RESEARCH ARTICLE

Effect of cooling system on feed and water intake, body weight gain and physiological responses of Murrah buffaloes during summer conditions

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Abstract Twelve Murrah buffalo heifers were selected and divided equally into two groups. Group-I (experimental) animals were kept under fan-cum-mist system and group-II (control) animals under normal ambient conditions. Dry and wet bulb temperatures were recorded throughout the study and THI was calculated. The Average dry bulb temperature was 33.09±0.37°C at 1600 h under natural conditions. Fan-cum-mist system reduced dry bulb temperature by 2.21°C and wet bulb temperature by 1.55°C from their respective temperatures recorded under natural conditions. Physiological responses viz. rectal temperature, skin temperature, respiration rate and pulse rate of both groups were recorded at 0900h and at 1400h under both conditions. Overall average of RT was 100.76±0.15°F and 101.11±0.35°F at 9.00 hrs, which increased to 101.48±0.31°F and 102.75±0.29°F at 14.00 hrs in experimental and control groups, respectively. Fan-cum-mist system lowered the RT by 1.27°F than natural conditions. ST of group-II was higher (98.49±0.42°F) than group-I (96.54±0.38°F) animals at 14.00 hrs. During afternoon, RR and PR were lower in group-II compared to group-I by 3 breaths/min and 4 beats /min, respectively. The body weight gain was significantly higher ($P<0.05$) in experimental animals than group-II. Water intake of experimental animals were lower (17.15±0.59 kg/day) compared to control group (20.04±0.55 kg/day). The fan-cum-mist system helped in amelioration of heat stress by lowering the physiological responses and enhancing the animal's growth and reducing water requirement. Therefore, fan-cum-mist system could be used as managemental tool for sustaining animal's productivity during heat stress.

Keywords : Growth, Water intake, Physiological responses, fan-cum-mist system , Murrah buffalo

Introduction

The productivity of Murrah buffalo undergoes seasonal changes and it has been established that the productivity is affected both directly and indirectly by climatic extremes (West, 2003). The productivity remains unaffected relatively within the zone of thermal comfort. The animals that are exposed to chronic stress, try to acclimatize in the adverse condition with the help of phenotypic responses to environmental changes (Collier and Collier, 2012). When the heat load of an animal is greater than its capacity to lose heat, a portion of the metabolizable energy used for production must be diverted to assure thermal balance (Kumar *et al.*, 2011). In order to reduce production losses and to provide comfort to the animals there is a need to modify the environmental conditions at micro levels. Experiments have shown that growth rate and milk yield of cattle and buffaloes decline due to rise in ambient temperature especially during hot and hot humid seasons (Sirohi and Michaelowa, 2007). Therefore, proper shelter is necessary for maintaining the animal productivity under different agro climatic conditions. Heat alleviating measures viz. fan, coolers, foggers, mist, showers, wallowing etc. may be used for reducing the thermal stress effects. Keeping the above facts in mind, the present study was planned to improve the growth rate and feed intake of buffalo heifers by ameliorating adverse heat stress effects using the fan-cum-mist system.

Materials and Methods

Selection, feeding and maintenance of animals

The present study was carried out on Murrah buffalo heifers

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at NDRI, Karnal, situated at an altitude of 250 meter above mean sea level, latitude and longitude position being 29° 42" N and 79° 54" E, respectively, with ambient temperature in summer as high as 45°C and in winter as low as 0°C. Twelve Murrah buffalo heifers were selected from herd of NDRI, Karnal and further divided equally (6 each) into two groups. First group (experimental) of animals were kept under fan cum mist system and another group (control) of animals were kept under normal existing climatic conditions from May to September, 2011.

The experimental animals were maintained as per standard feeding and management practices followed at NDRI, Karnal, India. The animals were feed *ad libitum* roughages and water was available round the clock. The concentrates mixture was feed as per Kearl (1982) feeding standard. Concentrate mixture consisted of mustard cake, maize, wheat bran, rice bran, mineral mixture and salt. The crude protein (CP) and total digestible nutrients (TDN) of diet was 12% and 60%, respectively.

