EFFECT OF HEAT STRESS ON BEHAVIOUR AND PRODUCTIVITY OF DAIRY COW

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Abbreviations

THI	Temperature Humidity Index
Tre	Rectal Temperature

ABSTRACT

Due to the effects of heat stress, the dairy industry in tropical countries must deal with a number of difficulties. This study presents a novel method for examining the behavioural symptoms of heat stress, including panting, increased respiratory rate, and restlessness. The majority of the cows under study also exhibited other symptoms like refusal to eat and refusal to lie down. The temperature humidity index (THI) is another important indication that was taken into consideration for this investigation. In this study, 150 cross-bred cows were used, and the majority of them displayed behavioural symptoms and decreased milk output as a result of heat stress. The THI level was over the comfort level of 15 farms. The maximum THI index was over 80 and no farms environment were below the THI threshold level, which only points to a hot environment and poor farm management practices. The majority of the cows also had higher rectal temperatures. Currently, heat alleviation techniques include air movement (fans), wetting (soaking) the cow's body surface, high-pressure mist (evaporation) to cool the air in the cows' habitat, and structures made to reduce solar radiation transfer. Finally, producers may now optimize the positive impacts of photoperiod length while reducing negative effects because of a greater understanding of how photoperiod affects cattle.

CHAPTER 1: INTRODUCTION

Bangladesh is known as a hot and humid country. Dairy farmers in Bangladesh have to face losses due to the heat stress effect. Dairy cattle thrive in an ideal environmental temperature range between 5°C and 25°C, often called the thermal comfort zone (McDowell, 1972). Within this range, they experience minimal physiological stress and achieve peak productivity (Folk, 1974). However, when temperatures exceed 25°C, dairy cattle exhibit heightened respiration rates and rectal temperatures, resulting in reduced milk production and reproductive performance (Bitman et al., 1984).

As the core body temperature rises, cows employ heat-loss mechanisms such as panting and sweating (Spain and Spiers, 1998). Heat stress poses a significant challenge to dairy production globally, negatively impacting both productivity and profitability (Fuquay, 1981; West, 2003; Bryant et al., 2007).

Growth, milk production, and reproduction suffer under heat stress due to significant changes in biological functions induced by the stress (Habeeb et al., 1992; Silanikove, 1992). High-producing cows are particularly vulnerable to heat stress because their increased milk yield requires higher feed intake, resulting in more metabolic heat (West et al., 2003).

Cows at all production levels exhibit an inverse relationship between milk yield and heat stress (Ravagnolo et al., 2000; West, 2003).

When ambient temperatures rise, animals attempt to regulate their core body temperature by modifying physiological and metabolic functions (Bernabucci et al., 2010). Many behavioural, health, and performance issues stem from these physiological and metabolic adjustments (Bernabucci et al., 2010; Wheelock et al., 2010).

Dairy cattle are particularly sensitive to elevated ambient temperatures compared to other ruminants due to their high metabolic rate and limited water retention mechanisms in the kidneys and gastrointestinal tract (Bernabucci et al., 2010). Similarly, neonatal, postpubertal, and lactating cattle are especially prone to thermal stress (Collier et al., 1982a).

Triiodothyronine (T3) and thyroxine (T4), hormones associated with metabolic regulation, are influenced by climatic changes (Perera et al., 1985).

Holsteins, a competitive breed in intensive dairy farming, demonstrate high productivity directly linked to metabolic heat production, exacerbating the challenge of maintaining stable body temperature in high-temperature conditions.

Various environmental modifications, including the use of water sprays and fans (Armstrong, 1994) and evaporative cooling (Ryan et al., 1992) in shaded areas, have been recommended to alleviate heat stress.

In higher temperatures, animals reduce their feed intake by approximately 3-5% per additional degree of temperature, resulting in decreased productivity (Collier & Gebremedhin, 2015; Tedeschi & Fox, 2020).

Besides temperature, relative humidity plays a significant role, in regulating latent heat exchange from animals and thus impacting their thermal balance. The Temperature and Humidity Index (THI) is the most widely used environmental indicator for assessing heat stress in animals (Thom, 1959).

