



Microclimatic Alterations in Loose Housing Systems and Their Impact on THI and Haemato-biochemical Parameters of Lactating Murrah Buffaloes

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ABSTRACT

Background: Heat stress adversely affects the physiological mechanisms responsible for thermoregulation and maintenance energy in dairy animals. In buffaloes, high ambient temperature and humidity during summer can affect health, productivity and welfare. Microclimatic modifications in housing systems may help to mitigate these effects.

Methods: The study was conducted at the Department of Livestock Production Management, LUVAS, Hisar, India. Eighteen lactating Murrah buffaloes were assigned to three loose housing treatments (six animals each): (T₁) concrete flooring with corrugated asbestos roofing (control); (T₂) concrete flooring with glass wool (50 mm) plus white painted roof; and (T₃) concrete flooring with expanded polyethylene sheet (70 mm) plus white painted roof. Temperature-humidity index (THI) and haematological parameters (haemoglobin, packed cell volume, lymphocytes, monocytes) along with biochemical parameters (glucose, total protein, albumin, SGOT) were recorded and analyzed.

Result: THI values were significantly ($P < 0.05$) lower in both T₂ and T₃ compared to T₁. Haematological (haemoglobin, packed cell volume, lymphocytes, monocytes) and biochemical parameters (glucose, total protein, albumin) showed significant improvement ($P < 0.05$) in T₂ and T₃ groups relative to the control, indicating better physiological status. Among biochemical indices, SGOT and glucose exhibited the strongest associations with THI. Microclimatic modifications, effectively reduced heat stress and improved the haematological and biochemical profiles of lactating Murrah buffaloes under summer conditions, thereby enhancing their overall performance and welfare.

Key words: Asbestos, E.P.E., Glasswool, Haemato-biochemical, Microclimatic modifications, Murrah buffaloes.

INTRODUCTION

In India, the Murrah buffalo (*Bubalus bubalis*) plays a vital role in the rural economy as a triple-purpose animal, supplying milk, meat and draught power. The Murrah buffalo is extensively exported to other nations to enhance local buffalo productivity, attributed to its high milk yield potential feed efficiency and adaptability (Dhillod *et al.*, 2018). This vulnerability of heat stress is attributed to their dark skin, reduced hair density, fewer sweat glands and limited evaporative cooling capacity (Marai and Habeeb, 2010), which adversely affects their haemato-biochemical profile. The climatic conditions of a particular region, like air temperature and relative humidity, may result in heat stress (Kumar *et al.* 2025). Heat stress is assessed using the Temperature-Humidity Index (THI), with values over 72 considered stressful, above 78 as moderately severe and over 80 as critical for dairy animals (Thom, 1959). Sheds can improve animal welfare and should be designed to maximize ventilation and protection from the solar load (Das 2018). White, green and aluminium paints exhibit solar radiation reflectance of 75%, 50% and 45%, respectively (Sastry and Thomos, 2012). Narwaria (2020) demonstrated that the use of EPE sheets for roofing decreased the Temperature-Humidity Index (THI) by 1.5 to 2.0 units during peak summer months. Yanto *et al.* (2023)

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observed a 7.4% decrease in ambient temperature through the application of glass wool insulation in tropical housing. Heat stress results in reduced haemoglobin (Hb), red blood cell (RBC) counts and serum protein levels, which can be attributed to hemodilution and impaired metabolism (Morar *et al.*, 2018). Apart from physiological alterations, Haemato

biochemical indicators provide valuable insights into the farm animal welfare and serve as indirect measure of THI-related stress (Slayi and Jaja, 2025). Of late, one of the important stress alleviation strategy in farm animals had been to deploy necessary interventions in confinement housing considering local climatic conditions, construction and its upkeep costs. If heat stress issues are to be minimized in future, the effective measures could be the installation of cooling, ventilation and shade systems (Thornton *et al.* 2022). Insulated and reflective roofs reduced heat stress and improved haemoglobin, Serum glucose, proteins levels and overall health of animals (Narwaria, 2020; Kumar *et al.*, 2023; Vijayakumar *et al.*, 2013).

