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Ameliorative measures to mitigate the heat stress in buffaloes – A review

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1. Introduction

Buffaloes are predominantly kept by small-scale farmers in developing nations, who typically raise one or two animals within mixed crop-livestock setups. India boasts the largest buffalo population globally, reaching 109.85 million. Notably, buffalo milk contributes a significant 57% to India's total milk production, ranking the country 5th globally in meat production and 1st in buffalo meat output. In the 2022-23 period, meat production surged by 5.6%, totaling 9.77 million tonnes. Buffaloes are prized not only for their meat but also for their high-fat milk content. Additionally, buffaloes are utilized for draft purposes (BAHS, 2023). Stress in animals is characterized by a non-specific response aimed at maintaining homeostasis when facing extreme or prolonged environmental challenges. This stress can manifest physically through fatigue or injury, or physiologically due to factors like hunger, thirst, or temperature regulation (Faught et al., 2020). Heat stress occurs when animals are unable to adequately dissipate heat, particularly in high ambient temperatures and humidity, leading to adverse effects on health and productivity. Thermal stress arises when environmental conditions surpass animal upper or lower critical temperatures, necessitating increased basal metabolism to cope. Heat stress occurs when ambient temperatures exceed the thermo-neutral zone (Pawar et al., 2022).

2. Heat stress in buffaloes

Heat stress negatively impacts the performance of both dairy cattle and buffaloes, with the dairy sector being particularly susceptible to the effects of global warming and climate change (Pawar et al., 2022). Buffaloes, in particular, display heightened distress when exposed directly to solar radiation. Despite having a slightly lower body temperature compared to cattle, buffaloes' dark skin absorbs a significant amount of solar radiation due to its coloration and the sparse nature of their hair. Moreover, buffaloes possess fewer sweat glands compared to cows, resulting in a less efficient evaporative cooling system. Additionally, their thyroid-adrenal mechanism is less effective (Petrocchi et al., 2023). These factors, including the distribution of sweat glands, dark

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skin color, and sparse body hair, collectively diminish heat tolerance in buffaloes. Exposure to hot conditions triggers various biological changes in buffaloes, such as decreased feed intake, reduced efficiency in utilizing their diet, disturbances in water and mineral balances, as well as disruptions in metabolic functions and hormonal secretions. This can lead to decreased milk yield and quality, as well as diminished fertility due to reduced heat manifestation. Physiologically, heat stress in buffaloes results in increased heart and respiration rates, heightened blood flow to the skin, and intensified sweating, leading to electrolyte loss, dehydration, and inflammation. During the summer months, as ambient temperatures rise and body temperatures consequently increase, cows tend to decrease their feed intake as a coping mechanism against heat stress. This gradual decline in feed intake contributes to a decrease in milk production and alterations in milk composition (Omran, 2021).

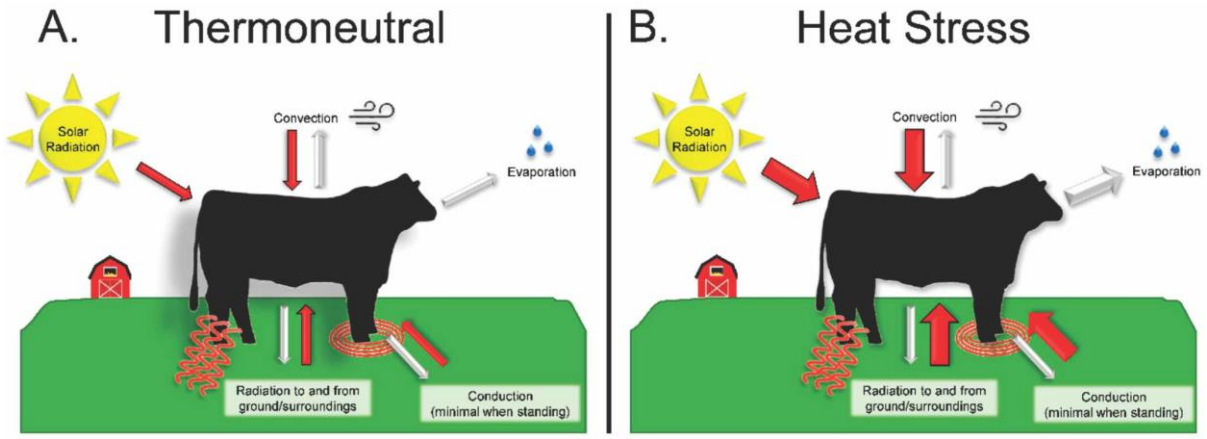

Figure 1 Mechanism of heat stress management in dairy animals

3. Methods to measure heat stress

Thermal parameters such as temperature, humidity, wind speed, and solar radiation are fundamental in calculating heat transfer. These parameters combine to generate various indicators useful for assessing the stress levels experienced by animals. Among these indicators, the temperature-humidity index (THI) is widely utilized as it combines air temperature and humidity into a single index, providing insight into animal comfort levels. The THI, initially proposed by Thom in 1958, is extensively employed to gauge heat stress in conditions ranging from moderate to hot (Umar et al., 2021). However, the threshold THI values denoting different levels of heat stress vary based on factors such as geographical location, breed, age, and physiological condition of the animal. Buffaloes exhibit distinct physiological traits compared to cattle, making them more susceptible to distress when exposed to direct solar radiation or hot weather. Characteristics such as dark skin, sparse hair coat, less efficient evaporative cooling, and limited sweating capacity contribute to this susceptibility. For buffaloes, THI thresholds indicating heat stress are

