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Effect of Different Heat Ameliorating Measures on Micro-Climatic Variables in Loose Houses During Hot Humid Season in Murrah Buffalo Heifers

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ABSTRACT

The present investigation was conducted to study the effect of heat ameliorating measures on micro-climatic variables in the loose houses during hot-humid season. In the study different heat ameliorative measures viz. control (T0), cooling jacket (T1), cooling jacket + forced ventilation (T2) and sprinkler + forced ventilation (T3) were utilized to ameliorate the thermal stress in Murrah buffalo heifers (n = 24). Daily maximum and minimum temperatures relative humidity (RH) and temperature humidity index (THI) 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. Significantly ($P<0.05$) lower maximum temperature was observed in T3, T2 and T1 groups (29.93 ± 0.19, 30.43 ± 0.18 and 31.27 ± 0.19°C, respectively) as compared to T0 group (32.25 ± 0.19°C). However, significantly ($P<0.05$) lowest minimum temperature was found in T3, T2 and T1groups (25.28 ± 0.22, 25.81 ± 0.23 and 26.60 ± 0.23°C, respectively) and higher minimum temperature in T0 group (27.60 ± 0.22°C). We observed significantly ($P<0.05$) lower RH in T3 and T2 groups (69.84 ± 0.57 and 71.93 ± 0.51%, respectively) than those of T0 (77.18 ± 0.49) at 2.00 pm. During the peak hot period significantly ($P<0.05$) lower temperature humidity index (THI) was reported in T3, T2 and T1 groups (78.89 ± 0.24 and 79.43 ± 0.25 and 81.39 ± 0.23, respectively) as compare to T0 group (82.36 ± 0.20). Therefore, it can be concluded that forced ventilation with sprinklers or cooling jacket is an important mean to protect animals from thermal stress under loose houses during hot-humid season.

Keywords: Cooling jacket, forced ventilation, heat stress, Murrah buffalo heifer, THI

In the present scenario, climate change and global warming is the biggest threat for dairy industry in tropical and sub-tropical regions of the world (Gaughan *et al.* 2009) including India. The basic concept of thermal stress management through micro-climate conditioning involves reduction in heat gain through solar radiation and high environmental temperature and promotion of heat loss in animals by means of evaporative cooling. Extended periods of high ambient temperature coupled with high relative humidity compromise the ability of the dairy bovines to dissipate excess body heat (Marai *et al.* 2009). Therefore, for effective evaporative cooling various cooling methods must be coupled with forced ventilation by means of high speed air circulator fan. Under direct evaporative cooling, sprinkling followed by forced ventilation, reduces body temperature (Igono *et al.* 1987; Turner *et al.* 1989), improves feed intake (Strickland *et al.* 1989) and increases the milk yield (Flamenbaum *et al.* 1986). In dairy animals water spray with or without fans had improved production performance during heat stress (Collier *et al.* 2006). It has also been observed that increasing airflow and wetting frequency had a dramatic effect on the evaporative heat loss from the skin of dairy animals (Hillman *et al.* 2001). It has been found that duration and frequency of sprinkling in the shade are the most critical for milk production in dairy animals (Domingos *et al.* 2013). Currently 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). Somparn *et al.* (2004) recognized four livestock welfare categories based on THI value viz. no stress level (THI $\leq$ 74), alert conditions (THI = 75-78), danger conditions (THI = 79-83) and emergency conditions (THI $\geq$ 84) which is applicable for both cattle and buffaloes. Vale (2007) observed that THI > 75 has a negative effect on reproductive performances of buffaloes.

Buffaloes are more sensitive to solar radiation and high ambient temperature due to poor thermal tolerance because of dark body colour, relatively less number of sweat glands per unit area of skin and thick epidermal layer of skin which reduce heat loss by evaporative cooling (Marai and Habeeb, 2010).

