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Uniqueness of seasons in Kerala – Implications on thermal stress and productivity of animals

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Abstract

Pattern of seasons in Kerala, with predominantly hot humid climate, has been found to be hostile for the enhancement of animal productivity. In the context of climate change, alterations and inconsistencies of the seasons has been reported worldwide. Hence, weather parameters of Kerala were studied over a period of six years with emphasis on the seasonality and causation of thermal stress in animals. The study was carried out at Livestock Research Station, Thiruvazhamkunnu. Ambient temperature (AbT) and humidity of six years were collected from Automatic weather stations (AWS) and Temperature Humidity Index (THI) was calculated using formula. The weather parameters were analysed for monthly, seasonal and yearly pattern and the findings are discussed. It is evident that summer season in Kerala (March to May) does not correspond to the entire long day period. Even though AbT and THI were increasing from January onwards with increasing day length, onset of raining in June causes sudden drop in AbT responsible for the peculiar Kerala climate. Climatic parameters in September were more similar to October-November (North-east monsoon) than June to August (South-west monsoon). Even though December to February (post monsoon) forms winter season in rest of the country, the lowest temperature recorded in the study was 18.3 ºC, making the term "winter" a misfit except for high ranges. Thus it appears that four quarters of three months each, designated as South-west monsoon, North-east monsoon, Post monsoon and Summer forms better classification of seasons in Kerala and THI was high enough to cause thermal stress throughout the year.

Keywords: *Season; Kerala; Climate; THI; Stress; Weather*

Climatic factors have been found to play a crucial role in the regulation of physiological processes in animals. The potential impact of seasons on a particular animal species is reflected by the seasonal pattern of reproduction (Hansen, 2009; Kutty and Mathew, 2000). While photoperiod formed the major regulator of circannual rhythm of breeding activity, ambient temperature (AbT) regulated the circadian and seasonal rhythms through the influence on endocrine and molecular mechanisms of reproductive events (Marai *et al*., 2008). In countries of arid and semi-arid regions, high AbT during the summer months, and moderate to high AbT together with high humidity,

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contributed by intermittent rainfall of the months adjoining summer, have been found to be the potential regulators of seasonality in animals (Macias-Cruz *et al*., 2016).

Hot humid climate prevailing in Kerala has already been found to be hostile to enhancement of the productivity of dairy cattle. Prevalence of high atmospheric humidity (RH) during most part of the year contributed by extended rainy season and stretched out sea shore, together with moderately high AbT caused by geographical proximity to the equator makes the climate of Kerala highly adverse for animal welfare with a distinct pattern of seasonality, compared to other regions of the country. Different classifications of seasons in Kerala are being used in various studies and the classification most often used is with four months under Southwest monsoon (June to September), two months under North East monsoon (October and November) and three months each under winter (December to February) and summer (March to May). This classification is mainly based on the occurrence of monsoon rain fall and direction of wind causing the rain (Kumar, 2013; Rao, 2013).

The climate change phenomena has been found to cause major threats for enhancement of animal productivity especially at the tropical regions contributed by increasing atmospheric temperature (AtT) and is being projected upto 0.2 degree Celsius (°C) per decade, reaching 1.5°C above the level of pre-industrial period, between 2030 and 2050 (IPCC, 2018). Alterations and inconsistencies of the seasons have also been reported in various parts of country and were found to be seriously affecting crop and animal production. In this context, weather parameters of Kerala already having peculiar climate and seasonal pattern were studied over a period of six years with emphasis on the seasonality and causation of thermal stress in animals.

Materials and methods

The study was carried out at the dairy farm of Livestock Research Station (LRS), Thiruvazhamkunnu in Palakkad district, under Kerala Veterinary and Animal Sciences University. Weather parameters in the past six years starting from September 2013 to August 2019 were collected from the Automatic Weather Station (Campbell Scientific, CR 800 series data logger) situated at the station and two other weather stations located at VFPCK Karimpuzha and Elavanchery, situated within 25 kilometers from the station.

