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SPATIAL AND TEMPORAL CLASSIFICATION OF KERALA BASED ON TEMPERATURE HUMIDITY INDEX (THI)

Prasad A[1*], Kannan A[2], Gleeja V.L[3], Anil K. S[4], Joseph Mathew[5] and Girish Varma G[6]

[1]Assistant Professor, Department of Livestock Production Management, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, [2]Associate Professor and Head, LRS, Thiruvizhamkunnu, Kerala, [3]Assistant Professor, Department Statistics, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, [4]Professor and Head, ULF Mannuthy, Thrissur, [5]Professor, Department of Livestock Production Management, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, [6]Professor, Veterinary Physiology, College of Veterinary and Animal Sciences, Mannuthy

E-mail: prasad@kvasu.ac.in (**Corresponding Author*)

Abstract: The study was conducted with the objectives to delineate THI zones in Kerala with respect to thermal comfort of dairy cattle. Daily meteorological data for the past ten years (from 2002 to 2011) was collected from thirteen different weather stations located in different agro ecological zones of Kerala. The ten year average of daily THI, temperature and humidity of each weather station and of the entire state of Kerala were calculated. Moving averages were used to find periods. The 60 day moving average of THI at all the thirteen weather stations for the past ten years were calculated. Altitude was found to have significant effect on THI ($p<0.05$). The present study suggests following linear equation to predict THI from altitude.

THI = -0.0151 X Altitude in meters + 91.923 ($R^2 = 0.9339$)

There is similarity in pattern of THI in all zones and the highest THI period in Kerala is from 19-Feb to May 27(98 days).

Keywords: Thermal stress, THI, Climatic classification, Kerala climate.

INTRODUCTION

There is no place in the world where climate is perfectly conducive at all times for dairy cattle. Climatic constraints exist at somewhere or at some time in every geographical entity. In a hot humid tropical environment thermal stress is the major climatic constraint. Kerala is tropical humid state in India having high percentage of crossbreds among cattle population. For cattle, increased air temperature and humidity measured as Temperature Humidity Index (THI) above critical thresholds are related to low dry matter intake (DMI) and to reduced efficiency of milk production (West, 2003). The Temperature Humidity Index (THI) combines the values of temperature and humidity to measure intensity of heat exposure through a formula to evaluate a unique thermo physiological effect (Jendritzky *et al*., 2002). There were climatic classification attempts with dairy cattle interpretations using temperature

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and humidity alone and using thermal indices. THI based zonation was done in Mediterranean area by Gantner *et al* 2011. Hence the study was conducted with the objectives to delineate THI zones in Kerala with respect to thermal comfort of dairy cattle.

MATERIALS AND METHODS

Daily meteorological data for the past ten years (from 2002 to 2011) was collected from thirteen different weather stations located in different agro ecological zones of Kerala, India. Which were maintained by Indian Meteorological Department (IMD) and Kerala Agricultural University (KAU). The following method was used for statistical analysis to find out the spatial and temporal classification of Kerala based on THI.

From the daily maximum and minimum temperature, the daily average temperature was calculated and from the morning and evening relative humidity values average relative humidity was calculated. Ten years daily average of both temperature and humidity was used to find out the average THI. THI calculated using maximum temperature was designated as Maximum THI. From among the different THI formulae, the THI was calculated using the formula THI = db◦F- {(0.55-0.55RH) (db◦F-58)} (LPHSI 1991).

Each weather station was assumed as representing the meso climatological jurisdiction for evolving a zonation based on THI (Rao 2008). The ten year average of daily THI, temperature and humidity of each weather station and of the entire state of Kerala were calculated.

The average THI of each station was compared using paired T test in SPSS software for spatial classification of THI zones in Kerala and (GIS) software was used to prepare THI based map of Kerala. The comparative relation between average THI altitude was also analysed.

Temporal Classification

Moving averages were used to find periods. The 60 day moving average of THI at all the thirteen weather stations for the past ten years were calculated. The highest 60 day moving average of THI was taken as the most probable highest THI period in a year.

RESULTS AND DISCUSSION

Classification of Kerala based on THI

The weather stations across the state in the decreasing order of their THI based on ten years daily data and corresponding average THI are given in Table 1 and Fig 1. The table also contains the latitude, longitude, altitude, period of highest THI of that particular station and average of maximum THI and average THI of respective stations. Paired t tests conducted on

average THI delineated the weather stations into six statistically significantly different THI groups ($p<0.05$). Average THI delineated the weather stations into six statistically significantly different THI groups ($p<0.05$). Altitude was found to have significant effect on THI ($p<0.05$). The figure 1 shows the variation in THI with relation to altitude in Kerala. The present study suggests following linear equation to predict THI from altitude.

