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# Biometeorological aspects of conception rate in cattle

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## ABSTRACT

The vulnerability of animal production to Thermal Humidity Index (THI) has hardly been documented in India and hence one study on climate and weather on the conception rate of cattle was conducted at Pantnagar, Uttarakhand. In the study, meteorological data (2000 to 2010) were collected from agrometeorological Observatory, Pantnagar and were used to compute six different types of Thermal Humidity Index by giving different weightage to dry bulb temperature and humidity. The relationship between Thermal Humidity Index and overall conception rate of animal was established to select the most appropriate THI for practical application.

***Key Word:*** Conception rate, Biometeorology, THI,

Agriculture along with live stock management is still the main and principal livelihoods in rural India. The livestock sector accounts for 40 per cent of the world's agriculture Gross Domestic Product (GDP). It employs 1.3 billion people, and creates livelihoods for one billion of the world's population living in poverty (FAO, 2006). Large variety of livestock population and their low productivity in Uttarakhand are the hallmark of livestock population in the State. The growth and production of farm animals are being controlled by both climate and weather of a region. Certain environmental conditions are found optimum for their growth and production. Higher and profitable milk production occurs when weather elements are within cardinal range. Outside this range the animal has to suffer with meteorological stress. To adapt to this stress the animal requires additional energy that would otherwise be available for productive processes. Heat stress in dairy animals has long term effect on both milk production and birth rates. The approximate thermal comfort zone for optimum performance of adult cattle of India is reported to be 10-27°C (Mather, 1974). Hot and humid environmental conditions cause heat stress in cows. Heat stress induces behavioural and metabolic changes. Heat stress has adverse effects on milk production and reproduction of dairy cattle (Kazdere *et al.*, 2002; West, 2003; Hansen, 2007). In this context several Temperature-Humidity Indices (THI) have been used to estimate the degree of thermal stress experienced by cattle. Bovines feel comfortable when THI is less than 72, and they show sign of heat stress when THI is greater than 72. The literatures on the effect of THI on conception rate are limited and hence the study was undertaken.

## MATERIALS AND METHODOLOGY

To assess the impact of Thermal Humidity Index on conception rate, a study was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar (Uttarakhand). The daily and monthly weather data of Pantnagar were collected for a period of eleven years (2000 to 2010) from the meteorological Observatory located at Norman E. Borlaug Crop Research Centre (CRC), G. B. Pant University of Agriculture and Technology, Pantnagar. Weather data comprised of dry bulb temperature and wet bulb temperature, rainfall, wind velocity, sunshine hours, evaporation and relative humidity. The monthly artificial insemination data of eleven years (2000 to 2010) were used to calculate the conception rate of cattle. Cattle and buffaloes were usually bred for a specific purpose of milk production and also to produce offspring with desired traits. In the present study the overall Conception Rate (CR) was calculated using given equation:

$$Conception\ Rate = \frac{Total\ No.\ Of\ animals\ Conceived}{Total\ No.\ Of\ animals\ Inseminated} \times 100$$

The following formulae were used to calculate the Thermal Humidity Index:

**a)** THI1 = $(1.8 \times T_{db} + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26.8)]$ (NRC, 1971);

**b)** THI 2 = $(0.35 \times T_{db} + 0.65 \times T_{wb}) \times 1.8 + 32$ (Bianca, 1962);

**c)** THI 3= $(0.15 \times T_{db} + 0.85 \times T_{wb}) \times 1.8 + 32$ (Bianca, 1962);

**d)** THI 4 = $[0.4 \times (T_{db} + T_{wb})] \times 1.8 + 32 + 15$ (Thom, 1959);

**e)** THI 5 = $(T_{db} + T_{wb}) \times 0.72 + 40.6$ (NRC, 1971); and

**f)** THI 6 = $(0.8 \times Tdb) + [(RH/100) \times (Tdb - 14.4)] + 46.4$ (Mader *et al.*, 2006).

Where in db: mean dry bulb temperature in $^0$C; wb: mean wet bulb temperature in$^0$C; RH: mean relative humidity in %.

***Relationship between weather parameters, THI and conception rate***

The relationship between different weather parameters (average temperature, rainfall and relative humidity), and THI and conception rate was developed by regressing conception rate with individual weather parameter. The coefficient of determination was also computed to test the significance of relationship. Trend - lines were developed between conception rate and different weather parameters to understand type of relationship between them.

