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Seasonal Variations in Reproductive Performance of Crossbred Cows in Kerala and the Influence of Climatic Stress Factors over a Period of Six Years

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ABSTRACT

Affection of the reproductive performance forms early indicator of the influence of adverse environment on physiological processes. Comparing fertility parameters with climatic variables over the years helps to understand the impact, magnitude and determinants of climate change on animal system. Objective of the present study was to assess the yearly and seasonal variations in reproductive performance of crossbred cows, and the influence of thermal stress factors over a period of past six years. Retrospective data collected from farm records and climatic data were analysed using SPSS software. Climatic parameters such as maximum and minimum temperature, relative humidity and THI showed highly significant ($P<0.001$) seasonal variation. THI was consistently high at a level for causing mild to moderate stress all over the years. However, fertility parameters did not show significant variation across seasons. Between years, fertility parameters varied significantly and climatic variables did not. No significant correlation was found between fertility parameters and climatic variables across seasons, even though time series analysis showed significant correlation between these parameters. In spite of significant variation of climatic variables between seasons and fertility parameters between years, lack of significant seasonal variation of the fertility parameters appears to be due to the inconsistency of seasonal pattern between the years. To conclude, no obvious interrelationship between climatic variables and fertility parameters was evident between seasons, even though THI values were beyond the level of thermal comfort for dairy cattle and is attributed to the adaptation of animals to changing climate through continuous rearing at the same place, and passive selection over the years.

Keywords: Climate, Cattle, Fertility, THI, Season

Affection of the reproductive performance forms the early signal that indicates the impact of adverse environment on physiological processes (De Rensis *et al.* 2017). Hence, it is important to study the seasonal pattern and the trend of reproductive parameters in the recent past (Kutty, 2005; Sonmez *et al.* 2005) and comparing the same with fluctuations of climatic variables (Bouhroum *et al.* 2015) so that the magnitude and determinants of climate change impact on animal system can be understood (Collier *et al.* 2017) and necessary changes can be incorporated in management to maintain / enhance the productivity (Ross *et al.* 2017). Thus, the objective of the present study was to assess the variations in reproductive performance of crossbred cows between seasons and years over a period of past six years, together with analysis of the influence of thermal stress factors recorded in this locality during the same period.

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MATERIALS AND METHODS

The study was carried out at Livestock Research Station, Thiruvazhamkunnu under Kerala Veterinary and Animal Sciences University. The farm is situated at an altitude of 60-70 meters above mean sea level, with latitude and longitude positioning denoted by 11° 21'N and 76°21' E, respectively. The farm was having around 300 heads of crossbred cattle (evolved from local cattle crossed with Holstein, Brown Swiss and Jersey over many generations). The animals were managed intensively as per the recommendations and standard practices for cross bred dairy cattle. Breeding was exclusively through artificial insemination (AI) over many years and the details were recorded. The study involved collection of retrospective data from the breeding registers over a period of 6 years from 2013-2019 and was compared with climatic data for the same periods obtained from the Automatic weather station situated within the farm premises.

Information collected include total number of breedable females, age at first calving, number of estrus recorded, inter estrus interval, service period, total number of AI done, double AI proportion, services per conception, conception rate, calving to conception interval, pregnancy loss, inter calving interval, proportion of pregnant animals and total number of calvings per month. Climatic variables used for comparison included daily average temperature, maximum and minimum temperatures and relative humidity. THI values were calculated using the formula for LPHS (Livestock and Poultry heat stress) index and different levels of stress based on THI values were classified as per Armstrong (1994).

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

Where, T - Average temperature in Degree Fahrenheit

RH - Percent relative humidity

The data were analysed using SPSS soft ware (SPSS V. 24.0.) for descriptive details, correlations and Univariate Anova for variances. The data were compared between four quarters of the year comprised of September to November (SON), December to February (DJF), March to May (MAM) and June to August (JJA), which corresponds to the four seasons prevalent in Kerala such as north east monsoon, post monsoon, summer and south west monsoon (Kutty, 2013) to assess the pattern of seasonality. Correlation between climatic variables during the period such as ambient temperature, relative humidity and THI values with fertility parameters were worked out to understand the influence of climatic variables on fertility parameters

RESULTS AND DISCUSSION

Classification of the seasons in the present study was done as four quarters of three months each as followed in a previously study (Kutty 2013), where in various climatic variables influencing reproductive processes such as ambient temperature and humidity, THI, amount of rainfall, day length and hours of sunshine are taken into consideration. This classification of season is slightly different from seasons all over India (Kumar 2013) and seasons often described in Kerala, which is mainly based on the direction of wind causing the monsoon rain fall (Rao 2013). Further, Kerala lack a typical winter season except in high ranges which forms only a very small proportion of land area.