THI = -0.0151 X Altitude in meters + 91.923 ($R^2 = 0.9339$).

Table 1. THI Based Spatial and Temporal Details of Weather Stations of Kerala (2002-2011)

Stations	Latitude in degrees	Longitude in degrees	Altitude (m)	Highest 60 day THI Period		Maximum THI	Average THI
				Calendar day			
				March	May		
Panniyur	12.07	75.40	14	18	17	101.08	95.32
Punalur	9.01	76.93	56	2	1	96.25	92.61
Cochin	10.15	76.40	9	16	15	96.03	92.43
Thiruvananthapuram	8.48	76.92	5	21	20	95.80	91.42
Vellayani	8.43	76.99	21	20	19	95.25	91.26
Pattambi	10.80	76.18	62	18	17	95.69	90.95
Kozhikode	11.13	75.95	88	3	2	95.25	90.91
Vellanikkara	10.54	76.28	22.5	17	16	95.52	90.80
Kottayam	9.59	76.52	3	15	14	94.67	90.75
Peelikode	12.19	75.14	10	27	26	94.94	90.18
Alleppy	9.49	76.33	2	3	2	93.58	90.09
Wayanad	11.61	76.21	921	18	17	84.17	78.79
Pampadumpara	9.79	77.15	1040	19	18	81.82	75.48

Same data was used to prepare the THI map of Kerala using GIS (Fig1).

