

Environmental (heat stress) on livestock production

introduction

Increased frequency of life-threatening events like cyclones, droughts, floods, tsunamis, and wildfires are expected to happen in the changing climate event. Among the agricultural sector, crops and livestock are particularly vulnerable to the devastating effects of climate change ultimately deteriorating the agricultural production.

Heat stress emerges as one of the primary direct impacts of climate change which drastically affect the agriculture production. The severity of heat stress can be assessed by THI index (temperature-humidity index), which is one of the well-established tools to analyze the thermal stress worldwide. However, the effects of heat stress are further influenced by relative humidity, solar radiation, and wind speed. But the THI only takes into account the temperature and humidity effects without considering wind speed and solar radiation. This warrants further investigations to identify a more appropriate index to quantify the impact of climate change.

Animal and heat stress

All animals have a defined thermo neutral zone, where in they maintain the normal body temperature without altering its behavioral and physiological functions. Any deviations in this zone may ultimately end up in altering the normal physiological mechanisms to cope with the adverse environmental temperature. Thermal stress may affect the productive functions such as milk, meat and reproductive performance. Behaviorally in order to cope up to the heat stress challenges, animals generally increase their water intake and reduce their feed consumption. Thermoregulatory mechanisms to heat stress are species specific and therefore, the magnitude of reduction in their production performance also differs between them.

Endocrine responses are one of the principal regulators of animal adaptation to heat stress challenges. The hypothalamo-pituitary adrenal (HPA) axis play an integral role in regulating the neuroendocrine mechanism during heat stress condition . This neuro-endocrine

mechanisms which help the livestock to survive in a specific environment.

Climate Change and Heat Stress

Climate change is the most critical global issue that hampers both human welfare as well as the global ecological balance. Rising fossil fuel burning and land use changes have emanated, and are emitting a large number of greenhouse gases into the earth's atmosphere. This increases the global temperature ultimately resulting in climate change. The most concerned global consequences of climate change include the elevating sea surface temperature and rising sea level accompanied by the melting of glaciers and ice caps in a polar region.

Heat stress is one of the major intriguing factors associated with the changing climatic condition. Global temperature is rising at an alarming level. All biotic organisms possess a thermo neutral zone within which their biological functioning will be optimum. The rise in ambient temperature negatively affects the productive functions in all organisms. The internal mechanisms of plants, animals, and intrusive alien species get altered as a result of a change in environmental conditions thereby altering the sustainable production of these species. As an ultimate consequence, agriculture and livestock sector which are the major contributors in securing food security get destabilized by climate change.

Animals adaptation

Adaptation is the morphological, anatomical, physiological, biochemical and behavioral characteristics of the animal which promote the welfare and favors the survival of the animal in a specific environment. Heat stress can cause a significant effect on livestock production mainly by decreasing the feed and water availability. Therefore, sustainable production from livestock requires well adaptation of the animals to the testing climatic conditions.

The animals' exhibit various adaptive responses like:

- 1- increased respiration rate panting, sweating.

- 2- decreased metabolic activity , Utilization of energy for the adaptive mechanisms will reduce the productive and reproductive performances.
- 3- The well adapted animals require less amount of energy to cope up with extreme conditions.
- 4- In addition, increased feed conversion rate is also expressed in well-adapted animals than the less adapted ones.

Different Mechanisms of Livestock Adaptation to Heat Stress

The biological response to stress is divided into acute and chronic phases, with the acute phase lasting hours to a few days and the chronic phase lasting several days to weeks. However, it might depend on the severity of stress which hampers the animal production and the survivability of the animal in extreme climatic conditions. In order to maintain the homeostasis, the animal has to control their thermoregulatory mechanism by implementing certain adaptive responses. There are various adaptive responses exhibited by the animal when exposed to different environmental stresses, such as:

1- behavioral, 2- physiological, 3- blood biochemical, 4-cellular 5- neuro-endocrine responses.

However, the most significant **behavioral changes** observed mainly during heat stress conditions are:

1- seeking shade 2-increased standing time 3-reduced feed intake 4- more consumption of water.

physiological adaptive responses

- 1- increased respiration rate, sweating rate, and rectum temperature
- 2- the body temperature is also considered as ideal indicators to reflect the impact of a range of stresses in animals and it represents the whole thermoregulatory mechanisms in the animal body. Moreover, physiological responses are one of the primary pathways by which the animal survive in extreme environmental conditions.

Blood biochemical responses shown by the animal might have influenced by certain factors like nutrition, sex, age, diseases and stress factors. Heat stress significantly alters the levels of hemoglobin (Hb), packed cell volume (PCV), plasma and glucose level in the blood. heat stress increases the level of oxygen consumption of the animals by influencing the respiration rate. Moreover, the increased levels of oxygen consumption reduce the partial pressure of carbon dioxide in the blood and ultimately result in respiratory alkalosis. The increased PCV during heat stress condition could be attributed to severe dehydration of these animals.

