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Effect of heat mitigation methods on growth performance of Murrah buffalo heifers in loose housing system

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Abstract
A study was conducted to assess the effect of heat mitigation methods on the body weight, average daily gain and body measurements of Murrah buffalo heifers in loose housing system. The experiment was conducted on 18 Murrah buffalo heifers of age 1.5 to 2 years, maintained at Buffalo Research Station (BRS), Venkataramannagudem, Andhra Pradesh and were randomly allotted into three groups i.e., group reared under conventional asbestos roof (control), group provided with dried coconut leaves over the conventional asbestos roof (T_1) and group provided with dried coconut leaves over the conventional asbestos roof and ceiling fans along with water splashing (T_2) for a period of 90 days with a prior 15 days acclimatization period. The study revealed that the overall average daily gain of T_2 group (362.96±7.89) was significantly ($p<0.01$) higher than control group (315.19±10.91). The overall mean chest girth (cm) was significantly ($p<0.05$) higher in T_2 group (153.36±0.66) than control group (150.82±0.69). The mean overall height at withers (cm) was significantly ($p<0.05$) higher in T_2 group (120.74±0.29) than control group (119.57±0.28). The overall body length, poll length and tail length were not significantly differed among the groups, however higher values were observed in T_2. It is concluded that provision of heat mitigation methods such as roof insulation and evaporative cooling resulted in higher growth of Murrah buffalo heifers compared to animals under conventional asbestos roof.

Keywords: Murrah buffalo, heat mitigation, growth, average daily gain, roof insulation, evaporative cooling

1. Introduction
India is a predominantly agricultural nation, with more than two- thirds of the population living in rural areas and relying on the agriculture and related industries for their livelihood. As per the latest livestock census (2019) in India, the total buffalo population is 109.85 million and ranks first in the world. The buffalo population has been increased by 1.1% since the previous census (2012). They contribute about 20.5% of the total livestock in India. Buffalo is the major contributor to milk in India. As a tropical country, India experiences high temperatures during summer. Animal production is constrained in many places of the world because of heat stress. (El-Tarabany *et al*. 2017) [5]. Thermal stress has impact on growth performance of animals (Baumgard *et al*. 2012) [3]. It also hampers the lateral appetite center in the hypothalamus, as this leads to depleted feed intake. Heifers are a crucial investment for the future of any dairy herd. They are more susceptible to stress than adults including the thermal stress. This will hinder their reproductive performance like delay in ovulation and conception, anestrus, silent estrus etc. In order to hinder the adverse effects of heat stress, the management practices should be suitable and economical to the farmers. Hence, the present research was conducted to assess the effect of heat mitigation methods on the growth performance of Murrah buffalo heifers.

2. Materials and Methods
The materials and methods adopted for the experiment are described below:

2.1 Animals and treatments
The experiment was carried out on 18 healthy Murrah buffalo heifers with an average age of 1.5 to 2 years which were maintained at Buffalo Research Station, Venkataramannagudem, Sri Venkateswara Veterinary University, Tirupati. The heifers were selected randomly with similarity based on age and body weight and were divided into three groups as follows:

2.1.1 Control: Heifers under conventional asbestos roof in the covered area and no other heat alleviation managemental practices; T_1: Heifers under dried coconut leaves over the asbestos roof and no other heat alleviation managemental practices; T_2: Heifers under dried coconut leaves over the asbestos roof and ceiling fans along with water splashing. The water splashing was done with a hose pipe at a frequency of three times per day for 15 min each.

The animals were housed in their respective group 15 days prior to the experiment as an acclimatization period and the study was carried out for a period of 90 days during summer.

2.2 Feeding and watering

The experimental heifers were fed as per the standards of ICAR (2013) [6]. Green fodder (Super Napier) was given adlibitum along with weighed amount of concentrate mixture according to their body weight. An adlibitum clean and fresh drinking water were available round the clock to all the heifers throughout the study period.

2.3 Health management

The heifers were dewormed prior to the experiment. Deworming and vaccination schedules were followed regularly. Standard operating procedures were carried out for sanitization of feed and water mangers, animal sheds and gutter.

