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**Research Paper**

# Genotype x environment interaction on fertility traits of crossbred dairy cows under tropical climatic conditions of India

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## ABSTRACT

Present study was envisaged to examine existence of genetic group x THI in crossbred cows at institute herd of ERS, ICAR-NDRI, Kalyani, West Bengal. 1041 fertility records each on service period (SP) and conception rate (CR) and weather parameters spanned over 22 years (1994-2015) were collected; arranged under three THI groups; thermal comfort (THI<72), two heat stress zones (THI 72-78) and THI>78 and six genetic groups.SP was longest (163.61 ± 6.83 days) when THI>78and lowest (149.27±6.69 days) during THI<72. CR was lowest (65.66±2.73 %) when THI>78 and highest (70.54±2.8 %) at THI<72. Genetic group x THI was non-significant on SP and CR. However, there was re-ranking of genetic groups across three THI zones. Genetic group bearing 50% Jersey + 50% Tharparkar followed by 50% Jersey + 50% Red Sindhi exhibited least increase in SP (5.09 and 6.37 days) when THI>78.Cows bearing 50% Jersey and 50% indigenous cattle inheritance followed by 50% Jersey + 50% Red Sindhi and 50% Jersey + 50% Tharparkar depicted least drop in CR at THI>78 (-2.38, -2.40 and -3.6%) in comparison to THI<72. The genetic group with>75% Jersey depicted maximum increase in SP (15.33 days) and drop in CR (-7.43%) at THI>78.

***Key words***: THI, genotype x environment, heat stress. crossbred cows

Genotype x environment interaction (G×E) helps in assessing to what level the predicted superiority of animals under a particular environment will be expressed in a different environmental condition (Mulder *et al.,* 2006). Genotype × environment is observed when performances of different genotypes varies in different environmental conditions and causes re-ranking of genotypes across the environments. Crossbred cows with different degrees of exotic inheritance play crucial role in Indian dairy sector by contributing 26% of the total milk production in the country (BAHS-GOI, 2019). However, tropical climatic conditions prevailed in our country influences the dairy production system, heat stress being one of the major stressors. Temperature Humidity Index (THI) combining the joint effect of temperature and humidity serves as an efficient yardstick of heat stress on animals. In dairy cattle industry, fertility traits serve as the most significant components, as reduced fertility lengthens the resume cycles after parturition and decreases profit from the farm (De Vries 2006; Schneider *et al.,* 2005). Thus, selection of genotypes that can perform well both in thermal comfort and heat stress conditions becomes an important factor in breeding programs. Therefore, present study was designed with the objective to examine the existence of genotype (genetic groups with different degrees of exotic inheritance) × environment (THI) on fertility traits like service period and conception rate in crossbred dairy cows of different genetic compositions at institutional herd of ICAR-National Dairy Research Institute, Eastern Regional Station, Kalyani, West Bengal, India.

## MATERIALS AND METHODS

The present study was conducted at Eastern Regional Station of ICAR- National Dairy Research Institute (NDRI), Kalyani located in the lower Gangetic basin of West Bengal in Nadia district, India at an altitude of 9.75 meters above mean sea level with latitude and longitude position of 22° 58'30"N and 88° 26'4"E, respectively. Generally, the climate is hot -humid tropical monsoon in nature with average annual maximum and minimum temperatures of 39°C and 12°C, respectively (Rai *et al.,* 2020).

A total of 1041 fertility records each on service period (SP) and conception rate (CR) of crossbred cows and meteorological data *viz*; maximum temperature ($^0$C), minimum temperature ($^0$C), relative humidity (%)spanned over twenty-two years (1994-2015) were collected from records maintained at the institute. The data were further standardised and 819 records each on SP and CR were included for the present study.