Quarters mean values of major environmental variables recorded during the 6 years study period such as Maximum and minimum temperature and relative humidity are shown in Table 1 and monthly trends are illustrated in Fig. 1.

All of these climatic parameters varied significantly ($p < 0.01$) between the seasons with highest temperature attained during MAM (summer) and minimum during DJF (post monsoon) which agrees with the report

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Table 1: Maximum, minimum and mean of ambient temperature, relative humidity and THI of the locality during the four seasons

		SON	DJF	MAM	JJA	Mean	F-value
Ambient temperature °C	Max	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
	Min	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
	Mean	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
Relative humidity (%)	Max	98.03 ± 0.60[bc]	93.61 ± 1.41[a]	95.20 ± 1.14[a b]	99.00 ± 0.24[c]	96.46 ± 0.64	6.70
	Min	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
	Mean	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
THI	Max	89.55 ± 0.42[b]	91.98 ± 0.31[c]	95.76 ± 0.49[d]	85.99 ± 0.50[a]	90.82 ± 0.77	87.967
	Min	70.65 ± 0.34[b]	64.50 ± 0.36[a]	70.02 ± 0.44[b]	72.53 ± 0.20[c]	69.42 ± 0.64	98.969
	Mean	78.43 ± 0.17[b]	76.42 ± 0.22[a]	81.35 ± 0.33[c]	77.81 ± 0.21[b]	78.51 ± 0.39	73.410

Values with different letters as superscript in a row varies significantly

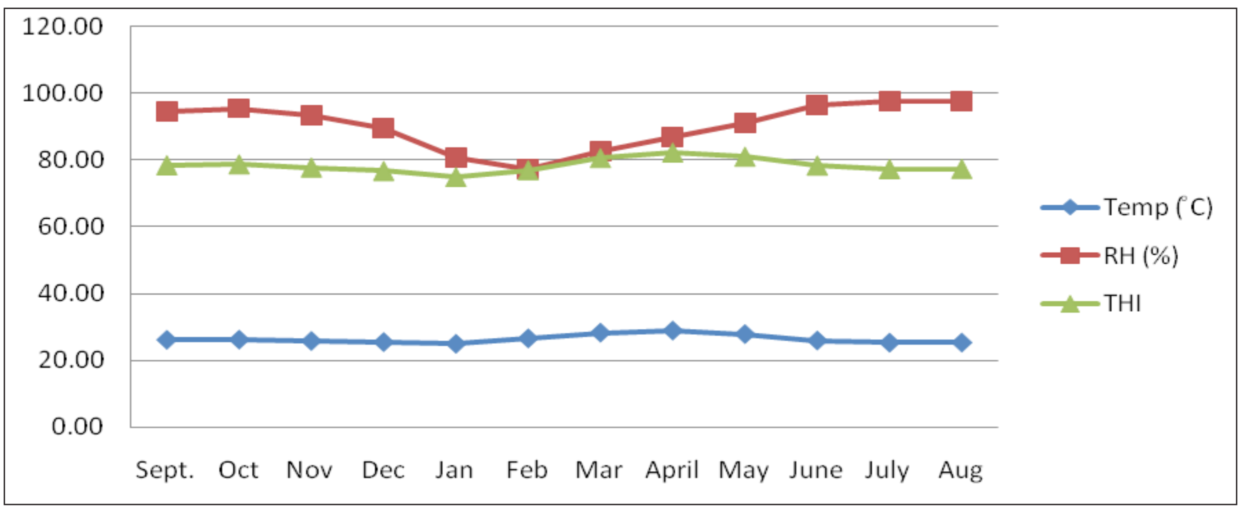

Fig. 1: Monthly averages of climatic variables during the 6 years

of Sonmez *et al.* (2005). However due to narrow range of variation between maximum and minimum temperatures, daily mean temperature was lowest during monsoon and followed by post monsoon. Relative humidity also varied significantly between seasons ($p<0.01$) with the maximum, minimum and daily mean was highest during JJA (south west monsoon) and lowest in post mosoon.