Recording of climatic conditions

The environmental variables viz. dry and wet bulb temperature, relative humidity was recorded (Table 4 & 5) during the entire period of the study under natural and under fan-cum-mist system and temperature humidity index (THI) was calculated using following formula (Johnson *et al.* 1963).

$$THI = 0.72\ (Tdb + Twb) + 40.6$$

Where: Tdb = dry bulb temperature (°C), Twb = wet bulb temperature

Recording of physiological parameters, feed intake and body weight gain

The physiological parameters viz. respiration rate (RR) and pulse rate (PR) were recorded from flank movement and coccygeal artery, respectively. The rectal temperature (RT), skin (ST) and tympanic temperature (TT) were recorded using electronic thermometer and non contact tele thermometer respectively. These physiological responses viz. RT, ST, RR and PR of both groups of buffalo heifers were recorded during forenoon and afternoon under fan-cum-mist system and natural climate conditions. Weekly dry matter intake (DMI), body weight gains (Kg) and water intake (litre) was recorded during the entire period of the study.

Statistical methods

The data analysis was done using SAS software, Version (9.1) of the SAS System for Window, Copyright© (2011) SAS Institute Inc., Cary, NC, USA. Data from different experiments are presented as mean± SE. The pair-wise comparison of means was carried out using Tukey's multiple comparison test. The difference at $P \leq 0.05$ was considered to be statistically significant.

Results and Discussion

The results of feed intake, physiological responses, water intake and body weight gain have been presented in table 1 to 3 and the environmental variables recorded in table 4 and 5.

Maximum (Tmax), minimum temperature (Tmin) and temperature humidity index (THI)

The Tmax and Tmin increased under both the conditions i.e. under natural and controlled micro climatic (fan-cum-mist system) conditions. The Tmax increased from 27.65 ± 0.28°C and 27.68 ± 0.29°C at 7.00 hrs to 31.56 ± 0.28°C and 32.81 ± 0.32°C under fan-cum-mist system and natural exposure conditions at 13.00 hrs respectively (Table 4). The rise in Tmax under natural conditions was 5.41°C due to solar radiation over 7.00 hrs at 16.00 hrs. (Table 4). During the same period Tmax under fan-cum-mist system increased only by 3.65°C (Table 4). Similarly, the Tmin was also increased with the increase in solar radiation. The increase in Tmin at 16.00 hrs was 2.86°C and 4.34°C over the 25.74 ± 0.23°C and 30.15± 0.33°C recorded at 7.00 hrs, respectively under fan cum mist and natural conditions (Table 4). Kumar *et al.* (2009) reported 0.9°C lower temperature under fan cum mist system compared to natural conditions. Aggarwal (2011) also reported similar findings under showering system compared to natural exposure conditions.

The temperature humidity index (THI) considered being the scale for measuring the heat stress on animals was calculated at different intervals of exposure (Table 5). The duration and intensity of Tmax and THI (>72) has adverse effects on different breeds of cattle and buffaloes depending upon their adaptability to tropical climatic conditions. The THI values were also increased with the increase in Tmax and Tmin during different months of study (Table 5). The THI increased under natural and controlled conditions, but the increase under natural condition was higher (87.62±0.78) compared to fan-cum-mist system (85.37±0.66) system at 1600h during June month (Table 5). Valtorta *et al.* (2002) also suggested spray evaporative cooling (mist, foggers and sprinkling systems) as an effective way of cooling dairy animals. However, the single use of a sprinkling and fan system for 30 minutes before milking, has proved to be more useful to relief the dairy animals from heat stress by lowering the THI.

Physiological responses

The results of physiological responses in terms of respiration

Table 1 Rectal, skin and tympanic temperature of Murrah buffalo heifers during different months