Weather parameters such as daily average temperature (AvT), average relative humidity (AvRH), maximum temperature (MxT), minimum temp-erature (MnT), maximum relative humidity (MxRH) and minimum relative humidity (MnRH) were collected from the hourly recordings of AbT and RH. Temperature Humidity Index (THI) values were calculated from AvT and AvRH using the formula for livestock and poultry heat stress index (LPHSI, 1990) given by

$$THI\ (LPHSI) = T - \left(\left(0.55 - \frac{0.55 \times RH}{100}\right) \times (T - 58)\right)$$

Where T - Average temperature (in Degree Fahrenheit)

RH - Per cent relative humidity

Derived data were analysed using statistical software SPSS V. 24.0 for monthly, quarterly, half yearly and annual patterns with emphasis on the chances for the occurrence of thermal stress in dairy cattle. Weather parameters were compared between already established seasons and operational classification of seasons corresponding to four quarters adopted from an earlier study (Kutty, 2013) in order to assess their suitability for interpreting the possibility of climatic stress affecting the animal productivity and the observations are described.

Results and discussion

Monthly average of daily AvT (in °C) was lowest during January (25.06) and highest in April (28.99). MnT also had the same pattern (18.32 versus 24.16). However, monthly average of MxT had different pattern with the highest during March (37.04) and the lowest (29.70) in July. Monthly mean of daily AvRH during the 6 years was highest (97.75 %) in July and lowest (77.37 %) in February. The THI calculated from daily AvT and AvRH showed highest monthly mean during April (82.28) as against the lowest of 75.10 during January. Even though THI 72 is often considered as the demarcation for the zone of thermal comfort for dairy animals (Dash *et al.* 2016), none of the months had THI below 75.

Quarterly mean values of major environmental variables recorded during the study period such as maximum, minimum and daily average of AbT and RH are shown in Table 1. All of these climatic parameters varied significantly ($P<0.001$) between the seasons with highest daily mean AbT during MAM and the minimum during DJF. Quarterly means of THI calculated from daily mean values of AbT and RH are compared in Table 2. THI ranged from the lowest in DJF to highest during MAM indicating exposure of the animals to varying levels of mild to moderate stress throughout the year.

Other Climatic Stress Factors

Quarterly means of MxT, MnT, MxRH and MnRH are shown in Table 3. The extent of daily variation of these variables determines the severity of TS exposed. Hence, the variation between maximum and minimum of AbT and RH are also included in Table 3.

While MnT and MxT attained highest during MAM, lowest of these two variables were during DJF and JJA, respectively. Similarly, highest means of MnRH and MxRH were during JJA, while the lowest were during DJF and MAM, respectively. The differences between MnT and MxT had similar seasonal pattern as that of MnRH and MxRH with the lowest and highest variations during JJA and DJF respectively; also showing inverse relationship with day length pattern. However, the variations of MxT and the difference between MnT and MxT were not significant between quarters corresponding to four seasons of the region indicating persistence of high AbT across all the seasons.

Seasons in Kerala

Based on the occurrence of monsoon rainfall and direction of wind causing the rain (Kumar, 2013; Rao, 2013), seasons in Kerala are classified with four months under Southwest monsoon (June to September), two months under North East monsoon (October and November) and three months each under winter (December to February) and summer (March to May). However, comparison of weather parameters together with day length and raining pattern showed that four quarters of three months each better represent seasons in Kerala as reported in earlier study (Kutty, 1995; Kutty, 2013).

