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Assessment on the changing pattern in feed intake, water intake and FCE due to roof modifications in buffalo heifers during summer

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Abstract
An attempt was made to study the effect of microclimate alterations on feed and water intake and feed conversion efficiency of buffalo heifers during summer at buffalo farm of LPM, LUVAS, Hisar (Haryana). Twenty buffalo heifers (8-18 months of age) were divided into four groups (5 heifers in each group) *viz.* T_1 (control): Corrugated asbestos roof; T_2: Corrugated asbestos roof painted white on upper side; T_3: Corrugated asbestos roof having EPE (Expanded polyethylene) sheet on lower side and T_4: Corrugated asbestos roof painted white on upper side and EPE sheet on lower side. Feed and water intake was recorded fortnightly for two consecutive days. The overall total dry matter intake as well as water intake (both voluntary water intake and total water intake) didn't differ significantly ($P>0.05$) in different groups whereas; overall DMI per 100 kg body weight was significantly high ($P<0.05$) in T_3. FCE was better in the T_4 group. So it can be concluded that microclimate alterations helped heifers in better relieving the heat load thereby increasing feed intake and better FCE as compared to heifers in existing asbestos roofs.

Keywords: Buffalo heifer, roof modifications, feed intake, water intake, feed efficiency

Introduction
Dairy animals are homeotherms (maintain constant body temperature) and therefore, in a tropical climate country like India when the environmental temperature rises, the animals are subjected to heat stress. The result is reduced performance like decline in feed intake, increase in water intake, growth reduction, loss in body weight and sometimes even death from extreme heat stress (Hahn and Mader, 1997; Gaughan *et al.*, 2000; Lefcourt and Adam, 1996; Mader *et al.*, 1999) [7, 6, 13, 14]. Buffaloes having thick and black skin, sparse hair coats, besides, small sized and less dense sweat glands are more prone to heat stress (Jat, 2002) [9]. In hot-humid climates, although buffalo attempts to acclimatize through physiological changes including cutting down on feed intake and heat production, this does not come without sacrificing part of its productivity finally resulting in decreased performance (Kumar *et al.*, 2018) [12]. Decrease in stress conditions significantly increases the animal comfort thus resulting in better production (Perissinotto *et al.*, 2006; Navarini *et al.*, 2009) [20, 17]. Similarly, water is the most functional agent in the body, playing an important role in mastication, digestion, absorption, distribution of nutrients and disposal of harmful end products of metabolism through various excretory channels. Water also has a high latent heat of evaporation (2400 J/g) and its evaporation from the lungs and skin gives it a further role in the regulation of body temperature (Mc Donald *et al.*, 1995) [16]. The total water requirement of ruminant is met from different sources such as, (i) Voluntary Water Intake (VWI) (ii) water consumption as part of forages and feeds and (iii) metabolic water. There are studies that indicate the direct association between water intake and environmental temperature (Arias *et al.*, 2008) [1]. Heat is generated by Nutrient metabolism which must be dissipated in a warm climate by physiological processes to maintain thermo-neutrality. Microclimate alteration strategies involve modification of existing shed structure by using highly reflective materials like white paint or low thermal conductive materials like expanded polyethylene (EPE) (low thermal conductive) sheets. It reduces the stress on the animals caused due to extremes of climatic conditions. Therefore the present study was envisaged to know the effect of roof modifications on the feed intake, water intake and FCE in buffalo heifers in summer.

Material and Methods

The materials and various methods adopted for the investigation described in this article are as:

Animals and Treatments

Twenty Murrah buffalo heifers of 8-18 months of age were selected from the buffalo herd of Livestock Production Management (LPM) and Buffalo Research Centre (BRC) of Department of Livestock Production and Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences (LUVAS), Hisar. Heifers were dewormed and sprayed against ectoparasites before the commencement of study. After the preliminary adjustment period of 10 days prior to the start of the experiment, the heifers were divided into four groups of five heifers each on the basis of similarity in body weight and age and then, one of the four treatments was given to each group randomly. *viz.* T1 (Control): corrugated asbestos roof, T2: corrugated asbestos roof painted white on upper side, T3: corrugated asbestos roof having 70 mm thick heat resistant EPE sheet on lower side, T4: corrugated asbestos roof painted white on upper side and 70 mm thick heat resistant EPE sheet on lower side.

Ad libitum, seasonal green fodder was offered to all the heifers daily during the entire experiment period. All the experimental buffalo heifers were fed on balanced ration as per the requirements and ICAR (2013) [8] standards. The quantity of different feeds given to heifers of each group was adjusted at fortnightly intervals as per the change in body weight of heifers. Clean and fresh drinking water was made available in each shed all the time.