2.4 Body weight

The body weight (kg) of heifers in all groups were recorded at fortnight intervals throughout the experiment using a weigh bridge located at the research station. The total weight gain of animals was obtained by calculating the difference between initial and final body weights.

2.5 Average daily gain

The average daily gain (ADG) was calculated fortnightly and also for overall experiment. It was calculated by using the following formula:

$$\text{ADG} = \frac{\text{Final Weight (kg)} - \text{Initial Weight (kg)}}{\text{Number of days}}$$

2.6 Body measurements

The body measurements of experimental heifers were recorded early in the morning before feeding at fortnight intervals using a measuring tape in centimetres by making the animal to stand squarely on the even ground in the covered area of the shed as per Archana *et al*. (2021) [2].

A) Body length (BL): The horizontal distance between point of shoulder and of pin bone same side.

B) Chest girth (CG): The minimum distance of body circumference around the chest, ventrally at the point of elbow, measured in centimetres.

C) Height at withers (HAW): The vertical distance measured from the base of the hoof to the highest point at withers, measured in centimetres.

D) Poll length (PL): The horizontal distance between two polls, measured in centimetres.

E) Tail length (TL): The distance between top of base of the tail to the end excluding the switch, measured in centimetres.

2.7 Statistical analysis

The data obtained was subjected to one way analysis of variance (ANOVA) with the formula of David. B. Duncan (1955) [4] using SPSS IBM, version 22.0, SPSS Chicago (US).

3. Results and Discussion

3.1 Body Weight (kg) and Average Weight Gain (kg)

The body weight (kg) of experimental Murrah buffalo heifers was recorded at fortnightly intervals during the study period (Table 1). The mean initial body weights (kg) of control, T_1 and T_2 were 228.00±9.43, 227.67±9.31 and 227.67±7.37, respectively which increased to 256.37±7.82, 258.05±7.81 and 260.33±6.33, respectively at the end of study period. The overall mean body weight (kg) of control, T_1 and T_2 was 241.56±3.35, 242.44±3.39 and 243.45±2.93, respectively.

The table revealed that the overall mean body weight and average weight gain in all the three groups did not differ significantly. The body weight in heifers was increased with increase in their age. Similarly, Singh (2000) [7] reported that there was no significant difference in body weight of Murrah buffalo heifers reared under thatched roof, groups under aluminium foils pasted asbestos roof, white painted asbestos roof and asbestos roof. Verma *et al*. (2022) [8] also reported that there was no difference in final body weight of Murrah buffalo heifers group provided with cooling jacket and forced ventilation, group provided with intermittent sprinkling + forced ventilation and heifers group without cooling.

Table 1: Effect of heat mitigation methods on body weight (kg) of Murrah buffalo heifers

Fortnight	Groups		
	Control	T_1	T_2
Initial	228.00±9.43	227.67±9.31	227.67±7.37
1	232.13±9.28	232.18±9.04	232.52±7.21
2	236.35±8.83	237.10±8.99	237.57±7.10
3	241.05±8.24	242.17±8.39	243.03±6.67
4	245.97±8.32	247.32±8.28	248.60±6.55
5	251.08±8.16	252.63±8.01	254.38±6.42
6	256.37±7.82	258.05±7.81	260.33±6.33
Overall Mean±SE	241.56±3.35	242.44±3.39	243.45±2.93
Average weight gain	28.37±1.63	30.38±1.63	32.67±1.20

3.2 Average daily gain (ADG)

The average daily gain (g) of heifers was calculated fortnightly throughout the study period (Table 2). The average daily gain in control, T_1 and T_2 during first fortnight was 275.56±11.24, 301.11±20.10 and 323.33±10.72, respectively which increased to 352.22±28.15, 361.11±21.18 and 396.67±13.19, respectively at 6th fortnight.

The perusal table revealed that the overall ADG of T_2 group was significantly (p<0.01) higher than control group. This might be due to increased dry matter intake as result of evaporative cooling effect and roof insulation in T_2 group heifers. Similarly, Verma *et al*. (2022) [8] also reported that average daily gain was significantly higher (p<0.0001) in heifers provided with cooling effect.

