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EFFECT OF HEAT STRESS ON PHYSIOLOGICAL AND HORMONAL PARAMETERS OF CROSSBRED HEIFERS IN SOUTHERN REGION OF TAMIL NADU

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ABSTRACT
Heat stress is widely recognized as a stressful condition that affects physiological, behavioural and hormonal responses of dairy cattle and buffaloes. The dairy sector is more vulnerable to global warming and climate change. The temperature humidity index (THI) is the widely used index to measure the magnitude of heat stress in animals. An attempt was made to study the effect of heat stress on physiological and hormonal responses in crossbred Holstein Friesian heifers during the summer season in an organized cattle farm, KSE Limited, Dindigul, Tamil Nadu, India. Twelve healthy Holstein Friesian heifers each around one to two years of age were selected for the experiment. The rectal temperature, respiration rate, pulse rate and various hormones level were measured in different seasons to know the effect of heat stress in heifers. The season had no significant effect on rectal temperature, triiodothyronine (T3) and thyroxine (T4) level. However, it had a significant effect on respiration rate ($P \leq 0.01$), heart rate ($P \leq 0.01$) and cortisol level ($P \leq 0.05$) in heifers. The respiration rate, pulse rate and cortisol level are lowest in winter season and highest in summer season. This necessitates the adoption of proper management interventions in the form of nutrition modification and environment modification in order to ameliorate the effects of heat stress on crossbred heifers during the summer season.

KEYWORDS: Heat stress, Season, Temperature humidity index, Hormone, Crossbred heifers, Holstein Friesian

INTRODUCTION

Livestock sector in India is contributing 4.6 % of the total Gross Domestic Product (GDP) and 26% of the agricultural GDP (BAHS, 2018). It plays a crucial role in livelihood activity for the farmers. The cattle and buffaloes are known for their milk production and they contribute approximately 96% to total milk production in India. Though milk production in India is 176.3 million tonnes in 2017-18 with a growth rate of 6.62% and it is projected to produce 255 million tonnes in 2021-22 (NAPDD Vision-2022 Report, 2018). This target will be achieved if there is an optimum balance between productivity and fertility. Productivity is a very broad term which is influenced by various factors including genetic, nutritional, hormonal, physiopathology, management and environment or climate. The productivity traits in dairy animals show a moderate heritability value, and this indicates that most of the variations are determined by non-genetic factors or environmental effects (Thiruvenkadan *et al*., 2010). The main environmental factors affecting livestock system includes air temperature, relative humidity, solar radiation, atmospheric pressure and wind speed. All these environmental factors are pooled to produce heat stress on animals, which is defined as any combination of environmental variables producing conditions that are higher than the temperature range of the animal's thermo-neutral zone (Ravagnolo and Misztal, 2002). Heat stress occurs in an animal when there is an imbalance between heat production within the body and its dissipation. Considerable variation exists for heat tolerance between individual species/breeds and even within the same species/breeds (Birendra Kumar *et al.,* 2019).

Tamil Nadu is an agrarian state located in southernmost part of India. It extends North latitude between 8°5' to 13°35' and East longitude between 76°15' to 80°20'. It is divided into seven agro-climatic zones such as north-east, north-west, west, southern, high rainfall, high altitude hilly and Kauveri delta zone. The climate of the Tamil Nadu ranges from dry sub-humid to semi-arid with an ambient temperature of 24-34°C, relative humidity of 70% and annual rainfall is about 945 mm. It experiences fairly moderate temperatures in winter and high temperatures in summer. Since these climatic conditions lead to discomfort and stress in livestock population, their productivity is reduced. Therefore present study was undertaken to evaluate the environmental heat stress on physical and hormonal parameters of crossbred heifers in the southern region of Tamil Nadu.

MATERIALS AND METHODS

Experimental animals

Twelve healthy Holstein Friesian heifers each around one to two years of age were selected for the experiment in an organized cattle farm, KSE Limited, Dindigul, Tamil Nadu. The animals were reared under a loose housing system with lean-to type asbestos roof shed. The floor

space was provided at $4m^2$ per animal and provisions for feeding and watering arrangements were made hygienically as per standard methods. Experimental period was divided into 3 seasons, *viz*. spring (February to April), summer (May to August) and winter (November to January).

Climatic measurements

The daily recording of temperature (maximum and minimum) was measured by a maximum and minimum thermometer at 0900 and 1400h. The daily relative humidity was recorded by using dry and wet bulb reading and the chart was hung by a thread in the covered area underneath the roof. The temperature humidity index (THI) was calculated as per the following formula (McDowell *et al.,* 1976),

THI = 0.72(wet bulb temperature + dry bulb temperature) + 40.6

Measurement of physiological parameters

The physiological parameters of experimental animals had taken in the morning at 7 AM and evening at 4 PM. Rectal temperature was measured with the help of simple mercury thermometer. Pulse rate is measured by observing pulse from the coccygeal artery. Respiration was also measured by silently observing the movement of the thoracoabdominal region for each experimental animal.