September is the month of equinox, with equal duration of day and night at the equator. In the present study, weather

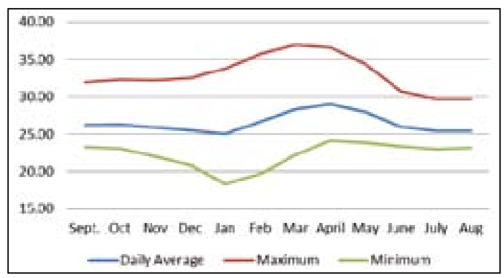

Fig. 1. Monthly mean ambient temperature of six years in °C

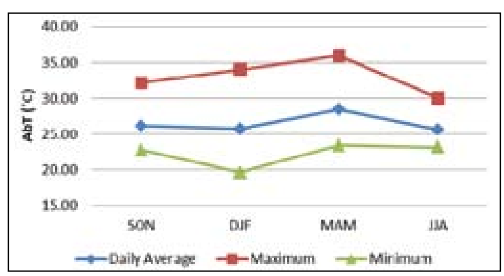

Fig. 2. Quarterly means of ambient temperature for six years

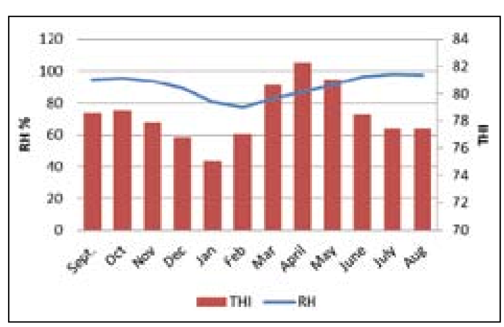

Fig. 3. Monthly means of RH and THI

Table 1. Maximum, minimum and daily mean values of ambient temperature and relative humidity (Mean ± SE) of the study area during the four seasons

Variable	SON	DJF	MAM	JJA	Mean	F-value
MxT (°C)	32.17±0.28^{b}	34.01±0.19^{c}	36.00±0.33^{d}	30.08±0.28^{a}	33.06±0.47	84.59
MnT (°C)	22.79 ±0.28^{b}	19.62±0.31^{a}	23.41± 0.23^{b}	23.19±0.09^{b}	22.25±0.34	52.34
AvT(°C)	26.15 ±0.08^{a}	25.77 ±0.14^{a}	28.43 ±0.28^{b}	25.62 ±0.14^{a}	26.49 ±0.25	56.35
MxRH (%)	98.03±0.60^{bc}	93.61±1.41^{a}	95.20±1.14^{ab}	99.00±0.24^{c}	96.46±0.64	6.70
MnRH (%)	71.82±3.99^{b}	45.10±1.78^{a}	53.51±3.27^{a}	86.14±2.26^{c}	64.14±3.60	38.87
AvRH (%)	94.54±0.95^{b}	82.61±2.02^{a}	86.98±1.96^{a}	97.32±1.05^{b}	90.36±1.43	18.49

Values with different superscripts in each row varied significantly (P<0.001)

Table 2. Maximum, minimum and daily mean THI values across quarters

Quarters	**THI**		
	Min	**Max**	**Mean** ± SE
SON	77.92	79.15	78.43±0.17^{b}
DJF	75.87	77.11	76.42± 0.22^{a}
MAM	80.52	82.51	81.36±0.33^{c}
JJA	76.86	78.31	77.82±0.21^{b}

Values with different superscript varies significantly (P<0.001) between seasons

Table 3. Quarterly mean ± SE of maximum and minimum temperature and relative humidity and the extent of variations between seasons

Weather parameters	**Season**					**P value**	**P value**
	SON	**DJF**	**MAM**	**JJA**	**Total**		
Min. AbT (**ºC**)	24.25 ± 0.34^{ab}	22.09 ± 1.19^{a}	26.30 ± 0.66^{b}	24.75 ± 0.38^{b}	24.35 ± 0.55	5.754*	0.021
Max. AbT (**ºC**)	33.08 ± 0.70	34.72 ± 0.86	35.93 ± 1.84	30.82 ± 0.98	33.64 ± 0.77	3.527^{ns}	0.068
Min RH (%)	63.17 ± 5.45^{bc}	41.55 ± 5.11^{a}	52.63 ± 9.43^{ab}	75.67 ± 3.46^{c}	58.25 ± 4.65	5.431*	0.025
Max RH (%)	94.62 ± 0.50^{b}	90.89 ± 1.08^{a}	89.72 ± 0.63^{a}	94.92 ± 0.32^{b}	92.54 ± 0.75	14.414**	0.001
Max-Min AbT	8.84 ± 1.04	12.62 ± 1.03	9.62 ± 2.44	6.06 ± 0.59	9.28 ± 0.94	3.459^{ns}	0.071
Max- Min RH	31.45 ± 5.11^{ab}	49.34 ± 4.05^{b}	37.09 ± 9.78^{ab}	19.25 ± 3.17^{a}	34.28 ± 4.17	4.221*	0.046