Even though the results look good, there isn't much data comparing how well glass wool and EPE sheets with white paint work as roofing insulation for Murrah buffaloes in loose housing systems in India's climate. This study aims to evaluate the effects of roofing-based microclimatic modifications, specifically glass wool and EPE false ceilings with reflective white paint over asbestos roofing, on THI, haematological responses and biochemical profile in lactating Murrah buffaloes during summer in a loose housing system.

MATERIALS AND METHODS

The current research was carried out at the Buffalo farm of the Department of Livestock Production Management, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar. The herd under investigation was maintained in a loose housing and group management arrangement. The experiment's run spanned from August to October 2024.

In this experiment, 18 lactating Murrah buffaloes post colostrum (3 days after calving) phase from parity 1st to 5th were randomly grouped into three treatment groups (6 in each group) in loose housing system to ensuring uniformity in parity and duration of the experiment was 90 days (3 months). These treatment groups were as follows:

T₁ (Control):- Concrete flooring with corrugated asbestos sheets roofing.

T₂:- Concrete flooring with glass wool (50 mm) + white painted roof.

T₃:- Concrete flooring with expanded polyethylene sheet (70 mm) + white painted roof.

Temperature humidity index (THI)

THI was calculated from temperature and relative humidity using equation (NRC 1971):

$$(1.8 \times T_{db} + 32) - \{(0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26.8)\}$$

Where,

T_{db} = Dry bulb temperature (°C).

RH = Relative humidity (%).

Using the MS45TM automatic haematology analyzer, EDTA vial blood samples were examined to estimate blood parameters (haemoglobin, packed cell volume, red blood cells, white blood cells, lymphocytes, neutrophils and

monocytes). Using an Automated Random Access Clinical Chemistry Analyzer (EM Destiny 200) TM, Erba Diagnostics Mannheim GmbH, serum samples were examined for serum glutamic-oxidoacetic transaminase (SGOT), serum glutamic-pyruvic transaminase (SGPT), glucose, total protein (TP), albumin and globulin.

Statistical analysis

The IBM SPSS statistics 20 software program for Windows was used to statistically examine the experimental data. The one-way analysis of variance was used to examine the data. According to Snedecor and Cochran (1994), Duncan's test was used to identify significant differences between the treatment means. A significance level of P<0.05 was taken into consideration. Pearson's correlation coefficient was used to evaluate the association between the Temperature-Humidity Index (THI), certain hematological and biochemical parameters. Correlation coefficients with P<0.05 were considered statistically significant, while those with P<0.01 were considered highly significant, according to a two-tailed significance test.

RESULTS AND DISCUSSION

Temperature-humidity index (THI)

The mean values of the THI of different experimental treatment groups across all the study periods are showed in Table 1. The results indicated that the T₂ group had a significantly (P<0.05) lower THI compared to the control (T₁) and T₃ groups. The efficiency of insulated and reflective roofing materials in reducing heat stress is demonstrated by the fact that T₂ (Glasswool + White painted roof) maintained the lowest THI values, followed by T₃ (E.P.E. Sheet + White painted roof). This result is consistent with Habeeb *et al.* (2018), who found that buffalo health is negatively impacted by THI values above 75, which indicate moderate stress and THI values above 78, which indicate severe heat stress. The results of Petrocchi *et al.* (2023), who showed that insulated roofing successfully lowers heat accumulation within animal sheds, are comparable to this. Amit (2019) and Narwaria (2020), who observed lower morning and evening THI values under EPE sheet and paddy straw thatch roofs compared to standard asbestos roof sheds during the summer, further support the current findings. The findings also align with research conducted by Kamal *et al.* (2014), Sivakumar *et al.* (2017) and Maurya *et al.* (2018), which noticed that, in comparison to basic asbestos roof sheds, THI values were lower under a variety of roofing materials, including thatch, tile, agromat and polycarbonate plastic sheets. Similarly, Sinha *et al.* (2019) also reported significantly (P<0.01) lower mean THI value for treatment shed with fogger plus fans and mosquito net as compared to control shed with sprinkler. Muhiedeen *et al.* (2020) reported that three layers of glass wool reduced internal shed temperatures by 1.5°C. In contrast to our findings, Henry *et al.* (2024) documented non-significant (P<0.05) difference between THI values