Feed intake

The feed intake during the experiment was determined on the basis of weighing of feed and fodder offered and the left over for two consecutive days fortnightly. This feed intake was used for estimation of Dry Matter Intake (DMI) and Feed Conversion Efficiency (FCE). During this period all the animals were tethered and fed green fodder, roughages and concentrate mixture individually.

Dry Matter Intake (kg/day)

DMI (dry matter intake) from all feed sources was calculated separately and then all added to find out the total dry matter intake of heifers for each treatment group. The dry matter (DM) content of each feed sample was determined by drying a known weight of sample in a moisture cup overnight at 100 ± 2ºC in a hot air oven. Loss in weight was calculated as moisture and balance reported as dry matter. This was repeated fortnightly for two consecutive days by taking representative samples of feed and fodder and then an average of two days were taken.

The dry matter was calculated as per following formula:

$$\text{Dry Matter (\%)} = \frac{W_2\text{-}W}{W_1\text{-} W} \times 100$$

Where,

W = Weight of empty tray (g)

W_1= Weight of tray with sample before drying (g)

W_2= Weight of tray with dried sample (g)

Dry matter intake of animal was calculated as per following formula:

Dry Matter Intake = Weight of Feed × Dry Matter (%) in Feed

Feed conversion efficiency (FCE)

FCE was determined fortnightly for each heifer by dividing Average dry matter intake (kg) from Average weight gain (kg)/day in each treatment.

Water intake

The water intake of individual heifers was determined fortnightly for two consecutive days and then average value of two days was taken. For this a measured quantity of fresh water was offered *ad libitum* individually to each heifer by placing a graduated bucket full of water before the heifer thrice a day. Refusals were measured to know the actual voluntary water intake. Simultaneously, the water available from the feed and fodder consumed by heifer on that particular day was calculated on the basis of their moisture content. The total water intake for that particular day was thus obtained by adding the voluntary water intake and the water consumed through feed and fodder.

Statistical Method

The means of data obtained from the studies were compared by one way analysis of variance (ANOVA) as per the methods described by Snedecor and Cochran (1994) [27]. The data was analyzed using "SPSS" software (version-17).

Results

Dry Matter Intake (kg/day)

Fortnightly total DMI from all feed sources *viz.* concentrate, green fodder and wheat straw in different treatment groups is presented in table-1. The overall daily total DMI per heifer was 4.92±0.45, 4.99±0.60, 5.12±0.49 and 5.26±0.66 kg in T_1, T_2, T_3 and T_4, respectively. The perusal of the table revealed that there was no significant difference among treatments in overall daily total DMI, however, the values were always higher in T_4.

Table 1: Mean ± SE of fortnightly average Dry Matter Intake (kg) of heifers

Fortnight	Asbestos roof (T_1)	White painted roof (T_2)	EPE sheet roof (T_3)	White painted and EPE sheet roof (T_4)
I	4.15±0.42	4.18±0.58	4.26±0.52	4.38±0.53
II	4.71±0.44	4.79±0.58	4.86±0.48	4.96±0.65
III	4.89±0.44	4.97±0.61	5.06±0.48	5.13±0.67
IV	5.06±0.47	5.12±0.63	5.32±0.52	5.41±0.69
V	5.27±0.47	5.36±0.63	5.53±0.49	5.75±0.69
VI	5.41±0.45	5.50±0.60	5.67±0.48	5.94±0.72
Overall	4.92±0.45	4.99±0.60	5.12±0.49	5.26±0.66

DMI per 100 kg body weight and per kg metabolic body size of heifers during different fortnights in different treatments is presented in table-2 and 3, respectively.

The overall value of DMI per 100 kg body weight was 2.59±0.06, 2.65±0.03, 2.79±0.05 and 2.74±0.06 kg and the corresponding value for per kg metabolic body size were

0.086±0.004, 0.087±0.004, 0.092±0.004 and 0.092±0.005 kg for treatment T_1, T_2, T_3 and T_4, respectively. The perusal of the table showed that treatment had a significant effect on DMI per 100 kg body weight. Heifers under T_3 consumed significantly (P<0.05) more DM as compared to T_1 however no significant difference was observed between T_2, T_3 and T_4 as well as between T_1 and T_2. This indicates that the heifer in T_3 and T_4 were under less climatic stress due to provision of the EPE sheet. However, less DM in T_1 indicates that the heifers in this group were not comfortable due to heat stress and to reduce the heat load, they consumed less dry matter.

