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Could roof modification in buffalo shed during summer affect skin temperature in heifers!

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Abstract
An attempt was made to study the effect of microclimate alterations on skin temperature of buffalo heifers during summer at buffalo farm of LPM, LUVAS, Hisar (Haryana). Twenty buffalo heifers (8-18 months of age) were divided into four groups (5 heifers in each group) *viz.* T_1 (control): Corrugated asbestos roof; T_2: Corrugated asbestos roof painted white on upper side; T_3: Corrugated asbestos roof having EPE (Expanded polyethylene) sheet on lower side and T_4: Corrugated asbestos roof painted white on upper side and EPE sheet on lower side. Skin temperature was recorded for every animal at 7:00 AM as well as 2:00 PM at fortnightly intervals. The overall skin surface temperature at different body locations was always significantly ($P<0.05$) high in T_1 at 7:00 AM as well as 2:00 PM. So it can be concluded that heifers kept in EPE sheet in modified sheds (T_3 and T_4) kept the values of skin temperature on lower side proving its superiority for thermal insulation**,** whereas; asbestos roofs without any modification (T_1) got heated up in the forenoon and releases heat as thermal radiation in afternoon causing heat stress in heifers.

Keywords: Buffalo heifer, roof modifications, EPE sheet, white paint, skin temperature

Introduction
The study of skin temperature is an important aspect to provide proper care and management to improve health especially in a tropical country like India where the production capacity of the animals is hampered by the thermal stress caused due to extreme weather conditions. The ability of the animal to maintain normal body temperatures by cutaneous and respiratory heat dissipation plays a predominant role in adaptation of cattle in hot climates (Gebremedhin and Wu, 2001) [6]. If the skin surface temperature is below 35^{0}C, the temperature gradient between the core and skin is large enough for the animals to effectively use all routes (i.e., convection, conduction, radiation, and evaporation) of heat exchange (Cappola *et al.* 2002) [4]. Above this surface temperature, animals begin to store heat, rectal temperature rises and cutaneous heat loss plays the major role in body temperature control mechanism besides increased respiration rates (Pollard *et al.* 2004) [12]. It is well known that environmental temperature affects skin surface temperature (Arp *et al.* 1983) [3]. The body extremities are recognized as the main locations for regulating heat loss or storage (Klir and Heath, 1992, Vanden Heuvel *et al.* 2004) [9, 17]. The changes in skin temperature at various sites indicate that temperature of skin surface not only varies with the change in the environmental temperature but it also varies in different parts of the body at a particular period of time (Singh and Singh, 2006) [14]. Surface temperature measured by Infrared thermometer at different sites of the buffalo heifer body can be used as an indicator of animal welfare under different production conditions. Rhoads *et al.* (2009) [13] found an increase in the surface temperature in dairy cattle on exposure to heat stress. Alam *et al.* (2011) [2] observed no differences in skin temperature. So the present study was done to assess the effect of microclimate alterations on the skin temperature of buffalo heifers using highly reflective materials like white paint or low thermal conductive materials like EPE sheets.

Material and Methods
Animals and Treatments
Twenty Murrah buffalo heifers of 8-18 months of age were selected from the buffalo herd of Livestock Production Management (LPM) and Buffalo Research Centre (BRC) of Department of Livestock Production and Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences (LUVAS), Hisar.

Heifers were dewormed and sprayed against ectoparasites before the commencement of study. After the preliminary adjustment period of 10 days prior to the start of the experiment, the heifers were divided into four groups of five heifers each on the basis of similarity in body weight and age and then, one of the four treatments was given to each group randomly *viz.* T_1 (Control): corrugated asbestos roof, T_2: corrugated asbestos roof painted white on upper side, T_3: corrugated asbestos roof having 70 mm thick heat resistant EPE sheet on lower side.T_4: corrugated asbestos roof painted white on upper side and 70 mm thick heat resistant EPE sheet on lower side. All animals were fed as per ICAR (2013) feeding standard.

Skin surface temperature of buffalo heifers was recorded at 7:00 AM and 2:00 PM fortnightly by using an infrared thermometer (keeping it 2-3 inch away from the desired surface) from eleven different body sites (Forehead, Neck, Shoulder, Fore limb, Knee joint, Fore digits, Back, Thigh, Hind limb, Hock joint, Hind digits).

Statistical Method

The means of data obtained from the studies were compared by one way analysis of variance (ANOVA) as per the methods described by Snedecor and Cochran (1994) [15]. The data was analyzed using “SPSS” software (version-17).

Results

Skin temperature measured at different body locations (table-1) can be used as an indicator of animal welfare under different production conditions. Overall values for skin temperature at 7:00 AM differ significantly (P<0.05) between T_1 and T_3, whereas, the difference was non-significant between T_1 and T_2; T_2 and T_4 as well as T_3 and T_4 while at 2:00 PM the difference was significant (P<0.05) between the groups whereas; for average values T_1 (97.31±0.21) and T_2 (96.75±0.19) differ significantly (P<0.05) from T_3 (95.59±0.25) and T_4 (95.45±0.10).

