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Effect of different types of dairy cattle shelters on micro-climatic variable in rural West Bengal

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ABSTRACT

The study was conducted to find out the impact of different shelter types on environmental variables. Five different types of housing systems namely; Shelter-1: GI sheet roof with brick/mud floor with no surrounding wall; Shelter-2: GI sheet roof with brick/Rcc floor and brick/jute stick wall; Shelter-3: Tile roof with brick floor and no wall; Shelter-4: Tile roof with brick floor and brick/jute stick wall, and Shelter–5: Polythene sheet roof with mud floor and jute stick wall were selected in two villages. The inside maximum and minimum temperatures, wet and dry bulb temperatures of all the shelter system were recorded. Season significantly influenced ($P<0.01$) maximum and minimum temperatures, relative humidity and temperature humidity index (THI) of different housing systems. Shelter-4 had lower maximum temperature ($P<0.01$) as compared to shelter-1. THI and RH values were lower in shelter-3 during all the seasons as compared to other housing systems indicating thereby more thermally comfortable environment. Shelter-1 and 2 had higher maximum temperature, THI and RH and also involved higher cost of construction than tile roof. Animals kept in shelter-5 were uncomfortable due to higher maximum temperature in all seasons and the maximum temperature was higher even during winter season. Cows maintained in shelter 3 produced significantly more milk in comparison to cows maintained in other housing systems. It was concluded that shelter-3 could be made more comfortable by giving provision of adequate ventilation, regular water bath, adequate drinking water and feed formulations to sustain productivity of cows in summer.

Key words: Cow, Climatic stress, Environmental variable, Shelter type, Season, Thermal comfort

Macro- and micro-climate has profound effect on growth, milk production and reproduction of dairy animals based on the degree of comfort. Shelter design and construction material determine the microenvironment and thermal comfort inside the shed (Adam 2006, Badino 2007). An efficient shelter will enable to reduce thermal stress and thereby help to increase animal productivity (Sharma and Singh 2002, Kaur and Singh 2004). The climatic condition in Nadia district of West Bengal is hot and humid during most part of the year leading to profound influence on animal productivity. The literature on environmental variables in various types of dairy cattle housing systems of rural West Bengal is lacking. The present study was carried out to find out the impact of different types of shelter systems on micro-climatic variables in rural West Bengal.

MATERIALS AND METHODS

The study was conducted for a period of one year in two villages during summer, rainy and winter seasons from January to December 2004. Five different types of housing systems with parameters of types of roof, floor, wall, ventilation and drainage system were selected for the study. In total, 20 types of housing systems with 10 houses from each village having equal proportion of identical types of housing, i.e. two number of similar cattle sheds under each type of housing per village were identified for collection of microclimatic data. Maximum and minimum ambient temperatures, dry bulb and wet bulb temperatures were recorded twice a day at 6:00 AM and 2:00 PM at fortnightly intervals, respectively. The temperature humidity index (THI) was calculated using the empirical relationship $THI = 0.72 (DBT + WBT) + 40.6$ (Esmay and Dixon 1986). The recorded values of dry bulb and wet bulb temperature (°C) were used for determination of relative humidity (RH) of the air with the help of 'Hygrometric Tables'. The experimental data was classified according to 5 shelter systems and 3 seasons, i.e. summer (March–June), rainy (July–October) and winter (November–February). The housing systems were shelter-1 : GI sheet roof with brick/mud floor and no surrounding wall, shelter-2: GI sheet roof with brick/Rcc floor and brick/jute stick wall, shelter-3: Tile roof with brick floor and no wall, shelter-4: Tile roof with brick floor and brick/jute stick wall, and shelter-5: Polythene sheet roof with mud floor and jute stick wall. The influences of shelter systems and seasons

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on maximum and minimum temperatures, THI and RH were analyzed separately with two way fixed effect analysis of variance (Snedecor and Cochran 1968). The analysis of RH was done after angular transformation of the data. As the season effect was significant the data were analyzed season-wise for all the parameters. The differences between the means were tested for significance by comparing with least significant difference.

RESULTS AND DISCUSSION

Maximum temperature: In the present study, season significantly influenced (P < 0.01) all the environmental variables ((Tables 1–3). During summer, shelter type significantly influenced (P< 0.01) maximum temperature. The inside maximum temperature of GI sheet roof with brick/ mud floor and having no wall (shelter-1) and polythene sheet roof with mud floor and jute stick wall (shelter-5) were found the highest (Table 1). The difference between shelter-1 and shelter-4 for maximum temperature was significant, whereas, other differences were non significant. In general, shed having no wall had higher temperature than the shed with wall, due to effect of reflected radiation as well as direct radiation. Sharma and Singh (2002) observed higher maximum temperature in loose housing system during most of the months. In the present study, shed with polythene sheet roof having walls had high temperature during most of the months mainly due to high absorption of heat by the polythene sheet. Further, shed having tile roof had lower maximum temperature as compared to other types of shelter systems. Kaur and Singh (2004) observed lowest DBT in shelter having RCC roof as compared to asbestos roof shelters and conventional tree shelters. During rainy season maximum and minimum temperatures non-significantly varied in different shelter systems, maximum temperature was high (P<0.01) in shelter-5 in winter in comparison to other shelter systems. The minimum temperature was non-significantly different in winter season in all the types of shelters.

