



Effect of different heat ameliorating measures on the micro-climate of buffalo sheds during hot-dry summer

K K VERMA¹, MUKESH SINGH², TRIVENI DUTT³, G K GAUR⁴, B H M PATEL⁵, P K BHARTI⁶, U S NARWARIA⁷, M R VERMA⁸ and J K CHAUDHARY⁹

Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh 243 122 India

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ABSTRACT

Present investigation studied the effect of heat ameliorating measures on micro-climate of sheds of Murrah buffalo heifers during hot dry summer. Buffalo heifers (24) were categorised in 4 groups (6 in each), viz. control (T₀), cooling jacket (T₁), cooling jacket+forced ventilation (T₂) and sprinklers+forced ventilation (T₃). Daily minimum and maximum and dry and wet bulb temperatures of both micro and macro-climate were measured at 10.00 AM and 2.00 PM of Indian Standard Time (IST) by using maximum and minimum and dry and wet bulb thermometer, respectively. Significant reduction in maximum temperature was observed in T₃, T₂ and T₁ groups than control group. However, significantly higher minimum temperature was found in T₀ group as compared to T₃, T₂ and T₁ respectively. Relative humidity (RH) was significantly lower in T₃ and T₂ (65.67±0.48 and 65.97±0.53%, respectively) than T₀ (68.51±0.56%) group at 10.00 AM whereas, at 2.00 PM significant reduction in RH was observed in T₃, and T₂ (55.31±0.51 and 57.20±0.62) than T₀ (58.96±0.63%) group. During peak hot periods, significantly lower Temperature humidity Index (THI) was found in T₃, T₂ and T₁ than T₀ group. However, at 10.00 AM significant reduction in THI was found in T₃ and T₂ groups than T₀ group. The findings of the present study indicated that forced ventilation along with sprinklers and cooling jacket had helped in protecting the animals from thermal stress under loose housing system during hot-dry summer.

Key words: Cooling jacket, Forced ventilation, Heat stress, Murrah buffalo heifer, THI

In the present scenario, climate change is the biggest threat for dairy industry in tropical and sub-tropical regions of the world (Gaughan *et al.* 2009). The climate of any area is comprised of temperature, humidity, precipitation/rainfall, wind velocity, solar radiation, barometric pressure and ionization for a long period. Due to tropical climate in most part of India, buffaloes are exposed to harsh environmental conditions during summer season. When long periods of high ambient temperature coupled with high relative humidity, compromise the ability to dissipate excess body heat in dairy animals (Marai *et al.* 2009). In tropics and subtropics, heat stress is the major constraint on animal productivity (Marai *et al.* 2007, Shelton 2000). It has been reported that effect of heat stress is aggravated when heat stress is accompanied with high ambient humidity (Marai *et al.* 2002). Dark coat colour, relatively lesser density of sweat gland and thick epidermis make buffaloes relatively

more sensitive for solar radiation due to poor thermal tolerance (Marai and Habeeb 2010). At present, Temperature Humidity Index (THI) is the most commonly used index to assess degree of thermal stress in dairy and beef cattle particularly under hot-humid season (Morton *et al.* 2007). For reducing heat load in buffaloes, different methods (shade, water splashing, sprinkling, showering, fanning, forced ventilation and wallowing, etc.) have been tried with varied success (Turner *et al.* 1989, Strickland *et al.* 1989, Calegari *et al.* 2003, Collier *et al.* (2006).

To ameliorate thermal stress Khongdee *et al.* (2010), suggested several managerial measures, viz. sprinklers and fan (Gaughan *et al.* 2010), foggers, misters and modified roofing (normal roof fitted with woven polypropylene shade cloth). However, there is no any information available on the effect of cooling jacket with or without forced ventilation on conductive and evaporative cooling in Murrah buffaloes. Thus, the present investigation was conducted to study the effect of different heat ameliorating measures on the micro-climatic variables under loose houses during hot-dry summer.