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**Table 1:** Genotype (Genetic Group) X Environment (THI) for service period (days)

| GG | Genetic Composition | SP THI<72 | Rank THI<72 | SP THI 72-78 | Rank THI 72-78 | SP THI >78 | Rank THI>78 | Overall |
|---|---|---|---|---|---|---|---|---|
| 1 | 50% Jersey and 50% Tharparkar | 149.64 | 4 | 149.94 | 2 | 157.25 | 2 | 152.28 |
| 2 | 50% Jersey and 50% Red Sindhi | 137.27 | 1 | 137.07 | 1 | 146.02 | 1 | 140.12 |
| 3 | 50% Jersey + 50% more than two Indigenous Breeds | 150.83 | 5 | 163.38 | 4 | 163.79 | 3 | 159.33 |
| 4 | 25% Jersey and 25% Holstein with 50% indigenous inheritance | 145.4 | 2 | 167.67 | 5 | 167.12 | 4 | 160.06 |
| 5 | >50% to <75% Jersey inheritance | 166.76 | 6 | 172.99 | 6 | 179.45 | 6 | 173.07 |
| 6 | ≥75% Jersey | 145.69 | 3 | 161.54 | 3 | 168.03 | 5 | 158.42 |

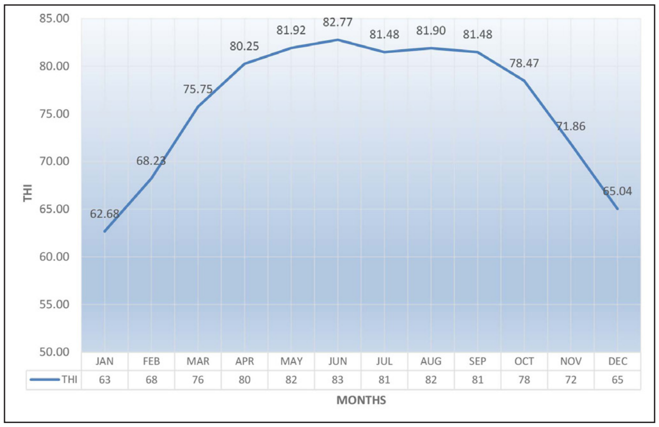


**Fig. 1:** Trend of monthly average THI (1994-2015)

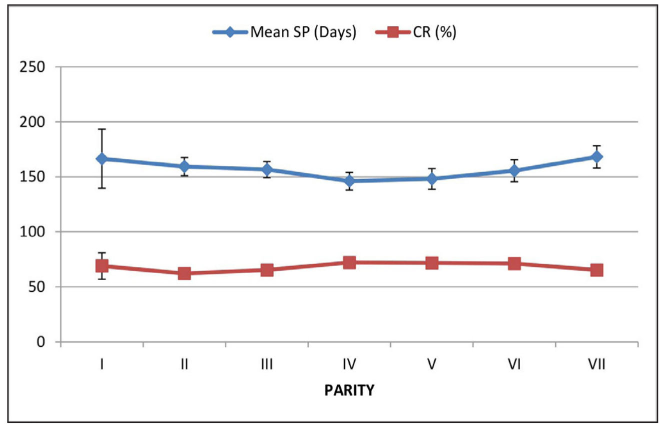


**Fig. 2:** Parity-wise service period (days) and conception rate (%) of crossbred dairy cows

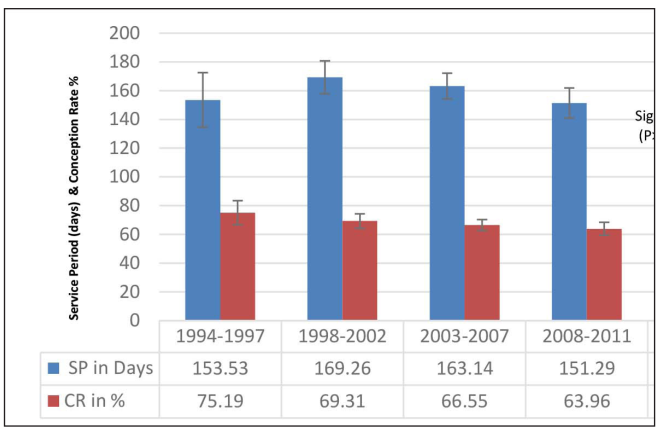


**Fig. 3:** Effect of period of successful service on fertility traits

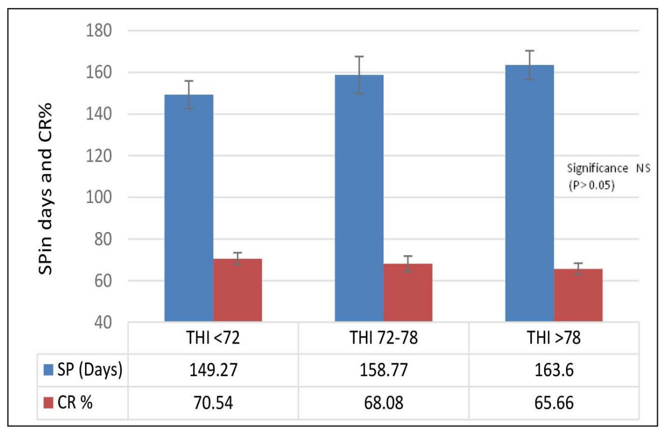


**Fig. 4:** Trend of fertility traits under different THI zones (1994-2015)

***Estimation of temperature humidity Index (THI)***

The monthly average temperature ($^0$C) and relative humidity (%) were estimated from the meteorological data and were used to compute monthly average THI for each year and further 22 year's monthly average THI was computed. The formula developed by National Oceanic and Atmospheric Administration (NOAA, 1976) was used to compute THI.