* Significant(P<0.05), ** Significant (P<0.01), ^{ns} Non-significant

Means with different superscripts vary significantly within a column

parameters of September was found to have more similarity to that of October-November period with respect to AbT, RH and THI than the previous period of June to August. Simlar pattern was also evidenced with respect to amount of rainfall, day length and hours of sunshine. Since all these weather parameters are more influential on thermal comfort as well as reproductive processes of the animals, the month of September was considered together with October and November, to form the operational classification of seasons in this study as four quarters of three months each.

The period of December to February forms the winter season in rest of the country (Kumar, 2013). However, the lowest temperature recorded in the study location across the year was 18.3 ºC indicating lack of winter climate. Hence the period of DJF was designated as post monsoon to denote the climate that prevails in most parts of the state. Thus it can be inferred that Kerala is lacking a winter season except in high ranges.

Monthly trends of mean AbT in °C of the six years are shown in Fig. 1. Both AvT and MnT showed a steep rise from the lowest to highest in a matter of three months. MxT had its lowest monthly average in July (29.70) and attained the highest average during March (37.04). Even though day length is the primary regulator of MnT and MxT as seen in other parts of the country, early occurrence of rain fall in Kerala (Rao, 2013) caused a major drop in AbT starting from April, changing the pattern of MxT irrespective of the day length and the same resulted in the lowest MxT and AvT respectively during June and July.

As shown in Fig 2. quarterly means of daily AvT and MnT had almost the same pattern of variations, whereas MxT showed a consistent increase from JJA to MAM and a subsequent drop to the lowest in JJA, attributable to the effect of monsoon rainfall. Thus, even though the highest averages of all the types of temperatures were in summer (MAM), the lowest of MxT and AvT was in JJA and only MnT had the lowest mean value in DJF. This in turn makes it very clear that there is no winter season in the study locality. Hence, the usage of the term post monsoon is well substantiated, deviating from the usual description of DJF as winter in other parts of the country with clear cut climatic features, especially the lowest of AbT (Kumar, 2013).

Even though climatic categorization necessitate at least 30 years weather data, similarity of the pattern between the two studies 25 years apart (Kutty 1995) and striking deviation from the existing categorization of seasons, formed the basis for proposing the revised categorization, even though further studies are indiated to establish the same.

The pattern of MnT and MxT as shown in Fig. 1 showed increasing difference between the two starting from December, attaining maximum in January, maintains almost same level until March and therefter declined. Comparing the two half years of rainy and non-rainy seasons, there is significant difference ($P<0.001$) between MnT and MxT, with more difference during non-rainy than rainy season. The range of variation between MnT and MxT appears to have direct association with the day length since shortest day length is during December (Winter solstice) and increases thereafter to equalize the duration of day and night hours during March (Spring equinox). Even though the difference between MnT and MxT started to reduce from March, the rate of reduction was very slow until June - the period of longest days (Summer Solstice) and there after declines faster until September (Autumn equinox) and start to increase again thereafter.

The trend of mean RH for the six years (Fig.1) showed significant variation between months with the lowest mean value (77.37 %) during February and the highest (97.75 %) in July. It is evident that the RH is associated with rainfall, since the two months of lowest and highest RH corresponds respectively the periods of lowest and highest rainfall in the region. Correspondingly, quarterly means of all the three measurements of RH (Table 1) showed similar pattern of variation across seasons with the lowest in DJF, increased therafter to reach the highest in JJA and decreased again towards the lowest in DJF.