Fig 1. THI map of Kerala

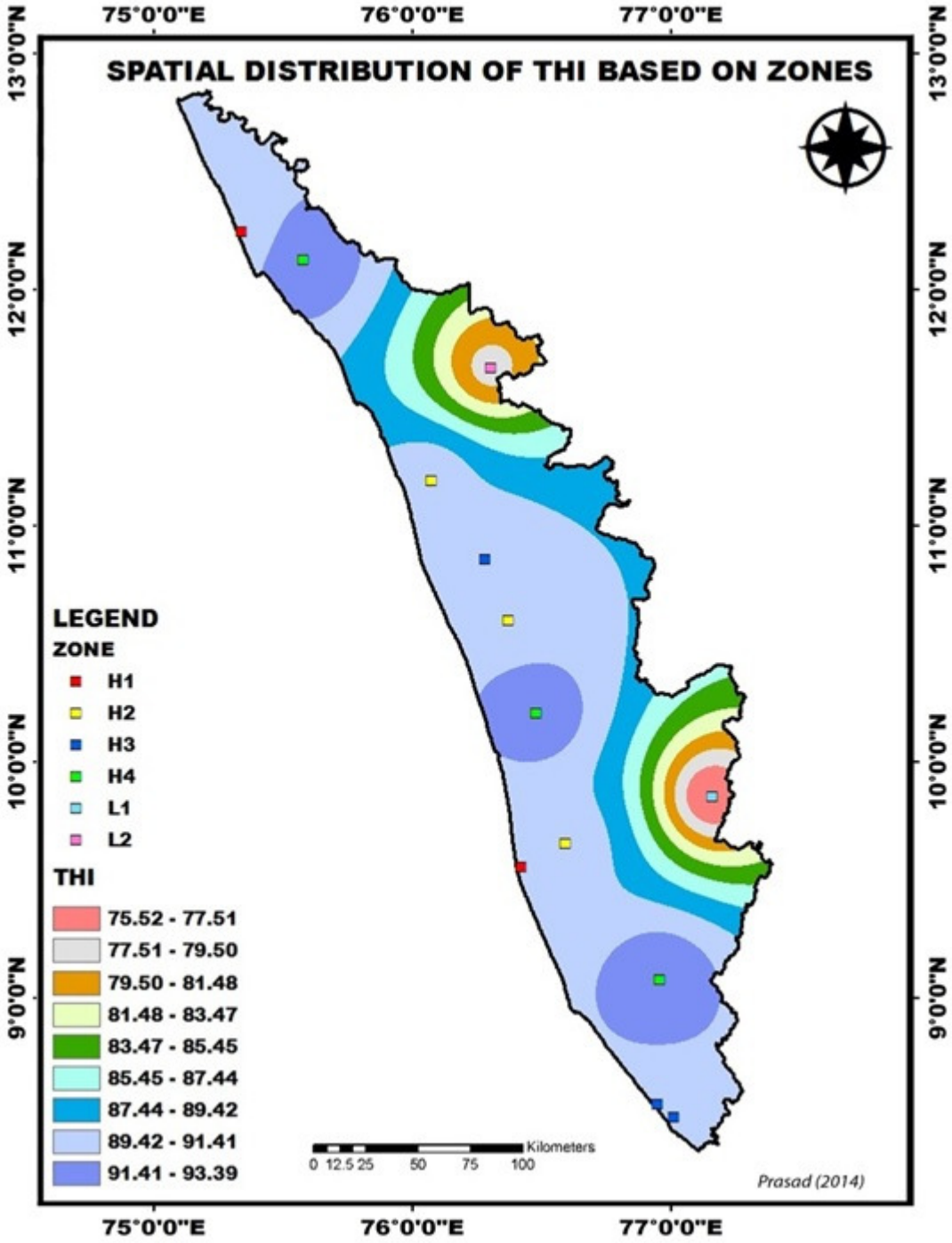


Table 2. Grouping of Weather Stations based on THI

Statistical grouping of weather stations	Stations under each group	Average THI
LI	Pampadumpara	75.52
L2	Wayanad	78.73
H1	Alappy Peelikkode	89.87
H2	Kozhikkode Kottayam Vellanikkra	90.66
H3	Pattambi Trivandrum Vellayani	91.07
H4	Cochin Punalur Panniyur	93.40

Figure 2 shows the THI of each Julian day for the different weather stations. There is similarity in pattern of THI in all stations of Kerala. Figure 3 shows the average of averages of all thirteen weather stations depicted as the Average THI of the state of Kerala. Highest THI period in Kerala is from 19-Feb to May 27(98 days).

From the 60 day moving average of THI of Kerala (Fig 4), the highest 60 day period of THI was found to be between March 17 and May 16. Daily averages of THI of all the thirteen weather stations for ten years plotted graphically illustrated the most probable average THI of each Julian day in the respective area (Fig 5). The figure also show that though there was difference in THI values among different stations, showed a similar pattern of the THI graph in a year.