$$THI = 0.8\,T_a + (RH/100) \times (T_a - 14.3) + 46.4$$

Where, $T_a$ – ambient air temperature (°C), RH – relative humidity (%)

***Classification of genetic groups and THI zones***

The institute herd have crossbred cows bearing different genetic compositions and were classified into six genetic groups based on percent of exotic inheritance and indigenous cattle inheritance and number of available records. The genetic groups were 50% Jersey and 50%Tharparkar; 50% Jersey and 50% Red Sindhi; 50% Jersey and 50% indigenous inheritance from more than two indigenous breeds; 25% Jersey and 25% Holstein with 50% indigenous inheritance; >50% to <75% Jersey inheritance

**Table 2:** Genotype (Genetic Group) X Environment (THI) for conception rate%

| GG | Genetic Composition | THI <72 | Rank at THI <72 | THI 72-78 | Rank at THI 72-78 | THI >78 | Rank at THI >78 | Overall |
|---|---|---|---|---|---|---|---|---|
| 1 | 50% Jersey and 50% Tharparkar | 72.57 | 3 | 71.65 | 1 | 68.97 | 1 | 71.06 |
| 2 | 50% Jersey and 50% Red Sindhi | 70.29 | 5 | 69.36 | 3 | 67.89 | 2 | 69.18 |
| 3 | 50% Jersey + 50% more than two Indigenous Breeds | 62.42 | 6 | 60.36 | 6 | 60.04 | 6 | 60.97 |
| 4 | 25% Jersey and 25% Holstein with 50% indigenous inheritance | 72.79 | 2 | 68.69 | 5 | 65.66 | 4 | 69.05 |
| 5 | >50% to <75% Jersey inheritance | 72.81 | 1 | 68.47 | 4 | 66.46 | 3 | 69.25 |
| 6 | ≥75% Jersey | 72.34 | 4 | 69.95 | 2 | 64.91 | 5 | 69.03 |

