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Original Research Article

EFFECT OF HEAT STRESS ON PRODUCTION PERFORMANCE IN DAIRY ANIMALS

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Abstract *The high-temperature stress and combination of high temperature and humidity during summer months in Punjab is an important factor for dairy cows as it directly affects the daily milk yield of dairy cows. The research was conducted on to effect of high-temperature stress on different parameters associated with daily milk yield. For this purpose, 5 freshly parturated Sahiwal breeds of dairy cows were to evaluate the effect of temperature humidity index on Daily milk yield at different temperature humidity index levels i.e. comfortable (≤ 70), mild stress (71–80), moderate stress (81–90), and stressful (≥90) zone. Blood samples were collected and centrifuged to get serum and ELISA was accomplished by using a spectrometer. Results revealed high significant (P < 0.001) increment in cortisol and triglycerides concentration and high significant reduction in serum progesterone (P < 0.001) and Luteinizing hormone (P < 0.001) concentration in cows during stressful environments. Daily milk yield has significant (P < 0.05) variation and a decreasing trend in cows from comfortable to stressful conditions. Progesterone and LH had a highly significant positive correlation with daily milk yield. Cortisol and triglycerides had a non-significant negative correlation with daily milk yield. It is concluded that heat stress has a negative impact on the daily milk yield as it disturbs the hormonal balance of the animal.*

Keywords: *Heat stress; Temperature; humidity index; Progesterone; milk*

Introduction

Dairy cows raised in subtropical climates face challenging weather patterns that include prolonged periods of high temperatures and intense sun exposure. It has been used to integrate the high milking potential of tropical cattle with the flexibility of crossbred cows (Bello et al., 2009). The high milk-producing exotic cows have been bred with local varieties of cows as the local cows had more high-temperature stress tolerance (Kim and Rothschild, 2014). Even then the local varieties of cows are affected by high temperatures. Given the strong correlation between metabolic heat generation and output level, genetic advancements that improve production qualities may also increase susceptibility to high thermal loads (Storm et al., 2024).

In tropical and subtropical regions, heat is one of the main stresses for dairy cattle (Storm et al., 2024). A variety of meteorological conditions e.g. temperature, humidity, and their combination, can be hazardous to domestic animal growth and productivity. High humidity combined with ambient temperatures raises stress levels and causes additional discomfort, which lowers the animals' physiological and metabolic activity (Speakman et al., 2008).

In the world of dairy farming, having a calf every year and getting the most milk from a cow is thought to be ideal. The majority of farmers in Pakistan raise dairy cattle with the primary purpose of getting milk from them. The primary source of milk production in

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Pakistan's irrigated rural and peri-urban areas is dairy cows. Therefore, the purpose of this research was to evaluate how heat stress affected the blood metabolites and milk output of graded crossbred cows in a subtropical Pakistani environment. (Bernabucci et al., 2010)

Materials and Methods

Five Sahiwal cows freshly parturated were selected for this research. After routine milking, animals were provided with seasonal fodder in two intakes and also allowed to graze for 1.5-2.0 hours. Wheat straw combined with green berseem or oats was the basic ration during both spring and winter. The herd was provided with different local fodder i.e. Mott grass or green maize/sorghum-Sudan hybrid in the summer and autumn. One kilogram of concentrate was given for every two liters of milk that a cow produced. In equal amounts, the ingredients were maize oil cake, wheat bran, and cotton seed cake.

Usually, during the winter months, cows are kept in barns during the night and are free in the open yards in the daytime. In this research, animals were kept in open yards at night and in barns during the day throughout the summer and fall. All year round, fresh drinking water was available for free. The cows were milked by hand twice a day at regular intervals. Temperate Humidity Index (THI) was used to represent how relative humidity and ambient temperature affected each other. Throughout the experiment, the relative humidity and air temperature fluctuated. The THI was computed according formula given by (Ravagnolo and Misztal 2000) using the mean values of relative humidity and ambient temperature that were noted throughout the experiment. The temperature humidity index was calculated by following the formula and average data was used for analysis.