Collection of blood Sample

The blood sample was collected from each experimental animal in three different seasons namely winter, spring and summer at 15 days interval. 1-2 ml of blood was collected from the jugular vein of each animal in a sterile polypropylene vial with adding anticoagulant for the isolation of plasma for the evaluation of hormonal profile.

Measurement of hormonal parameters

Cortisol, Triiodothyronine (T3) and Thyroxine (T4) levels of experimental animals in each season were estimated using the kit supplied by Erba Diagnostics Mannheim GmbH, Germany.

Statistical analysis of data

Data were computed and analyzed statistically according to methods of Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The mean ambient temperature and temperature humidity index (THI) prevailing during the experimental period is presented in Table I. The highest maximum temperature was observed in summer (39.02°C) followed by spring (31.23°C) and winter season (24.56°C). It is may be due to increased solar radiation, ground reflection of sunlight and lack of green cover during summer. Reena *et al.* (2016) suggested that the shed orientation, type of roof, cross ventilation of shed and height of roof play a significant role to maintain the shed temperature. THI was found to be highest in summer (86.24) and lowest in winter season (56.73). Armstrong (1994) categorized THI values into five different classes as no stress with THI value <72, mild stress (72-78), moderate stress (79-88), severe stress (89-98) and dead cows with THI >98. Hence, the crossbred heifers reared in summer season fall under moderate category indicating a stressful condition of the animal.

TABLE I. Environmental parameters prevailing during the experimental period

Parameters	Spring	Summer	Winter
Maximum temperature (°C)	31.23 ± 2.08	39.02 ± 2.42	24.56 ± 1.89
Minimum temperature (°C)	24.56 ± 2.32	29.22 ± 1.54	12.23 ± 1.78
Temperature humidity index (THI)	67.89 ± 5.49	86.24 ± 6.88	56.73 ± 4.82

Effect of season on physiological parameters

The physiological parameters of crossbred heifers are presented in Table II. The rectal temperature did not differ significantly in different seasons but the highest recorded during summer season and the lowest in winter season. These findings are close in accordance with Singh *et al*. (2014) and Bhat *et al.* (2016). The respiration rate and pulse rate significantly differed among seasons. These parameters are highest in summer and lowest in winter. Bhat *et al.* (2016) reported that increased respiration rate is the first reaction when animals are exposed to an environmental temperature above the thermo-neutral zone.

TABLE II: Effect of season on physiological parameters of crossbred heifers

Time	Parameters	Spring	Summer	Winter
Morning	Temperature (°F)	100.63 ± 0.08	101.34 ± 0.02	100.01 ± 0.05
	Pulse rate	65.42^{b} ± 1.32	70.22^{c} ± 0.63	63.66^{a} ± 0.78
	Respiration rate	21.89^{b} ± 0.09	29.24^{c} ± 0.48	18.72^{a} ± 0.12
Evening	Temperature (°F)	100.82 ± 0.13	101.88 ± 0.06	100.16 ± 0.07
	Pulse rate	69.82^{b} ± 1.12	75.03^{c} ± 1.63	67.52^{a} ± 0.78
	Respiration rate	24.55^{b} ± 0.23	35.66^{c} ± 0.08	21.28^{a} ± 0.32

Means bearing different superscript in the same row differ significantly (P<0.01)

Effect of Season on Hormonal Assay

Effect of seasonal stress on cortisol, T3 and T4 levels were presented in Table III. The cortisol level is higher in summer (5.64 ng/ml) than the spring (4.12 ng/ml) and winter (3.83 ng/ml). This may be due to activation of the hypothalamic-pituitary-adrenal cortical axis (HPA) and sympathoadrenal medullary axis during heat stress. It leads to an increase in the plasma concentration of cortisol and corticosterone levels (Singh *et al.,* 1984). Comin *et al.* (2011) suggested that the summer season has a stressful effect on the animal's physiological and hormonal parameters that may be overcome through well-managed farming systems. A non-significant decreasing trend was found in the T3 and T4 concentration with increasing thermal exposure. This can be explained by the findings of Silanikove (2000) who have reported that thyroid

hormones take a long time to achieve new steady levels in response to heat stress. Chaudhary *et al.* (2015) also reported that a significant decrease in T3 level with an increase in THI value.

Table III: Effect of season on hormone profile of crossbred heifers

Parameters	Spring	Summer	Winter
Cortisol (ng/ml)	4.12 ± 1.48^{b}	5.64 ± 0.77^{c}	3.83 ± 1.12^{a}
T3 (ng/ml)	1.68 ± 0.68	1.52 ± 0.20	1.72 ± 0.94
T4 (ng/ml)	36.86 ± 1.11	34.25 ± 1.22	35.39 ± 1.07

Means bearing different superscript in the same row differ significantly (P<0.05)

CONCLUSION

The heat stress has adverse effects on the physiological and hormonal parameters of Holstein Friesian heifers. The THI is the most commonly used index to measure the level of heat stress in animals. The months from May to August under heat sensitive zone show the average THI level above 85. This necessitates the adoption of proper management interventions in the form of nutrition modification and environment modification in order to ameliorate the effects of heat stress on crossbred heifers.

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