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Effect of heat stress on pregnancy rates of crossbred dairy cattle in Terai region of Uttarakhand, India

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ABSTRACT

Objective: To test whether heat stress during one or both of the critical periods (pre-insemination and post-insemination) causes reduction in pregnancy rates of crossbred dairy cattle in Terai region of Uttarakhand. **Methods:** Data on metereological (ambient temperature and humidity) and reproductive (date of artificial insemination and day 60 reproductive status) variables were collected for a total of 1199 inseminations and allocated, on the basis of temperature humidity indices during 30 days before and after insemination, to one of the four groups: Thermoneutral-thermoneutral (TN-TN), Thermoneutral-heat stress (TN-HS), Heat stress-thermoneutral (HS-TN), and heat stress-heat stress (HS-HS). **Results:** *Chi*-square analysis of the day 60 pregnancy data revealed lower ($P<0.05$) pregnancy rate in HS-HS (20.5%) compared to TN-TN (32.6%), TN-HS (30.2%) and HS-TN (31.8%) groups. However, differences among the latter three groups were not significant. **Conclusions:** These results indicate that reduction in pregnancy rates of crossbred dairy cattle due to heat stress in the Terai region was evident only when both growth of the ovulatory follicle and fertilization and early embryonic development occurred in the heat stress period. In addition, the study showed that use of temperature humidity indices rather than the traditional seasonal classification could provide more accurate insights into the effects of heat stress on pregnancy rates of crossbred dairy cattle in the Terai region.

1. Introduction

Heat stress has been defined as the sum of forces external to a homeothermic animal that acts to displace body temperature from the resting state[1]. Several indices have been used to estimate the magnitude of heat stress in dairy cattle but temperature-humidity index (THI) that incorporates the effects of both temperature and relative humidity (RH) is, by far, the most commonly used index[2]. Heat stress has adverse effects on the reproductive efficiency of dairy cattle[3,4]. Pregnancy rates following artificial insemination (AI) are reduced in the heat stressed animals[5,6]. Conceptually, this adverse effect of heat stress on the pregnancy rate could involve multiple underlying mechanisms. The most likely mediating causes include aberrations in follicular growth[7], oocyte competence[8], hormone secretion[7], uterine blood flow[9], endometrial function[10], and embryonic development[11].

Climate in the Terai region of India typically involves a heat stress period, a thermoneutral period, and transitions between the two during each year. Therefore, there are instances when either the growth of the ovulatory follicle or fertilization and early embryonic development or both occur during the heat stress period. In this study, we used this metereological distribution to our advantage to design an observational model to test whether the reduction in pregnancy rate results from differential effects of heat stress on follicular function or fertilization and early embryonic development or from the combined effects on both.

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2. Materials and methods

This study was conducted in Pantnagar, located in the Terai region of Uttarakhand at 29°N latitude and 79.3°E longitude at an altitude of 243.8 m above mean sea level. Data on temperature and humidity were collected from the metereological observatory at the Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, India and mean THIs (daily and monthly) were calculated using the following formula [12]:

Mean THI = [0.8 × mean T + (mean RH/100) × (mean T −14.3) + 46.4], where T is the temperature, and RH is the relative humidity.

Data on the date of AI and the corresponding day 60 pregnancy diagnosis (pregnant or non-pregnant) were collected for a total of 1 199 inseminations in crossbred dairy cows maintained at Instructional Dairy Farm, G.B. Pant University of Agriculture and Technology over a period of 24 months (July 2010 to July 2012). Based on the daily mean THI values, the inseminations were classified into four groups:

1)Thermoneutral-Thermoneutral (TN-TN): A minimum of 30 days each before and after insemination with mean THI values less than 72.

2)Thermoneutral-Heat stress (TN-HS): A minimum of 30 days before insemination with mean THI values less than 72 and a minimum of 30 days after insemination with mean THI values equal to or greater than 72.

3)Heat stress-Thermoneutral (HS-TN): A minimum of 30 days before insemination with mean THI values equal to or greater than 72 and a minimum of 30 days after insemination with mean THI values less than 72.

4)Heat stress-Heat stress (HS-HS): A minimum of 30 days each before and after insemination with mean THI values equal to or greater than 72. Differences in pregnancy rates (%) between the above groups were analyzed for statistical significance by *Chi*-Square test using an interactive calculation tool[13]. Differences were considered significant at $P<0.05$.