The perusal table reveals that the values for skin temperature at different body locations were low at 7:00 AM and about 3-10^{0}F higher at 2:00 PM. This finding is also supported by Phulia *et al.* (2010) [10] who reported that changes in body ST at different sites were low (P<0.01) in the morning (9:00 AM) and about 5-10^{0}C higher in the afternoon (3:00 PM). Skin temperature at forehead, back, neck, shoulder and thigh was more in all the sheds, probably due to larger body surface area exposed to solar radiation.

Knee, fore-digits, hock and hind-digits showed lower skin temperature in the all sheds during all the fortnights, this could be due to less surface area exposed to solar radiation. The results corroborated with the findings of Phulia *et al.* (2010) [10] and Singh and Singh (2006) [14] who reported that the ST of extremities are significantly (P<0.01) lower than other body parts; the extremities were cooler by 4-10^{0}C as compared to body trunk.

The table suggested that the forehead skin temperature (^{0}F) was significantly more (P<0.05) in T_1 (96.86±0.54) and T_2 (96.61±0.51) as compared to T_3 (95.25±0.21) and T_4 (95.41±0.30) at 7:00AM. However at 2:00 PM, the temperature was more (P<0.05) in T_1 (104.84±0.12) as compared to T_2, T_3 and T_4 (103.70±0.26, 103.07±0.25 and 102.10±0.12). Similarly, neck temperature of T_1 (96.39±0.38) was significantly (P<0.05) high as compared to T_3 (95.09±0.42) and T_4 (94.95±0.22) but it did not differ significantly with T_2 (95.92±0.29) whereas, at 2:00 PM it differed significantly (P<0.05) from all the treatments. The skin temperature of shoulder and knee did not differ significantly between the treatments at 7:00 AM whereas, at 2:00 PM the shoulder temperature of T_1 (102.88±0.29) differ significantly (P<0.05) with T_3 (101.38±0.26) and T_4 (100.25±0.43), while for knee T_1 (98.79±0.22) differ significantly (P<0.05) with T_4 (97.09±0.56) only. Fore limb temperature of T_1 (94.91±0.41) and T_2 (94.51±0.34) differed significantly (P<0.05) from T_3 (92.84±0.45) and T_4 (92.91±0.40) in morning whereas, in evening T_4 (98.38±0.35) differ significantly (P<0.05) from T_1 (100.66±0.24), T_2 (100.24±0.24) and T_3 (99.78±0.31). The morning as well as evening temperature at fore-digits was significantly (P<0.05) high in T_1 as compared to T_3. Similar trends were seen in back, thigh area and hind limb temperatures. The average temperature of hock joint and hind digits, respectively, in T_1 (96.08±0.28 and 91.68±0.28) and T_2 (95.43±0.33 and 91.27±0.40) was significantly (P<0.05) higher than in T_3 (94.24±0.31 and 89.66±0.30) and T_4 (94.28±0.22 and 89.86±0.15).

Table 1: Mean ± SE of overall mean Skin Temperature (^{0}F) of heifers

Body parts	Time	Asbestos roof (T_1)	White painted roof (T_2)	EPE sheet roof (T_3)	White painted and EPE sheet roof (T_4)
Forehead	7:00 AM	96.86±0.54^a	96.61±0.51^{ab}	95.25±0.21^c	95.41±0.30^{bc}
	2:00 PM	104.84±0.12^a	103.70±0.26^b	103.07±0.25^c	102.10±0.12^d
	Average	100.85±0.31^a	100.15±0.37^a	99.16±0.17^b	98.75±0.21^b
Neck	7:00 AM	96.39±0.38^a	95.92±0.29^{ab}	95.09±0.42^b	94.95±0.22^b
	2:00 PM	102.83±0.16^a	101.80±0.21^b	101.09±0.25^{bc}	100.64±0.37^c
	Average	99.61±0.17^a	98.86±0.22^b	98.09±0.33^c	97.79±0.23^c
Shoulder	7:00 AM	97.45±0.44	97.20±0.38	96.11±0.36	96.51±0.62
	2:00 PM	102.88±0.29^a	102.16±0.20^{ab}	101.38±0.26^b	100.25±0.43^c
	Average	100.17±0.29^a	99.68±0.28^{ab}	98.74±0.29^{bc}	98.38±0.40^c
Forelimb	7:00 AM	94.91±0.41^a	94.51±0.34^a	92.84±0.45^b	92.91±0.40^b
	2:00 PM	100.66±0.24^a	100.24±0.24^a	99.78±0.31^a	98.38±0.35^b
	Average	97.79±0.27^a	97.38±0.17^a	96.31±0.34^b	95.64±0.27^b
Knee	7:00 AM	91.83±0.65	90.78±0.55	90.45±0.46	90.44±0.47
	2:00 PM	98.79±0.22^a	98.61±0.41^a	97.60±0.36^{ab}	97.09±0.56^b
	Average	95.31±0.25^a	94.69±0.47^{ab}	94.02±0.37^b	93.77±0.35^b
Fore-digits	7:00 AM	88.44±0.52^a	87.59±0.38^{ab}	86.36±0.26^b	87.40±0.41^{ab}
	2:00 PM	95.01±0.23^a	94.26±0.43^a	93.10±0.31^b	92.73±0.38^b
	Average	91.72±0.27^a	90.92±0.22^b	89.73±0.16^c	90.07±0.31^c
Back	7:00 AM	98.05±0.51^a	97.87±0.42^a	95.98±0.48^b	96.86±0.26^{ab}
	2:00 PM	104.52±0.33^a	103.42±0.24^b	102.79±0.30^b	101.92±0.16^c