Though there are several studies have been conducted to ameliorate the thermal stress in dairy animals by using sprinklers and fan (Gaughan *et al.* 2010), foggers, misters and modified roofing (normal roof fitted with woven polypropylene shade cloth) (Khongdee *et al.* 2010). However, there is no study is available on conductive and evaporative cooling using cooling jacket in buffaloes. Therefore, keeping above intricacies the present investigation has been designed to study the effect of different heat ameliorating measures on the micro-climatic variables under loose houses during hot-humid season.

MATERIALS AND METHODS

Study area

The present study was conducted on Murrah buffalo heifers (n = 24) maintained at Cattle and Buffalo farm, Indian Veterinary Research Institute, Izatnagar for a period of three months (August 2014- October 2014) during hot- humid season. The study area is located at an altitude of 169 m above the mean sea level, at the latitude of 28 29′ North and 79 24′ East. A sub-tropical climate with maximum ambient temperature (45°C) and minimum temperature (approximately 2°C) prevailed in the area. However, RH at the study place was between 45.46 and 93.93%.

Experimental design and animals

Murrah buffalo heifers (n = 24) were categorized into four groups (six in each) viz. control group (T0), cooling jacket group (T1), cooling jacket + forced ventilation group (T2) and sprinklers + forced ventilation group (T3). Cooling jackets used in the study were made up of double layered thick cloth *(Chagal)* able to hold and cool the water through evaporative cooling. In this study 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): 1440, Air Delivery (M3/ min): 270*) were used as a tool for forced ventilation in the groups T2 and T3. These Air Circulator- fans were fitted at a height of 6′ 8′′ in the wall (at an angle of 40-45^{O}) at one end of the standing area inside the shed. In T1 group only cooling jackets were utilised during the experimental period (between 9.00 am to 6.00 pm) without any forced ventilation. However, both cooling jacket and wall mounted high speed air circulator fan for forced ventilation were utilized in T2 group continuously during the experimental period. In T3 group the metallic (copper) sprinklers were fitted in a pipe at 7′ 7′′ above the ground level 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. In this group sprinkling was carried out for a period of 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 experimental period except during sprinkling time.

Measurement of macro and micro-climatic variables

Daily ambient temperature (maximum and minimum) and RH of macro (outside the shed) and micro (inside the shed) environment in various groups were recorded

Table 1: Minimum (Min.) and maximum (Max.) temperature (°C), Relative Humidity (RH) (%) and Temperature Humidity Index (THI) of micro-climate (inside the shed) and macro-climate (outside the shed) during hot-humid season

