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EFFECT OF DIFFERENT HOUSING SYSTEMS ON AMBIENT TEMPERATURE AND TEMPERATURE HUMIDITY INDEX (THI) IN HOT AND HUMID REGION

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Abstract: A study was conducted to evaluate the effect of different types of housing systems on microclimate. Three different types of housing systems viz. Conventional (T1), raised platform slatted (T2) and Simple open with kaccha flooring were studied. Dry bulb Temperature (DBT) and Wet Bulb Temperature (WBT) recorded at morning and afternoon. The relative humidity and THI were calculated. The morning average RH of T1, T2 and T3 housing systems were 84.29 ± 1.66, 80.04 ± 1.78 and 80.43 ± 1.34 respectively and the evening average RH of T1, T2 and T3 housing systems were 79.73 ± 1.63, 74.35 ± 1.71 and 72.65 ± 1.47 respectively which were not found significant within the housing systems. The morning average THI of T1, T2 and T3 housing systems were 78.27 ± 0.61, 77.49 ± 0.65 and 75.5 ± 0.7 respectively which were not found significant. The evening average THI of T1, T2 and T3 housing systems were 81.53 ± 0.34, 80.51 ± 0.38 and 78.36 ± 0.44 respectively. The results showed that the THI inside T3 housing system was significantly lower ($P<0.05$) than T1 (conventional) and T2 (Slatted) housing systems respectively. The result showed the average THI 0f T1, T2 and T3 housing systems was 81.86±0.37, 78.83±0.83 ,79.11±0.82; 81.68±0.43, 77.37±0.82, 77.86±0.84 and 78.87±0.43, 75.51±0.92 ,76.39±1.18 during rainy, winter and summer season respectively and significantly higher during rainy season than summer and winter respectively.

Keyword: Housing systems, Slatted, Temperature Humidity Index, Rainy.

INTRODUCTION

Housing types and its building materials has effect on inside environment and which affects their performance in terms of growth, physiology, behavior etc. Increasing temperatures have significant and adverse implications for livestock productivity. Among other things, the effect of the animals to thermoregulation (DeShazer et al, 2009). Other studies have reported heat stress- induced adverse impacts on production in goats (Lu 1989; Lallo et al. 2012; Salama et al. 2014) and sheep (Marai et al. 2008). The THI has a useful tool to judge the livestock productivity response as a function of climate (Ravagnolo et al. 2000; Hahn et al. 2003; Dikmen and Hansen 2009; Marai and Habeeb 2010). It is based on air temperature and relative humidity (RH) with different weightings for different species (Hahn et al. 2009) and is an indicative measure of 'the sum of forces external to the animal that acts to displace body

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temperature from its set point' (Dikmen and Hansen 2009). Hot and Humid region of Maharashtra in India is characterized by average annual temperature of 24°-26°C with around 220-370 cm of annual precipitation. Most of the rainfall is received between June to September and during this season the humidity is almost to 90-100%. The summer season also shows the high humidity in environment. Till now very few systematic studies has been conducted to evaluate the Effect of different housing systems on ambient temperature and Temperature Humidity Index (THI) in hot and humid region especially in Konkan area of India. The present study was therefore, designed to evaluate THI within three different types of housing systems in hot-humid region of India. Microclimate of shade and its relation with macroclimate has been reviewed here.

MATERIALS AND METHODS

The study was conducted at the Instructional Livestock Farm Complex of Mumbai Veterinary College, Mumbai situated at Aarey Colony, Unit No.3 Goregaon (East). The Livestock Instructional Farm Complex situated 100 meter above sea level at 29.42^0 N latitude and 79.54^0 E longitudes. Climate with a high level of humidity can be characterized as moderately hot. The average annual temperature is 24°-26°C and an average total rainfall of 220-370 cm. In summer, the temperature exceeds 32 °C (90 °F) and in winter, the maximum temperature remains up to 30 °C (86 °F). The minimum average temperature in summer is calculated up to 25 °C (77 °F), whereas in winter it becomes 20.5 °C (68.9 °F).