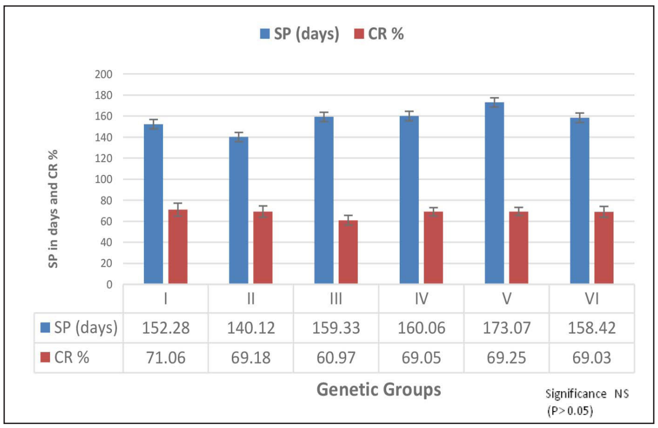


**Fig. 5:** Impact of genetic group on fertility traits

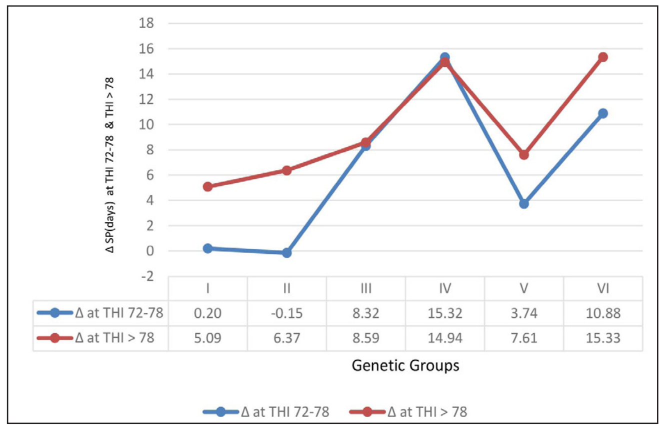


**Fig. 6:** Changes in service period (days) of genetic groups THI 72-78 and THI above 78 compared to thermal comfort zone (THI<72)

and ≥75% Jersey. As per available literature, THI value of <72 is considered as comfortable zone (Armstrong, 1994). The present data set was classified into three THI zones: THI ≤ 72 as comfort zone, two heat stress zones THI = 72 to 78as moderate heat stress and THI above 78 as severe heat stress period for studying genotype environment interaction.

***Statistical analysis***

The effect of non-genetic factors like parity, period of successful insemination was estimated using least squares analysis for non-orthogonal. The model was used with the assumption that different components being fitted into the model were linear, independent and additive. The spearman's rank correlation of genotypes across the three THI zones was estimated as per Steel and Torrie (1960).

$$r_g = 1 - \Sigma 6di^2/n(n^2\text{-}1)$$

The existence of genotype environment interactions was examined by using interaction model. The interaction model is an extension of the traditional genetic model by adding random interaction of genotype and environment as a component and making P = G + E + G × E. The model used in present study was as follows:

$$Y_{ijklmn} = \mu + POSS_i + PA_{j+}GG_k + THI_l + (GGXTHI)_{kl} + e_{ijklm}$$

where, $Y_{ijklm}$= observation of m[th] animal of l[th]THI group, k[th] genetic group, j[th] parity and i[th] period of successful service $\boldsymbol{\mu}$= overall mean; $POSS_i$ = fixed effects of i[th] period of successful service (1 to 5); $PA_{j}$ = fixed effects of j[th]parity (1 to 7); $GG_k$ = fixed effects of k[th] genetic group (1 to 6);$THI_l$ = fixed effects of l[th] THI zone (1 to 3); $(GGXTHI)_{kl}$ = fixed effects of genetic group THI interaction (1 to 18);$e_{ijklm}$ = random error ~ NID (0, $\sigma^2$e)

## RESULTS AND DISCUSSION

The monthly average THI ranged from 62.68 (January) to 82.77 (June). The monthly average THI was below 72 only during four months: January, February, November and December (Fig.1). The THI was above 78 during seven months (April to October). Armstrong (1994) determined THI index lower than 72 as the thermal comfort zone while beyond 90 cause severe stress even leading to death. Mandal *et al.,*(2017) classified heat stress on crossbred dairy cows of ERS, ICAR- NDRI herd into two groups slight to moderate heat stress (THI <80) and severe heat stress (THI≥80) and reported that 66.6% of the days of the year were moderately stressful and 33.4% were severe stressful.