MATERIALS AND METHODS

Experimental design and management of animals: The present study was conducted on Murrah buffalo heifers

Present address: ¹Ph.D Scholar (drkkvermavet@gmail.com), ^{2,3,4}Principal Scientist (drmsingh9@gmail.com, triveniduttvri@gmail.com, gyanendrakg@gmail.com), ⁵Senior Scientist (mpatellpm@gmail.com), ⁶Scientist (pkish.1002@gmail.com) LPM Section, ⁸Senior Scientist, (medramverma@rediffmail.com), ⁹Ph.D (vetjitu@gmail.com), Livestock Economics, Statistics and Information Technology. ⁷Assistant Professor (bnkupendra@gmail.com), Rewa Veterinary College, M.P.

maintained on cattle and buffalo farm, Indian Veterinary Research Institute, Izatnagar for 3 months (May 2014- July 2014) during hot- dry summer. Murrah buffalo heifers (24) were divided into 4 groups (6 in each) viz. control group (T_0), cooling jacket group (T_1), cooling jacket + forced ventilation group (T_2) and sprinklers + forced ventilation group (T_3). A double layered thick cotton cloth (*Chagal*) was utilized to make the cooling jacket where water filled in the channels were cooled by evaporative cooling. The high speed air circulator fans (air circulator - Wall 24", Sweep: 600 mm, Volts (V): 230, AC Cycles (C/S): 50, Power: 180 W, Speed (RPM): 1, 440, air delivery (M3/min): 270) were utilized to create the forced ventilation in T_2 and T_3 shed during the course of study. These fans were mounted at a height of 6' 8" in the wall (at an angle of 40–45°) at one end of the standings inside the sheds. Buffalo heifers under T_1 group were subjected to cooling jacket alone. However, both cooling jacket and wall mounted high speed air circulator fan were utilized in T_2 group continuously during the experimental period (between 9.00 AM to 6.00 PM). In T_3 group, buffalo heifers were subjected to sprinklers and forced ventilation where sprinkling was carried out for 10 min at 2.00 h interval between 9.00 AM to 6.00 PM and high speed air circulator fan was run throughout the whole experimental period except during sprinkling time. The metallic (copper) sprinklers were fitted in a pipe at 7' 7" above the ground level over to wet the animal's body completely in the shed. However, the pipe was connected to a water tank fitted with a monoblock pump (0.5 hp) for sprinkling.

Recording of macro and micro-climatic parameters: The minimum and maximum temperature and RH of both macro (outside the shed) and micro (inside the shed) environment in various groups were measured at 10.00 AM and 2.00 PM of Indian Standard Time (IST) by using maximum and minimum thermometer and dry and wet bulb thermometer, respectively. These thermometers were hanged at equal heights on the animal body level using thread under the

shed in each group. Similarly, both the instruments were also hanged at equal heights in open area for recording the macro-climatic parameters. To calculate the RH values (%) in different groups, dry and wet bulb thermometer reading were utilized. However, THI values in different groups and outside the shed were also calculated by using the following formula (Mc Dowell 1972).

$$\text{THI} = 0.72 (\text{wet bulb temperature} + \text{dry bulb temperature}) + 40.6$$

In the present study, descriptive statistics were used to calculate daily minimum and maximum temperature, RH and THI. However, the mean values of different groups were compared by two-way analysis of variance (ANOVA) without interaction using general linear model. All the analyses were performed using SPSS 11.0 statistical package.

RESULTS AND DISCUSSION

In the present study, both macro and micro-climatic parameters viz. minimum and maximum temperature (Table 1), RH (Table 2) and THI (Table 3) during the experimental period have been presented and discussed. The macro-climate during the study viz. overall minimum and maximum temperatures were 26.74 ± 0.17 and $37.09 \pm 0.30^\circ\text{C}$, respectively. The results indicated that macro-climate was very stressful during the course of study period.

