ACCLIMATORY RESPONSES ACCORDED BY HEAT STRESS IN FARM ANIMALS: A REVIEW

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ABSTRACT
Globally, the climate is changing and this poses a threat to the survival and productivity of farm animals. One of the most important and critical consequences of climate change is increasing surface temperature all over the world resulting from increasing amount of greenhouse gases (water vapour, carbon dioxide, Nitrous oxide, Methane and ozone) concentration in the atmosphere. This elevates concentration of greenhouse gases in the atmosphere leads to an increase in the ambient temperature which is a contributing factor to heat stress in farm animals. Heat stress is any combination of environmental factors that causes the effective body temperature of the animal to be higher than the thermo neutral zone of the animal. Heat stress occurs when the core body temperature of a normal activity resulting from a total heat load (internal production and environment) exceeding the capacity for heat dissipation. This prompts behavioural, physiological, neuroendocrine and behavioural responses to reduce the stress. Behavioural responses of farm animals include increased water intake, reduced feed intake, increased standing and reduced lying behaviour. Physiological responses of farm animals to heat stress include increase in heat rate, respiration, rectal temperature, pulse rate, sweating rate, body temperature and reduction in rumination time in ruminants. Neuroendocrine responses of farm animals to heat stress is coordinated by the functioning of three neuroendocrine axis; the hypothalamic - pituitary – adrenal axis, hypothalamic - pituitary – thyroid axis and sympathetic – adrenal medullary axis. Metabolic responses of farm animals involve a reduction in the secretion and activity of thyroid hormones as regulated by the hypothalamic-pituitary-thyroid axis. Climate change is seen as a formidable challenge for farm animal production. Therefore, to achieve an optimum return from the livestock sector, understanding in depth, the various acclamatory responses of farm animals is necessary.
Keywords: Acclimatory, Responses, Heat stress, Farm animals

INTRODUCTION

Climate refers to the long-term average atmospheric conditions characteristic of a region over extended periods, while climate change signifies substantial and enduring alterations in these conditions over similar timescales. Climate change is a significant threat to the survival and productivity of farm animals globally (Afsal *et al.,* 2018; Cheng *et al*., 2022). The Intergovernmental Panel on Climate Change (IPCC) describes climate change as a long-term shift in the planet's climate, driven by human activities that alter the atmosphere's composition (IPCC, 2007). This change can have far-reaching consequences for animal health, growth, and productivity. Heat stress is a primary consequence of climate change that can significantly reduce farm animal output and endanger the livestock industry (Afsal *et al.,* 2018). As production levels increase, animals become more sensitive to stress, making them more vulnerable to heat stress (Hahn, 1995). Furthermore, genetic improvement programs aimed at enhancing production qualities may inadvertently make animals more susceptible to high environmental temperatures (Kadzere *et al.,* 2002). Rising greenhouse gas concentrations, including carbon dioxide, water vapor, nitrous oxide, methane, and ozone, contribute to increasing surface temperatures worldwide (Aleena *et al*., 2016).

This warming can have devastating effects on livestock, particularly in tropical and subtropical regions (Roush, 1994). Homeothermic animals have a thermoneutral zone, where they can maintain their normal body temperature with minimal energy expenditure, regardless of the environmental temperature (Yousef, 1987). However, when environmental factors like temperature, humidity, air movement, and solar radiation exceed a certain threshold, animals enter a state of heat stress. Heat stress occurs when an animal's core body temperature exceeds its normal range, due to an overwhelming heat load from both internal production and environmental factors. As a result, the animal's ability to dissipate heat is compromised, triggering physiological and behavioural responses to mitigate the stress. This work aimed to review the different acclimatory responses of farm animals to heat stress.

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Behavioural Reponses to Heat Stress in Farm Animals

Behavioural responses, such as changes in feeding, drinking, and standing/lying patterns, help animals cope with heat stress (Hafez, 1968; Giannone *et al.,* 2023).

Physiological Responses to Heat Stress in Farm Animals

Physiological responses include increased respiration rate (RR), rectal temperature (RT), pulse rate (PR), and skin temperature (ST). These changes help animals dissipate excess heat and maintain homeostasis (Sharma *et al.,* 2013; Marai *et al.,* 2007). For instance, RR increases to enhance respiratory evaporative cooling, while rectal temperature rises as animals struggle to maintain thermal balance (Kadzere *et al.,* 2002; McManus *et al.,* 2009). Sweating rate (SR) is another crucial mechanism for heat dissipation, influenced by factors like weather, hair coat properties, and skin color (Gebremedhin *et al.,* 2008). For example, animals with black and dark fur tend to absorb more heat than those with white eor light fur, thereby, increasing their sweating rate (Hillman *et al.,* 2001; da Silva *et al.,* 2003).