between different roofing materials of dairy cattle shed in Cauvery delta region. The observed variations between T_1 and T_2 imply that microclimatic changes, like white-painted and insulated roofs, are very successful in lowering THI, which enhances buffalo productivity and welfare in humid and hot weather. This finding aligns with Kumar (2015), who documented reduced THI by using insulated roofing materials.

Haematology and serum biochemistry parameters

The mean values of different Haematology and Biochemical Parameters of lactating Murrah buffaloes housed under different experimental sheds has been presented in Table 2.

The mean values of haemoglobin (g/dl) were significantly ($P<0.05$) higher in T_2 and T_3 as compared to T_1 across all fortnights except on fortnight VI. Similar to the finding of Berian *et al.* (2019), the study showed that lactating Murrah buffaloes under expanded polyethylene (E.P.E.) plus white-painted roofs (T_3) and glass wool plus white-painted roofs (T_2) had higher hemoglobin (Hb) levels than those under asbestos roofs (T_1). The T_2 and T_3 groups' higher hemoglobin levels suggest an improved ability to carry oxygen, most likely as a result of less heat stress and better thermal regulation (Barman *et al.*, 2017; Casella *et al.*, 2013). Narwaria (2020) found that haemoglobin levels were higher in EPE-insulated sheds (10.61 ± 0.08 g/dl) compared to asbestos sheds (10.43 ± 0.09 g/dl). Vijayakumar *et al.* (2013) reported increases in haemoglobin of 0.7 g/dl and glucose levels of 6-8 mg/dl in buffalo heifers subjected to fan and sprinkling systems. Similarly, Sinha *et al.* (2019) documented significantly ($P<0.05$) increased in haemoglobin concentration for treatment shed with fogger plus fans and mosquito net as compared to control shed with sprinkler. The overall mean PCV % was significant ($P<0.05$) highest in T_1 , followed by T_3 , while T_2 exhibited the lowest PCV. The animals living under asbestos roofs may have been dehydrated and had thicker blood because T_1 's packed cell volume (PCV) was significantly higher than T_2 's and T_3 's (Verma *et al.*, 2022). In contrast to our findings, Vasantha *et al.* 2024 results revealed that there is no significant ($P>0.05$) difference was observed in Hb and PCV values among all weeks as compared to control.

The mean values of RBC and WBC did not differ significantly ($P>0.05$) among various treatment groups. The non-significant differences, however, were in line with

Maurya's (2018) findings, which showed that erythrocyte counts remained constant under various roofing conditions. Similar to the findings of Narwaria (2020), white blood cell (WBC) counts did not significantly differ between the treatments, suggesting that environmental changes have a negligible effect on immune cell levels. In contrast to our findings, Sinha *et al.* (2019) results showed significant ($P<0.05$) increased in white blood cells treatment shed with fogger plus fans and mosquito net as compared to control shed with sprinkler. The mean haematological parameters such as lymphocyte (%) and monocyte (%) showed significant ($P<0.05$) difference in microclimatic modified sheds buffaloes as compared to control group buffaloes. T_2 and T_3 had significantly lower lymphocyte percentages than T_1 , indicating that heat stress was reduced and immune balance was enhanced in insulated sheds. Under better microclimatic conditions, monocyte percentages were lowest in T_2 and highest in T_1 , suggesting a decrease in systemic inflammatory responses (Maurya *et al.*, 2013; Gao *et al.*, 2019). In contrast to our findings, Sinha *et al.* (2019) reported non-significant ($P<0.05$) difference in both lymphocyte (%) and monocyte (%) in treatment shed as compared to control shed. The haematological parameters results indicated that microclimatic modifications to the roofs for better climate control help keep lactating Murrah buffaloes cooler and reduce heat-related health problems, which in turn supports their overall health and productivity.