Significant ($P < 0.05$) reduction in maximum temperature (Table 1) was observed in T_3 , T_2 and T_1 groups than control. However, minimum temperature significantly ($P < 0.05$) higher minimum temperature was found in T_0 group as compared to T_3 , T_2 and T_1 , respectively.

Significant ($P < 0.05$) reduction in maximum temperature was observed in T_3 , T_2 and T_1 groups than control group. However, minimum temperature significantly ($P < 0.05$) higher minimum temperature was found in T_0 group as compared to T_3 , T_2 and T_1 , respectively. The lower minimum and maximum temperature in the treatment

Table 1. Minimum and maximum temperature of micro-climate (inside the shed) and macro-climate (outside the shed) during hot-dry season

Months	Micro-climate									
	Control (T_0)		Cooling jacket (T_1)		Cooling jacket + Forced ventilation (T_2)		Sprinkler + Forced ventilation (T_3)		Macro-climate	
	Min. ($^\circ\text{C}$)	Max. ($^\circ\text{C}$)	Min. ($^\circ\text{C}$)	Max. ($^\circ\text{C}$)	Min. ($^\circ\text{C}$)	Max. ($^\circ\text{C}$)	Min. ($^\circ\text{C}$)	Max. ($^\circ\text{C}$)	Min. ($^\circ\text{C}$)	Max. ($^\circ\text{C}$)
I	30.07 $\pm 0.24^a$	34.93 $\pm 0.26^A$	28.70 $\pm 0.19^a$	33.67 $\pm 0.22^A$	27.97 $\pm 0.18^a$	32.67 $\pm 0.23^A$	27.40 $\pm 0.14^a$	32.07 $\pm 0.19^A$	25.67 $\pm 0.28^b$	37.53 $\pm 0.34^A$
II	30.17 $\pm 0.20^a$	35.20 $\pm 0.27^A$	28.77 $\pm 0.17^a$	33.67 $\pm 0.20^A$	28.13 $\pm 0.18^a$	32.67 $\pm 0.18^A$	27.60 $\pm 0.16^a$	32.37 $\pm 0.14^A$	27.33 $\pm 0.23^a$	38.77 $\pm 0.50^A$
III	28.71 $\pm 0.20^b$	33.06 $\pm 0.27^B$	27.87 $\pm 0.21^b$	32.16 $\pm 0.25^B$	27.32 $\pm 0.20^b$	31.35 $\pm 0.28^B$	26.90 $\pm 0.19^b$	31.00 $\pm 0.27^B$	27.19 $\pm 0.29^a$	35.03 $\pm 0.46^B$
Over all	29.64 $\pm 0.14^v$	34.38 $\pm 0.18^X$	28.44 $\pm 0.12^w$	33.15 $\pm 0.15^Y$	27.80 $\pm 0.11^x$	32.22 $\pm 0.15^Z$	27.30 $\pm 0.10^y$	31.80 $\pm 0.13^Z$	26.74 $\pm 0.17^z$	37.09 $\pm 0.30^W$

Mean bearing different superscript (a, b) with in the column differ significantly ($P < 0.05$) at 10.00 AM and (A,B) differ significantly ($P < 0.01$) at 2: 00 PM of IST. Mean bearing different superscript (v,w,x,y, z) within the row differ significantly ($P < 0.05$) at 10.00 AM and (W,X,Y,Z) differ significantly ($P < 0.05$) at 2: 00 PM of IST.

groups might be attributed to the fact that water sprinkling and water jacketing might have helped in reducing the ambient temperature in the shed and high speed air circulator fan has insured better exchange of warm and humid air with fresh cool air. However, high ambient temperature in T₀ group may be because of poor ventilation due to inefficient air exchange inside the shed. During thermal stress, sprinklers and fans may be utilized to ameliorate the heat load in dairy animals (Gaughan *et al.* 2010). The present findings are in agreement with Vijaykumar *et al.* (2009) who reported significant reduction in the minimum and maximum temperature reduced in buffalo heifers subjected to sprinklers + ceiling fan than non cooled heifers. Suadsong (2012) also observed lower ambient temperature in tunnel ventilated barns than outside.

