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

K K VERMA[1], MUKESH SINGH[2], TRIVENI DUTT[3], G K GAUR[4], B H M PATEL[5], P K BHARTI[6], U S NARWARIA[7], M R VERMA[8] and J K CHAUDHARY[9]

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 (T_0), cooling jacket (T_1), cooling jacket+forced ventilation (T_2) and sprinklers+forced ventilation (T_3). 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 T_3, T_2 and T_1 groups than control group. However, significantly higher minimum temperature was found in T_0 group as compared to T3, T_2 and T_1 respectively. Relative humidity (RH) was significantly lower in T_3 and T_2 (65.67±0.48 and 65.97±0.53%, respectively) than T_0 (68.51±0.56%) group at 10.00 AM whereas, at 2.00 PM significant reduction in RH was observed in T_3, and T_2 (55.31±0.51 and 57.20±0.62) than T_0 (58.96±0.63%) group. During peak hot periods, significantly lower Temperature humidity Index (THI) was found in T_3, T_2 and T_1 than T_0 group. However, at 10.00 AM significant reduction in THI was found in T_3 and T_2 groups than T_0 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 managemental 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.

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

MATERIALS AND METHODS

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

THI=0.72 (wet bulb temperature + 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±0.30°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								Macro-climate	
	Control (T_0)		Cooling jacket (T_1)		Cooling jacket + Forced ventilation (T_2)		Sprinkler + Forced ventilation (T_3)			
	Min. (C°)	Max. (C°)	Min. (C°)	Max. (C°)	Min. (C°)	Max. (C°)	Min. (C0)	Max. (C°)	Min. (C°)	Max. (C°)
I	30.07 $\pm0.24^a$	34.93 $\pm0.26^A$	28.70 $\pm0.19^a$	33.67 $\pm0.22^A$	27.97 $\pm0.18^a$	32.67 $\pm0.23^A$	27.40 $\pm0.14^a$	32.07 $\pm0.19^A$	25.67 $\pm0.28^b$	37.53 $\pm0.34^A$
II	30.17 $\pm0.20^a$	35.20 $\pm0.27^A$	28.77 $\pm0.17^a$	33.67 $\pm0.20^A$	28.13 $\pm0.18^a$	32.67 $\pm0.18^A$	27.60 $\pm0.16^a$	32.37 $\pm0.14^A$	27.33 $\pm0.23^a$	38.77 $\pm0.50^A$
III	28.71 $\pm0.20^b$	33.06 $\pm0.27^B$	27.87 $\pm0.21^b$	32.16 $\pm0.25^B$	27.32 $\pm0.20^b$	31.35 $\pm0.28^B$	26.90 $\pm0.19^b$	31.00 $\pm0.27^B$	27.19 $\pm0.29^a$	35.03 $\pm0.46^B$
Over all	29.64 $\pm0.14^v$	34.38 $\pm0.18^X$	28.44 $\pm0.12^w$	33.15 $\pm0.15^Y$	27.80 $\pm0.11^x$	32.22 $\pm0.15^Z$	27.30 $\pm0.10^y$	31.80 $\pm0.13^Z$	26.74 $\pm0.17^z$	37.09 $\pm0.30^W$

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 sprinklelers + 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 T_3 and T_2 than T_0 group at 10.00 AM whereas, at 2.00 PM significant reduction in RH was observed in T3, and T_2 than T_0 group (Table 2). The lower RH in T_3 and T_2 groups than T_0 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 T_3 and T_2 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 T_0 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 T_3, T_2 and T_1 than T_0 group (Table 3). However, at 10.00 AM significant reduction in THI was found in T_3 and T_2 groups than T_0 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								Macro-climate	
	Control (T_0)		Cooling jacket (T_1)		Cooling jacket + Forced ventilation (T_2)		Sprinkler + Forced ventilation (T_3)			
	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 $\pm1.10^a$	62.10 $\pm0.88^A$	69.27 $\pm0.90^a$	61.97 $\pm0.84^A$	66.67 $\pm0.97^a$	56.67 $\pm0.91^B$	66.00 $\pm0.89^b$	55.17 $\pm0.65^B$	75.30 $\pm1.25^a$	46.30 $\pm0.73^B$
II	65.23 $\pm0.59^b$	55.43 $\pm1.03^C$	64.60 $\pm0.79^b$	56.80 $\pm1.25^B$	63.60 $\pm0.75^b$	54.70 $\pm1.21^B$	62.77 $\pm0.50^c$	52.73 $\pm0.92^C$	68.47 $\pm1.21^b$	47.60 $\pm0.81^B$
III	69.45 $\pm0.86^a$	59.32 $\pm1.01^B$	69.94 $\pm0.89^a$	63.81 $\pm0.79^A$	67.58 $\pm0.89^a$	60.13 $\pm0.86^A$	68.16 $\pm0.78^a$	57.94 $\pm0.82^A$	73.42 $\pm1.02^a$	56.81 $\pm0.91^A$
Over all	68.51 $\pm0.56^y$	58.96 $\pm0.63^W$	67.96 $\pm0.55^y$	60.89 $\pm0.64^V$	65.97 $\pm0.53^z$	57.20 $\pm0.62^X$	65.67 $\pm0.48^z$	55.31 $\pm0.51^Y$	72.41 $\pm0.73^x$	50.31 $\pm0.68^Z$

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								Macro-climate	
	Control (T_0)		Cooling jacket (T_1)		Cooling jacket + Forced ventilation (T_2)		Sprinkler + Forced ventilation (T_3)			
	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 $\pm0.41^B$	76.40 ±0.32	80.00 $\pm0.30^B$	76.03 ±0.26	79.20 ±0.21	75.87 ±0.44	79.07 ±0.36	81.53 ±0.55	86.63 $\pm0.52^B$
II	77.50 ±0.24	84.00 $\pm0.26^A$	76.87 ±0.32	80.90 $\pm0.26^A$	75.60 ±0.41	79.87 ±0.35	75.23 ±0.48	79.43 ±0.39	83.03 ±0.88	88.70 $\pm0.85^A$
III	77.42 ±0.22	84.03 $\pm0.30^A$	76.39 ±0.34	81.19 $\pm0.32^A$	75.58 ±0.34	79.81 ±0.28	75.45 ±0.37	79.06 ±0.36	83.39 ±0.65	89.03 $\pm0.53^A$
Over all	77.24 $\pm0.17^y$	83.54 $\pm0.20^X$	76.55 $\pm0.19^y$	80.70 $\pm0.18^Y$	75.74 $\pm0.20^z$	79.63 $\pm0.17^Z$	75.52 $\pm0.25^z$	79.19 $\pm0.21^Z$	82.66 $\pm0.41^x$	88.13 $\pm0.39^W$

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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