Table 2: Effect of heat mitigation methods on average daily gain (g) of Murrah buffalo heifers

Fortnight	Groups		
	Control	T_1	T_2
1	275.56±11.24	301.11±20.10	323.33±10.72
2	281.11±30.23	327.78±8.33	336.67±11.89
3	313.33±40.33	337.78±41.91	364.44±32.23
4	327.78±19.35	343.33±14.48	371.11±13.41
5	341.11±13.16	354.44±20.25	385.56±12.93
6	352.22±28.15	361.11±21.18	396.67±13.19
Overall Mean±SE	315.19±10.91^{b}	337.59±9.46^{ab}	362.96±7.89^{a}

3.3 Body measurements

3.3.1 Body length

The initial body length (cm) of control, T_1 and T_2 was 114.47±1.46, 114.27±1.52 and 114.38±1.18, respectively which increased to 117.83±1.56, 118.58±1.63 and 120.03±1.19, respectively at the end of study period (Table 3). The overall body length was higher in T_2 group (117.02±0.51) followed by T_1 (116.41±0.59) and control (116.09±0.55) but there was no significant difference.

Similar results were observed in the findings of Singh (2000) [7], who found no significant difference in body length of Murrah buffalo heifers reared under aluminium foils pasted asbestos roof and thatched roof when compared with asbestos roof. Similarly, Amit [1] *et al*. (2021) [8] who found no significant difference in body length of Murrah buffalo heifers reared under different roof modifications.

Table 3: Effect of heat mitigation methods on body length (cm) of Murrah buffalo heifers

Fortnight	Groups		
	Control	T_1	T_2
Initial	114.47±1.46	114.27±1.52	114.38±1.18
1	114.88±1.47	114.90±1.52	115.10±1.18
2	115.53±1.44	115.58±1.53	115.88±1.19
3	116.12±1.46	116.40±1.52	116.88±1.16
4	116.70±1.48	117.20±1.52	117.92±1.16
5	117.15±1.55	117.95±1.55	118.93±1.19
6	117.83±1.56	118.58±1.63	120.03±1.19
Overall Mean±SE	116.09±0.55	116.41±0.59	117.02±0.51

3.3.2 Chest girth

The initial chest girth (cm) of control, T_1 and T_2 was 149.00±1.88, 148.95±1.86 and 148.97±1.46, respectively which increased to 152.98±1.88, 155.25±1.86 and 158.73±1.16, respectively at the end of study period (Table 4). The overall chest girth was significantly (p<0.05) higher in T_2 (153.36±0.66) than control group (150.82±0.69). This might be due to the energy obtained by heifers in T_2 group was utilized for growth rather than body temperature maintenance.

Similar results were observed in the findings of Singh (2000) [7], who noticed that the chest girth was significantly (p<0.05) higher in Murrah buffalo heifers reared under aluminium foils pasted asbestos roof and thatched roof when compared with asbestos roof.

Table 4: Effect of heat mitigation methods on chest girth (cm) of Murrah buffalo heifers

Fortnight	Groups		
	Control	T_1	T_2
Initial	149.00±1.88	148.95±1.86	148.97±1.46
1	149.52±1.89	149.68±1.85	149.25±1.03
2	149.98±1.90	150.42±1.85	151.72±0.94
3	150.72±1.91	151.52±1.84	152.85±0.97
4	151.35±1.92	152.60±1.83	154.80±0.99
5	152.17±1.90	153.95±1.84	156.60±1.11
6	152.98±1.88	155.25±1.86	158.73±1.16
Overall Mean±SE	150.82±0.69^{b}	151.77±0.73^{ab}	153.36±0.66^{a}

3.3.3 Height at withers

The initial height at withers (cm) in control, T_1 and T_2 was 118.50±0.74, 118.40±0.74 and 118.52±0.61, respectively which increased to 120.77±0.74, 121.77±0.63 and 122.88±0.48, respectively by sixth fortnight (Table 5). The overall height at withers was significantly (p<0.05) higher in T_2 group (120.74±0.29) than control group (119.57±0.28). The lower height at withers in control group heifers might be due to stress caused by heat load.