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typically categorized as follows: THI 68-72 for mild heat stress, THI 73-76 for moderate stress, and THI ≥77 for severe heat stress (Chikkagoudara et al., 2022).

THI was calculated from environmental variables using the following equation
$THI = (1.8 \times T_{db} + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26.8)]$
Where, T_{db} = dry bulb temperature (°C); RH = relative humidity (%).

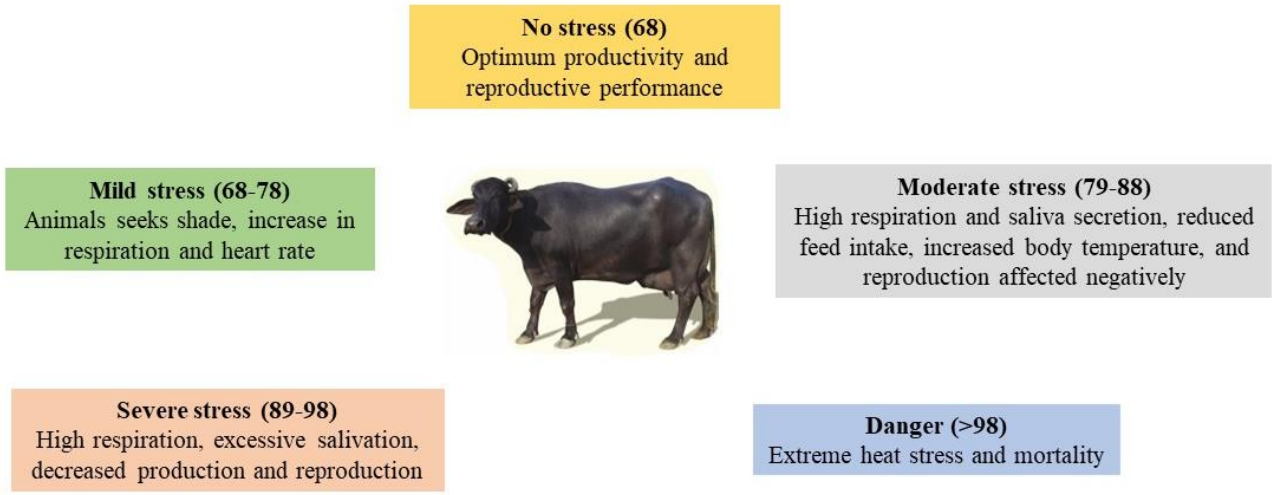

Figure 2 Heat stress THI in dairy animals

4. Monitoring the heat stress in buffaloes

- Changes in consciousness
- Abnormal vital parameters: Elevated heart rate, respiration rate, rectal temperature
- Unusual salivation
- High body temperature (106 – 108°F).
- Dizziness

5. Mitigation strategy for heat stress

Buffaloes experience increased heat stress when their natural adaptive behaviors, like seeking shelter, wallowing, or accessing water, are restricted. Research indicates that buffaloes are more effective at regulating their body temperature when allowed to immerse themselves in water rather than relying solely on showers for cooling (Purohit et al., 2020). While having pools may not always be feasible, it's essential to implement appropriate heat stress management measures to safeguard their well-being and productivity. To alleviate heat stress in buffaloes, several management practices can be employed. These include providing ample shade to shield them from direct sunlight, enhancing air circulation to promote cooling, and regularly wetting the animals with cold water to facilitate evaporative cooling. These measures help mitigate the adverse effects of heat stress, ensuring the animals remain healthy and productive (Napolitano et al., 2023).

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5.1. Feeding and nutritional strategies

During hot weather, several key aspects of nutritional management must be addressed for buffaloes. This includes formulating specialized diets to accommodate reduced dry matter intake while ensuring sufficient availability of essential nutrients and preventing nutrient excesses that can exacerbate heat stress (Petrocchi et al., 2023). The energy requirements of lactating buffaloes rise during high temperatures, primarily due to increased metabolic energy needs. Water intake is paramount for buffaloes in hot climates, closely linked to dry matter intake and milk production. Regardless of the rate of increase, ample water must always be accessible to buffaloes under such conditions. Additionally, supplementation of minerals and vitamins with antioxidant properties is crucial to counteract the production of free radicals induced by heat exposure. Maintaining electrolyte balance becomes vital during hot weather, as alterations in mineral metabolism impact the buffalo's electrolyte status. Therefore, mineral supplementation becomes imperative to support buffalo health in hot climates (Sammad et al., 2020).