The overall mean SGOT levels were highest in T_1 , followed by T_3 and lowest in T_2 group but the differences was non-significant ($P>0.05$) among treatments groups. The overall mean SGPT values were highest in T_3 , followed by T_1 and the lowest in T_2 but didn't differ significantly among treatment groups. This is consistent with Vijayakumar *et al.* (2013), but it differs from reports by Kamal *et al.* (2016) and Narwaria (2020) of significant SGOT reductions under insulated sheds. Similarly, there was no significant change in SGPT levels across T_1 , T_2 and T_3 , which is in line with Narwaria (2020) and Kamal *et al.* (2016) but not the same as Maurya (2018), who reported significant decrease in modified sheds. The overall mean glucose levels were significantly ($P<0.05$) higher in T_2 , followed by T_3 and the lowest in T_1 group. The blood glucose levels of the microclimatic modified sheds animals were significantly ($P<0.05$) higher than those of the control group, suggesting improved roofing and metabolic status (Narwaria, 2020). Maurya (2018) documented serum glucose levels of

Table 1: Mean values of Temperature-humidity Index of experimental sheds with microclimatic modifications in loose house system.

	Treatments		
	T_1 (Asbestos roof)	T_2 (Glasswool + white painted roof)	T_3 (E.P.E. Sheet + white painted roof)
At start of experiment	81.01 $\pm$ 1.20	77.61 $\pm$ 1.64	79.15 $\pm$ 1.87
At end of experiment	76.83 $\pm$ 1.21	70.35 $\pm$ 0.99	73.29 $\pm$ 1.21
Overall average	78.35 $\pm$ 1.05	73.86 $\pm$ 1.17	76.21 $\pm$ 1.38

*Means bearing different superscripts in same row differs significantly ($P<0.05$).

50.20±1.48 mg/dl beneath polycarbonate roofs compared to 43.57±2.04 mg/dl beneath cement roofs. The overall mean total protein level was significantly ($P<0.05$) highest in T_2 , followed by T_3 , while the lowest value was recorded in T_1 . The overall mean albumin levels were significantly ($P<0.05$) higher in T_2 and T_3 compared to T_1 treatment groups. Throughout the study period, albumin levels are non-significant higher in T_2 and T_3 as compared to T_1 group except in fortnight V where difference was significant among treatments group. The overall mean globulin levels were highest in T_2 , followed by T_3 and T_1 group but there is non-

significant difference among treatment groups. While globulin stayed constant across groups, as also reported by Sahu *et al.* (2018) and Kamal *et al.* (2016). Total serum protein and albumin were significantly higher in T_2 and T_3 compared to T_1 , indicating better protein metabolism, which is consistent with Narwaria (2020). Total serum protein levels increased by 5-7% and albumin levels by 4-5%, when using reflective and insulated roofs (Kumar *et al.*, 2023). These findings suggest that microclimatic modifications using glass wool and E.P.E. sheets with white paint improve metabolic health and serum proteins levels in lactating

Table 2: The mean values of different Haematology and Biochemical Parameters of lactating Murrah buffaloes housed under different experimental sheds with microclimatic modifications in loose house system.