Months	Minimum (Min.) and maximum (Max.) temperature (°C)									
	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. (°C)	Max. (°C)	Min. (°C)	Max. (°C)
Aug.	28.93 ± 0.16^{b}	33.42 ± 0.23^{B}	28.26 ± 0.21^{c}	32.58 ± 0.19^{C}	27.42 ± 0.15^{c}	31.58 ± 0.19^{C}	26.80 ± 0.16^{c}	31.26 ± 0.20^{C}	27.26 ± 0.17^{c}	35.58 ± 0.31^{C}
Sept.	28.20 ± 0.16^{b}	32.70 ± 0.13^{B}	27.10 ± 0.20^{b}	31.53 ± 0.20^{B}	26.43 ± 0.17^{b}	30.87 ± 0.18^{b}	25.90 ± 0.20^{b}	30.27 ± 0.20^{B}	25.30 ± 0.23^{b}	34.17 ± 0.20^{B}
Oct.	25.68 ± 0.42^{a}	30.64 ± 0.36^{A}	24.48 ± 0.41^{a}	29.71 ± 0.35^{A}	23.61 ± 0.39^{a}	28.87 ± 0.30^{A}	23.16 ± 0.39^{a}	28.29 ± 0.32^{A}	21.32 ± 0.49^{a}	32.13 ± 0.43^{A}
Over all	27.60 ± 0.22^{z}	32.25 ± 0.19^{Y}	26.60 ± 0.23^{y}	31.27 ± 0.19^{X}	$25.81\pm.23^{x}$	30.43 ± 0.18^{W}	25.28 ± 0.22^{x}	29.93 ± 0.19^{W}	24.62 ± 0.32^{w}	33.96 ± 0.24^{Z}
	Relative Humidity (RH) (%)									
	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
Aug.	81.19 ± 0.87^{a}	76.68 ± 1.00^{A}	79.80 ± 0.68^{a}	75.64 ± 0.80^{A}	77.29 ± 0.73^{a}	70.35 ± 0.90^{A}	77.32 ± 0.76^{a}	68.35 ± 1.07^{A}	83.48 ± 1.02^{a}	77.39 ± 0.60^{AB}
Sept.	82.13 ± 1.15^{a}	77.50 ± 0.82^{A}	80.73 ± 0.98^{ab}	78.43 ± 0.68^{B}	78.03 ± 0.97^{a}	71.36 ± 0.82^{A}	77.87 ± 0.82^{a}	68.87 ± 0.73^{A}	88.63 ± 0.84^{b}	78.70 ± 0.88^{B}
Oct.	82.38 ± 0.79^{a}	77.38 ± 0.70^{A}	82.68 ± 0.93^{b}	79.45 ± 0.92^{B}	80.87 ± 0.83^{b}	74.06 ± 0.80^{B}	80.64 ± 1.00^{b}	72.26 ± 0.98^{B}	87.64 ± 0.66^{b}	75.77 ± 0.84^{A}
Over all	81.90 ± 0.54^{x}	77.18 ± 0.49^{Y}	81.07 ± 0.51^{x}	77.83 ± 0.49^{Y}	78.74 ± 0.51^{w}	71.93 ± 0.51^{X}	78.61 ± 0.52^{w}	69.84 ± 0.57^{W}	86.56 ± 0.54^{y}	77.27 ± 0.46^{Y}
	Temperature Humidity Index (THI)									
Aug.	78.13 ± 0.34^{b}	83.39 ± 0.28^{B}	77.06 ± 0.27^{b}	82.06 ± 0.34^{B}	76.51 ± 0.24^{b}	80.80 ± 0.29^{C}	76.22 ± 0.24^{b}	80.06 ± 0.30^{B}	84.16 ± 0.57^{b}	90.26 ± 0.49^{B}
Sept.	76.27 ± 0.24^{a}	81.93 ± 0.24^{A}	76.20 ± 0.34^{ab}	81.70 ± 0.34^{B}	74.77 ± 0.26^{a}	79.43 ± 0.24^{B}	75.06 ± 0.22^{ab}	79.07 ± 0.24^{B}	82.13 ± 0.55^{a}	87.37 ± 0.41^{A}
Oct.	76.71 ± 0.40^{a}	81.74 ± 0.41^{A}	75.55 ± 0.65^{a}	80.42 ± 0.47^{A}	74.29 ± 0.69^{a}	78.06 ± 0.56^{A}	73.90 ± 0.68^{a}	77.55 ± 0.52^{A}	81.13 ± 0.68^{a}	86.16 ± 0.62^{A}
Over all	$77.04+0.21^{x}$	$82.36+0.20^{Y}$	$76.27+0.27^{x}$	$81.39+0.23^{X}$	$75.19+.028^{w}$	$79.43+0.25^{W}$	$75.06+0.27^{w}$	$78.89+0.24^{W}$	$82.49+0.37^{y}$	$87.93+0.35^{Z}$

Mean bearing different superscript (a,b,c, d) with in the column differ significantly ($P<0.05$) at 10.00 AM and (A,B,C, D) differ significantly ($P<0.05$) 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 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. The RH values (%) were calculated using dry and wet bulb thermometer reading for different groups. 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

Statistical analysis

In the present study descriptive statistics were used to calculate daily minimum and maximum temperature, RH and THI. These values in 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

The micro and macro climatic variables viz. minimum and maximum temperature, RH and THI during the experimental period have been presented in Table 1. Among macroclimatic variables the overall minimum and maximum temperatures were 24.62 ± 0.32 and 33.96 ± 0.24 C while the overall THI was observed to be 82.49 ± 0.37 and 87.93 ± 0.35 at 10.00 am and 2.00 pm, respectively. These values clearly indicated that the environmental conditions were quiet stressful during the experimental period.