	Average	101.28±0.40^{a}	100.65±0.30^{a}	99.39±0.37^{b}	99.39±0.09^{b}
Thigh	7:00 AM	95.43±0.39^{a}	95.08±0.25^{a}	93.55±0.37^{b}	93.96±0.41^{b}
	2:00 PM	101.44±0.19^{a}	101.03±0.26^{a}	99.66±0.26^{b}	98.74±0.13^{c}
	Average	98.44±0.27^{a}	98.06±0.23^{a}	96.61±0.28^{b}	96.35±0.19^{b}
Hind Limb	7:00 AM	94.35±0.46^{a}	93.70±0.36^{ab}	92.45±0.36^{b}	93.11±0.41^{ab}
	2:00 PM	100.65±0.24^{a}	100.62±0.31^{a}	98.70±0.28^{b}	98.21±0.33^{b}
	Average	97.50±0.30^{a}	97.16±0.33^{a}	95.58±0.31^{b}	95.66±0.33^{b}
Hock Joint	7:00 AM	92.61±0.44^{a}	92.24±0.30^{a}	90.43±0.33^{b}	91.50±0.36^{ab}
	2:00 PM	99.55±0.48^{a}	98.63±0.66^{ab}	98.05±0.31^{bc}	97.06±0.24^{c}
	Average	96.08±0.28^{a}	95.43±0.33^{a}	94.24±0.31^{b}	94.28±0.22^{b}
Hind digits	7:00 AM	88.31±0.40^{a}	87.40±0.31^{ab}	86.21±0.29^{c}	87.20±0.37^{bc}
	2:00 PM	95.04±0.60^{a}	95.13±0.79^{a}	93.11±0.62^{b}	92.51±0.19^{b}
	Average	91.68±0.28^{a}	91.27±0.40^{a}	89.66±0.30^{b}	89.86±0.15^{b}
Overall	7:00 AM	94.06±0.39^{a}	93.54±0.31^{ab}	92.25±0.32^{c}	92.75±0.25^{bc}
	2:00 PM	100.56±0.09^{a}	99.96±0.11^{b}	98.94±0.20^{c}	98.15±0.13^{d}
	Average	97.31±0.21^{a}	96.75±0.19^{a}	95.59±0.25^{b}	95.45±0.10^{b}

Means bearing different superscripts in a row differ significantly (P<0.05)

In the present study, heifers kept in asbestos roofs without any modification (T_1) showed maximum skin temperatures at all the body points at 2:00 PM. The probable reason may be asbestos sheet which heated up in the forenoon and releases heat as thermal radiation in afternoon (Thomas and Sastry, 2007) [16] whereas EPE sheet in modified sheds (T_3 and T_4) kept the values on lower side proving its superiority for thermal insulation as depicted in the results. It is well known that environmental temperature affects skin temperature (Das *et al.* 1997; Piccione *et al.*, 2003) [5, 11] and different body locations differ in their ability to dissipate heat. The results corroborated with the study of Kamal (2013) [8] who observed that the mean body ST of calves shows significant difference (P<0.05) between 9:00 AM and 2:00 PM under all the sheds except those under asbestos roof. Similarly, Singh and Singh (2006) [14] found that temperature was lower at different locations of fore and hind legs than other body parts. Aggarwal and Singh (2008) [1] observed that in the morning, both groups had similar skin temperature but in the evening the wallowing group was significantly (P<0.01) cooler than the showering group.

Conclusion

Use of EPE sheets on the inner side of the existing sheds altered microclimate of heifers indicating highly superior thermal insulation power of EPE sheet thus reduced heat stress resulting in low skin temperature at different body locations while conventional asbestos roof was unable to cut down the heat load falling on it through radiations, thus it could not provide proper microclimate to heifers witnessed by high skin temperature. White painted roof might have lesser protection against direct sunlight which indicates that white painted roof was also insufficient to provide better micro-environment to heifers during summer however; the conditions were more favourable as compared to conventional asbestos roof. So, it can be concluded that a new material like EPE sheets, owing to its superiority for thermal insulation, can be used on the inner side of existing sheds.

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