The research work was carried out Madgyal lambs were selected from Madgyal sheep unit of the Institute and allocated six to each of the three treatment groups (lodging), Viz: conventional housing system having Concrete flooring with asbestos roof (T1), slatted housing system having wooden platform flooring with asbestos roof (T2) and simple housing system having kaccha muroom flooring and cover the all sides with chain link and with asbestos roof (T3). The study was conducted for 1 year covering all the three seasons namely rainy season (June-September), winter season (October -January) and summer season (February- May).

Meteorological parameters and Temperature Humidity Index (THI):

Dry and wet bulb temperature inside each shed was recorded on weekly basis at morning 8 a.m and evening 2 p.m. throughout the experiment. For this the Dry and Wet bulb thermometer (sling psychrometer) was fixed inside each shed. Temperature Humidity Index (THI) was assessed by the following formula. (Veterinary Handbook by Tristan Jubb, 2012).

THI = $0.8x\ T\ ^0C + (RH\ \%)\ x\ (T\ ^0C-14.4) +46.4$. (Thom, 1959)

(T= dry bulb temperature, RH = Relative Humidity which is calculated from dry bulb and wet bulb temperature and with the help of the chart.)

Statistical analysis: The Data of DBT, WBT, RH and THI were subjected to analyze through completely randomized design model.

RESULTS AND DISCUSSION

Impact of different housing systems on different indoor meteorological parameters viz. dry bulb temperature (DBT ^{0}F), wet bulb temperature (WBT ^{0}F), relative humidity (RH %) and temperature humidity index (THI) were recorded and presented in Table 1. Statistical analysis was performed to calculate mean and standard errors of each parameter.

The average (morning and evening) and morning DBT and WBT was not significant within housing systems (Table 1& 2). The evening average DBT T1, T2 and T3 housing systems were 29.22 ± 0.22, 29.07 ± 0.25 and 27.78 ± 0.25 respectively. The results showed that the evening DBT inside open simple housing system was significantly lower ($P<0.05$) than conventional and Slatted housing systems. The evening average WBT T1, T2 and T3 housing systems were 26.39 ± 0.25, 26.39 ± 0.25 and 23.88 ± 0.34 respectively. The results showed that the WBT inside simple open housing system was significantly lower ($P<0.05$) than conventional where Slatted housing systems remains at par. The average (morning and evening), morning RH was not significant within housing systems (Table 3).

The average and morning THI was not significant within housing systems (Table 4). The evening average THI of T1, T2 and T3 housing systems were 81.53 ± 0.34, 80.51 ± 0.38 and 78.36 ± 0.44 respectively. The results showed that the THI inside simple open housing system was significantly lower ($P<0.05$) than conventional and Slatted housing systems. The results are in accordance with Boraei (2017), who studied the temperature, relative humidity and THI during afternoon period was significantly differed within housing system. The results studied by Bhatta et al (2017) are similar with this study who found the values of DBT, WBT and THI were higher in closed shed than in open. Where the result is not in accordance with De et al (2015) who found the RH and THI were significant within different housing system.

Seasonal average temperature humidity index (THI):

The THI was recorded and presented seasonally in Table 7. The result showed the average 0f T1, T2 and T3 housing systems was 81.86±0.37, 78.83±0.83 ,79.11±0.82; 81.68±0.43, 77.37±0.82, 77.86±0.84 and 78.87±0.43, 75.51±0.92 ,76.39±1.18 during rainy, winter and summer season respectively. The average THI was statistically significant ($p < 0.05$) during different seasons. Conventional housing system showed significantly higher THI during rainy season than summer and winter season respectively. Slatted housing system showed the significantly higher ($p < 0.05$) average THI during rainy season than summer and winter season respectively. Simple open type housing system showed significantly higher average THI during rainy season than winter season where summer season remains at par.

The results were similar with Bhatta *et al* (2017), Salles *et al* (2020) which showed THI is higher in rainy season compared to other seasons. Roy et al (2010) studied that season significantly influenced inside wet and dry bulb temperatures, relative humidity and temperature humidity index (THI) of different types of shelter system. The THI obtained within different housing systems of this study are not in accordance with the De *et al* (2015) who found THI was significantly differed within housing system during winter season.