Implications on thermal stress

AbT forms the main contributor of TS and is precipitated by elevation of RH as it interfere evaporative cooling mechanisms of the body (Polsky and Keyserlingk, 2017). Hence, simultaneous elevation of both becomes more stressful to the animals. However, it is less likely under climatic situation of Kerala since rainfall regulates both these variables in an opposite manner. This is evident not only in this study but the earlier study as well (Kutty, 1995). The period of highest RH (97.75 %) happened to be during July which is the period of lowest mean for MxT (29.70 °C). Likewise, RH is lowest in February while highest mean of MxT is during the adjoining months such as March (37.04 ºC) followed by April (36.57ºC) and February (35.74 ºC). Thus, besides extremes of AbT and RH, moderate elevation of both these variables and their different combinations also produces more stress in animals. Thus a composite measurement of AbT and RH becomes more meaningful in the context of TS.

Monthly trend of mean THI (LPHSI) for the six years is shown in Fig. 3. The pattern of THI variation across months had more similarity with that of AvT than RH, indicating more influence of AvT to the THI than RH. Across seasons, highest mean value for daily AvRH was during JJA and the lowest during DJF. As shown in Table 2, THI value was highest during MAM and lowest during DJF. Thus, quarterly averages of THI and AbT followed same pattern, while the pattern was different for RH.

Highest mean value for THI was observed during MAM – the quarter of high AbT and moderate RH, while lowest of mean THI was during DJF characterized by lowest RH and low AbT. THI was moderate during JJA (the quarter of highest RH and lowest AbT) as well as SON (with moderate values for RH and AbT) as shown in Tables 1 and 2. Thus, combinations of moderate AbT and RH contributes TS more often than higher values of AbT and RH, since occurrence of both together is less likely in Kerala climate (Kutty, 2013; Rao, 2013).

Lowest of monthly mean THI (75.87) exceeded the THI level prescribed for thermal comfort of dairy cattle (68 to 72) (Schuller *et al.*, 2014), indicating that the animals are exposed to mild to moderate TS throughout the year, irrespective of the months or seasons. THI remained within the level for mild stress (72 to 79) during most of the seasons and even elevated to the level for moderate stress (80 to 89) during summer (MAM). However, THI of the study locality in any of the seasons did not reach the level for severe stress (90 or more) during the period of study.

Even though well defined seasons comparable to temperate region is lacking in the tropical climate, seasonal pattern of reproductive performance has been well established among farm animals (Kutty, 2005; Sonmez *et al.,* 2005). Various factors have been reported as determinants of the seasonal variations (Bouhroum *et al.,* 2014), major one being TS (Wolfenson *et al.,* 2000; Collier *et al.,* 2017) influenced by AbT and RH (Kutty, 2005; De-Rensis, *et al.,* 2017).

Photoperiodicity also forms major regulator of seasonality and TS (Kilgoura *et al*., 2012). Besides direct influence through pineal gland secretion, photoperiodicity influences reproduction in animals indiretly by regulating AbT and RH (Orihuela, 2000). Hence classification of the seasons as four quarters of three months each appears better for studies on animal productivity as it considered not only AbT and raining but day length as well, as the main regulators of season and thermal stress affecting performance of the animals.

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References

Bouhroum, N., Bensahli, B. and Niar, A. 2014. Effect of season on artificial insemination in Holstein dairy cows. *J. Exp. Biol.Agri. Sci.* **2** : 178-181.

Collier, R.J. Renquist, B.J. and Xiao, Y.A. 2017. 100-Year Review: Stress physiology including heat stress, *J. Dairy Sci.***100** (12): 10367-10380.

Dash, S., Chakravarty, A.K., Singh, A., Upadhyay, A., Singh, M. and Yousuf, S. 2016. Effect of heat stress on reproductive performances of dairy cattle and buffaloes: A review. *Vet. World.* **9** (3): 235 - 244.

De-Rensis, F., Lopez-Gatius, F., Ispierto, I.G., Morini, G. and Scaramuzzi, R.J. 2017. Causes of declining fertility in dairy cows during the warm season. *Theriogenology* **91:** 145 - 153.

