastically that causes the huge economic loss (Panda et al. 2016). Physiological parameters viz. rectal temperature, respiration rate and heart rate are the best indicators for assessing the adaptability of goats (Al Dawood, 2017). Sanusi et al. (2011) reported the higher rectal temperature and pulse rate in heat stressed goats. Respiration rate is used as the reliable indicator of heat stress (Okoruwa 2014). During the present investigation, the average respiration rate of group I, II and III was 76.11±1.03, 67.22±0.06 and 70.49±0.61 breaths per minute respectively during forenoon. The RR was found to be lower in the group II animals which were maintained under fan in the shed followed by group III and group I. The RR increased significantly during afternoon over morning values in all the groups due to increase of THI. The results of the present study are in agreement with Hooper et al. (2018) and Alam et al. (2011) who reported higher respiration rate during heat stress in goats. Fahmy (1994) also reported higher respiration rate of goats during summer compared to winter and during walking by Khan and Ghosh (1989). When high relative humidity is combined with the high ambient temperature; there was a further increase in respiratory frequency of goats (Phulia et al. 2010; Hamzaoui et al. 2013). The severity of heat stress can

Table 1: Effect of different housing systems on physiological responses and skin temperatures (°C) at different anatomical sites of crossbred goats

Groups	Parameters	Forenoon	Afternoon	Overall Mean ± S.E
Control (Group-I)	Respiration Rate/min	76.11±1.03	89.23 ^b ±0.85	82.67±1.45
	Rectal Temperature (°C)	38.74±0.02	38.83±0.44	38.78±0.41
	Skin temperature at different anatomical sites (°C)			
	Head	35.48±0.23	35.87±0.16	35.68±0.14
	Dorsal	35.87±0.64	38.50±1.94	37.18±1.05
	Ventral	34.25±0.33	35.52±0.79	34.88±0.45
	Ear	37.55±0.25	37.95±0.25	37.75±0.18
	Upper Leg	35.52±0.14	36.57±0.58	36.04±0.33
	Lower Leg	34.32±0.35	35.15±0.69	34.73±0.39
	Modified shed(Group-II)	Respiration Rate/min	67.22±0.56	88.22 ^b ±0.60
Rectal Temperature (°C)		38.56±0.03	38.82±0.02	38.69±0.02
Skin temperature at different anatomical sites (°C)				
Head		34.42±0.35	34.90±0.17	34.66±0.20
Dorsal		34.88±0.22	35.38±0.11	35.13±0.14
Ventral		34.35±0.39	34.73±0.20	34.54±0.22
Ear		37.02±0.23	37.47±0.42	37.24±0.24
Upper Leg		34.83±0.26	35.42±0.21	35.13±0.18
Lower Leg		33.47±0.32	34.75±0.11	34.11±0.25
Outside(Group-III)		Respiration Rate/min	70.48 ^a ±0.61	91.98 ^b ±0.73
	Rectal Temperature (°C)	38.66±0.02	38.67±0.31	38.67±0.16
	Skin temperature at different anatomical sites (°C)			
	Head	36.13±0.63	40.08±1.12	38.11±0.85
	Dorsal	40.10±0.56	41.75±1.00	40.93±0.60
	Ventral	35.90±0.75	37.27±0.58	36.58±0.50
	Ear	38.28±0.43	39.95±0.28	39.12±0.35
	Upper Leg	36.87±0.66	38.93±0.71	37.90±0.56
	Lower Leg	36.30±0.73	38.73±1.17	37.52±0.75

Fig. 1 Thermographs of crossbred goats in different housing systems



be categorized according to panting rate (breaths/min) (low: 40–60, medium: 60–80, high: 80–120, and severe: >200), as it appears to be the most accessible and easiest way for evaluating the impact of heat stress (Silanikove 2000). The increased respiration rate is probably indicating an effort of animals to maintain their normal body temperature by increasing their heat dissipation through evaporative cooling.

Measurement of rectal temperature is an important method for evaluation of physiological status of the farm animals as well as an ideal indicator of their adaptability to extreme climatic conditions (Sanusi et al. 2011). The rectal temperature of goats during forenoon was 38.73±0.02, 38.57±0.03 and 38.68±0.03°C in group I, II and III respectively. Slight increase in the rectal temperature of goats was observed during afternoon over forenoon values. The results of the present study are in accordance with Swenson and Reece (2006) who reported that the rectal temperature of goats varies from 38.3°C to 40.0°C and are used as an indicator of stress. No significant changes in rectal temperature of goats during present study in afternoon with the increase in THI is inconsistent with those of Fahmy (1994) and Marai et al. (2007), who reported that heat stress increased rectal temperatures in goats. The reason for the difference in the results might be due to different experimental conditions and/or breed and age of goats.

The skin surface temperature (ST) of goats was recorded at different anatomical sites during forenoon and afternoon. The skin surface temperature of all experimental groups of goats was numerically higher during afternoon compared to forenoon values. This higher skin temperature during afternoon is mainly due to increase in THI. Darcan et al. (2007) also reported the increase in skin temperature due to increase in THI. The lowest overall mean values of ST was recorded at the lower part of legs

i.e. 34.73±0.39 °C, 34.11±0.25 °C in group I and II respectively, whereas in group III the lowest value (36.58±0.50 °C) was found at ventral region of the goats. These observations of lower skin temperature are in accordance with Phulia et al. 2010. Kelly (2006) also reported significant lower temperature of lower part of the legs. Whereas the highest skin surface temperature was recorded at ears and dorsal surface of the goats (Table 1). Ayo et al. (1998) and Minka and Ayo (2014) also reported the highest values on the ears region of the body. The skin temperature of head, upper part of leg was in between the temperature of ear/ dorsal and lower leg/ ventral region of the body (Table-1). These variations in the skin temperature at different anatomical sites might be due to the direct exposure of the body parts to the ambient conditions and the muscular activity of the different body parts.

Conclusion

IRT may be a useful non-invasive and accurate tool to detect the level of environmental stress and can also be used for diagnosis of inflammatory diseases. Further the results demonstrated the effects of high THI on the daily rhythmicity of physiological responses of crossbred goats. The information generated may also be beneficial for the evaluation of the welfare and productivity of small ruminants under hot humid conditions. Finally it can be stated that the crossbred goats must be protected from direct exposure to higher THI conditions.

Acknowledgements

Authors thankfully acknowledge the Director, ICAR-NDRI, Karnal for providing the required facilities to accomplish this research work.

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