CONCLUSION

In hot and humid region of Maharashtra the morning DBT, WBT, RH and THI were not significantly differed within different housing systems. But the afternoon DBT, WBT, RH and THI showed significant difference within housing system and are higher in Conventional housing systems compared to slatted and open simple with kaccha floor housing system respectively. The THI showed the significant difference within season. The THI is significantly higher in rainy season than summer and winter season respectively. The overall average DBT, WBT, Rh and THI showed numerically lower values inside the simple open with kaccha murum flooring and slatted housing system than the conventional type of housing system.

Table1: Average monthly dry bulb temperature ^{0}F (DBT) inside the different housing systems.

Sr.No.	DBT inside different housing types					
	Morning			Evening		
	T_1	T_2	T_3	T_1	T_2	T_3
1	27.98 ± 0.13	29.2 ± 0.58	28 ± 0.28	28.58 ± 0.05	30 ± 1.08	28.2 ± 0.07
2	29.58 ± 0.25	29.5 ± 0.29	27.25 ± 0.43	30.08 ± 0.43	30 ± 0.41	27.98 ± 0.23
3	27.43 ± 0.71	27.25 ± 0.75	25.9 ± 0.37	28.3 ± 0.72	28.25 ± 0.75	26.7 ± 0.51
4	28 ± 0.82	27.5 ± 0.65	25.9 ± 0.48	30.75 ± 1.36	30.25 ± 1.44	29.05 ± 0.66
5	28.35 ± 0.62	28 ± 0.82	26.13 ± 0.41	30.08 ± 0.56	30 ± 0.58	27.5 ± 0.82
6	27.13 ± 0.47	26.75 ± 0.52	24.38 ± 0.75	30.58 ± 0.28	30.25 ± 0.48	28.43 ± 0.48
7	22.88 ± 0.88	22.25 ± 0.78	20.75 ± 0.75	26.55 ± 0.38	26.1 ± 0.42	24.65 ± 0.65
8	23.08 ± 0.89	22.53 ± 1	20.68 ± 0.88	28.65 ± 0.74	28.1 ± 0.82	25.95 ± 0.67
9	23.93 ± 0.22	23.55 ± 0.21	22.58 ± 0.83	28.35 ± 0.49	27.95 ± 0.55	27.15 ± 0.43

10	26.8 ± 0.37	26.48 ± 0.34	26.75 ± 0.52	29.13 ± 0.33	28.85 ± 0.4	29.45 ± 0.54
11	28.63 ± 0.28	28.35 ± 0.3	28.73 ± 0.23	30.28 ± 0.13	30.1 ± 0.1	30.18 ± 0.28
12	27.5 ± 0.86	27.25 ± 0.85	25.65 ± 0.75	29.33 ± 0.23	29 ± 0.27	28.08 ± 0.62
Avg.	**26.77 ± 0.35#**	**26.6 ± 0.38#**	**25.28 ± 0.39#**	**29.22 ± 0.22^{a}**	**29.07 ± 0.25^{a}**	**27.78 ± 0.25^{b}**

Means bearing different superscripts (a, b) differ significantly ($p < 0.05$) between housing types (DBT: Dry Bulb Temperature.)

Table.2 Average monthly wet bulb temperature ^{0}F (WBT) inside the different housing systems.