Minimum temperature: The minimum temperature was non significant between shelters in all the seasons. The close shed had the higher inside minimum temperature in summer and winter in comparison to shed having no wall. Sharma and Singh (2002) reported higher minimum temperature in August in loose housing system, while in closed housing minimum temperature was higher in March, July to September and November to January. The higher minimum temperature in close shed could be attributed to ineffective loss of absorbed heat and poor ventilation. Among the closed shed, shelter-5 had the lowest minimum temperature during winter months due to effective loss of absorbed heat. In general, it can be stated that cows kept in shelter-3 were more comfortable during summer, where as during winter, cows were comfortable in close shed with tile/GI sheet roof. Covering of open sides of shed in extreme weather condition with gunny bags, plastic sheet, bamboo mat, and straw panels

Table 1. Season-wise average maximum and minimum temperatures in different shelter systems

Seasons→ Shelter systems↓	No. of observations	Summer		Rainy		Winter	
		Max. temp (°C)	Min. temp (°C)	Max. temp (°C)	Min. temp (°C)	Max. temp (°C)	Min. temp (°C)
Overall mean	160	36.98±0.64	26.54±0.39	31.70±0.26	25.43±0.32	26.81±0.49	15.88±0.48
Shelter-1	32	37.72^{a}±0.67	26.03^{a}±0.91	31.83^{a}±0.54	25.62^{a}±0.71	26.38^{a}±1.12	15.52^{a}±1.23
Shelter-2	32	36.48^{ab}±1.32	26.98^{a}±0.81	31.94^{a}±0.46	25.51^{a}±0.54	26.07^{a}±1.08	16.23^{a}±1.34
Shelter-3	32	36.45^{ab}±1.24	25.93^{a}±0.94	31.68^{a}±0.42	25.27^{a}±0.72	26.45^{a}±1.17	15.72^{a}±0.92
Shelter-4	32	35.95^{b}±1.20	26.82^{a}±0.71	31.21^{a}±0.52	25.64^{a}±0.73	26.56^{a}±1.12	16.45^{a}±1.18
Shelter-5	32	37.21^{ab}±1.22	26.92^{a}±0.83	31.96^{a}±0.55	25.09^{a}±0.81	28.03^{b}±0.73	16.00^{a}±0.41

a-b means with similar superscripts for shelter effect do not differ significantly from each other.

Table 2. Season-wise average THI values in different shelter systems

Seasons→ Shelter systems↓	No. of observations	Summer		Rainy		Winter	
		6 AM	2 PM	6 AM	2 PM	6 AM	2 PM
Overall mean	160	78.79±0.45	87.34±0.64	77.59±0.58	81.14±0.24	64.78±0.48	74.43±0.71
Shelter-1	32	78.07^{ab}±0.51	87.25^{ab}±0.97	77.69^{a}±0.68	80.64^{a}±0.17	64.54^{ab}±0.55	74.01^{ab}±0.98
Shelter-2	32	79.11^{ab}±0.42	87.43^{ab}±1.02	77.99^{a}±0.67	81.33^{a}±0.26	65.08^{ab}±0.39	74.32^{ab}±0.94
Shelter-3	32	77.95^{a}±0.47	86.52^{a}±0.63	77.32^{a}±0.66	80.49^{a}±0.18	63.78^{a}±0.73	73.58^{a}±0.99
Shelter-4	32	78.54^{ab}±0.41	87.09^{ab}±0.59	77.65^{a}±0.74	81.14^{a}±0.29	64.57^{ab}±0.74	74.33^{ab}±0.72
Shelter-5	32	79.84^{b}±0.75	88.23^{b}±0.85	77.33^{a}±1.04	81.80^{a}±0.46	65.91^{b}±0.42	75.92^{b}±0.52

a-b means with similar superscripts for shelter effect do not differ significantly from each other.

