University of Thi-Qar Journal of agricultural research

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

Physiological and Environmental Stress Situations and Their Impact on The Physiological Processes of Ruminants: Article Review

Hanan Waleed Kasim Agwaan

Department of Animal Production, College of Agriculture and Forestry, University of Mosul, Iraq
Email:*hanan_aqwaan@uomosul.edu.iq*

I. Abstract:

The physiological and natural stressors influencing ruminants are assorted and essentially affect their wellbeing, efficiency, and welfare, frequently coming about in significant financial misfortunes for animals' businesses due to diminished development, propagation, and expanded illness frequency. Ruminants have a specialized stomach related framework with a multi-chambered stomach that depends on microbial aging, and push can disturb this sensitive adjust, driving to modified digestion system, diminished bolster admissions, and compromised resistant work. Stressors are classified as physiological such as malady, regenerative occasions, and administration hones or natural, counting climate-related components like warm, cold, stickiness, and lodging conditions, all of which can trigger hormonal reactions through actuation of the hypothalamic-pituitary-adrenal pivot, raise glucocorticoid levels, and smother resistant and regenerative capacities. Inveterate presentation to these stressors not as it were modifying behavioral designs such as bolstering, social intelligent, and resting but moreover requires physiological adjustments like acclimatization and hereditary choice for strength, highlighting the significance of administration procedures that adjust the environment, make strides sustenance, and join behavioral preparing to relieve stretch impacts. Tending to these challenges through investigate, especially centering on hereditary inconstancy and long-term considers, is significant for improving ruminant efficiency and welfare within the confront of climate alter and advancing agrarian frameworks.

Keywords: Behavior, Physiological, Ruminants, Stress, Welfare

1. *Introduction*

Stress can be defined as the physiological processes and the concomitant biological responses that try to preserve, restore and adapt constantly the stability (homeostasis) of the internal environment of the individual or population exposed to a broad range of stressors (1). As a consequence of these changes, when severe or prolonged, stress can also alter the internal environment of the individual or population, for instance concentration of hormone, blood sugar, and body temperature, which can also produce adverse pathological consequences or diseases (2).Stressors are agents or conditions that elicit the stress response. Farm animals are exposed to multifaceted challenges, which can negatively affect their well-being, reproductive and productive performances (3) .As a consequence of the location of the livestock industries, as well as

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

originating from climate change, novel and well-known environmental stressors are increasingly becoming more pronounced(4) .In ruminants, various environmental, management, and social stressors have been identified and highlighted. The ways in which these stressors affect biological systems through physiological cascades, their impact on farm animal overall well-being and performances in terms of growth, reproduction, lactation, and immunity are also discussed .These stressors are of global concern due to the potential significant economic costs associated with their accumulative effects: e.g., for beef cattle more than 1 billion USD/ year cannot be slaughtered because of low weight gain; more than 2 billion USD/ year in losses associated with decreased reproductive performance, increased embryo mortality, stillbirths, and calving complications; and more than 1-billion- USD/ year spent combating bovine respiratory diseases (5). Further economic losses occur due to decreased milk production of 7.95 million tons (5 billion USD), increased cell counts of milk, and increased mastitis cases and treatment cost of about 1 billion USD annually (6).The aim of the attached article is to explore the physiological and environmental stressors affecting ruminants and their impact on the animals' overall health, welfare, and productivity. The article discusses how stress influences ruminant physiological processes such as digestion, metabolism, and immunity, and examines how various factors like disease, climate conditions, and management practices contribute to stress. It highlights the significant economic losses incurred due to stress-related reductions in growth, reproduction, and milk production, emphasizing the importance of s

2. *Overview of Ruminant Physiology*

Ruminants are mammals that digest plant-based food by fermenting it in a specialized stomach prior to digestion, which is done by enzymatic hydrolysis (7) .Ruminants are excellent herbivores and have distinctive digestive apparatuses that macerate plant food and ferment it in a multi-compartment stomach before being digested in a relatively simple intestine. Ruminants mostly graze low-energy feeds and have evolved complex adaptive mechanisms and behaviors to utilize these feeds .The ruminant stomach consists of four compartments: the reticulorumen, the omasum, and the abomasum. In the digestive process, the animal ingests the feed, which subsequently enters the rumen and reticulum (8).In these two compartments, saliva is mixed with the feed, and the fermentation of the feed by the reticulo-rumen microorganisms takes place (9).Fermented food particles too large for the omasum are ruminated. Here, dry matter and nutrients are absorbed. The abomasum, like the stomach of rodents and humans, secretes a significant amount of hydrochloric acid and pepsin for further food digestion and protein hydrolysis(10) .Ruminant digestion is stimulated by factors such as a large fiber load, chewing the cud, distension of the reticulo-rumen, and consuming protein and soluble carbohydrates. It is inhibited by stress, anxiety, and destruction of the daily pasture(11) .Once food reaches the reticulo-rumen, it stimulates a cascade of activities and leads to fermentation and digestion involving a diversity of specialized microorganisms. The development and regulation of the microbiota (composed of fungi, bacteria, archaea, and protozoa) is essential for the success of all animals, especially ruminants(12) .Changes in feed composition may affect the balance between the microbiome-host physiology and diet, thus affecting the development and stability of the microbiome and securing homeostasis of the animal's body.