3. Results

Analysis of metereological data of the Terai region over the selected years (2010 to 2012; Table 1) revealed periods of thermoneutral zone (THI < 72), mild heat stress (72 < THI ≤ 79), and moderate heat stress (79 < THI < 90) [14]. Periods of severe heat stress (THI ≥ 90) were, however, not evident.

Out of the 1 199 inseminations, a total of 887 inseminations could be allocated to the four groups: TN-TN (n=242), TN-HS (n=106), HS-TN (n=66), and HS-HS (n=473). *Chi*-Square analysis of the pregnancy rates revealed a decreased ($P<0.05$) pregnancy rate in the HS-HS group compared to TN-TN, TN-HS, and HS-TN groups. However, there was no difference in the pregnancy rates among the latter three groups (Figure 1).

Table 1
Monthly temperature-humidity indices in Terai region of Uttarakhand, India (2010 to 2012).

Year	Mean Monthly THI values (2010 to 2012)											
	January	February	March	April	May	June	July	August	September	October	November	December
2010	54	61	70	76	79	81	81	81	78	74	67	59
2011	53	61	67	73	79	80	81	81	80	73	66	59
2012	56	60	67	74	77	81	82	81	79	71	64	58
Mean	54.3	60.7	68.0	74.3	78.3	80.7	81.3	81.0	79.0	72.7	65.7	58.7
SEM	0.88	0.33	1.00	0.88	0.67	0.33	0.33	0.00	0.58	0.88	0.88	0.33

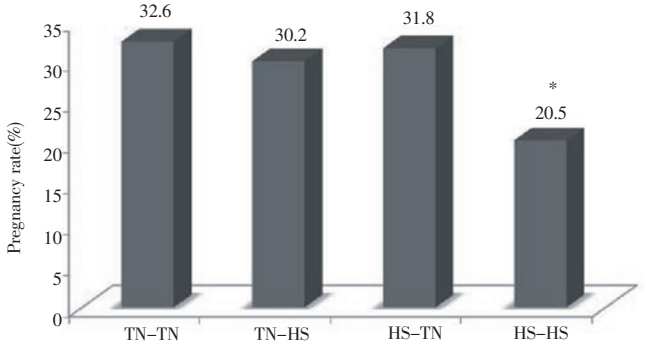

Figure 1. Effect of heat stress on pregnancy rates in crossbred dairy cattle in Terai region of Uttarakhand, India.
* indicates a significantly reduced ($P<0.05$) pregnancy rate in HS-HS group compared to the other three groups.

4. Discussion

In the Terai region, as per the common classification, each year is divided into three seasons[15]; monsoon (June to September), winter (October to January), and summer (February to May). However, with regard to the investigations on heat stress in dairy cattle, the traditional seasonal classification of the region is arbitrary and does not provide an accurate index of the heat stress with respect to its effects on the biological system. Support for this claim comes from the thermoneutral periods (mean monthly THI < 72) evident in some of the months (February and March) included in summer in the traditional classification. Another deviation was the observation of mild heat stress (72 < THI ≤ 79) in October, included in winter in the traditional

metereological classification. Therefore, results of the previous investigations that evaluated seasonal variations in pregnancy rates in the Terai region[16] should be interpreted with a bit of caution, considering the potential confounding effects of the deviation from the expected climatic effects on the biological system of the animal during the reported seasons.

Results on pregnancy rates in the four groups indicate that for heat stress to cause a significant reduction in the pregnancy rate of crossbred cows in the Terai region, the growth of the ovulatory follicle as well as fertilization and early embryonic development should occur in the heat stress period. These observations lend support to our view that some degree of compensation occurs when either the pre-insemination (follicular function and oocyte competence) or the post-insemination (fertilization and early embryonic development) events occur in the thermoneutral period. The latter aspect has been well tested and supported by several research studies that used *in-vitro* embryo production (IVEP) and transfer to bypass the effects of heat stress on conception in dairy animals[17]. However, experimental studies on the former aspect are meager. An experimental model could be envisaged wherein oocytes are collected in the thermoneutral period, but fertilized and cultured under conditions of heat stress and transferred into cows subjected to natural or induced heat stress.

In summary, the present study indicated that the use of temperature humidity indices rather than the traditional seasonal classification could provide more accurate insights into the effects of heat stress on pregnancy rates of crossbred dairy cattle in the Terai region. The reduction in pregnancy rates was evident only when both growth of the ovulatory follicle and fertilization and early embryonic development occurred in the heat stress period.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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