Temperature humidity index (y) = $-7.3036x + 111.36$, R2 = 0.976

During each session, 10 ml blood samples were aseptically taken from the jugular vein of each cow using syringes. Specimens of blood were sent instantly to the lab so that serum could be separated by centrifugation for 15 minutes at 2000 rpm. The samples of serum extracted were stored for later lab analysis at -10 °C. The concentrations of cortisol, luteinizing hormone (LH), and progesterone (P4) in serum were measured using an ELISA reader (IRMECO model, U2021) in addition to commercial kits (Amzinx Microlisa TM kits). A spectrophotometer was used to measure the concentration of total protein, triglycerides, and serum glucose using kits (AMEDA Laboradiagnostik GmbH).

Statistical Analysis

The mean data of all parameters of all five cows were analyzed through ANOVA described by (steel et al. 1997) and correlation was found between different parameters with DMY by using the method described by (Dewey et al. 1959).

Results

Serum cortisol concentration in five Sahiwal cows in different THI (Temperature humidity index) from comfort to stress is given in Fig 1.

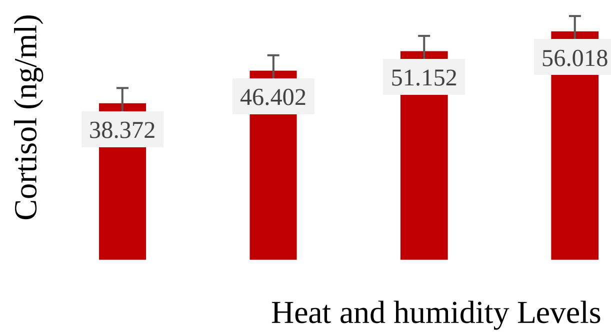

Fig. 1 Variation of cortisol level (mg/dl) in selected cows under various THI treatments

An increasing trend in the cortisol concentration with heat stress in cows can be seen. Highly significant differences in THI levels i.e. comfort, mild, moderate, and stressful have been seen in table 1.

Table 1 Analysis of variance for different parameters related to milk production in 5 cows' blood serum

	MSS of Stress levels	MSS of Cows
Daily Milk Yield	0.13**	0.07**
Cortisol level	847.37**	1220.24**
Triglycerides level	534.59**	435.11**
Progesterone level	0.26**	0.18**
Luteinizing Hormone level	9.25**	17.02**

Significant: 0.01-0.05 Highly significant: > 0.01 Non- Significant: < 0.05

Cows were also statistically highly different from each other in serum cortisol levels. The serum cortisol was found non-significantly (P=0.20) correlated with DMY (daily milk yield) (Table 2).

Table 2 Correlation of different parameters affecting DMY in 5 Sahiwal cows

	Cortisol	Progesterone	Triglycerides	LH
Progesterone	-0.68			
Triglycerides	0.03	0.08		
LH	-0.77	0.85	0.15	
DMY	-0.17	0.67	-0.16	0.37

The level of **triglyceride** concentration in the blood increased linearly from comfort to stressful zone (Fig. 2). The result of ANOVA showed that the triglyceride levels of all five cows and all the THI

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levels were found highly significantly different from each other. There was a non-significant correlation between triglyceride and DMY (Table 2).

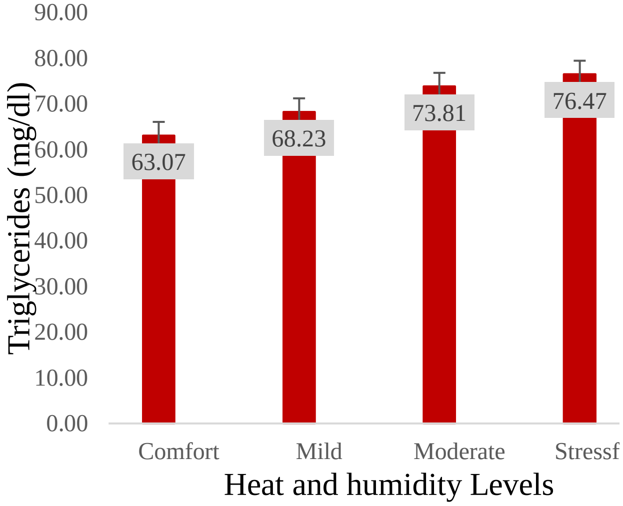

Fig. 2 Variation of serum triglycerides level (mg/dl) in the blood of selected cows under various THI treatments