Parameters		Treatments		
		T_1 (Asbestos roof)	T_2 (Glasswool + white paint)	T_3 (E.P.E. sheet + white paint)
Haemoglobin (g/dl)	At start of experiment	9.91 ^a ±0.29	10.72 ^{ab} ±0.12	11.25 ^b ±0.36
	At end of experiment	10.83 ^a ±0.14	13.40 ^b ±0.22	12.30 ^c ±0.15
	Overall average	10.32 ^a ±0.18	11.82 ^b ±0.20	11.62 ^b ±0.24
Packed cell volume (%)	At start of experiment	34.00 ^b ±0.55	31.17 ^a ±1.22	33.72 ^{ab} ±0.73
	At end of experiment	37.07 ^a ±0.48	32.55 ^b ±1.79	33.20 ^{ab} ±1.52
	Overall average	33.77 ^b ±0.50	30.74 ^a ±0.38	31.76 ^a ±0.25
Red blood cells (m/mm ³)	At start of experiment	6.22±0.32	5.57±0.32	6.55±0.52
	At end of experiment	5.41 ^a ±0.05	5.69 ^b ±0.07	5.43 ^a ±0.09
	Overall average	5.96±0.15	5.71±0.11	6.01±0.13
White blood cells (m/mm ³)	At start of experiment	11.02±0.59	9.78±0.38	11.06±0.43
	At end of experiment	9.85 ^a ±0.14	8.45 ^b ±0.48	8.95 ^{ab} ±0.29
	Overall average	10.13±0.30	9.48±0.32	10.07±0.25
Lymphocytes (%)	At start of experiment	55.47±3.66	51.60±4.87	51.00±4.39
	At end of experiment	41.67 ^b ±0.16	35.27 ^{ab} ±3.28	34.18 ^a ±1.70
	Overall average	46.83 ^b ±1.46	42.43 ^a ±1.05	41.90 ^a ±1.06
Monocytes (%)	At start of experiment	2.58±0.14	2.28±0.06	2.46±0.15
	At end of experiment	2.33 ^b ±0.12	1.75 ^a ±0.26	1.73 ^a ±0.04
	Overall average	2.17 ^b ±0.06	1.90 ^a ±0.03	1.97 ^a ±0.04
SGOT (IU/L)	At start of experiment	20.88±5.33	15.09±1.34	15.91±1.60
	At end of experiment	4.97 ^a ±1.23	6.25 ^{ab} ±1.22	8.58 ^b ±0.52
	Overall average	12.53±1.11	10.06±0.73	11.33±0.80
SGPT (IU/L)	At start of experiment	15.81 ^b ±1.2	8.56 ^a ±1.14	13.75 ^{ab} ±2.8
	At end of experiment	24.45±2.62	26.11±1.30	23.63±0.60
	Overall average	20.27±0.37	19.55±0.70	20.53±0.70
Glucose (mg/dl)	At start of experiment	48.56±2.80	57.83±5.65	55.17±6.45
	At end of experiment	56.57±4.26	67.63±3.50	60.70±3.07
	Overall average	52.32 ^a ±0.5	59.82 ^b ±3.06	54.71 ^{ab} ±2.1
Total protein (g/dl)	At start of experiment	2.42±0.24	2.78±0.19	3.52±0.59
	At end of experiment	6.17±0.82	6.95±1.01	5.28±0.43
	Overall average	4.91 ^a ±0.31	6.23 ^b ±0.30	5.58 ^{ab} ±0.48
Albumin (g/dl)	At start of experiment	1.60 ^a ±0.06	2.23 ^b ±0.09	2.29 ^b ±0.14
	At end of experiment	1.49±0.16	1.41±0.23	1.76±0.20
	Overall average	1.79 ^a ±0.04	2.11 ^b ±0.08	2.13 ^b ±0.12
Globulin (g/dl)	At start of experiment	0.82±0.20	0.54±0.14	1.23±0.58
	At end of experiment	4.68±0.68	5.54±1.11	3.52±0.50
	Overall average	3.13±0.30	4.12±0.29	3.45±0.42

*Means bearing different superscripts in same row differs significantly ($P<0.05$).