***Development of statistical model***

Statistical models were developed for analyzing the cumulative impact of different weather parameters on conception rate. The models were developed by taking monthly weather data as independent variable and monthly data on conception rate as dependent variable. SPSS software was used for this purpose. The stepwise forward selection approach was adopted to develop statistical model. General representation of single variate and multivariate models is given as

$$Y = a + b_1*(X_1) + b_2*(X_2) + \ldots\ldots + b_7*(X_7)$$

Where in above equation a is constant, $b_1, b_{2 \ldots} b_7$: regressing coefficient and $X_1, X_{2 \ldots} X_7$ are independent weather variables.

***Use of statistical model for evaluating the response of climate change***

Climatic scenarios developed by Murari Lal *et al.* (2001) for India was considered for evaluating the response of animal to changing climate scenario. The statistical models developed in the previous section were used by changing the values of weather variables. The effect of climate change on conception rate was analyzsed considering current conception rate and projected conception rate as explained below:

$$Effect\ of\ climate\ change\ on\ CR\ (\%) = \frac{\Sigma(CRp - CRcc)}{CRp} \times 100$$

Where $CR_p$ = Average conception rate at present level

$CR_{cc}$ = Average conception rate in projected climate

**Table 1:** Relationship between yearly average of conception rate and various yearly average of THI

| Formula | $R^2$ Value |
|---|---|
| THI 1 | 0.659 |
| THI 2 | 0.622 |
| THI 3 | 0.616 |
| THI 4 | 0.613 |
| THI 5 | 0.614 |
| THI 6 | 0.669 |

## RESULTS AND DISCUSSION

***Variation in THI***

In present study Thermal Humidity Index was calculated through six different formulae to find out best method of THI computation, which shows promising relationship with conception rate (Table 1). Variation in different Thermal Humidity Index has been shown in Fig.1. For further study, only THI 6 was taken into consideration. The maximum & minimum values of THI 1 were 81.29 and 55.6 respectively in the months of July and January. Thermal Humidity Index was highest in the month of August (82.91) and found least in the month of January (52.43) for THI 2. The average value of THI 2 was recorded as 72.52 with $R^2$ value 0.622. Similarly in the case of THI 3 and THI 4, highest value was recorded in August (82.3, 87.9 respectively) and lowest value was found in month of January (51.4, 63.87). The coefficients of determination were 0.616 and 0.613 respectively with mean values of THI 3 and THI 4 of 67.73 and 77.83 respectively. For THI 5, the value ranged from 57.4 (January) to 81.6 (August) with an average value of 71.56 and the coefficient of determination was 0.614. While for THI 6 the highest value of Thermal Humidity Index was found during July (81.16) and the least was with January (55.49). From the above information it could be concluded that the Thermal Humidity Index was highest either in month of July or August and was least in the month of

**Table 2:** Multi-variables Model for conception rate with $R^2$ values

| Model. No. | Multiple variable model equation | $R^2$ |
|---|---|---|
| 1 | $Y = 14.389 + 0.96*(X_1)$ | 0.434 |
| 2 | $Y = 15.79 + 1.083*(X_1) - 0.44*(X_2)$ | 0.723 |
| 3 | $Y = 25.95 + 1.083*(X_1) - 0.468*(X_2) - 0.09*(X_3)$ | 0.768 |
| 4 | $Y = 31.021 + 0.528*(X_1) - 0.726*(X_2) - 0.148*(X_3) + 0.0004*(X_4)$ | 0.807 |
| 5 | $Y = 40.79 + 0.78*(X_1) - 0.75*(X_2) - 0.200*(X_3) + 0.010*(X_4) - 0.124*(X_5)$ | 0.838 |
| 6 | $Y = 64.07 + 1.21*(X_1) - 0.703*(X_2) - 0.7*(X_3) + 0.014*(X_4) - 0.953*(X_5) + 1.107*(X_6)$ | 0.876 |
| 7 | $Y = 83.56 + 1.503*(X_1) - 0.49*(X_2) - 0.146*(X_3) + 0.02*(X_4) - 1.43*(X_5) + 1.69*(X_6) - 0.269*(X_7)$ | 0.895 |

**Note**: Y=Average conception rate, $X_1$= Average monthly bright sunshine hours, $X_2$=Average monthly wind velocity (km/hr), $X_3$=Average monthly relative humidity, $X_4$= Sum of monthly rainfall in mm, $X_5$= Average THI 8, $X_6$= Average monthly temperature ($^{O}$C), $X_7$=Average monthly evaporation.