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

2.1. ***Digestive System***

The ruminant digestive system is composed of the forestomach and the glandular stomach, which are the most frequently studied in relation to the mucosal microbiome (13).The forestomach is the primary compartment of the ruminant digestive system and consists of several unique anatomical and functional subcompartments: the rumen, reticulum, and omasum (14).The rumen and reticulum, which are anatomically and functionally interconnected compartments responsible for the initial fermentation and breakdown of feeds in the ruminal community, are strongly developed and nearly symmetrically arranged (reticulo-rumen). The abomasum is the glandular stomach that chemically digests food through digestion aided by gastric juices secreted in response to the hormone gastrin(15) .The microbial community (microbiome) of the ruminant digestive system includes bacteria, archaea, protozoa, and fungi, and it is dependent on the management, species, age, structure and content of the diet, feeding system, and housing(16) .The quantity and quality of feed is the main factor modulating changes in the microbiome and the host because diet is the main energy and nutrient source of the microbiome(17) .The microbiome-host physiology and diet interact to shape the development and stability of the resulting microbiome, which is thought to adaptively balance the competing metabolic and physiological requirements of the host nutrition and health and the microbiome retention and growth (10).The housing system not adapted to the needs of animals is one of the factors disturbing the microflora of the digestive system, which may result in diseases and inadequate development of young ruminants (18).The balance between the microbiome-host physiology and diet directly affects the development and stability of the resulting microbiome, ensuring adequate homeostasis of the animal's body. Stress disrupts the balance of the microbiome-host diet, which affects the development of the microbiome, and action incorporating various measures adapted to the animal can improve the welfare and health of the animal (19).

2.2. ***Metabolic Processes***

Ruminants are particularly adept at metabolic changes that modulate circulating acetate and halt the invasion of excessive proteins to maximize depots of fat (20) .The design feature of the rumen and the large diversity of microbes which dwell within it demonstrates a sophisticated interaction with the animal host. Fungi, protozoa, and bacteria are the major microbial groups of the rumen which live and cooperate with one another (21) .The fatty acids serve as the energy substrates of the animal host while the enzymes of the microbes degrade carbohydrates and proteins to be fermented into fatty acids. Non-esterified fatty acids (NEFAs) are oxidized for energy, mainly via the tricarboxylic acid (TCA) cycle, or incorporated into acyl-CoAs to form lipids such as triacylglycerols and phospholipids(22) .Bacterial peptidases can degrade intermolecular peptide bonds of proteins that are from different polypeptides, which serve as protein builders to form *Streptococcus bovis* Proteins of rendering plants are two-dimensional polypeptide macromolecules composed of numerous close-ended peptide chains, which can be reduced to various sizes of peptide chains(23) .Cattle can spontaneously exercise the freshman reaction to take the portion of one or multiple peptide chains for the formation of replicating peptide chains. Denatured proteins can be readily utilized by rumen microbes. Lactating cows are subjected to metabolic adjustment to allocate nutrients preferentially for milk production while withdrawal of feeds forces mobilization of body fat reserves as energy substrates

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

(24).Stress reduces the utilization of NEFAs and alters nutrient partitioning in tissues, resulting in reduced productive capacities and animal performance. Ruminal acidosis occurs more often with high-grain diets triggering metabolic syndrome and physical and hormonal stress responses (25).Stress affects feed intake, metabolism, and physiology, but the effects could differ depending on the sex of individuals and on the types and intensities of stressors (26).Improving the economic sustainability of cattle production requires a comprehensive understanding of stress and its effects on ruminant physiology and metabolism.

2.3. *Thermoregulation*

In the study of Thermoregulatory Response of Blackbelly Adult Ewes and Female Lambs during the Summer under Tropical Conditions in Southern Mexico (27) .it was reported that the most important parameter to determine the presence of heat stress can be considered to be an increase in Rectal Temperature (RT). When the homeostatic balance is altered, a heat exchange is activated, which is reflected in a change in RT. In this study, the ewes presented changes in their RT by time of day, which could indicate adaptation to Temperature-Humidity Index (THI) values higher than the comfort zone (28).Another physiological parameter under heat stress conditions is an increase in corporal temperature. Animals in heat stress transport heat from inside the body to the skin through blood flow. Average RT (38.26 ± 0.03 °C) showed slightly higher values than those reported for animals in the comfort zone (28) .The RM of ewes under comfort conditions varies from two to three movements every two minutes. In the present study, the values recorded (1.43 ± 0.06 movements/min) were below normal because ewes of hair breeds in heat stress make physiological adjustments by decreasing metabolic activity and feed consumption, simultaneously with an increase in BF. Increases in CRT and RM were observed during the afternoon, when the THI also reached the maximum value. RM is the number of times that the rumen moves in order to mix and process its content (29). However, when feed consumption is reduced by the effect of heat stress and water consumption is increased, these movements can decrease RM frequency(30) .The Capillary Refill Time (CRT) is defined as the time required for the return of pale color to normal pink after the application of pressure on the gingiva. In unhealthy animals, the CRT can indicate poor circulation causing peripheral tissue perfusion. In the present study, the CRT was greater during the afternoon, regardless of the experimental group(31) .This is probably due to the fact that the ewes are stressed during the non-evaporative phase where the blood is in the periphery. Heat stress in ewes is detected through changes in RT and BF. Naturally, RT and THI are higher in the afternoon and, consequently, so are the values of other physiological variables (32) .