Cows may begin displaying signs of heat stress when the Temperature-Humidity Index (THI) reaches approximately 68 (Zimbelman et al., 2009).

However, heat-stressed cows exhibit lower plasma non-esterified fatty acid concentrations and a higher rate of peripheral glucose utilization, indicating that glucose uptake by other tissues reduces the amount available for milk synthesis (Rhoads et al., 2009). A decrease in feed intake precedes a reduction in milk production during heat stress, with the most significant decrease occurring approximately 48 hours after the onset of stress (Spiers et al., 2004; Collier et al., 1981).

Concerning dairy cattle, their daily activities include approximately 3 to 5 hours of eating, 7 to 10 hours of ruminating, 30 minutes of drinking, 2 to 3 hours of milking, and approximately 10 hours of resting (Grant & Albright, 2001).

Behavioural changes become apparent when environmental temperatures exceed the animal's tolerance threshold, serving as early indicators of welfare, health, and productivity issues (Fournel et al., 2017).

The objective of the study is to determine how heat stress affects dairy cattle's behaviours and productivity.

CHAPTER 2: MATERIALS AND METHOD

2.1 Climate Data

Bangladesh has a humid, warm climate influenced by pre-monsoon, monsoon, and post-monsoon circulations and frequently experiences heavy precipitation and tropical cyclones. Bangladesh's historical climate has experienced average temperatures around 26°C, but range between 15°C and 34°C throughout the year. The warmest months coincide with the rainy season (April-September), while the winter season (December-February) is colder and drier (Climate Risk Country Profile: Bangladesh, 2021: The World Bank Group).

2.2 Study Area and Period

This study was conducted in two distinct regions: the Chattogram metropolitan area and Karnaphuli, both located within the Chattogram district of Bangladesh. These areas are renowned for their significant dairy cattle populations, with Karnaphuli being recognized as the largest dairy zone in Bangladesh. The selection of these areas was motivated by the absence of previous research, making them ideal for this study. The study was conducted from March 11th to July 17th, 2022, aligning with the summer season in Bangladesh to investigate heat stress in animals.

FIG 1: Map of Study Area (Karnaphuli and Chattogram City Corporation)

2.3 Study population and Selection of farm

A total of 150 cows were included in the study, sourced from 15 different dairy farms in the Chattogram district. The selection of these farms and animals was carried out in a random manner, with each farm housing a minimum of 5 dairy cows.

2.4 Data Collection

To meet the study's objectives, a questionnaire was designed to capture relevant information. The questionnaire covered general farm details and emphasized physiological and production data related to the cows. Data collection was conducted through face-to-face interviews. The study collected data from a total of 150 cows across 15 randomly selected farms. The questionnaire also gathered farm demographic data, including the frequency of water and feed consumption, roofing materials, the presence of ceilings and exhaust fans, shed surroundings, and shed height. Data concerning individual cows, such as rectal temperature, respiration rate, panting, saliva drooling, tongue protrusion, neck extension, and milk yield, were recorded. These individual cow data were collected using tools such as stethoscopes and thermometers, with some data being observed through close examination of the animals, including panting, saliva drooling, tongue protrusion, and neck extension.

2.5 Temperature-Humidity Index

The study accurately calculated the Temperature-Humidity Index (THI) for all selected farms. Measurements of temperature and humidity were taken using a thermo-hygrometer. The Temperature-Humidity Index (THI), a widely utilized indicator for assessing the effects of heat stress on livestock traits (Lallo et al., 2018), was computed following the formula outlined by the National Research Council (NRC, 1971), as shown below:

$$\mathbf{THI = (1.8 \times T + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times T - 26)}$$

Where T is the Celsius temperature of the air and RH is the relative humidity expressed as a percentage.