The THI (LPHSI) value calculated based on daily average of the temperature and relative humidity varied from 75.87 to 82.51 with a mean THI of 78.51±0.39. The level of THI obtained in this study exceeds the comfort level prescribed for dairy cattle (THI 68 to 71) (Armstrong, 1994; Polsky & von Keyserlingk, 2017). Hence the animals were exposed to stress prone climate throughout the year irrespective of the season, with significant upward rise during summer. However, THI for severe stress (> 90) was not attained even during summer months even though it is usual occurrence in other parts of the country.

To understand the range of variation possible, THI was also calculated using daily maximum and minimum values of temperature and relative humidity for all the seasons. However, there existed an inverse relationship between the temperature and humidity (Armstrong, 1994) so that maximum recorded temperature and relative humidity of any particular period will not occur simultaneously. Hence THI calculated based on daily mean figures of climatic variables will be the relevant one for assessing the influence of thermal stress (Polsky & Von-Keyserlingk, 2017).

Between seasons, there was highly significant (P<0.01) variation in THI values based on the daily averages of temperature and humidity (Sonmez *et al.* 2005). In none of the seasons, the THI value was within the zone of comfort (< 72), but continued at the level for mild stress (72 to 79) during most of the seasons and even elevated to the level for moderate stress (80 to 90) during summer (MAM) months, which is in agreement with the report of Harikumar (2017). However, THI value did not reach the level for severe stress (> 90) during any seasons of the study period.

Table 2: Monthly average figures of the animal stock under different categories compared between the seasons

Stock parameter	SON	DJF	MAM	JJA	Mean
Total cows	93	91	90	90	91
Cows in milk	55	57	57	54	55
Breedable cows in milk	18	19	19	18	18
Breedable dry cows	13	11	12	13	12
Breedable heifers	39	39	38	39	39
Total breedable females	70	70	69	69	69
Pregnant cows	34	35	30	29	32
Pregnancy proportion	26	28	24	23	25
Calvings per month	7	5	5	7	6

Animal stock available under different categories of breeding during the study period was compared between years and four seasons. Monthly figures of the stock under different breeding categories and its seasonal fluctuations are shown in Table 2. Even though there was highly significant variation (p<0.01) between the years with respect to breedable animals under different categories, number of pregnant animals and pregnancy proportion in the herd, none of these variables were found to have significant variation between seasons during the study period of 6 years. This may be due to the inconsistency of monthly variations that gets nullified while taking the quarterly means.

Table 3: Monthly averages of the breeding activities compared between seasons

Breeding parameter	SON	DJF	MAM	JJA	Mean
Estrus detected	34.6 ± 3.2	33.2 ± 4.3	29.1 ± 3.2	30.0 ± 2.4	31.7 ± 1.6
Animals inseminated	25.8 ± 4.0	29.1 ± 6.10	23.0 ± 1.9	22.7 ± 1.1	25.1 ± 1.9
Total number of AI done	25.4 ± 2.8	24.5 ± 4.1	19.5 ± 1.8	23.5 ± 2.5	23.2 ± 1.4
Breeding proportion	76.5 ± 7.3	74.5 ± 5.1	70.3 ± 8.0	79.5 ± 4.6	75.2 ± 3.1
Total conceptions	7.7 ± 1.2	5.3 ± 0.7	5.3 ± 0.7	6.4 ± 1.0	6.2 ± 0.5
Abortions detected	0.4 ± 0.3	0.3 ± 0.1	0.2 ± 0.2	0.2 ± 0.1	0.3 ± 0.1
Conception rate	37.4 ± 3.1	35.2 ± 7.4	37.5 ± 5.8	36.3 ± 7.6	36.6 ± 2.9
Calvings / adult females	5.6 ± 0.8[b]	3.8 ± 0.5[a]	3.8 ± 0.4[a]	5.1 ± 0.8[b]	4.6 ± 0.3*

*. Variations significant at 5 % level.