Relative Humidity (RH) was significantly ($P < 0.05$) lower in T₃ and T₂ than T₀ group at 10.00 AM whereas, at 2.00 PM significant reduction in RH was observed in T₃ and T₂ than T₀ group (Table 2). The lower RH in T₃ and T₂

groups than T₀ group might be due to better ventilation by means of high speed air circulator fan fixed at one end of the standing. Forced ventilation in T₃ and T₂ groups replaced warm and humid air by fresh air which further improved the process of evaporative cooling in buffalo heifers. However, vapours present in the respired air increase the RH as there was no mechanical ventilation used in T₀ group. The present results are supported by Vijaykumar *et al.* (2009) who found lower RH in buffalo heifers subjected to ceiling fan and sprinklers+ceiling fan than in non cooled heifers. Kamal (2014), also reported significant reduction in mean ambient temperature under agro net than asbestos with canvas shading roof, thatch and tree shade.

Significantly ($P < 0.05$) lower Temperature humidity Index (THI) was found in T₃, T₂ and T₁ than T₀ group (Table 3). However, at 10.00 AM significant reduction in THI was found in T₃ and T₂ groups than T₀ group. THI is the most commonly used index to measure the degree of thermal stress in dairy animals (Morton *et al.* 2007). THI values

Table 2. RH values (%) of micro-climate (in different groups under the shed) and macro-climate (out side the shed) during hot-dry season

Months	Micro-climate									
	Control (T ₀)		Cooling jacket (T ₁)		Cooling jacket + Forced ventilation (T ₂)		Sprinkler + Forced ventilation (T ₃)		Macro-climate	
	10.00 AM	2.00 PM	10.00 AM	2.00 PM	10.00 AM	2.00 PM	10.00 AM	2.00 PM	10.00 AM	2.00 PM
I	70.80 ±1.10 ^a	62.10 ±0.88 ^A	69.27 ±0.90 ^a	61.97 ±0.84 ^A	66.67 ±0.97 ^a	56.67 ±0.91 ^B	66.00 ±0.89 ^b	55.17 ±0.65 ^B	75.30 ±1.25 ^a	46.30 ±0.73 ^B
II	65.23 ±0.59 ^b	55.43 ±1.03 ^C	64.60 ±0.79 ^b	56.80 ±1.25 ^B	63.60 ±0.75 ^b	54.70 ±1.21 ^B	62.77 ±0.50 ^c	52.73 ±0.92 ^C	68.47 ±1.21 ^b	47.60 ±0.81 ^B
III	69.45 ±0.86 ^a	59.32 ±1.01 ^B	69.94 ±0.89 ^a	63.81 ±0.79 ^A	67.58 ±0.89 ^a	60.13 ±0.86 ^A	68.16 ±0.78 ^a	57.94 ±0.82 ^A	73.42 ±1.02 ^a	56.81 ±0.91 ^A
Over all	68.51 ±0.56 ^y	58.96 ±0.63 ^W	67.96 ±0.55 ^y	60.89 ±0.64 ^V	65.97 ±0.53 ^z	57.20 ±0.62 ^X	65.67 ±0.48 ^z	55.31 ±0.51 ^Y	72.41 ±0.73 ^x	50.31 ±0.68 ^Z

Mean bearing different superscript (a,b,c) with in the column differ significantly ($P < 0.05$) at 10.00 AM and (A,B,C) differ significantly ($P < 0.01$) at 2: 00 PM of IST. Mean bearing different superscript (w, x, y, z) within the row differ significantly ($P < 0.05$) at 10.00 AM and (W,X,Y,Z) differ significantly ($P < 0.05$) at 2: 00 PM of IST.