CHAPTER 3: RESULTS

Table 1: Farm Environment, Housing and Management (N=15)

Traits	Category	Frequency (%)
Frequency of fresh drinking water supply	Three times a day	2(13.3%)
	Four times a day	5 (33.33%)
	Available whole day	8 (53.33%)
Stocking Density	Low	5 (33.33%)
	Normal (40-60 sq. ft.)	10 (66.67%)
Shower frequency	Once/day	1 (6.67%)
	Two times/day	9 (60%)
	Three times/day	3(20%)
	Four times/day	2 (13.33%)
Roof Insulation material	Aluminum Foam Sheet	5 (33.33%)
	Bamboo	7 (46.67%)
	No material	3 (20%)
The presence of a ceiling fan	Present	13 (86.67%)
	Absent	2 (13.33%)
Exhaust fan	No exhaust fan	9 (60%)
	Two fans	4 (26.67%)
	Four fans	2 (13.33%)
Temperature-Humidity Index	80-89(moderate-severe heat stress)	5 (33.33%)
	72-79(mild to moderate heat stress)	10 (66.67%)
	= (68-71) Heat stress threshold	0 (0%)

The survey findings indicate that a significant portion of Dairy Cows, approximately 53.33%, have access to fresh drinking water continuously available throughout the day. A slightly smaller proportion, about 33.33%, have access to fresh water four times daily, and 13.33% receive it three times daily. In terms of stocking density, the majority of Dairy cows (66.67%) report a normal stocking density ranging from 40 to 60 square feet, while the remaining 33.33% have a lower stocking density.

Regarding shower frequency, the most common frequency is twice a day, reported by 60% of Dairy cows, followed by three times a day at 20%, four times a day at 13.33%, and once a day at 6.67%. Bamboo is the most prevalent roof insulation material, chosen by 46.67% of Dairy Cows, followed by aluminium foam sheets at 33.33%. Approximately 20% of Dairy cows do not have any insulation material in place.

When it comes to ventilation, the majority (86.67%) have a ceiling fan installed in their space, while the remaining 13.33% do not. In contrast, a significant portion of Dairy cows (60%) do not have an exhaust fan. Among those who do, 26.67% have two exhaust fans, and 13.33% have four.

In terms of comfort, A temperature-humidity index of 72 to 79 indicates mild to moderate heat stress for the majority of responders (66.67%), whereas an index of 80 to 89 indicates moderate to severe heat stress for 33.33%. None of the responders fell below the 68–71 heat stress threshold.

Table 2: Cow Data

Traits	Category	Frequency (%)
Rectal temperature of the cow	Normal range (100.4-102.8 °F)	72(48%)
	Above 102.8 °F	78(52%)
Respiration rate	Normal (26-50/minute)	69(46%)
	Rapid (>50/min)	81(54%)
Panting	Yes	82(54.67%)
	No	58(38.67%)
Drooling of Saliva	Present	71(47.33%)
	Absent	79(52.67%)
Tongue Protrusion	Present	68(45.33%)
	Absent	82(54.67%)
Neck Extension	Present	72(48%)
	Absent	78(52%)
Milk Yield	> 15 liter/day	70(46.67%)
	≤ 15 liter/day	80(53.33%)
Reduced Feed Intake	Yes	105(70%)
	No	45(30%)
Refuse to lie down	Yes	108(72%)
	No	42(28%)
Convulsion	Yes	55(36.67%)
	No	95(67.33%)
Restlessness	Yes	90(60%)
	No	60(40%)

The temperature of most cows (52%) registers above the normal threshold of 102.8 °F, while 48% maintain a normal temperature. A substantial portion of cows (54%) display a rapid respiration rate, exceeding 50 breaths per minute, while 46% maintain a normal rate. A majority of cows behaviours(54.67%) exhibit panting behaviors, whereas 38.67% do not pant. A slightly higher percentage of cows (52.67%) do not experience saliva drooling in comparison to those (47.33%) that do. Additionally, more cows (54.67%) do not protrude their tongues compared to

those (45.33%) that do so. A slight majority of cows (52%) do not extend their necks, as opposed to those (48%) that do.
In terms of milk production, most cows (53.33%) yield 15 liters of milk or less per day, while 46.67% produce more than 15 liters daily. A significant majority of cows (70%) exhibit reduced feed intake, and an even more substantial majority (72%) refuse to lie down. Convulsions are experienced 7 40% do not display this behavior.