Monthly averages of breeding activities compared between seasons in Table 3. Most of the study parameters varied between seasons with the lowest performance during summer months though the differences were non significant. However, contrary to the earlier reports (Bouhroum *et al.* 2014), conception rate of AI was comparatively better during summer, which might be due to reduced number of estrus detected (Sonmez *et al.* 2005) so that only those few with prominent signs will be detected and inseminated leading to better conception.

Rather high incidence of prolonged estrus was observed in the herd (Kutty, 2006) and one of the main management strategies for prolonged estrus was to repeat the insemination on subsequent days of estrus prolongationi (Singh *et al.* 2012). In this respect details of estrus cycles managed with or without double AI were

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collected during the study period and the details are compared between seasons in table 4.

Table 4: Quarterly averages of Double and single AI performed each month and the success rate of inseminations across seasons

Breeding parameter	SON	DJF	MAM	JJA	Mean
Estrus cycles of breeding	20.7 ± 2.5	19.4 ± 3.8	15.2 ± 1.6	20.4 ± 3.1	18.9 ± 1.4
Double AI performed	4.8 ± 0.5	5.1 ± 0.7	4.3 ± 0.8	3.0 ± 0.9	4.3 ± 0.4
Single AI per cycle	15.9 ± 2.2	13.7 ± 3.3	10.9 ± 1.9	17.4 ± 3.8	14.5 ± 1.4
Double AI Proportion	25.7 ± 2.4	32.0 ± 4.6	28.4 ± 6.2	17.9 ± 6.2	26.0 ± 2.6
Single AI conc. Rate	30.4 ± 4.9	39.1 ± 10.3	34.5 ± 7.5	32.2 ± 8.8	34.0 ± 3.9
DAI Conception rate	51.0 ± 3.2	47.1 ± 3.4	40.9 ± 3.2	31.5 ± 6.9	42.6 ± 2.6

Variations not significant between seasons.

Season wise summary of other fertility indices of the herd during the study period are given in table 5.

Table 5: Season wise summary of herd fertility indices during the study period

Fertility indices	SON	DJF	MAM	JJA	Mean
Age at first calving	31.5 ± 6.4	35.3 ± 1.4	35.3 ± 0.6	36.0 ± 0.6	34.5 ± 1.6
Day to first PP heat	77.8 ± 13.5	90.0 ± 15.3	57.5 ± 6.5	62.0 ± 3.9	71.8 ± 5.7
Service period	120.2 ± 19.6	126.8 ± 17.2	103.5 ± 17.1	93.0 ± 10.	110.9 ± 8.1
Inter estrus interval	38.2 ± 2.3	39.4 ± 2.1	40.5 ± 3.4	39.5 ± 1.8	39.4 ± 1.2
AI per conception	2.6 ± 0.2	2.9 ± 0.4	2.8 ± 0.3	2.5 ± 0.2	2.7 ± 0.1
Calving- concep. interval	223.2 ± 27.8	251.2 ± 33.3	194.5 ± 38.4	229.8 ± 34.3	224.7 ± 16.2
Inter calving interval	467.7 ± 23.9	526.3 ± 38.7	469.5 ± 42.6	455.7 ± 29.6	479.8 ± 17.1

Univariate Anova for stock details, breeding related parameters and fertility indices over the 6 year period showed non significant variation between all the parameters except calvings among total females and success rate of double AI. Proportion of adult females calved was high ($P<0.05$) during SON and JJA compared to other two seasons. This may be due to increased number of conception to AI during SON and DJF being the months of lowest minimum temperature, day length and better green fodder availability, as these three parameters are important determinants of conception across seasons (De Rensis *et al.* 2003; Wolfensen *et al.* 2000).

Unlike other three seasons, conception rate of DAI was lowest during JJA and can be attributed to overall lowered conception during the season as reported by Sonmez *et al.* (2005), probably contributed by poor quality of oocyte (Al-Katanani *et al.* 2002) and altered endocrine profile being late consequences of summer stress (Torres-Júnior *et al.* 2008).