January at Pantnagar. This might be due to the fact that winter months (December, January, and February) were of great concern for conception rate. Thus there is a strong need to maintain warm environment in order to achieve higher conception rate during winter.

***Effect of average temperature on conception rate:***

During winter season *i.e.* January, February and March, the conception rate was found increasing with increase in average temperature as depicted in Fig. 2. While in summer and rainy season overall conception rate showed inverse relationship with mean temperature. Summing up there was a quadratic relationship between temperature and conception rate i.e. with increase in temperature, initially there was increase in conception rate and reached peak at approximately 20-24 $^{o}$C, and thereafter further increase in temperature did decrease the conception rate (Fig. 3). Similar result was given by Ingraham et al. (1971).

***Effect of rainfall on conception rate***

The effect of average rainfall on the conception rate of animals at Pantnagar has been shown in Fig. 4. It is inferred from the figure that up to approximately 200 mm rainfall, there was no effect of rainfall on CR but rainfall beyond this level did adversely affect the conception rate. This negative relationship could be attributed to the fact that the data on conception rate were from cows as very limited buffaloes were artificially inseminated. The behavior of cow was miserable during high intensive rainy day and this adversely affected the performance of cow.

***Conception rate and relative humidity:***

The effect of relative humidity on the conception rate has been explained in Fig. 5. Very low value of coefficient of determination ($R^2$ = 0.064) obtained from the analysis suggested that average humidity does not affect the conception rate.

***Relation between conception rate and THI***

Thermal heat Index is manifestation of temperature and relative humidity to measure the heat stress. This index has been developed and used as a weather safety index to monitor heat-stress and also to reduce heat-stress-related losses in animals. Thermal humidity indices calculated from different methods were related with overall conception rate of cattle. The association between THI and conception rate ranged from 0.659 (THI 1) to 0.669 (THI 6). THI 6 being firmly associated with the conception rate was selected for further analysis among the six methods studied. In the study Thermal Humidity Index (THI) exhibited quadratic relationship with conception rate. The analysis suggested that maximum conception rate was achieved at Thermal Humidity Index (THI) between 67 and 72 (Fig. 6) and Thermal Humidity Index (THI) value beyond this range adversely affected the conception rate. A study was conducted by Ingraham *et al.* (1971) and they concluded that higher mean daily THI value of above 70 on days prior to breeding was associated with a significant linear decline in CR. The CR depression was most pronounced during the season of higher THI.