Table 3. THI values of micro-climate (in different groups under the shed) and macro-climate (outside the shed) during hot-dry season

Months	Micro-climate									
	Control (T ₀)		Cooling jacket (T ₁)		Cooling jacket + Forced ventilation (T ₂)		Sprinkler + Forced ventilation (T ₃)		Macro-climate	
	10.00 AM	2.00 PM	10.00 AM	2.00 PM	10.00 AM	2.00 PM	10.00 AM	2.00 PM	10.00 AM	2.00 PM
I	76.80 ±0.37	82.57 ±0.41 ^B	76.40 ±0.32	80.00 ±0.30 ^B	76.03 ±0.26	79.20 ±0.21	75.87 ±0.44	79.07 ±0.36	81.53 ±0.55	86.63 ±0.52 ^B
II	77.50 ±0.24	84.00 ±0.26 ^A	76.87 ±0.32	80.90 ±0.26 ^A	75.60 ±0.41	79.87 ±0.35	75.23 ±0.48	79.43 ±0.39	83.03 ±0.88	88.70 ±0.85 ^A
III	77.42 ±0.22	84.03 ±0.30 ^A	76.39 ±0.34	81.19 ±0.32 ^A	75.58 ±0.34	79.81 ±0.28	75.45 ±0.37	79.06 ±0.36	83.39 ±0.65	89.03 ±0.53 ^A
Over all	77.24 ±0.17 ^y	83.54 ±0.20 ^X	76.55 ±0.19 ^y	80.70 ±0.18 ^Y	75.74 ±0.20 ^z	79.63 ±0.17 ^Z	75.52 ±0.25 ^z	79.19 ±0.21 ^Z	82.66 ±0.41 ^x	88.13 ±0.39 ^W

Mean bearing different superscript (A,B) differ significantly ($P < 0.01$) at 2: 00 PM of IST. Mean bearing different superscript (w,x,y, z) within the row differ significantly ($P < 0.05$) at 10.00 AM and (W,X,Y,Z) differ significantly ($P < 0.05$) at 2: 00 PM of IST.

were >72 in all treatment groups, indicating that heifers were in mild stress. Generally, mild stress is initiated at a THI >74 while at >80, stress becomes severe includes panting and standing up to facilitate evaporative cooling from the skin (Roy and Chatterjee 2010). The results presented in the Table 3 revealed that significant reduction of THI was observed in buffalo heifers subjected to cooling treatment than in non cooled heifers. The probable reason might be attributed to the fact that reduced ambient temperature by virtue of sprinklers and cooling jacket whereas, high speed air circulator fan might have improved the forced ventilation reduced the RH during the experimental period. Higher THI was observed at 2.00 PM might be due to rise in ambient temperature in different groups from 10.00 AM to 2.00 PM. Further, our findings had shown lesser difference between maximum (2.00 PM) and minimum (10.00 AM) THI which is supported by Khongdee (2008).

Our results showed that the different heat ameliorating measures reduced the micro-climatic variables during the peak hot hours of the day. Further, the comfortable microclimate improved the dry matter intake, physiological parameters (rectal temperature, pulse rate, respiration rate and surface temperature), hemato-biochemical parameters and behavioural performances of Murrah buffalo heifers during hot-dry summer.

It may be concluded from our findings that various heat ameliorating measures (cooling jacket, high speed air circulator fan either with sprinklers or cooling jacket) might have helped in ameliorating the thermal stress in Murrah buffalo heifers under loose houses during hot-humid season.