Cellular response is one of the genetic adaptive mechanisms shown by the animal to overcome the severity of heat stress. Gene expression changes include various molecular mechanisms pertaining to the different type of cells. This indicates that various tissues respond to the temperature above the thermo-neutral zone by bringing in the cellular adaptive responses which determine the genetic characteristics which ultimately controls the cellular homeostasis. Typically, the thermo tolerant genes like heat shock proteins and slick hair gene expression indicate the severity of heat stress in farm animals. They are activated by heat shock factors and their expression increased when cells are exposed to extreme heat stress. Heat stress-induced secretion of heat shock factors also stimulates both the endocrine and immune system via extracellular secretion of heat shock proteins. The various cellular responses to heat stress include:

- 1- inhibition of DNA synthesis, transcription, RNA processing and translation,
- 2- the progression of cell cycle,
- 3- disruption of cytoskeletal elements,
- 4- protein denaturation and changes in membrane permeability.

During stress, various **endocrine responses** are involved in improving the surviving ability of the animals. The Hypothalamus-Pituitary-Adrenal (HPA) axis is primarily responsible for the adaptive component of the neuro-endocrine stress response. Endocrine responses are one of the principal regulators of animal adaptation during exposure to challenging environments. Further,

the extreme level of stress may result in inducing changes in the secretion of all hypothalamic and pituitary hormones which alters the metabolism, immune response and behavior apart from altering the reproductive performance. The principal hormones which govern the animal adaptation include **glucocorticoids** **thyroid hormones**, **catecholamines**, **antidiuretic hormone** and **growth hormone**. When the animal is exposed to extreme environmental stress it results in the activation of the hypothalamo-pituitary adrenal axis (HPA) and sympatho-adrenal medullary axis (SAM). Generally, neuro-endocrine regulation was considered to be the principal regulator of all adaptive mechanisms which helps the animals to survive the stress. Figure 1 analysis the various neuro-endocrine mechanisms exhibited by farm animals to survive the stressful condition.

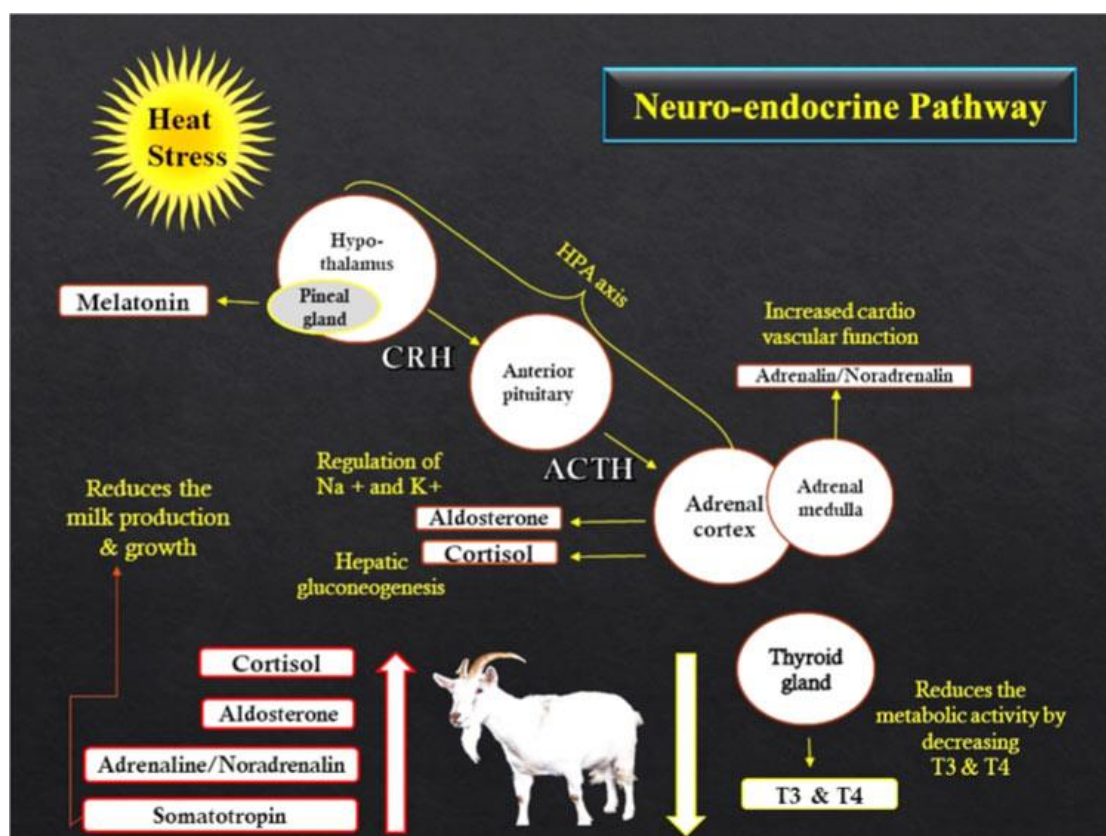


Figure 1: Neuro- endocrine adaptive mechanism in farm animals during heat stress conditions