Sr.No.	WBT inside different housing types					
	Morning			Evening		
	T_1	T_2	T_3	T_1	T_2	T_3
1	26.43 ± 0.33	27.54 ± 0.35	26.4 ± 0.39	26.6 ± 0.67	26.6 ± 0.67	26.13 ± 0.52
2	27.63 ± 0.35	27.05 ± 0.59	25.2 ± 0.62	27.78 ± 0.21	27.78 ± 0.21	25.23 ± 0.66
3	26.28 ± 0.28	25.93 ± 0.27	24.5 ± 0.33	26.68 ± 0.36	26.68 ± 0.36	24.5 ± 0.42
4	25.58 ± 0.83	24.5 ± 0.82	23.7 ± 0.33	26.7 ± 0.51	26.7 ± 0.51	24.63 ± 0.25
5	24.4 ± 0.62	23.33 ± 0.63	22.7 ± 0.44	26.05 ± 0.64	26.05 ± 0.64	24.03 ± 0.56
6	22.6 ± 0.98	21.53 ± 1.4	21.4 ± 1.27	25.73 ± 0.09	25.73 ± 0.09	24.1 ± 0.74
7	20.23 ± 1.77	19.03 ± 1.72	17.1 ± 1.33	22.8 ± 1.13	22.8 ± 1.13	19.23 ± 1.03
8	20 ± 0.61	18.85 ± 0.7	16.83 ± 0.78	24.8 ± 0.98	24.8 ± 0.98	20.58 ± 0.81
9	22.03 ± 0.48	20.93 ± 0.62	19.2 ± 1.24	26.63 ± 0.69	26.63 ± 0.69	22.13 ± 0.68
10	26.3 ± 0.47	25.35 ± 0.46	24.88 ± 0.41	27.08 ± 0.47	27.08 ± 0.47	25.4 ± 0.41
11	26.93 ± 0.42	25.83 ± 0.28	25.68 ± 0.34	27.95 ± 0.2	27.95 ± 0.2	26.33 ± 0.26
12	27.03 ± 0.72	26.03 ± 0.68	23.53 ± 0.74	27.93 ± 0.21	27.93 ± 0.21	24.35 ± 0.4
Avg.	**24.62 ± 0.43**	**23.9 ± 0.47**	**22.67 ± 0.49**	**26.39 ± 0.25^{a}**	**26.39 ± 0.25^{ab}**	**23.88 ± 0.34^{b}**

Means bearing different superscripts (a, b) differ significantly ($p < 0.05$) between housing types

Table.3 Average monthly relative humidity % (RH) inside the different housing systems.

Sr.No.	RH(%) inside different housing types					
	Morning			Evening		
	T_1	T_2	T_3	T_1	T_2	T_3
1	89.25 ± 3.22	88.2 ± 2.48	88.6 ± 2.25	86 ± 4.22	83 ± 3.56	85.5 ± 3.86

2	86.25 ± 2.39	81.5 ± 3.23	85 ± 2.38	84 ± 3.56	80.5 ± 4.05	80.5 ± 4.56
3	91.75 ± 4.13	90.5 ± 4.44	89.5 ± 0.96	88.75 ± 4.15	86.75 ± 4.57	84 ± 2.16
4	83 ± 8.19	79.25 ± 8.66	83.75 ± 4.21	74.25 ± 10.36	64.75 ± 8.93	69.75 ± 3.88
5	72.75 ± 5.79	65.5 ± 4.92	75 ± 1.29	73 ± 7.23	67 ± 7.22	75.5 ± 7.15
6	68 ± 4.42	61.5 ± 4.41	77.75 ± 6.01	67.5 ± 1.66	60.5 ± 1.85	70 ± 3.74
7	79.5 ± 7.37	74.75 ± 7.76	71.25 ± 7.74	73 ± 5.74	67.5 ± 6.2	60.25 ± 3.5
8	76.5 ± 2.75	72 ± 2.68	69.5 ± 3.28	73 ± 4.51	67.5 ± 4.66	61.75 ± 4.21
9	85.25 ± 2.75	80 ± 3.7	73.75 ± 4.44	78.5 ± 5.06	74.75 ± 4.85	64.75 ± 2.87
10	96.25 ± 0.85	91.75 ± 1.03	86 ± 0.91	85.25 ± 1.38	78 ± 1.15	72.25 ± 1.03
11	87 ± 2.12	82.25 ± 2.14	78.5 ± 1.55	83.75 ± 1.55	77.75 ± 0.85	73.75 ± 1.38
12	96 ± 1.35	91.25 ± 1.75	84.5 ± 3.52	89.75 ± 2.06	84.25 ± 2.84	73.75 ± 2.84
Avg.	**84.29 ± 1.66**	**80.04 ± 1.78**	**80.43 ± 1.34**	**79.73 ± 1.63**	**74.35 ± 1.71**	**72.65 ± 1.47**

Table.4 Average monthly temperature humidity index (THI) inside the different housing systems.