Buffaloes housed in sheds exhibit elevated heart rates during the night, which rapidly decrease when allowed access to pasture. This response is attributed to reduced radiation heat from nearby buffaloes and increased heat dissipation from the animals themselves when in an open pasture environment.

5.2. Shelter management

- Providing sun shade or shelter structures with a coverage area of 2.5 to 3 square meters per animal is recommended to ensure adequate protection for cattle, whether it's a single animal owned by a smallholder or multiple animals in a commercial herd (Petrocchi et al., 2023).
- If financially viable, it is advisable to pave all areas that will receive shade at some point during the day with high-quality concrete.
- When the longitudinal axis of the structure is oriented east-west, the floor plan under the roof will remain shaded throughout the day.
- By extending the floor approximately one-third of its length on the east and west sides, a paved surface can ensure shaded areas are available at all times (Napolitano et al., 2023).

5.3. Cooling strategy

- Wallowing involves rolling or floundering in mud or water, facilitated by increased blood vessels in the skin that aid in dissipating heat.
- Farmers often employ handheld hoses to spray water on buffaloes during the summer months to help cool them down. However, this method is time-consuming, utilizes a significant amount of groundwater, and offers limited relief from heat for the buffaloes. Additionally, water sprinklers generate a large volume of wastewater (Bah et al., 2022).

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- The use of sprinklers presents a potentially more effective cooling method for buffaloes compared to traditional hose spraying. Sprinkler systems, when strategically placed along feed bunks and in holding areas, can wet the animals regularly, aiding in heat removal. This method also reduces irritation from insects. It's essential to ensure that the droplet size is not too fine, but sufficient to wet the hair and skin. Excessive sprinkling can lead to wet bedding, potentially causing mastitis (Verma et al., 2023).
- Foggers are another method employed to cool buffaloes by providing water cooling. These systems lower the ambient temperature and increase the relative humidity in the surroundings, offering relief from heat stress.

5.4. Shade providing

Simple shading is a fundamental method for shielding animals from direct solar radiation during the daytime in summer. Trees and plants serve as highly effective sources of shade, not only offering protection from sunlight but also generating a cooling effect through the evaporation of moisture from their leaves. Providing shade has a positive impact on the physiological response of buffaloes to heat, leading to reductions in body temperature, heart rate, and respiration rate during the summer months (Verma et al., 2023). These practices help mitigate the effects of solar heat while enhancing heat dissipation from the animals. It's advisable to plant fast-growing shady trees in and around sheds and paddocks to ensure continuous shade coverage. Shade offers protection from adverse climatic conditions such as solar radiation, whether through permanent structures, temporary/artificial shade areas utilizing portable shade cloth (which blocks 50% of solar radiation), or naturally ventilated structures with open sidewalls (Chikkagoudara et al., 2022).

5.5. Genetic selection

Various genetic factors play a significant role in determining an animal's response and resilience to heat stress. As a result, considerable variations in these factors are observed among different breeds of livestock. Heritable traits such as coat structure and color, sweating efficiency, and tissue resistance greatly influence the ability to regulate body temperature. Therefore, selecting animals based on specific genetic markers for heat tolerance can effectively address the issue of heat stress in buffaloes by identifying those that are more tolerant to high temperatures (Petrocchi et al., 2023).

5.6. Feeding bypass protein

Dietary protein degradability plays a crucial role in managing heat stress conditions. Excessive protein intake is known to elevate heat production and reduce reproductive performance. However, in hot environments, the protein requirement of buffaloes rises while dry matter intake declines (Verma et al., 2023). As a result, the protein supplied to lactating buffaloes

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during summer may not always be adequate. Incorporating fish meal, a by-pass protein, into the diet has been found to increase milk yield and protein content in buffalo milk. Additionally, it decreases ruminal ammonia production. This strategy helps address the nutritional needs of buffaloes during hot weather, optimizing milk production while mitigating the adverse effects of heat stress (Petrocchi et al., 2023).

6. Conclusion

Effective management of heat stress in buffaloes is imperative for maintaining their health, welfare, and productivity, especially in regions with hot climates. Various strategies, including providing adequate shade, optimizing water access, implementing nutritional interventions, and utilizing genetic selection for heat tolerance, are essential components of a comprehensive heat stress management plan. Additionally, innovative approaches such as the use of by-pass proteins like fish meal can offer promising solutions to mitigate the impact of heat stress on buffalo performance. By adopting a multifaceted approach tailored to the specific needs and challenges of buffaloes in hot environments, farmers can ensure the well-being and sustainable production of these valuable animals. Continued research and practical implementation of heat stress management practices are essential to safeguard the resilience and vitality of buffalo populations in the face of climate change and rising temperatures.

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