Table 2: Mean ± SE of fortnightly average Dry Matter Intake (kg) per 100 kg body weight of heifers

Fortnight	Asbestos roof (T_1)	White painted roof (T_2)	EPE sheet roof (T_3)	White painted and EPE sheet roof (T_4)
I	2.33±0.07	2.38±0.05	2.50±0.08	2.50±0.07
II	2.58±0.06^{a}	2.66±0.02^{ab}	2.79±0.05^{a}	2.73±0.07^{ab}
III	2.62±0.05^{b}	2.69±0.03^{ab}	2.83±0.04^{a}	2.73±0.07^{ab}
IV	2.64±0.06^{b}	2.69±0.03^{ab}	2.87±0.06^{a}	2.78±0.07^{ab}
V	2.68±0.07^{b}	2.74±0.04^{ab}	2.89±0.04^{a}	2.86±0.05^{a}
VI	2.68±0.06^{b}	2.73±0.03^{ab}	2.86±0.04^{a}	2.85±0.05^{a}
Overall	2.59±0.06^{b}	2.65±0.03^{ab}	2.79±0.05^{a}	2.74±0.06^{ab}

Means bearing different superscripts in a row differ significantly (P<0.05)

Mc Dowell (1972) [15] reported that the heat stress in ruminants cause reduction in food intake due to reduced gut motility, less rumination, more concentrations of luminal contents (Attenbery *et al.*, 1968) [2] and decreased appetite (Warren *et al.*, 1974) [28] by having a direct negative effect on the appetite centre of the hypothalamus (Baile and Forbes, 1974) [3]. So, in response the body starts to maintain homeothermy by reducing feed intake (Mc Dowell, 1972) [15].

Table 3: Mean ± SE of fortnightly average Dry Matter Intake (kg) per kg metabolic body size of heifers

Fortnight	Asbestos roof (T_1)	White painted roof (T_2)	EPE sheet roof (T_3)	White painted and EPE sheet roof (T_4)
I	0.085±0.004	0.086±0.004	0.090±0.005	0.090±0.004
II	0.085±0.004	0.087±0.004	0.090±0.004	0.089±0.005
III	0.085±0.004	0.087±0.005	0.091±0.004	0.089±0.006
IV	0.086±0.005	0.087±0.005	0.093±0.004	0.092±0.006
V	0.087±0.005	0.088±0.005	0.093±0.004	0.094±0.005
VI	0.088±0.004	0.089±0.004	0.094±0.003	0.095±0.006
Overall	0.086±0.004	0.087±0.004	0.092±0.004	0.092±0.005

High ambient and rectal temperatures above critical threshold were also related to decrease in the DMI (West, 2003). The present findings are in agreement with Singh *et al.* (2008) [24] who reported lesser DMI by asbestos and no shed grouped kids as compared to agronet and tree. Similarly, Chauhan *et al.* (2011) [4], Yazdani and Gupta (2000) [30], Shrikhant and Kumar (2001) [22] and Jat *et al.* (2005) [10] reported significantly higher DMI by calves kept under thatch and RCC shed in comparison to calves under tree sheds. Similarly, Kamal (2013) [11] recorded significantly (P<0.05) higher total DMI in calves kept in agro-net compared with those in asbestos whereas, Patel (1991) and reported non-significant effect of housing on feed intake of buffalo heifers whereas; Singh (2000) [26] reported significantly (P<0.05) low DMI per kg metabolic size in buffalo heifers kept in asbestos as compared to those in aluminium foil pasted roof and thatched roof.

Feed Conversion Efficiency

The FCE has been presented in table-4. The overall FCE for the T_1, T_2, T_3 and T_4 group was 6.65±0.47, 7.42±0.92, 7.65±0.74 and 8.28±0.61, respectively. The perusal table reveals that there was no significant difference between the groups; however FCE was better in T_4. Heat gain from the environment might have been more for the heifers kept in T_1 during hot conditions and as a result, more dietary energy would have been utilized for the maintenance of homeothermy, thus reducing the FCE.

The results are in agreement with Ostergaard *et al.* (1989) [18] and Kamal (2013) [11] who reported that FCE is not affected by housing whereas; Shrikhant and Kumar (2001) [22] reported significantly lower (P<0.05) FCE in loose house covered with four feet wall (3.26±0.25) as compared to loose house with one side wall (3.13±0.19).

Table 4: Mean ± SE of fortnightly Feed Conversion Efficiency (FCE) of heifers

Fortnight	Asbestos roof (T_1)	White painted roof (T_2)	EPE sheet roof (T_3)	White painted and EPE sheet roof (T_4)
I	7.04±1.22	7.60±1.75	7.81±0.79	9.04±1.20
II	6.30±0.62	7.65±1.22	7.52±1.18	8.30±0.55
III	6.39±0.42	6.66±0.60	6.74±0.53	7.70±0.57
IV	6.47±0.41	7.06±0.75	7.71±0.59	7.86±0.54
V	6.61±0.31	7.60±0.97	8.06±1.07	8.35±0.54
VI	7.09±0.69	7.96±1.18	8.03±0.86	8.40±0.75
Overall	6.65±0.47	7.42±0.92	7.65±0.74	8.28±0.61

Water Intake (L/day)

Water is an important body constituent with wide ranging function in the metabolism, heat regulation and electrolyte balance. The water requirement of ruminants is affected by a number of factors like DM intake, type of ration, air and water temperature. Feed with relatively high moisture content decreases the quantity of drinking water required. The animal's size and growth stage will also have a strong influence on daily water intake. The water content of the animal's diet will influence its drinking habits.