Neuroendocrine Responses to Heat Stress in Farm Animals

Heat stress triggers various adaptive responses in farm animals, including neuroendocrine changes. These changes help animals cope with stress and maintain homeostasis (Afsal *et al.,* 2018). Stress compromises metabolic functions like reproduction, immunity, and growth (Moberg and Mench, 2000). The Hypothalamic-Pituitary-Adrenal (HPA) axis plays a major function in responding to heat stress. The activation of the HPA axis leads to the release of stress hormones like cortisol, growth hormone, and catecholamines (Bhimte *et al.,* 2018). Cortisol helps mobilize energy, while growth hormone regulates growth and metabolism. The Hypothalamic-Pituitary-Thyroid (HPT) axis also responds to heat stress by regulating energy expenditure and thermogenesis. Thyroid hormones, such as triiodothyronine (T3) and thyroxine (T4), increase metabolism and heat production (Silva, 2006). However, chronic heat stress can lead to decreased HPT activity to reduce metabolic heat production. The Sympathetic-Adrenal Medullary (SAM) axis coordinates responses to stress by releasing epinephrine and norepinephrine (De Castro *et al.,* 2015).

Metabolic Responses to Heat Stress in Farm Animals

Heat stress significantly impacts metabolic processes in livestock, influencing thermogenesis, energy balance, and nutrient utilization (Bernabucci *et al.,* 2010). Thyroid hormones play a crucial role in regulating thermogenesis, and their reduced activity is associated with heat stress (Rasoli *et al.,* 2004; Sejian *et al.,* 2013). According to Ekpo et al (2022); Christopher et al. (2019) feed sources high in fiber or energy content can increase metabolic heat production during digestion, exacerbating heat stress in livestock, including pigs, rabbits and snails. This can lead to reduced feed intake, dehydration, and impaired growth or reproduction due to the difficulty in maintaining their normal body temperature.

Protein metabolism is also affected, with reduced protein deposition and increased fat gain observed in heat-stressed animals (Ain Baziz *et al.,* 1996; Geraert *et al.,* 1996). Carbohydrate metabolism is disrupted with increased glucose utilization and reduced fatty acid oxidation (Baumgard and Rhoads, 2007). The tricarboxylic acid (TCA) cycle is negatively impacted, with acute heat stress accelerating the cycle and chronic heat stress increasing skeletal muscle abundance of pyruvate dehydrogenase kinase 4 (PDK4) (Gandhi *et al.,* 2011; Sanders *et al.,* 2009). Oxidative phosphorylation is also impaired, with heat stress inactivating complex I of the electron transport chain and reducing ATP synthesis (Downs and Heckathorn, 1998). Glycogenolysis, gluconeogenesis, and the Cori cycle are also affected, with increased glycogen breakdown and gluconeogenesis observed under chronic heat stress (Febbraio, 2001; Miova *et al.,* 2013). Lactate is used as an alternative fuel to produce glucose via the Cori cycle, ensuring glucose requirements of tissues (Slimen *et al.,* 2015).

CONCLUSION

Heat stress has a profound negative impact on the metabolic and neuroendocrine responses of farm animals. The activation of the hypothalamic-pituitary-adrenal (HPA) axis, hypothalamic-pituitary-thyroid (HPT) axis, and sympathetic-adrenal medullary (SAM) axis perform significant functions in regulating the animal's response to heat stress. Thyroid hormones, which regulate thermogenesis, are decreased in heat-stressed animals, leading to reduced metabolic rate and heat production. The HPA axis stimulates the release of cortisol, which mobilizes energy stores and helps maintain homeostasis. However, chronic heat stress can lead to decreased HPT activity, reducing metabolic heat production. Heat stress also disrupts metabolic processes, causing reduced feed intake, decreased protein deposition, and increased fat gain. By recognizing the complex interplay between these responses, researchers and producers can work together to develop effective management practices and nutritional interventions to support animal health and productivity in the face of heat stress.

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