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Exploring the interplay between skin temperature and rectal temperature as a key to assess heat stress in early lactating crossbred dairy cattle#

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Abstract

The thermal stress adversely affects the health and production of crossbred dairy cattle of Kerala especially when the animals are in the early lactation. The purpose of the current study is to investigate correlation between skin temperatures (ST) at various body regions with in-house temperature humidity index (THI) and rectal temperature (RT) so as to understand the feasibility of measuring ST for assessing heat stress in animals. Out of the total two sets of experimental animals used for the study, the first set included six crossbred cattle with their early lactation falling in the identified period with the least THI (December- February, season [illegible]). The second set comprised of animals with their early lactation falling in the maximum THI period (March- May, season [illegible]). In-house temperature, relative humidity and ST (forehead, neck, udder, forelegs and ear) were recorded at a three day intervals at 10.00 A.M., 2.00 P.M. and 5.00 P.M. A significant increase in ST was noted in all the five body regions during heat stressed season ($p<0.05$). The ST at neck and forehead showed strong correlation with ITHI and RT across specified time intervals within the second season. A consistent correlation was shown by the ST at forelegs with RT and ITHI even at moderate elevation of RT and ITHI. So it can be concluded that at higher RTs, measurements of ST from forehead and neck would give more reliable indication whereas the levels at which the body crossed the thermoregulatory threshold could clearly be identified from foreleg ST.

Keywords: *Heat stress, early lactation, skin temperature*

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Global climatic change has inflated the environmental temperature and humidity which had a great impact on livestock production and welfare. Especially in the challenging environment like hot humid tropical climate, maintaining optimum conditions for animal wellbeing and production has become even more difficult (Velayudhan *et al*., 2023). In par with the global trend, Thrissur district in Kerala, India also showed a significant elevation in ambient temperature by 0.6°C between 2011 and 2016 (Jisha, 2020). During heat stress, the animal is forced to use thermoregulatory mechanisms to maintain its physiological homeostasis by expending enormous energy which would otherwise have been used for production and maintenance. During the early lactation period, dairy cattle will experience severe metabolic stress due to high energy and nutrient requirements for sustained milk production. Heat stress and lactation stress will have a combined effect on animals that calve during the hot humid season of the year.

Evaluating the skin temperatures on the different body regions of animal will provide the idea about the intricate relationship between an animal's core temperature and the surrounding environment temperature (Velayudhan *et al*., 2023 and Yadav *et al*., 2017). It might also help in finding reliable skin temperature indicators for assessing an animal's heat load. So mapping of skin temperature can be used as a tool to understand the animal's thermal load status and also it decreases the need to depend on the invasive rectal temperature measurements (Salles *et al*., 2016). Understanding the association of skin temperatures of different locations with the thermal stress experienced by the animal would be of great help in adopting strategies to mitigate heat stress by targeting specific body regions.

Materials and methods

Location of study and collection of data

The research work was conducted at University Livestock Farm and Fodder Research and Development Station (ULF & FRDS), Mannuthy, Kerala Veterinary and Animal Sciences University (KVASU), Thrissur district in Kerala state. The research was carried out in two distinct phases: the first spanning three months, from December 2022 to February 2023, characterised by a relatively modest influence of heat stress; and the second phase from March to May, lasting another three months, during which the environment underwent a significant escalation in THI levels (Jisha, 2020). Two distinct sets of healthy animals were chosen for this study. In the first set, a group of six early lactating crossbred cattle, which had calved in the month of December was selected and designated as the control group. In the second set, animals that had calved in March were selected to ensure that these animals would fall within the heat-stressed category (March to May typically experiences elevated temperature-humidity index levels).In-house temperature (°C) and relative humidity (%) within the shelter were documented using an electronic digital logger (testo 174H, Testo SE &Co.KGaA, Germany) at three-day intervals during the course of the experiment, specifically at 10:00 A.M., 2:00 P.M., and 5:00P.M, and THI was calculated using those data (LPHSI, 1990). Skin temperature was recorded at 10.00 A.M, 2.00 P.M and 5.00 P.M by using an infrared thermometer (Testo 835- T1, Testo, Testo SE &Co.KGaA, Germany) on the udder, forehead, forelegs, neck and back of ear skin.

Analysis

Correlation of skin temperature of different body parts with varying THI and RT at 10.00 A.M, 2.00 P.M and 5.00 PM during both seasons were analysed by Pearson's correlation coefficients method using SPSS 24.0 version.