Hansen, P.J.2009. Effects of heat stress on mammalian reproduction. *Philosophical Transactions Royal Soc. Bio. Sci.* **364** (1534): 3341 - 3350.

IPCC. 2018. Summary for policymakers. In: Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industriallevels.

Electronic copies available from the IPCC website www.ipcc.ch

Kilgoura, R.J., Katsuji, U., Ishiwatab, T. and Gavin J.M. 2012.The behaviour of beef cattle at pasture. *Appl. Anim. Beh. Sci.* **138**: 12 - 17.

Kumar, M.S. 2013. Indian climatology; In Rao, G.S.L.H.V.P.and Varma, G.G. 2013. *Fundamentals of Livestock Meteorology*, Vol 1., Centre for Animal Adapatation to Environment and Climate Change Studies, Kerala Veterinary and Animal Sciences University. pp.72-98.

Kutty, C.I. and Mathew, S. 2000. Seasonal variation in morphomtery of male goats in Kerala.*Intas-Polivet* **1**: 299-304.

Kutty, C.I. 1995. Seasonal fertility of billy goats, *M. V. Sc. Thesis,* Kerala Agricultural University, Thrissur.100 p.

Kutty, C.I. 2005.Fertility of female goats across the seasons in Kerala.*Indian J. Anim. Reprod.* **26**(2): 113-116.

Kutty, C.I. 2013. Role of climate in reproductive pattern of small ruminants in humid tropics; Rao, G.S.L.H.V.P. and Varma, G.G., *Fundamentals of Livestock Meteorology*, Vol. II., Centre for Animal Adapatation to Environment and Climate Change Studies, Kerala Veterinary and Animal Sciences University, Pookode. pp. 194-202.

LPHSI. 1990. The livestock and poultry heat stress indices for cattle, sheep and goats. In: *The agriculture engineering technology guide*. Clemson University, Clemson, USA.

Macias-Cruz, U., Gastelum, M.A., Alvarez, F.D., Correa, A., Diaz, R., Meza-Herrera, C.A. and Avendano-Reyes, L. 2016. Effects of summer heat stress on physiological variables, ovulation and progesterone secretion in Pelibuey ewes under natural outdoor conditions in an arid region. *Anim. Sci. J.* **87**(3): 354 - 360.

Marai, I.F.M., El-Darawany, A.A., Fadiel, A. and Abdel-Hafez, M.A.M.2008.Reproductive performance traits as affected by heat stress and its alleviation in sheep - a review. *Trop. Sub-trop. Agroecosystems* **8**: 209-234.

Orihuela, A. 2000. Some factors affecting the behavioural manifestation of oestrus in cattle: a review. *Appl. Anim. Beh. Sci.* **70**: 1 -16.

Polsky, L. and Von-Keyserlingk, M.A.G. 2017. Invited review: Effects of heat stress on dairy cattle welfare. *J. Dairy Sci.* **100**(11): 8645 - 8657.

Rao, G.S.L.H.V.P. 2013. Introduction to Livestock Meteorology; In Rao, G.S.L.H.V.P. and Varma.G. G. 2013. *Fundamentals of Livestock Meteorology*. Vol 1., Centre for Animal Adapatation to Environment and Climate Change Studies, Kerala Veterinary and Animal Sciences University, Pookode. pp. 1-11.

Schuller, L.K., Burfeind, O. and Heuwieser, W. 2014.Impact of heat stress on conception rate of dairy cows in the moderate climate considering different temperature–humidity index thresholds, periods relative to breeding and heat load indices.*Theriogenology* **81**: 1050 - 1057.

Sonmez, M., Demirci, E., Turk, G. and Gur, S. 2005. Effect of season on some fertility parameters of dairy and beef cows in Elazig province. *Turkish J. Vet. Anim. Sci.* **29**(3): 821 - 828.

Wolfenson, D., Roth, Z. and Meidan, R. 2000. Impaired reproduction in heat- stressed cattle: basic and applied aspects. *Anim. Reprod. Sci.* **60**: 535 - 547. ■