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REFERENCES

- Calegari F, Calamari L and Frazzi E. 2003. Effects of ventilation and misting on behaviour of dairy cattle in the hot season in south Italy. *Proceedings of Fifth International Dairy Housing Conference*, 29–31 January, Fort Worth, Texas. ASAE, St Joseph, MI cattle. Transactions of the ASAE. **19**: 309–13.
- Collier R J, Dahl G E and Van Baale and M J. 2006. Major advances associated with environmental effects on dairy cattle. *Journal of Dairy Science* **89**: 1244–53.
- Gaughan J B, Mader T L, Holt S M, Sullivan M L and Hahn G L. 2009. Assessing the heat tolerance of 17 beef cattle genotypes. *International Journal of Biometeorology* **54**: 617–27.
- Gaughan J B, Bonner S, Loxton I, Mader T L, Lisle A and Lawrence R. 2010. Effect of shade on body temperature and performance of feedlot steers. *Journal of Animal Science* **88**: 4056–67.
- Kamal R, Dutt T, Patel B H M, Dey A, Chandran P C, Barari S K and Bhusan B. 2014. Effect of shade materials on microclimate of crossbred calves during summer. *Veterinary world* **7**: 776–82.
- Khongdee S. 2008. 'The effects of high temperature and housing modification on the productive and reproductive performance of dairy cows.' Thesis submitted to graduate school, Kasetsart university.
- Khongdee S, Sripoon S, Chousawai S, Hinch G, Chaiyabutr N, Markvichitr K and Vajrabukka C. 2010. The effect of modified roofing on the milk yield and reproductive performance of heat-stressed dairy cows under hot-humid conditions. *Animal Science Journal* **81** (5): 606–11.
- Marai I F M and Habeeb A A M. 2010. Buffalo's biological functions as affected by heat stress - a review. *Livestock Science* **127**(2): 89–109.
- Marai I F M, Habeeb A A M and Gad A E. 2002. Rabbit's productive, reproductive and physiological traits as affected by heat stress (a review). *Livestock Production Science* **78**: 71–90.
- Marai I F M, El-Darawany A A, Fadiel A and Abdel-Hafez, M A M. 2007. Physiological traits as affected by heat stress in sheep—a review. *Small Ruminant Research* **71**: 1–12.
- Marai I F M, El-Darawany A A, Abou-Fandoud E I and Abdel-Hafez M A M. 2009. Reproductive and physiological traits of Egyptian Suffolk rams as affected by selenium dietary supplementation during the sub-tropical environment of Egypt. *Livestock Research for Rural Development* **21**: 10.
- McDowell RE. 1972. Improvement of livestock production in warm climates. Pp. 410–49. Freeman, San Francisco.
- Morton J M, Tranter W P, Mayer D G and Jonsson N N. 2007. Effects of environmental heat on conception rates in lactating dairy cows: Critical periods of exposure. *Journal of Dairy Science* **90**: 2271–78.
- Roy P K and Chatterjee A. 2010. Effect of different type dairy cattle shelters on micro-climatic variables in rural West Bengal. *Indian Journal of Animal Sciences* **80** (8): 781–84.
- Shelton M. 2000. Reproductive performance of sheep exposed to hot environments. *Sheep Production in Hot and Arid Zones*. Pp. 155–62. (Eds) Malik R C, Razzaque M A and Al-Nasser A Y. Kuwait Institute for Scientific Research.
- Strickland J T, Bucklin R A, Nordstedt R A, Beede D K and Bray D R. 1989. Sprinkler and fan cooling system for dairy cows in hot, humid climates. *Applied Engineering Agriculture* **5** (2): 231–36.
- Suadsong S. 2012. Alleviating heat stress leads to improved cow reproductive performance. <http://dx.doi.org/10.5772/50881>.
- Turner L W, Chastain J P, Hemken R W, Gates R S and Christ W L. 1989. Reducing heat stress in dairy cows through sprinkler and fan cooling. *Applied Engineering Agriculture* **8**: 251–56.
- Vijayakumar P, Pandey H N, Singh M and Dutt T. 2009. Effect of heat ameliorative measures on the growth and physiological response of buffalo heifers during summer. *Indian Journal of Animal Sciences* **79** (4): 437–41.