Months	Rectal temperature (°F)				Skin Temperature (°F)				Tympanic Temperature (°F)			
	Experimental		Control		Experimental		Control		Experimental		Control	
	Forenoon	Afternoon	Forenoon	Afternoon	Forenoon	Afternoon	Forenoon	Afternoon	Forenoon	Afternoon	Forenoon	Afternoon
June	101.09 ±0.11	101.76 ±0.11	101.92 ±0.17	103.03 ±0.12	97.03 ±0.33	98.06 ±0.32	98.08 ±0.35	100.12 ±0.43	98.59 ±0.19	99.29 ±0.17	98.81 ±0.21	99.81 ±0.19
July	101.25 ±0.08	101.5 ±0.11	101.39 ±0.11	103.41 ±0.09	95.41 ±0.37	96.67 ±0.43	95.69 ±0.37	101.57 ±0.32	96.76 ±0.22	97.94 ±0.23	96.85 ±0.21	99.51 ±0.21
August	100.43 ±0.1	101.12 ±0.11	100.88 ±0.14	102.45 ±0.10	92.8 ±0.5	95.46 ±0.37	94.75 ±0.31	99.98 ±0.36	92.92 ±0.72	96.44 ±0.2	93.39 ±0.58	98.35 ±0.24
September	100.26 ±0.09	101.53 ±0.15	100.26 ±0.08	102.12 ±0.20	93.44 ±0.3	95.97 ±0.23	93.44 ±0.31	98.88 ±0.6	87.03 ±0.06	96.05 0.17	87.03 ±0.06	96.42 ±0.31
Average	100.86[a] ±0.06	101.48[b] ±0.06	101.21[a] ±0.08	102.84[b] ±0.07	94.99[a] ±0.25	96.69[b] ±0.21	95.66[a] ±0.22	100.37[b] ±0.22	95.17[a] ±0.36	97.74[b] ±0.14	94.97[a] ±0.35	98.82[b] ±0.15

"The values are means ± SE of six observations on six animals.
"The different superscript in a row indicate significant difference (P<0.05)

Table 2 Respiration and pulse rate of Murrah buffalo heifers during different months

Months	Respiration Rate/min				Pulse Rate / min			
	Experimental		Control		Experimental		Control	
	Forenoon	Afternoon	Forenoon	Afternoon	Forenoon	Afternoon	Forenoon	Afternoon
June	21.77±0.49	26.17±0.56	25.75±1.43	32.06±0.84	60.87±0.67	64.73±0.63	65.69±0.99	68.61±0.69
July	24.56±0.69	25.78±0.69	24.85±0.66	35.50±0.74	61.31±0.58	59.98±0.57	62.50±0.68	67.56±0.69
August	18.69±0.72	33.95±4.06	18.96±0.74	26.50±0.76	56.9±0.86	61.62±0.90	55.22±0.71	61.91±0.76
September	13.44±0.85	20.22±0.62	13.44±0.84	25.17±1.06	55.44±0.99	58.17±1.42	55.44±0.97	60.78±1.64
Average	20.84±0.44[a]	27.44±1.17[b]	21.71±0.53[a]	30.4±0.53[b]	59.31±0.41[a]	61.67±0.43[b]	59.91±0.54[a]	65.06±0.49[b]

"The values are means ± SE of six observations on six animals.
"The different superscript in a row indicate significant difference (P<0.05)

Table 3 : Water intake and body weight of Murrah buffalo heifers

Month	Water intake (lit/day)		Body weight (kg)	
	Experimental	Control	Experimental	Control
May	-------	------	193.67±16.52	184.17±16.44
June	18.49±1.07	21.58±0.88	213.00±15.26	225.33±25.93
July	20.67±1.01	23.46±1.03	241.50±17.05	240.50±27.94
August	14.60±0.83	16.54±0.84	254.33±16.22	241.67±28.04
September	13.04±1.44	18.25±1.42	275.33±19.59	252.33±29.64
Average	17.15±0.59[a]	20.04±0.55[b]	234.16±10.66[a]	228.80±11.96[b]

The different superscript in a row indicate significant difference (P<0.05)

rate, pulse rate, rectal temperature, skin and tympanic temperature has been presented in Table 1 and 2. The initial respiration rate and pulse rate recorded during forenoon was found to be higher in control group of animals during June month. In other months the forenoon values were almost at similar levels in both the groups of animals (Table 2). The respiration rate and pulse rate was found to be higher during afternoon in both the groups of buffalo calves. Vaidya *et al.*