***Effect of non-genetic factors on fertility traits***

The overall least-squares means for SP and CR of crossbred cows were 157.21 ± 5.60 days and 68.09 ± 2.34%, respectively. The effect of parity was significant (P<0.05) on SP while non-significant for CR. Maximum SP was observed during 7[th] parity (168.18 ± 10.08 days) followed by first parity (166.44 ±

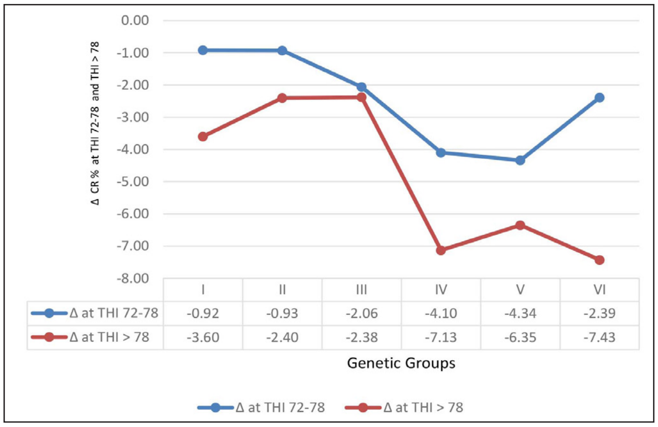


**Fig. 7**: Changes in conception rate (%) of different genetic groups at THI 72-78 and THI above 78 compared to thermal comfort zone (THI<72)

days); was shortest (146.15± 7.98 days) during 4th parity. The longer SP during first parity was also observed by Zewdu *et al.,* (2015). The trend of SP and CR across different parity is presented in Fig. 2. The CR was 68.94 ± 11.92% during first parity, declined during 2nd parity, remained above 70% during 4th to 6th parity again declined in 7th parity. Our result is in agreement with Bhagat and Gokhale (2013) and Pandey *et al.,* (2016). However, Talokar *et al.,* (2018) reported a significant effect of parity on percent conception per first insemination of Jersey crossbred cows. The effect of period of successful service was non-significant on both SP and CR (Fig.3). Talokar *et al.,* (2018) who recorded a non-significant effect of period of insemination on percent conception per first insemination of Jersey crossbred cows. Asimwe and Kifaro (2007) reported significant effect of period of service and parity on SP of dairy cattle.

***Effect of THI on fertility traits***

Effect of THI was non-significant on both SP and CR. However, service period was longest (163.61 ± 6.83 days) when THI was above78 and lowest (149.27 ± 6.69 days) at comfort period (THI <72). The CR was also lowest (65.66 ±2.73 %) at THI > 78 and highest (70.54 ±2.8 %) during THI <72 (Fig.4). Our study revealed the negative effect of heat stress on fertility traits (SP and CR). The SP increased and CR dropped with the rise of THI. Wolfenson *et al.,* (2000) explained the cause of reduced fertility under heat stress as hyper-prolactinemia, decrease in LH, inadequate follicle maturation and reduced estradiol production. The seasonal trend for SP was observed by Oseni *et al.,* (2004) who reported longest SP (166 days) of Holstein cows for March/April calving and shortest SP (130 days) for September calving. High temperature and humidity in spring and summer season leads to physiological disorders, upsetting the digestive system, disturbing acid-base chemistry and blood hormones and ultimately leading to longer service period in cows (Dash *et al.,* 2016). Conception rate of dairy cows in Australia was dropped at THI >72. The high heat stress before 3-5 weeks service and 1 week after service caused fall in conception rate. Thus, heat stress amelioration interventions should be implemented at least 5 weeks before expected service to 1 week after service (Morton *et al.,* 2007).