Results and discussion

Correlation of skin temperature with THI and RT

Skin temperature of neck and forehead showed significant (positive) correlation with THI in all the specified time intervals of second season (Table 1). Jeelani *et al*. (2019) observed that the skin temperature of head region showed highest direct relationship with THI and also observed that ST at head region followed the same trend as that of RT. In the current study, the significant (positive) correlation

Table 1 Pearson's correlation coefficients (r) of skin temperature (ST) at different body parts with varying in-house temperature humidity index (THI) of 10.00 AM, 2.00 PM and 5.00 PM

	Season	In-house THI		
		10.00 AM	2.00 PM	5.00 PM
Neck	I	0.351	0.120	-0.494
	II	0.661**	0.881**	0.701**
Forehead	I	0.381	-0.712**	-0.311
	II	0.757**	0.838**	0.729**
Udder	I	-0.324	-0.717**	-0.570*
	II	0.948**	0.700**	-0.263
Ear	I	0.200	-0.423	-0.187
	II	0.779	0.781**	0.123
Forelegs	I	0.247	0.701**	0.816**
	II	0.837**	0.719**	-0.766**

***Correlation is significant at 0.01 level (2-tailed)*
**Correlation is significant at the 0.05 level (2-tailed)*

(Table 2) noted between RT and ST of forehead and neck during elevated temperature is in agreement with the observation of Jeelani *et al*. (2019). It might be due to the limited influences by secondary factors such as contact with floor during lying, soaking the bedding with water etc. or due to less heat loss through sweating as the surface area is less in those regions compared to the others. Salles *et al*. (2016) used infrared thermography and mapped the temperature distribution of skin in cattle and found that the highest association with RT was noted for ST of forehead.

The relationship between ST in forelegs with RT and THI remained consistently correlated even at some moderate levels of RT and THI (not only during the highest temperatures) as depicted in tables 1 and 2. Salles *et al*. (2016) also found a higher correlation between ST at forelegs and THI and suggested that this might be highlighting the vital role of forelegs in facilitating heat exchange between body and its surroundings. The body extremities possess extensive venous network enabling effective heat dissipation. So during hot periods there will be increased blood supply towards these extremities to increase the heat loss (Burhans *et al*., 2022), and this might be the reason for observing alterations in foreleg temperature even at moderate levels of elevations in RT and THI which were not always appreciable in other parts of the body. So it can be concluded that for measuring hyperthermia or fever, forehead and neck temperature are more reliable. However, the first area to show alterations will be the forelegs when the body

Table 2. Pearson's correlation coefficients (r) of rectal temperature (RT) with the varying skin temperature (ST) at different body parts of 10.00 AM, 2.00 PM and 5.00 PM.

Time	Season	Neck	Forehead	Udder	Ear	Forelegs
10.00 AM	I	0.301	0.332	-0.276	0.181	0.181
	II	0.227	0.305	0.831**	0.544*	0.567*
2.00 AM	I	-0.190	-0.067	-0.277	0.057	0.458
	II	0.875**	0.827**	0.687**	0.780**	0.722**
5.00 PM	I	-0.312	0.063	-0.209	0.159	0.504*
	II	0.686**	0.704**	-0.353	-0.114	-0.726**

***Correlation is significant at 0.01 level (2-tailed)*
**Correlation is significant at the 0.05 level (2-tailed)*

crosses the thermoregulatory threshold and the rectal temperature begins to rise gradually. The reason for not getting a correspondingly increased correlation at higher temperatures may be due the efficient thermoregulatory mechanisms existing in the legs. Management practices adopted for alleviating thermal stress like wetting of the floor may also affect the readings from legs.

Kim (2018) analysed the behaviour pattern of cows with increasing THI and found that cows spend more time standing in order to enhance the ability to release heat from their body surfaces by maximising the surface area. Due to the higher importance of legs in thermoregulation the heat stressed animals will always show the tendency to stand up in stressed periods of the day. If such conditions prolong for longer periods of time the chances for developing laminitis will be more in these animals.

While considering the udder ST, even though it showed the highest correlation values (Table 1and 2) due to its highest metabolic activity, it presented a non-linear correlation. At some points, it showed very weak correlation, which might be due to the influence of the same secondary factors mentioned above. Kaufman *et al.* (2018) also observed a weak correlation between udder ST and THI and suggested that udder ST may be used to measure thermal load only at controlled environment and under natural conditions.

Conclusion

Skin temperature serves as an effective tool in assessing the heat stress in livestock during summer months. Skin temperatures in the neck and forehead exhibit a strong correlation with RT and THI in comparison to other anatomical sites. Skin temperature measurements from forelegs would be more reliable to assess the level at which the RT starts increasing during heat stress, as minor fluctuations in RT will be reflected in the skin temperature of forelegs. So in the absence of confounding factors, ST can be employed as a reliable indicator to assess the heat stress in crossbred dairy cattle.

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Conflict of interest

The authors declare that they have no conflict of interest.

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