FIG 2: Cow Refuses to Lie Down

CHAPTER 4: DISCUSSION

The study focused on presenting a novel approach to comprehending the effects of heat stress. This required examining a number of variables, including THI and other physiological measurements.

Roughly 66.67% of dairy cows are housed in adequate stocking density ranging from 40 to 60 square feet per cow, promoting their well-being. However, it's concerning that a third of the cows experience lower stocking densities, which could lead to stress and health issues.

Proper ventilation is essential to ensure the comfort of dairy cows. The majority (86.67%) use ceiling fans to improve air circulation. Conversely, 60% lack exhaust fans, which are essential for maintaining air quality by eliminating moisture. Among those with exhaust fans, there's a varied distribution, with some having two (26.67%) or four (13.33%) fans. Consistent and effective ventilation plays a vital role in the overall comfort and health of the cows.

The temperature-humidity index (THI) is important for assessing heat stress in dairy cows. A significant number (66.67%) of participants faced THI levels between 72 and 79, indicating mild to moderate heat stress. This is concerning as even slight heat stress can impact cow health and milk production. Additionally, 33.33% of cows experienced THI values from 80 to 89, indicating moderate to severe heat stress. None of the participants had THI readings below the 68-71 heat stress threshold. Trait responses that were connected with THI were used to create various "zones" that represented comfort, mild stress, or considerable heat stress (Brügemann et al., 2012; Habeeb et al., 2018).

Body temperature represents a summary of all thermoregulatory processes, making it a crucial marker of livestock animals' well-being, ability to reproduce, and productivity (St-Pierre et al., 2003). The fact that a majority of cows (52%) have temperatures surpassing the normal threshold of 102.8 °F is worrying. Cows in a thermoneutral environment (17.9 to 20.2°C ambient) had a rectal temperature of 39.0°C, according to Spiers et al. (2004). Conducted cooling reduced the cow's Rectal temperature (Tre) to values that were close to thermoneutral conditions. High Tre levels are a dependable indicator of heat stress (Gebremedhin et al., 2008; Suthar et al., 2012), About 54.67% of cows show signs of panting, which could be an indication of heat stress or discomfort brought on by poor ventilation or high temperatures in their surroundings. Respiration rates of cattle can be influenced by several factors, including age, level of production, body condition, DMI, housing design, cooling systems, and previous exposure to hot conditions (Gaughan et al., 2000). About 54% of cows have rapid breathing, with a rate greater than 50 breaths per minute. An increase in respiration rate is one of the most sensitive phenotypic signs of heat stress; RR >60 breaths/min is an indicator of heat stress in lactating dairy cows (Berman, 2005).

A total of 53.33% of cows produce no more than 15 litres of milk every day.

Because cows may eat less food, spend more energy cooling off, and produce less milk as a result of heat stress, this is a common side effect.

High-yielding exotic cows may not express their genetic potential to the fullest extent when exposed to conditions of heat stress, according to the interaction between genetics and the environment (Carabano et al., 2016).

Although it is well known that cattle adapt their energy metabolism to maintain stability in demanding circumstances, these physiological and metabolic changes can have an impact on performance traits like daily milk output [Mbuthia et al., 2021].

CHAPTER 5: CONCLUSION

Dairy farming in Bangladesh faces many challenges, one of the major effects is heat stress. The study identified a Temperature-Humidity Index value for the dairy farm environment, which is a major indicator of heat stress. A good management and multidisciplinary approach are necessary to prevent heat stress in dairy cattle. Focusing on heat-tolerant breeds is a good option, along with other managemental practices.

Recommendation

A good management and integrative approach are necessary to prevent heat stress in dairy cattle.

Good Management include Proper ventilation, Showering 3-4 times a day during high climate condition, giving fresh water, proper stocking density, Conducting cool air circulation are some effective way.

Focusing on heat-tolerant breeds is a good option, along with other managemental practices.

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