*Effect of genetic group on fertility traits*

The effect of genetic group was non-significant on SP and CR but cows with 50% Jersey and 50% Red Sindhi inheritance had shortest SP followed by 50% Jersey and 50% Tharparkar inheritance. The longest SP was observed in 50-75% of Jersey inheritance (Fig.5). However, cows with 50% Jersey and 50% Tharparkar inheritance had the highest CR and cows bearing 50% Jersey inheritance and 50%indigenous inheritance from more than two indigenous breed had the lowest CR (Fig.5). Our finding is in agreement with Talokar *et al.* (2018) who reported that the genetic combination of ½ Jersey × ½ Tharparkar had higher per cent conception after first service. Miah *et al*., (2004) reported non-significant effect of breed on conception rate in Bangladeshi crossbred cows. Although our findings report non-significant effect of genetic groups on CR, the differences in performances of different genetic groups is in agreement with Potdar *et al.,* (2016) who recorded a breed difference in conception rate of local indigenous and crossbred cows of Maharashtra. Holstein crossbred cows had lowest CR, followed by Jersey crossbred cows and indigenous cattle exhibited better conception rate.

***Effect of genotype (genetic group) X environment (THI) on fertility traits***

The present study revealed that the effect of genetic group x THI was non-significant on both SP and CR. The changes in SP (days) and CR (%) at THI 72-78 and THI>78 in comparison to THI<72 is depicted in Fig.6 and 7, respectively. The genetic group 50% Jersey + 50% Tharparkar followed by 50% Jersey + 50% Red Sindhi were the most heat tolerant breeds as they exhibited least increase in SP: 0.20 and 5.09 days and 0.15, 6.37 days at moderate and severe heat stress periods, respectively. Cows bearing 50% Jersey and 50% inheritance from indigenous cattle followed by 50% Jersey + 50% Red Sindhi and 50% Jersey + 50% Tharparkar depicted lesser drop in CR when at THI > 78 (-2.38, -2.40 and -3.6%, respectively) in comparison to CR at THI <72. Cows with > 75% Jersey inheritance followed by cows with 25% Jersey and 25% Holstein inheritance exhibited maximum decline in CR (-7.43% and -7.13%, respectively) and maximum increase in SP (15.33 and 14.94 days, respectively). Literatures are scanty on the behaviour of crossbred cows of different genetic groups at different THI zones. However, Kashyap, (2016) reported lowest CR in Karan Fries cows with >62.5% Holstein inheritance as compared to 50% and 50 to 62.5% Holstein inheritance during heat stress and critical heat stress periods at Karnal, Haryana. Dash, (2013) studied the effect of THI on fertility of Murrah buffaloes and recorded an increase in SP with increase in average THI above 75. SP was shorter during the cooler months with less THI while the months with higher THI (THI>75) increased SP. The average CR was highest (78%) in October while the lowest (59%) during August. The negative effect of heat stress on fertility can occur concomitantly with other effects of heat load such as decreased dry matter intake and enlarged negative energy balance, factors that may further influence reproductive performance (De Rensis and Scaramuzzi 2003).

***Spearman's rank correlation among genotypes across three THI zones***

The rank of the six genetic groups as per their SP and CR across the three THI zones is presented in table 1 and 2, respectively. For the CR, the spearman's rank correlation of genetic groups was 0.143 between comfort THI and THI 72-78; 0.657 for THI 72-78 and THI above 78; 0.371 between THI <72 and THI >78.For SP, the values were 0.60 between comfort THI and THI 72-78; 0.83 for THI 72-78 and THI above 78; 0.54 between THI <72 and THI >78. Although the effect of genotype x THI interactions was non-significant, there was re-ranking of the genotypes (genetic groups) across the three THI zones.

## CONCLUSION

The overall findings of our study revealed that the monthly average THI goes beyond 78 for seven months in a year. Though the role of genetic group x THI was found to be non-significant, cows bearing>75% Jersey inheritance followed by cows with 25% Jersey and 25% Holstein inheritance exhibited maximum decline in CR and increase in SP. There was re-ranking of genotypes across the three THI zones. Cows bearing 50% Jersey and 50% Tharparkar or Red Sindhi inheritance were the most heat tolerant group while cows bearing >75% Jersey inheritance as well as with Holstein Frisian inheritance were the least heat stress tolerant groups in relation to the influence of heat stress on fertility traits.

***Conflict of Interest Statement***: The author (s) declares (s) that there is no conflict of interest.

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