Table 3. Season-wise average RH values in different shelter systems

Seasons→ Shelter systems↓	No. of observations	Summer		Rainy		Winter	
		Max. RH (%)	Min. RH (%)	Max. RH (%)	Min. RH (%)	Max. RH (%)	Min. RH (%)
Overall mean	160	90.85±0.73	69.15±1.98	92.06±0.37	85.22±0.83	89.82±0.63	71.59±0.86
Shelter-1	32	89.54 ^{a}±0.44	67.26 ^{a}±3.28	90.67 ^{a}±0.21	84.35^{c}±0.74	88.08 ^{a}±0.45	71.05 ^{c}±0.46
Shelter-2	32	94.10 ^{b}±0.42	72.07 ^{b}±2.12	92.95 ^{b}±0.47	87.04 ^{b}±0.83	91.12 ^{b}±0.42	75.55 ^{b}±0.39
Shelter-3	32	88.18 ^{a}±0.83	66.57 ^{a}±2.29	90.66 ^{a}±0.30	82.35 ^{a}±0.89	87.51 ^{a}±0.26	67.43 ^{a}±0.62
Shelter-4	32	91.55 ^{c}±0.26	70.57^{bc}±1.95	93.12 ^{b}±0.32	86.74 ^{b}±1.04	91.05 ^{b}±0.32	73.07 ^{c}±0.42
Shelter-5	32	91.06 ^{c}±0.44	69.55 ^{c}±1.78	93.06 ^{b}±0.29	85.65^{bc}±1.05	91.59 ^{b}±0.63	71.12 ^{c}±0.56

a-c means with similar superscripts for shelter effect do not differ significantly from each other.

minimizes adverse effect of season (Nagpaul *et al*. 2005). The shelters with open areas facing the north and south directions were also thermally more comfortable (Kaur and Singh 2004). The protection of animal through wall around shed might influence micro-climatic condition of the study area where temperature and humidity play a key role.

Temperature humidity index: The average THI varied between 80.49 and 88.23 during mid-day of summer and rainy seasons and was lower ($P<0.05$; 73.58 to75.92) in winter season. The THI values during morning ranged between 63.78 and 79.84 for the whole year. The THI was lowest in cattle shed with tiled roof, brick floor and no wall (shelter-3) in all the seasons as compared to other types of housing systems (Table 2). However, in summer and winter seasons the differences between shelters-3 and 5 were statistically significant ($P<0.01$). Shelter-3 was thermally more comfortable with a mean THI value of 76.94 and was also economic. This fact was reflected by the milk yield (av. 6.19 kg/d) which was significantly higher ($P<0.01$) in comparison to milk yields (av. 4.90, 5.32, 5.60 and 4.28 kg/d) of cows managed under shelter 1, 2, 4 and 5, respectively. Shelter having GI sheet roof (shelter-1 and 2) had higher maximum temperature, THI and RH values and also involves higher cost of construction than tile roof. Loose housing system with central shed and RCC roof shed with rectangular openings in the upper north side and two-third open in south side had lowest THI (Sharma and Singh 2002, Kaur and Singh 2004). In the present study, THI values were higher in summer and rainy season in all the shelter systems which adversely influenced milk production of cows (Gao *et al*. 2000). Therefore, selection of higher heat resistance materials for the roof and increased height of cowshed reduces the shed temperature and minimizes effect of summer on milk yield (Gao *et al*. 2000).

The morning and evening THI values exceeded critical value of 72, except the morning THI during winter, which indicated that the animals were in stress micro-environment in all the shelter systems. Generally mild stress is initiated at a THI >74 while at THI >79 stress becomes severe, inducing panting, standing up to facilitate evaporation from the skin and drop in milk production. However, measures like thermally comfortable shelter with adequate ventilation, using mist blowers to wet the skin, providing cows with fan, sand bedding and adequate feed and drinking water minimized stress and maintained milk production (Singh *et al*. 2003, Adam 2006, Aggarwal and Singh 2005).

Shelter-1

Shelter-2

Shelter-3

Shelter-4

Relative humidity: Maximum as well as minimum relative humidity was higher in close type of sheds as compared to sheds having no wall (Table 3) which corroborates earlier reports (Sharma and Singh 2002, Kaur and Singh 2004). The relatively higher level of humidity in close type of sheds was mainly due to the presence of animals, urine, and water and lack adequate ventilation. The lowest values of RH were observed in shelter-3 followed by shelter-1.

During rainy season, the morning and evening RH was significantly higher ($P<0.01$) in all shelter types indicating thereby stress on the animals. The higher RH in rainy season was attributed to high humidity and frequent rainfall. In general, morning and evening RH values exceeds 70%, except evening RH during summer in shelter -1, 3 and 5. Adam (2006) reported cows were uncomfortable, when average humidity exceeded 70%. The negative diurnal changes in RH were observed in all the five shelters as well as in all the three seasons, due to rise in environmental temperature from morning to mid day/evening as a routine phenomenon as reported earlier also (Kaur and Singh 2004). The diurnal changes in RH were more in summer and less in winter and rainy season and were attributed to high maximum temperature and more variation between DBT and WBT.

Shelter-5

From the study of various shelter systems, it was concluded that shelter-3 had less stress on the cows maintained under rural condition in West Bengal and in this milk produced were significantly more ($P<0.01$) in comparison to cows maintained in other housing systems. However, provision of adequate ventilation, regular water bath, adequate drinking water and feed formulations during summer could further augment milk production and comfort to cows maintained in shelter-3 type.

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