Fig. 2. Daily average THI of different locations in Kerala

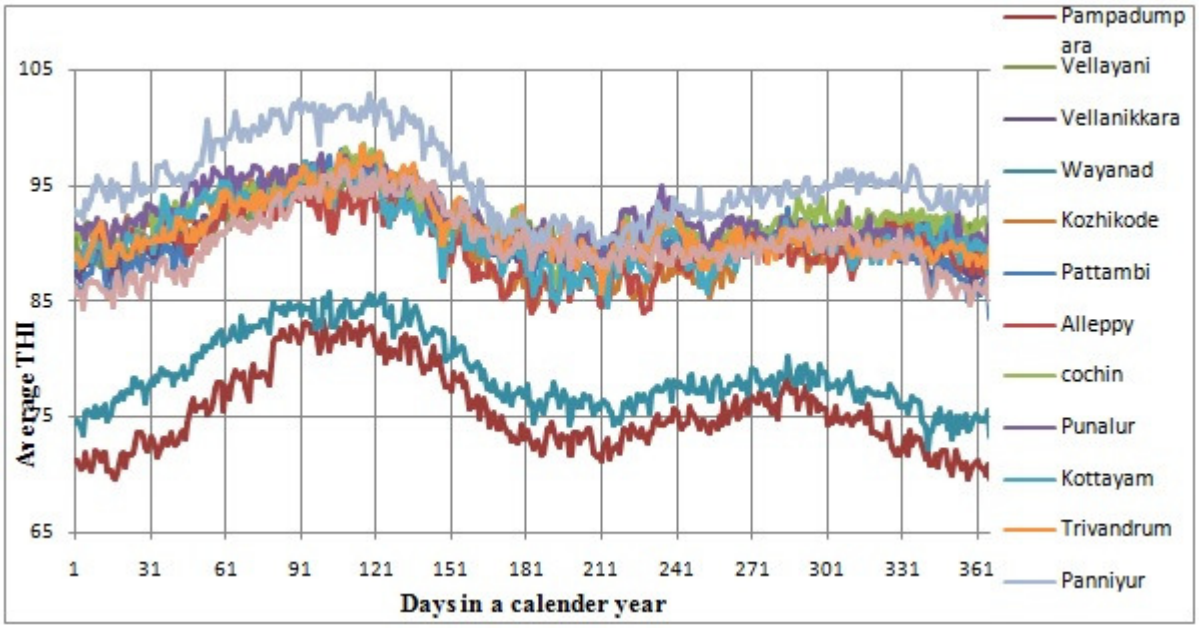
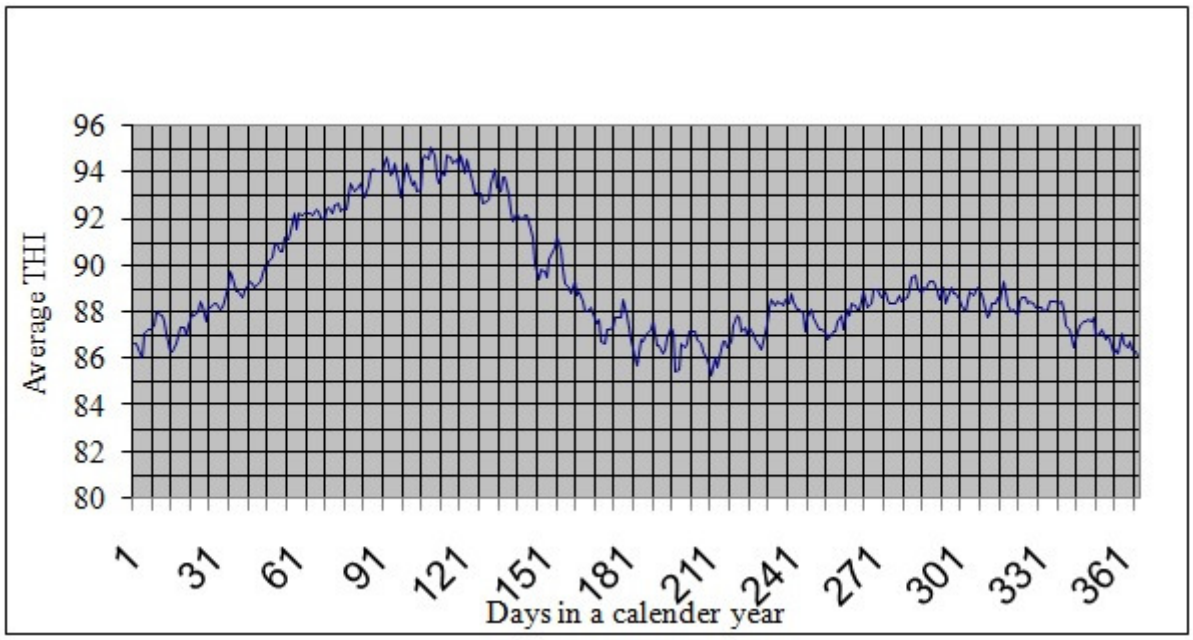
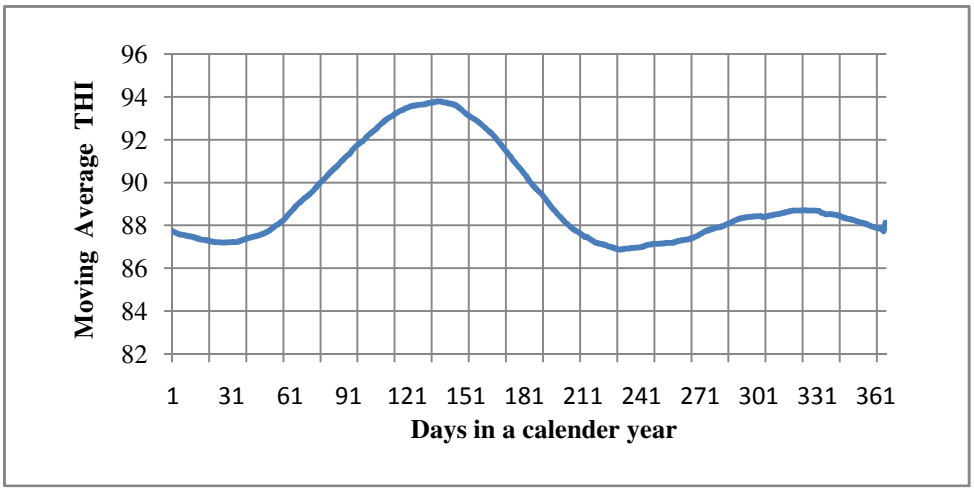


Fig. 3. Average THI of Kerala in a year



Many earlier works had classified the climate of Kerala into seasons. (Somanathan, 1980; Nishant, 2009; Sowmya, 2012). These were based on monthly average temperatures. English calendar months are not apposite to the monsoon based climate of Kerala. moreover, in thermal stress study in which even the minute to minute changes in thermal factors affecting the physiology of the animal; monthly or weekly averages are far from accurate and scientifically implausible over simplifications.

Fig. 4. Sixty day moving average THI of Kerala



The present study relied upon daily averages to accurately find out which are the high stress and which are period of low stress. So rather than seasonality classification this work has identified high thermal stress periods which are relevant in stress management of dairy cattle.

Conclusion

This classification can be used for adaptability and stress evaluation studies of animals especially dairy cattle. So, the spatial classification and stress status between the zones could be summarised as,

1. Extreme high stress zone (H4) - Pockets of severe stress
2. High stress zone (H1, H2, H3) – Major areas of high THI zone in the coastal and midland of the state of Kerala
3. Moderately comfortable zones (L2) – Comfortable THI zones with differing comfort levels at different altitudes closely related to high range
4. Comfortable zones (L1) –Comfortable THI zones of the high range

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