There was a highly significant decrease in serum **progesterone** from comfort to the stressful environment (Fig. 3). A Highly significant (P<0.001) positive correlation (0.67) was found between progesterone and DMY. The cows were highly significant in the production of progesterone at different levels of heat stress.

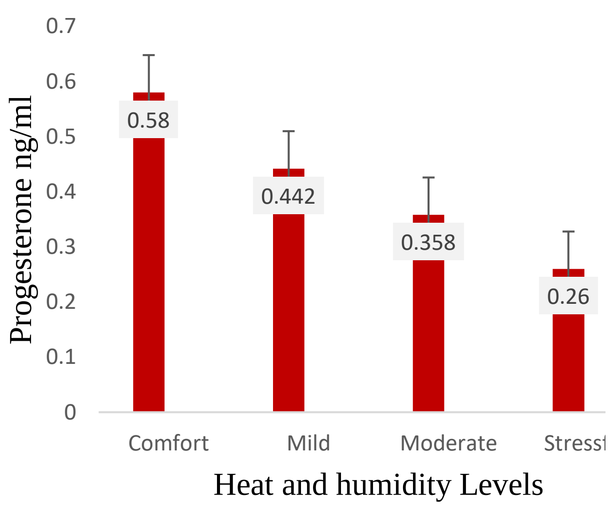

Fig. 3 Variation of progesterone level (mg/dl) in the blood of selected cows under various THI treatments

The mean **LH (Luteinizing hormone)** level in the blood of five Sahiwal cows is given in Fig. 4. The concentration of said hormone decreased from comfort to stressed level of heat stress. The results showed that the heat stress levels have highly significant effects on the serum LH concentration (Table 1).

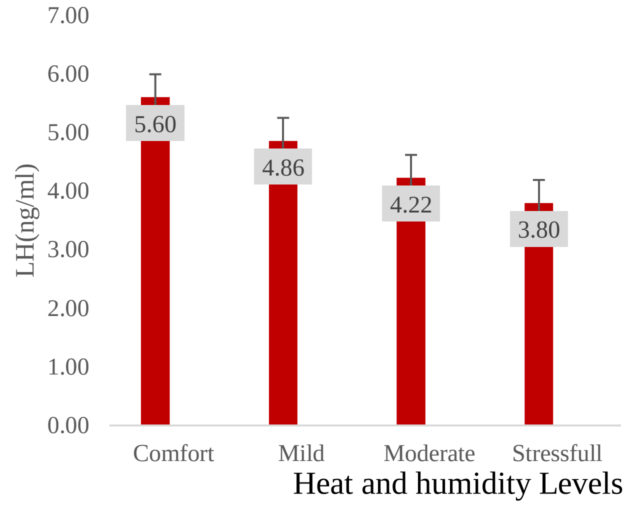

Fig. 4 Variation of LH level (mg/dl) in the blood of selected cows under various THI treatments

A highly significant (P = .004) positive association (0.37) was determined between LH and DMY. The mean value of DMY at different stress levels is given in Fig. 5. Daily milk yield showed significant variation among different stress levels. Continuous decrease in DMY was observed with temperature and humidity stress treatments The results showed that there was a continuous decrease in DMY from comfort to stressful zone.