The voluntary water intake (VWI) and total water intake (TWI) of heifers have been presented in table-5 and 6, respectively. The overall VWI (L/day) for one heifer was T_1 (18.90±1.80), T_2 (18.07±2.32), T_3 (17.39±1.79) and T_4 (16.73±2.25), whereas, corresponding values for total water intake TWI were 27.07±2.76, 26.15±3.63, 25.76±2.85 and 25.41±3.73 L/day, respectively.

The data revealed that the heifers in T_1 group consumed more quantity of water (both VWI and TWI) followed by T_2 and T_3 and least in T_4 but the difference was non-significant among the treatments. Water requirement increased in all the groups with increase in ambient temperature. The less water intake in T_4 grouped heifers may be due to less thermal stress because of the comfortable microenvironment as compared to other sheds. The results are in agreement with Rohilla and Ram (1990) [21], Singh *et al.* (2004) [25] who found non-significant effect of treatments on water intake. Similarly, Singal (2001) [23] concluded that the average daily voluntary and total water intake was not significantly influenced by the treatments.

Water intake was found to be positively related to maximum air temperature and hours of sunshine a day (Cowan *et al.* 1978) [5]. Patel *et al.* (1995) [19] reported less (P<0.05) intake of water by buffalo heifers kept under thatch roof than RCC, and tree shade.

Table 5: Mean ± SE of fortnightly Voluntary Water Intake (VWI) (L/day) of heifers

Fortnight	Asbestos roof (T_1)	White painted roof (T_2)	EPE sheet roof (T_3)	White painted and EPE sheet roof (T_4)
I	15.98±1.72	15.28±2.25	14.72±1.91	14.30±1.85
II	17.22±1.78	16.70±2.26	16.14±1.75	15.66±2.26
III	19.66±1.82	18.70±2.37	17.82±1.77	16.84±2.34
IV	20.34±1.89	19.30±2.49	18.48±1.91	17.42±2.44
V	19.82±1.84	18.84±2.31	18.20±1.69	17.64±2.27
VI	20.38±1.78	19.60±2.25	19.00±1.69	18.50±2.38
Overall	18.90±1.80	18.07±2.32	17.39±1.79	16.73±2.25

Table 6: Mean ± SE of fortnightly Total Water Intake (TWI) (L/day) of heifers

Fortnight	Asbestos roof (T_1)	White painted roof (T_2)	EPE sheet roof (T_3)	White painted and EPE sheet roof (T_4)
I	23.63±2.80	22.78±3.73	22.50±3.20	22.32±3.16
II	25.18±2.71	24.68±3.47	24.16±2.79	24.00±3.71
III	27.83±2.77	26.82±3.66	26.10±2.75	25.13±3.81
IV	28.55±2.88	27.36±3.83	27.09±2.95	26.10±3.94
V	28.19±2.78	27.02±3.57	26.78±2.70	26.63±3.75
VI	29.06±2.70	28.23±3.53	27.96±2.72	28.10±4.06
Overall	27.07±2.76	26.15±3.63	25.76±2.85	25.41±3.73

Yazdani and Gupta (2000) [30] found lower (P<0.05) voluntary water intake (L/day) in thatch group. Kamal (2013) [11] concluded that calves kept under asbestos consumed more (P<0.05) quantity of water followed by those in thatch roof and least in agro-net. Similarly, Barman (2016) observed that the buffalo calves kept in galvanized iron sheet roofs consumed significantly (P<0.05) more quantity of water followed by those in CGI sheet roof, asbestos roof and least in thatch roof. Contrary to our findings, Singh *et al.* (2008) [24] reported more water intake under agro-net in comparison to tree and asbestos.

Conclusion

Providing better microclimate to heifers by slight modifications i.e. by using EPE sheets in shed structures resulted in increased dry matter intake and better feed conversion efficiency while the conventional asbestos roofs were unable to reduce the heat load falling on it through radiations which was witnessed by decreased feed intake and more water consumption to alleviate the heat stress caused due to high ambient temperature underneath the asbestos roof. White painted roof was also insufficient to provide better micro-environment to heifers during summer however; the conditions were more favourable as compared to conventional asbestos roof.

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