Results indicated significantly ($P<0.05$) lower overall maximum temperature in T3, T2 and T1 groups (29.93 ± 0.19, 30.43 ± 0.18 and 31.27 ± 0.19^{o}C, respectively) as compared to T0 group (32.25 ± 0.19^{o}C). Furthermore, significantly ($P<0.05$) lowest minimum temperature was found in T3, T2 and T1groups (25.28 ± 0.22, 25.81 ± 0.23 and 26.60 ± 0.23^{o}C, respectively) compare to T0 group (27.60 ± 0.22^{o}C), which is in accordance with Vijaykumar *et al.* (2009), who reported the lowest minimum temperature in group kept under sprinklers and ceiling fans in Murrah buffalo heifers during heat stress.

The lowest minimum temperature in T3 and T2 groups might be due to fast air exchange through forced ventilation and better means of cooling (sprinkler and cooling jacket, respectively). However, higher maximum temperature in control group may be because of ineffective movement of air (ventilation) inside the shed as there was no any mechanical means of ventilation and cooling facility. Gaughan *et al.* (2010) also suggested the use of sprinklers and fans for ameliorating the thermal stress during heat stress.

RH value of both micro and macro climate has been mentioned in the Table 1. Significantly ($P<0.05$) lower RH values were observed in T3 and T2 groups (78.61 ± 0.52% and 78.74 ± 0.51%, respectively) as compared to control group at 10.00 am. Similarly, significantly ($P<0.05$) lower RH values were found in T3 (69.84 ± 0.57%) and T2 groups (71.93 ± 0.51%) than T0 group (77.18 ± 0.49%) at 2.00 pm. Our findings are in accordance with Vijaykumar *et al.* (2009). The lower RH values both at 10.00 am and 2.00 pm in T3 and T2 groups might be attributed to the forced ventilation using high speed air circulator fan. Further, we observed higher values (>72%) of RH in all groups which are supported by Roy and Chattergee, (2010) who reported significantly ($P<0.01$) higher RH values in sheds during hot-humid season.

Table showed significantly ($P<0.05$) lower THI in T3, T2 and T1 groups during peak hot hours (78.89 ± 0.24, 79.43 ± 0.25 and 81.39 ± 0.23, respectively) than T0 (82.36 ± 0.20) groups. However, significantly ($P<0.05$) higher THI was found in T0 (77.04 ± 0.21) as compare to T2 (75.19 ± 0.28) and T3 (75.06 ± 0.27) groups at 10.00 am during hot-humid season. Although relatively lower THI was observed in T1 group (76.27 ± 0.27) than those of control group at 10.00 am but difference was statistically non significant. The table reveals that the THI at 9:00 am was comparatively lower from THI at 2:00 pm in all the treatments groups which is supported by Kamal *et al.* (2014). Further, our findings had shown lesser difference between maximum (at 2.00 pm) and minimum (at 10.00 am) THI which is in agreement with Khongdee, (2008). Lower THI in T3 and T2 groups may be due to lower RH because of forced ventilation, resulting into better displacement of humid air by fresh air.

Besides, our findings also indicated that the positive effect of cooling methods on micro-climate inside the shed which further improved the physiological parameters (surface temperature, rectal temperature, respiration rate and pulse rate) of buffalo heifers during hot-humid season.

CONCLUSION

From the findings of present investigation it may be concluded that both cooling jacket and sprinklers in combination with forced ventilation helped to ameliorate the thermal stress in Murrah buffalo heifers under loose houses during hot-humid season.

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