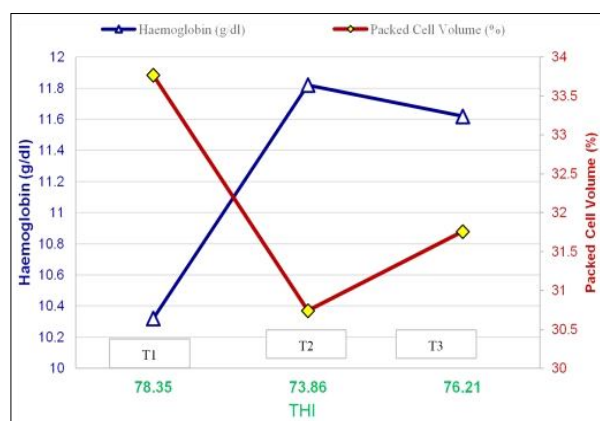


Fig 1: Effect of THI on haematology parameters of lactating murrah buffaloes housed under different experimental sheds with microclimatic modifications in loose house system.

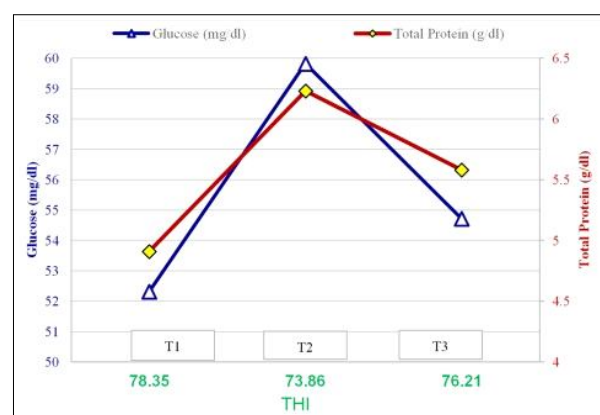


Fig 2: Effect of THI on biochemical parameters of lactating murrah buffaloes housed under different experimental sheds with microclimatic modifications in loose house system.

Murrah buffaloes by mitigating heat stress, without significantly altering hepatic enzyme activities.

The effect of THI on Haemato-biochemical parameters

The effect of THI on haemato-biochemical parameters of lactating murrah buffaloes were shown in Fig 1 and Fig 2. THI had a significant negative correlation with total protein ($P < 0.05$) and a highly significant positive correlation with SGOT ($P < 0.01$). Additionally, PCV, RBC, WBC, lymphocytes, monocytes and SGPT showed positive correlations, whereas Hb, glucose, albumin and globulin showed strong negative correlations. Overall, increasing THI had a significant impact on biochemical and hematological parameters, suggesting that heat stress caused significant physiological changes and trends that warrant further examination.

Glass wool and EPE sheets, combined with white paint on the roof, reduce heat stress by lowering the Temperature-Humidity Index (THI). Provides thermal insulation and humidity control on the other hand white paint reflects sunlight, further reducing heat absorption.

Together, these measures decrease heat stress on animals, improving haemato-biochemical profile, health status and welfare. Adoption of low-cost housing interventions such as insulation materials and microclimate modifications can be mainstreamed into climate-resilient livestock policies, improving animal welfare and productivity under global warming scenarios.

CONCLUSION

Microclimatic modification with glass wool and expanded polyethylene as a false ceiling and white-painted roofing significantly reduced THI and heat stress in lactating Murrah buffaloes. These modifications improved haemato-biochemical profiles, reflecting better physiological and metabolic status. Adoption of these cost-effective measures can support sustainable buffalo production, animal welfare and climate-resilient livestock management in tropical regions.

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Ethics statement

The study received ethical approval for animal experimentation from the Institutional Animal Ethics Committee (IAEC), India (No. IAEC/LUVAS/30/16).

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no conflict of interest.

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