Table 6: Fertility parameters with highly significant negative correlation across seasons

Sl. No.	Parameter 1	Dependant variable	Correlation coefficient
1	Number of single AI	Proportion of pregnant animals	-0.508**
2	Estrus cycles inseminated	Double AI proportion	-0.536 **
		Conception rate of AI	-0.638**
3	Age at first calving	Conception rate of total AI	-0.651**
		Conception rate of single AI	-0.662**
4	Total number of AI	Conception rate of total AI	-0.570**
		Conception rate of single AI	-0.536**
5	Number of calving	Service period	-0.481**

** Variation significant at 1 % level.

Comparison of the seasonal averages showed no significant correlation between fertility parameters and climatic variables. However there was significant negative correlation

Table 7: Stock related and breeding parameters having significant variation between years

Stock details	F-value	p value	Breeding parameters	F- value	p value
Total adult females	3.92	0.014	Proportion of estrus bred	10.98	<0.001
Total cows in the herd	9.99	<0.001	Double AI done	3.56	0.020
Milking cows in the herd	6.14	0.002	Double AI proportion	4.94	0.005
Dry cows in the herd	10.55	<0.001	DAI conception	3.12	0.033
Number of pregnant cows	4.86	0.005	Single AI during estrus	2.78	0.049
Herd pregnancy proportion	8.15	<0.001	Single A I conception	2.80	0.048
Breedable dry cows	7.57	0.001	Total conception	3.31	0.027
Breedable milking cows	6.08	0.002	AI Per conception	7.48	0.001
Breedable heifers	11.45	<0.001	Conception rate	5.26	0.004
Total breedable females	5.17	0.004	Inter estrus interval	2.97	0.040

between some of the fertility parameters as shown in table 6, and the same can be attributed to mutual dependence of these variables.

Year wise variation of the study parameters during the period of study are shown in Table 7. Many of the fertility parameters showed significant variation between years attributable to variations in the management situation, even though climatic variables did not vary significantly. Further, in spite of highly significant variation of fertility parameters between months and years, lack of significant variation between seasons appears to be due to the inconsistency of the seasonal pattern between the years so that the variation gets nullified upon comparison across few years. The weather conditions, especially the rain fall varies considerably, altering the pattern of seasonality between years (Rao 2013; Kumar 2013).

Comparison of study parameters between the two periods of low and high THI (72 to 78 and more than 78) also did not show significant variation. However time series analysis of correlation between the study parameters showed significant relationship among reproductive parameters and with climatic variables as reported by De Souza *et al.* (2016).

In spite of marked variations of fertility parameters (between the years) and climatic variables (between seasons) there was no significant interrelationship between the two categories. This means that fertility parameters compared in the study were not affected by climatic variables in a consistent pattern across the years of study period, even though the THI values were beyond the limit of thermal comfort for dairy cattle (Sonmez *et al.* 2005) throughout the year. Possible explanation for the lack of variation between seasons can be the adaptability of the animals to prevailing adverse climate (Collier *et al.* 2017; Thatcher *et al.* 2010) through continuous rearing at the same place and passive selection over the years. This is in agreement with the report of El-Tarabany & El-Bayoumi (2015) that crossbreds adapted to local climate had better reproductive performance attributable to the adpatation (Rashamol *et al.*, 2018) under the prevailing climatic conditions including high THI.

CONCLUSION

Retrospective data of stock details, breeding activities, fertility parameters and climatic variables over a period of 6 years was collected and analysed for seasonal variations and correlation between each other. Even though climatic parameters such as maximum and minimum temperature, relative humidity and THI showed significant (P<0.01) seasonal variation, most of the stock and fertility related parameters did not show significant variation. Even though THI value was consistently high at a level to cause mild to moderate stress throughout the year, breeding related parameters and fertility indices were more or less same across seasons. There was no significant correlation between fertility parameters and climatic variables across seasons, even though time series analysis showed significant correlation of some of the fertility parameters with climatic variables.

Between years, most of the fertility parameters showed highly significant variation, while climatic variables did not vary significantly. In spite of highly significant yearly variation of the fertility parameters, lack of significant variation between seasons appears to be due to the inconsistency of the seasonal pattern between the years. In spite of marked variations of fertility parameters (between the years) and climatic variables (between seasons) there was no obvious interrelationship between the two categories. Thus, lack of interrelationship between fertility parameters and climatic variables during the period is evident, even though the THI values were beyond the level for thermal comfort of dairy cattle throughout the year. This can be due to the adaptability of these animals to prevailing adverse climate through continuous rearing at the same place and passive selection over the years.

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