Sr.No.	**THI inside different housing types**					
	Morning			**Evening**		
	T_1	**T_2**	**T_3**	**T_1**	**T_2**	**T_3**
1	80.89 ± 0.33	82.77 ± 0.71	80.85 ± 0.53	81.45 ± 0.63	83.25 ± 1.36	80.75 ± 0.48
2	83.14 ± 0.45	82.29 ± 0.5	79.14 ± 0.88	83.58 ± 0.3	82.91 ± 0.2	79.7 ± 0.64
3	80.21 ± 0.74	79.74 ± 0.76	77.41 ± 0.57	81.3 ± 0.79	80.94 ± 0.9	78.08 ± 0.72
4	79.94 ± 0.92	78.64 ± 0.61	76.7 ± 0.44	82.72 ± 0.38	80.49 ± 0.79	79.79 ± 0.53
5	79.15 ± 0.68	77.62 ± 0.83	76.09 ± 0.65	81.79 ± 0.43	80.73 ± 0.38	78.14 ± 0.68
6	76.79 ± 1.15	75.43 ± 1.17	73.7 ± 1.51	81.77 ± 0.19	80.17 ± 0.48	78.96 ± 0.89
7	71.61 ± 1.99	70.23 ± 1.79	67.57 ± 1.36	76.56 ± 1.18	75.23 ± 1.21	72.35 ± 1.21
8	71.44 ± 1.22	70.21 ± 1.36	67.27 ± 1.26	79.72 ± 1.34	78.12 ± 1.36	74.28 ± 1.01
9	73.67 ± 0.51	72.57 ± 0.6	70.56 ± 1.56	80.02 ± 0.95	78.89 ± 1.06	76.39 ± 0.83
10	79.78 ± 0.75	78.67 ± 0.69	78.41 ± 0.78	82.26 ± 0.69	80.76 ± 0.78	80.82 ± 0.72
11	81.67 ± 0.44	80.54 ± 0.4	80.63 ± 0.44	83.91 ± 0.24	82.69 ± 0.17	82.17 ± 0.38
12	80.95 ± 1.38	79.9 ± 1.32	76.4 ± 1.17	83.24 ± 0.26	81.88 ± 0.33	78.91 ± 0.7
Avg.	**78.27 ± 0.61**	**77.49 ± 0.65**	**75.5 ± 0.7**	**81.53 ± 0.34^{a}**	**80.51 ± 0.38^{b}**	**78.36 ± 0.44^{b}**

Means bearing different superscripts (a, b) differ significantly ($p < 0.05$) between housing types

THI: Temperature Humidity Index.

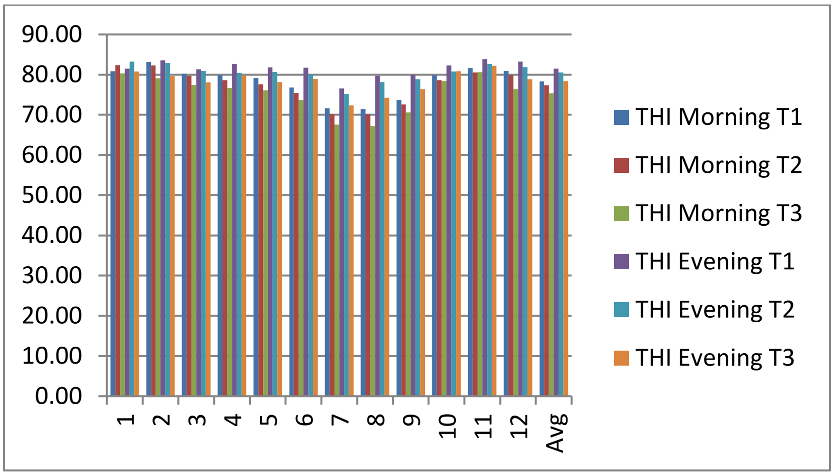

Fig.1 Average monthly temperature humidity index (THI) inside the different housing systems.