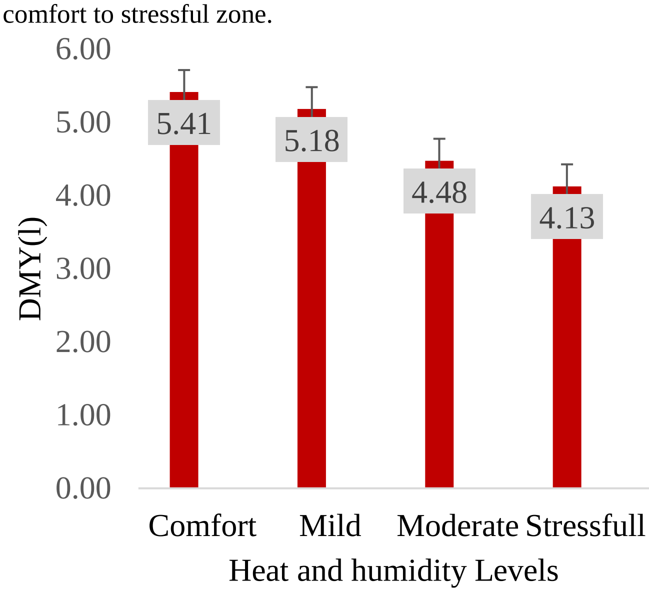

Fig. 5 Variation of DMY (mg/dl) in selected cows under various THI treatments

Discussion

Prolonged periods of stress, such as heat stress, in tropical and subtropical summers raise corticotropin levels. The activation of CRF (corticotropin-releasing factor) and AVP arginine vasopressin neurons in the paraventricular nucleus, as well as the

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secretion of these neuropeptides into the hypophyseal portal system, are the typical causes of this increased hypothalamic-pituitary-adrenal axis activity (Silva et al., 2024). In response to heat stress, the corticotrophs release pro-opiomelanocortin, which includes melanocyte-stimulating hormone, adrenocorticotropic hormone (ACTH), and endorphin (Szczepanska-Sadowska et al., 2024). To sustain milk production in cows, the ACTH acts on the adrenal gland's cortex and increases the release of glucocorticoids, or cortisol, resulting in a higher concentration of cortisol (Blond et al., 2024).

In this study, the effect of heat stress on milk yield was quite important. All five dairy cows, however, showed a linear drop in LH concentration pattern from the comfort to the stressed zone. It appears that during heat stress, increased cortisol levels harmed LH concentration and also on DMY. In the same way, cortisol response is thought to reduce LH in cows (Khodaei-Motlagh et al., 2011). Several researchers have also reported reduced levels of LH in peripheral blood circulation in cows that have experienced heat stress. The LH is positively correlated with yield. (Țogoe et al., 2024). According to Qureshi et al. (2002), buffaloes exhibit reduced levels of progesterone concentrations throughout the off-season, especially in the summer. Due to the heat stress, several additional research personnel also reported lower Progesterone concentrations (Thammahakin et al., 2024). On the other hand, others have noted that thermal stress results in an elevated amount of Progesterone (Mohammed et al., 2023). Another study found that when cows were exposed to heat stress, Progesterone levels remained unchanged. There was a positive correlation between progesterone and DMY (Guzeloglu et al., 2001). Our research on various heat stress levels showed a highly significant increase in the serum triglyceride level in five dairy cattle. According to reports from other researchers, the reduced triglyceride may be linked to a decrease in fodder intake of animals during heat stress (Blond et al., 2024). It can be deduced from the current triglyceride data that, in subtropical climates, cows with higher unusual blood levels consume less feed. The Data of DMY indicated that daily milk yield declined as heat stress increased. There was highly significant variation in milk production in different heat stress levels. Chen et al., (2024)

Conclusion

We concluded that the DMY of cows of the same breed (Sahiwal) were statistically highly significantly different from each other in the same set of THI index. The high positive correlation between progesterone and luteinizing hormone suggests that heat stress directly disturbs the hormonal balance of dairy cows due to which milk yield is badly affected. The serum cortisol and triglycerides have a non-signification correlation with DMY. The mean data of this research shows that these two parameters affect the DMY of cows but the effect is statistically non-significant.

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Declaration

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

The study was approved by authors.

Funding Statement

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Authors' Contribution

All authors contributed equally.

Conflict of interest

There is no conflict of interest among the authors of the manuscript.

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