(2010) also reported the higher RR and PR in growing and adult buffaloes during afternoon compared to forenoon due to exposure. Chander Bhan *et al.* (2013) reported positive correlation between RT, humidity and other physiological responses in Murrah buffaloes and Karan-Fries cattle. RT is considered as a good index of body temperature even though there is a considerable variation in different parts of the body core at different times of the day (Srikanda and Johnson, 2004). The overall mean values of RR during forenoon were 20.84 ± 0.44 and 21.71±0.53/min in experimental and control groups of animals respectively. The respective values increased to 27.44±1.17 and 30.40±0.53/min in experimental and control groups of animals (Table 2). The increase in RR was 7 breaths/min in experimental group and 9 breaths/min in control group of animals. Similarly, fan-cum-mist system helped in reducing the PR during afternoon in experimental animals compared to control group of animals. The overall increase in PR was 2 beats/ minute in experimental group and 5 beats/min control group of animals (Table 2). Singh and Singh (2006) and Das *et al.*, (1999) reported a circadian variations in RR and PR of Karan Fries cattle. The findings of the present study coincides with the results of Fuquay (1981) and Valtorta and Maciel (1998) who reported a variety of detrimental effects of heat stress on livestock with significant effects on milk production and reproduction in dairy cows (Valtorta *et al*., 1996). Similarly, Kumar *et al.* (2009) also found lower respiration (11 breaths/min) and pulse rate (2 beats/ min) in lactating buffaloes kept under cooling system (fan cum mist system) for six hours (1000hrs to 1600hrs) compared to their counterpart kept under natural climatic conditions.

The forenoon rectal temperature was found to be variable during different months (June to Sept.) of the experiments due to variable ambient conditions. The forenoon RT, ST and TT was found to higher during June and July months compared to August to Sept. months (Table 1). Average forenoon values of RT varied from 100.26±0.09 to 101.25±0.08 °F in experimental animals and 100.26±0.08 to 101.92 ± 0.17°F in control group of animals. The RT increased at different levels during different months in both group of animals (Table 1). The overall rise in RT in experimental group was 0.62°F and in control group was 1.63°F during afternoon over forenoon values indicating around 1°F lower RT in experimental group of animals (Table1). The results of present investigation are in accordance to those of Singh and Upadhyay (2009) who reported lower physiological responses (RR, PR, RT & ST) in protected compared to exposed group of dairy animals. Das *et al.* (2011) also reported the beneficial effect of washing buffaloes twice, thrice and four times in a day during summer season for lowering down the physiological responses. Singh *et al.* (2008) reported a positive relationship among Tmax and THI with RT in buffaloes kept under shed and exposed environmental conditions.

Skin temperature and tympanic temperature also followed the similar pattern of higher values during afternoon compared to forenoon values in both groups of buffalo heifers (Table 1). Shibu *et al.* (2008) also reported a rise in ST in heifers due to rise in ambient temperature. The overall mean values of forenoon ST was 94.99±0.25 and 95.66±0.22°F which rose to 96.69±0.21 and 100.37±0.22°F during afternoon in experimental and control group of animals respectively (Table 1). The rise in ST during afternoon over forenoon values was lower i.e. 1.7°F in experimental group and 4.71°F in control group of animals. The present findings are in general agreements with Das *et al.* (2011) and Singh and Upadhyay (2009) who reported the similar trend i.e. higher ST in exposed group compared to protected group of animals. Similar pattern was followed by the tympanic temperature i.e. higher rise in control group compared to experimental group of animals. The overall mean values during forenoon were 95.17±0.36 and 94.97±0.35°F in experimental and control group of animals, respectively. These respective values rose to 97.74±0.14 and 98.82±0.15°F during afternoon in experimental and control group of animals, respectively (Table 1). Davis *et al*. (2003) also reported significant effect of heat stress in feedlot cattle which altered feeding regimen as determined from tympanic temperature.