Table 6. Overall Average annual meteorological observations inside three housing systems. (morning, evening and average)

Timing	Groups	Dry bulb temp (0c)	Wet bulb temp (0c)	RH %	THI
Morning	T1	26.77±0.35	24.62±0.43	84.29±1.6	78.27±0.61
	T2	26.6±0.38	23.9±0.47	80.04±1.7	77.49±0.65
	T3	25.28±0.39	22.67±0.49	80.43±1.3	75.5±0.7
Evening	T1	29.22±0.22 a	26.39±0.25 a	79.73±1.6	81.53±0.34 a
	T2	29.07±0.25 a	25.31±0.3 ab	74.35±1.7	80.51±0.38 b
	T3	27.78 ±0.25b	23.88 ±0.34b	72.65±1.4	78.36±0.44 b
Average	T1	27.99 ±0.28	25.50±0.34	82.01±1.64	79.90±0.47
	T2	27.83±o.31	24.60±0.38	77.19±1.74	79±0.51
	T3	26.53±0.32	23.27±0.41	76.54±1.40	76.93±0.57

Means bearing different superscripts (a, b) differ significantly ($p < 0.05$)

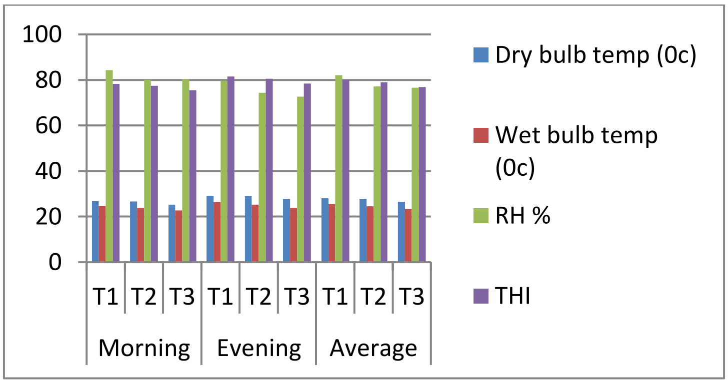

Fig.2: Overall Average annual meteorological observations inside three housing systems. (morning, evening and average)

Table 7. Seasonal average temperature humidity index (THI) inside different types of housing system

Housing system	Seasons		
	Rainy	Winter	Summer
T1	81.86 ± 0.37^{a}	78.83 ± 0.83^{b}	79.11 ± 0.82^{b}
T2	81.68 ± 0.43^{a}	77.37 ± 0.82^{b}	77.86 ± 0.84^{b}
T3	78.87 ± 0.43^{a}	75.51 ± 0.92^{b}	76.39 ± 1.18^{ab}

Means bearing different superscripts (a, b) differ significantly ($p < 0.05$)

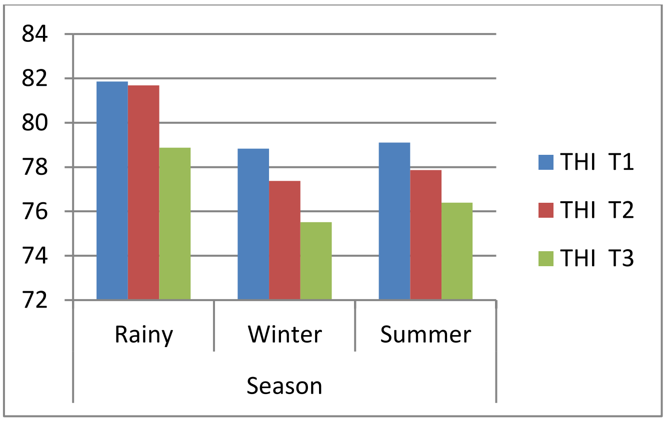

Fig. 3: Seasonal average temperature humidity index (THI) inside different types of housing system

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