***Development of model for CR based on weather variables***

An attempt was also made to develop the multi-

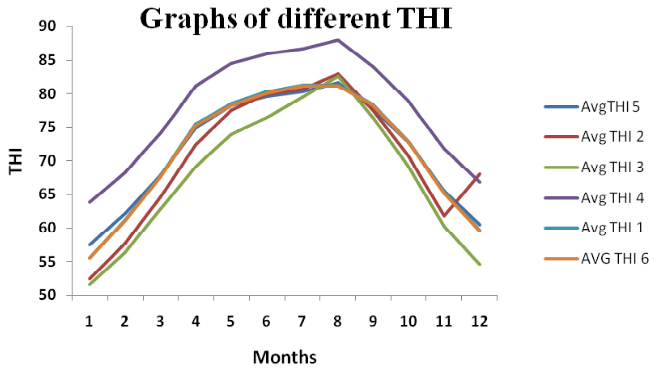


**Fig. 1** : Monthy Variation of different THI

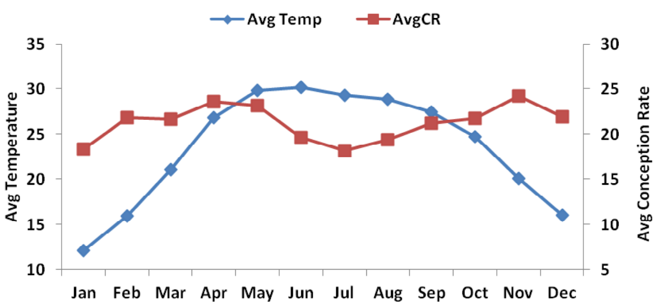


**Fig. 2 :** Monthy Variation of CR and average temperature ($^{o}$C)

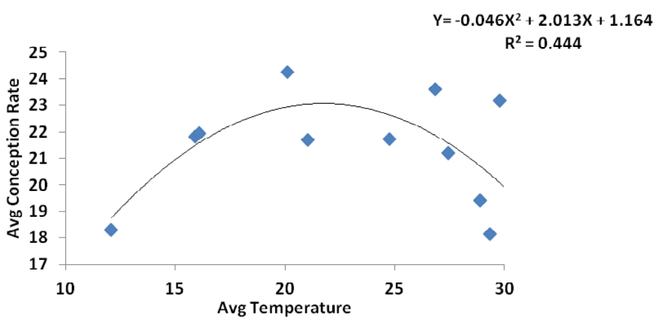


**Fig. 3 :** Relationship between CR and average temperature ($^{o}$C)

variables statistical model for prediction of conception rate using weather variables. SPSS software with stepwise forward selection approach was adopted for development of the model listed in Table 2. Model 1 included only one variable (sunshine hour) and the value of coefficient of determination was 0.434. Model-5was the best model among all as it exhibited the highest value of coefficient of determination (0.895). The reason for high value of $R^2$ must be using weather variables as much as possible. Under this concept based on the results obtained, it can be inferred that different weather variables used for the study alone were responsible for approximately 90 per cent variation in conception rate. Remaining 10 per cent variation in conception rate might be attributed to other factors such as health of animals, diseases and pests,

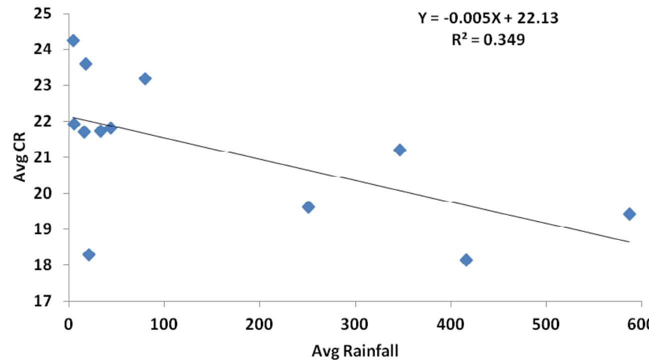


**Fig.4 :** Relationship between CR and rainfall (mm)

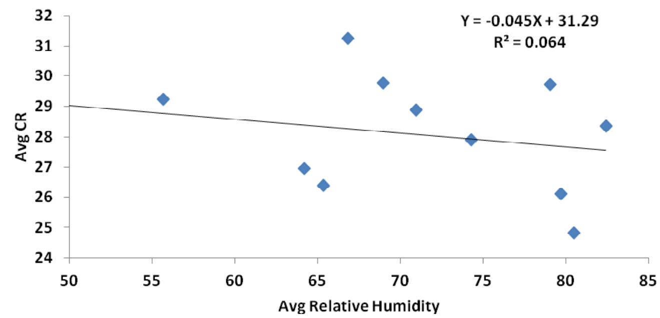


**Fig. 5 :** Relationship between CR and relative humidity

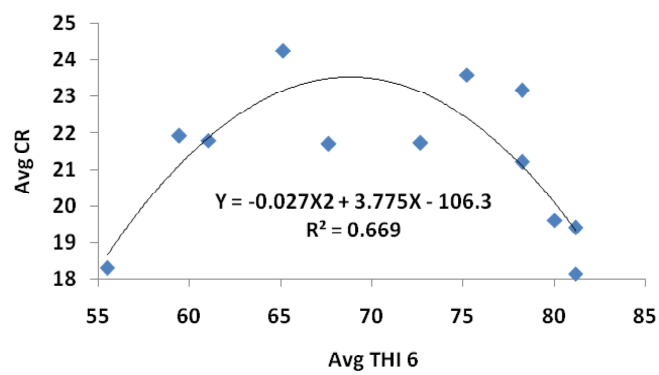


**Fig. 6 :** Relationship between yearly average of conception rate and yearly average of THI

availability of fodder etc. It would be important to state that the data of conception rate were taken from well managed single dairy of GBPUA&T, Pantnagar where sanitation, feed and fodder and different abiotic and biotic stresses were managed to maximum possible extent. When data from different locations and different dairies were taken, the contribution of weather parameters in conception rate might get decreased because the higher influence from other factors likes feed and fodder, and disease/pest as indicated else where of this paper.