Body Weight

The body weight gain is the most important parameter for deciding the age of puberty. The initial body weight of animals

Table 4 : Dry bulb and wet bulb temperature (°C) recorded during the experiment

Hours	Mist+ Fan		Without M+F	
	Dry Bulb Temperature	Wet Bulb Temperature	Dry Bulb Temperature	Wet Bulb Temperature
7:00	27.65±0.28	25.74±0.23	27.68±0.29	25.81±0.25
10:00	30.05±0.21	27.54±0.16	30.82±0.28	27.90±0.21
13:00	31.56±0.28	28.51±0.18	32.81±0.32	29.52±0.24
16:00	31.30±0.28	28.60±0.19	33.09±0.37	30.15±0.33
19:00	27.98±0.27	26.42±0.22	28.40±0.33	26.67±0.25

Table 5 : Temperature humidity index at different hours of the study

Hours	Condition	June	July	Aug	Sept
0700	Experimental	80.56±0.61	80.21±0.42	76.67±0.64	77.94±0.60
	Control	80.63±0.65	80.32±0.49	76.73±0.64	77.94±0.60
1000	Experimental	83.01±0.46	82.43±0.40	80.88±0.46	81.69±0.55
	Control	83.49±0.51	83.71±0.66	81.66±0.68	82.05±0.46
1300	Experimental	85.44±0.54	83.73±0.41	82.59±0.51	83.23±0.44
	Control	86.84±0.57	85.96±0.76	83.96±0.69	84.42±0.75
1600	Experimental	85.37±0.66	83.47±0.47	82.52±0.54	83.29±0.26
	Control	87.62±0.78	86.89±0.73	84.50±0.84	84.26±0.34
1900	Experimental	82.56±0.56	78.38±0.43	78.96±0.54	78.25±0.70
	Control	83.96±0.66	78.64±0.48	78.96±0.56	78.14±0.64

at the start of experiment was 193.67±16.52 and 184.17 ± 16.44 kg in experimental and control groups of animals, respectively. After the end of 4 month experiment the absolute body weight rose to 275.33± 19.59 and 252.33±29.64 kg in experimental and control group of animals, respectively. The body weight gain per day and in absolute terms was significantly higher in experimental group compared to control group of animals (Table 3). The average daily gain in experimental group was 544.4 gm/day and in control group was 454.4 gm/day. Similar to present findings Brobeck (1960) also reported that direct effect of higher ambient temperature in reduction of feed intake and ultimately growth rate of animals. During thermal stress, reduction in feed intake helped in prevention of hyperthermia, decreased nutrients availability for productive processes and ultimately decreased the animal's growth rate (Lough *et al.*, 1990).

Feed intake

Control and experimental buffalo heifers were monitored for dry matter intake (DMI) during the experimental period. Average DMI in control buffalo heifers were 5.80±0.71 kg/day. The DMI increased by 0.5 kg in experimental group of animals amounting to 6.3 kg/day (Fig 1). DMI /100 kg body weight was found to be 2.48 and 2.69 kg respectively in control and experimental buffaloes. Johnson *et al.* (1963) also reported significant declines in DMI when maximum THI reached to 77. Ahmed and El-Amin (1977) reported decrease in feed intake of HF and Boron cows by 0.24 and 0.06 g/kg/hr respectively due to heat stress. Singh *et al*. (2008) also reported a decrease in feed intake in heat exposed group of Karan Fries calves compared to protected group of animals during hot dry and hot humid conditions. Holter *et al.* (1997) established a significant negative correlation between THI and DMI for cows and suggested that the effect of THI is probably mediated through the effects of increasing body temperature of cow.

Water intake

Water is the most important component of the body. Water helps in maintaining the homeothermy in homeotherms by helping in thermoregulation by loosing heat through sweating and panting process. The water intake was significantly ($P<0.05$) lower in experimental group of animals compared to control group of animals. The overall average of water intake was 17.15±0.59 and 20.04±0.55 litres/day in experimental and control group of animals respectively (Table 3). The results of the present study are in accordance to those of Mader and Davis (2004) who reported lower water intake in feedlot cattle kept under sprinklers.

Conclusions

The cooing device (fan-cum-mist system) helped in reducing the different physiological responses (RR, PR, RT, ST&TT) and water intake significantly in experimental Murrah heifers compared to control. The cooling system also helped in improving the feed intake and growth rate in experimental animals. Therefore, based on the results obtained during the present study, it can be stated that fan-cum-mist system is very useful for improving the growth rate of the animals. Higher growth rate in experimental animals is the good indicator for reducing the age of puberty/maturity and therefore this cooling system will be helpful in the increasing total productive life of animals.

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