Similar results were observed in the findings of Singh (2000) [7], who noticed that the height at withers was significantly (p<0.05) higher in Murrah buffalo heifers reared under aluminium foils pasted asbestos roof and thatched roof when compared with asbestos roof.

Table 5: Effect of heat mitigation methods on height at withers (cm) of Murrah buffalo heifers

Fortnight	Groups		
	Control	T_1	T_2
Initial	118.50±0.74	118.40±0.74	118.52±0.61
1	118.80±0.74	118.88±0.75	119.63±0.63
2	119.12±0.75	119.33±0.74	120.15±0.61
3	119.40±0.73	119.98±0.77	120.78±0.59
4	120.03±0.77	120.61±0.79	121.28±0.61
5	120.37±0.76	121.13±0.66	121.95±0.55
6	120.77±0.74	121.77±0.63	122.88±0.48
Overall Mean±SE	119.57±0.28^{b}	120.01±0.30^{ab}	120.74±0.29^{a}

3.3.4 Poll length

The initial poll length (cm) of control, T_1 and T_2 was 21.53±1.20, 21.75±1.28 and 21.88±1.19, respectively which increased to 24.00±1.16, 25.52±1.23 and 26.28±1.17, respectively by the end of the study period (Table 6). The overall poll length was higher in T_2 group (23.87±0.47) followed by T_1 (23.75±0.47) and control group (22.60±0.43). The higher overall poll length of T_2 group might be attributed to the improved heat dissipation due to both evaporative cooling and roof insulation.

Table 6: Effect of heat mitigation methods on poll length (cm) of Murrah buffalo heifers

Fortnight	Groups		
	Control	T_1	T_2
Initial	21.53±1.20	21.75±1.28	21.88±1.19
1	21.77±1.19	22.70±1.23	22.35±1.18
2	22.13±1.18	23.20±1.25	22.95±1.19
3	22.43±1.13	23.73±1.23	23.77±1.17
4	22.90±1.15	24.35±1.23	24.53±1.18
5	23.47±1.17	25.03±1.20	25.30±1.19
6	24.00±1.16	25.52±1.23	26.28±1.17
Overall Mean±SE	22.60±0.43	23.75±0.47	23.87±0.47

3.3.5 Tail length

The mean initial tail length (cm) of control, T_1 and T_2 was 63.47±0.82, 63.40±0.92 and 63.32±0.69, respectively which increased to 66.05±0.87, 67.58±0.87 and 67.68±0.71, respectively by sixth fortnight (Table 7). The overall tail length was higher in T_2 followed by T_1 and control. The lower value in control group might be due to lower heat dissipation and higher surrounding temperature compared to treatment groups.

Table 7: Effect of heat mitigation methods on tail length (cm) of Murrah buffalo heifers

Fortnight	Groups		
	Control	T_1	T_2
Initial	63.47±0.82	63.40±0.92	63.32±0.69
1	63.73±0.83	64.00±0.85	63.80±0.69
2	63.92±0.88	64.50±0.85	64.40±0.72
3	64.40±0.88	65.15±0.83	65.50±0.65
4	64.85±0.89	65.88±0.85	66.02±0.71
5	65.43±0.88	66.72±0.87	66.82±0.70
6	66.05±0.87	67.58±0.87	67.68±0.71
Overall Mean±SE	64.55±0.33	65.32±0.37	65.36±0.34

4. Conclusion

Heat mitigation strategies like roof insulation by dried coconut leaves and evaporative cooling by fans and water splashing can enhance the average daily gain and body measurements such as chest girth and height at withers in heifers. Heifers reared under conventional asbestos roof without any heat alleviation measures utilise energy on maintaining body temperature rather than on growth. Therefore, providing roof insulation and evaporative cooling to buffalo heifers during the summer ensures their thermal comfort and growth performance.

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