***Effect of climate change on conception rate***

The conception rate (overall) is supposed to get decreased by 46 per cent. In many other studies it has been concluded that with increase in average temperature, the conception rate found to be decreased. Ingraham et al. (1971) analyzed the conception rate in relation to the temperature /THI and concluded that conception rate sharply get declined with increase in THI. In their study conception rate was found to decline from 55 to 10 per cent with increase in THI value from 70 to 84. The reason for decline in conception rate was attributed to the reduced duration of estrus cycle, and lengthening of the postpartum interval in multiparous cows (Amundson et al., 2005). This also might be due to changes in either or any one of the plasma hormone concentration and follicular growth (Ingraham et al., 1975).

## CONCLUSION

On the basis of results, it can be concluded that conception rate of cattle is strongly influenced by climatic variables. The optimum temperature for conception rate in cattle was found to be in the range of 20-24 °C. The departure (positive or negative) in temperature from this range cause decrease in conception rate. Similarly, it was found that the THI range of 67-72 is most favorable for conception rate in cattle. Another noteworthy finding of the present study is that rainfall upto 200 mm in a particular month does not affect the conception rate in cattle, however, once exceeds this limit, rainfall negatively affects the conception rate. The multivariate model developed to analyze the effect of climate change on conception rate also suggested that conception rate in changing climate (global warming scenario) will decrease by 46 percent by the year 2080.

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## REFFERENCES

Amundson, J.L., Mader, T,L., Rasby, R.J. and Hu, Q.S. (2005)." The Effects of Temperature and Temperature-Humidity Index on Pregnancy Rate in Beef Cows". Nebraska Beef Report, pp.10-12.

Bianca, W. (1962). "Relative importance of dry- and wet-bulb temperatures in causing heatstress in cattle", *Nature,* 195: 251-252.

FAO. (2006). "Livestock a Major Threat to the Environment: Remedies Urgently Needed"Retrieved from: http :// www. fao.org /newsroom /en /news/2006/ 1000448/ index.html.

Hansen, P.J. (2007). "Exploitation of genetic and physiological determinants of embryonic resistance to elevated temperature to improve embryonic survival in dairy cattle during heat stress" *Theriogenology,* 68 (S): S242-S249.

Ingraham, R.H., Gillette, D.D. and Wagner, W.D. (1971). "Relationship of Temperature and Humidity to Conception Rate of Holstein Cows in Subtropical Climate" *J. Dairy Sci.,* 57(4): 476-481.

Ingraham, R.H., Stanley, R.W. and Wagner, W.C. (1975). Relationship of Temperature and Humidity to Conception Rate of Holstein Cows in Hawaii. *J. Dairy Sci.,* 59(12): 2086-2090.

Kazdere, C.T., Murphy, M.R., Silanikove, N. and Maltz, E. (2002) "Heat stress in lactating dairy cows: A review" *Livest. Prod. Sci.*, 77: 59-91.

Mader, T.L., Davis, M.S. and Brown-Brandl. T. (2006). "Environmental factors influencing heat stress in feedlot cattle" *J. Anim. Sci*., 84: 712-719.

Mather, J.R. (1974). "Climatology: Fundamentals and Applications, McGraw-Hill Company" 180-198 pp.

Murari Lal, T. Nozawa, S. Emori, H. Harasawa, K. Takahashi, M. Kimoto, A. Abe Ouchi, T. Nakajima, T. Takemura and A. Numaguti, (2001). Future climate change: Implications for Indian summer monsoon and its variability, C*urrent Sci.,* 81(9):1196-1207

NRC. (1971)."A Guide to Environmental Research on Animals. Natl." *Acad. Sci.,* Washington, DC.

Thom, E. C. (1959). "The discomfort index" *Weather wise*, 12: 57-59.

West, J. W. (2003). "Effects of heat- stress on production in dairy cattle" *J. Dairy Sci.*, 86: 2131-2144.

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