3. *Types of Stress in Ruminants*

Stress is the body's reaction to demand. Most stressors can be classified as physiological or environmental. Physiological stressors are associated with health, reproductive, biological, or animal husbandry measures. Such stressors include chronic disease, false pregnancy, calving, lactation, and hormonal through the use of gonadotrophic hormones (33).Management procedures such as marketing, weaning, penning, and traveling also cause physiological stress. Environmental stressors are due to factors such as climate, housing design, social interactions, and surroundings, which can be grouped into thermal, dust, wind, and chemical contaminants(34). Physiological and Environmental Stress in Ruminants. Different stressors affect the

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

productivity, health and welfare of ruminants in different ways or patterns. Environmental stressors often elicit a change in rumen physiology, which is essential for dietary fermentation and nutrient utilisation, hence affecting the animal's overall productivity and health.The general metabolic and physiological consequences of environmental stressors such as heat, cold, humidity, dust, and gas are reviewed here. Adverse or uncomfortably high temperature, high humidity and air movement have raised concern about their effect on the wellbeing of farm animals, especially in tropical and (sub)tropical countries. This concern stems from the anticipated loss of productivity in terms of growth, reproduction, dairy production and meat quality as a result of the adverse impact of environment on the physiological processes which underpins these productive traits(35) .Physiological stress might also involve disease, false pregnancy, calving, lactation, travel, and other management procedures, all of which have been reported to have detrimental effect on ruminant health and productivity. Stressors could also interact together synergistically, producing effects that differ from what would be anticipated from simple addition (36).It is therefore imperative to know the possible effects or implications of different stressors on the productivity and welfare of ruminants in order to manage them effectively. Some examples of the impact of environmental and management stressors on reproduction, growth, milk and meat quality, and general health and welfare are highlighted here for ruminants(37) .

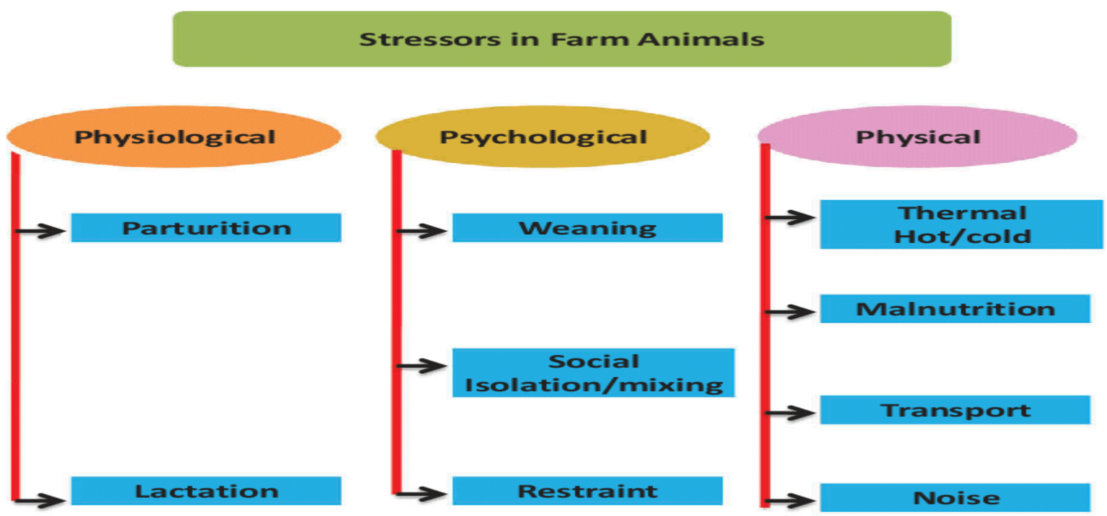

Fig. 1: Classification of various stressors affecting farm animals (38)

3.1. ***Physiological Stress***

A stressor is an event or a situation which causes a stress response. Stress striated muscles is a frightful term, but under physiological or environmental stress, these stress reactions are usual. They are referred to as normal stress responses. However, chronic stress charged exit Olympians performance inhibit rant Syndrome of stressors in individual animal performance (39).Ruminants are susceptible to physiological stress and environmental stress. When these stressors are attentive, the stress response is magnified. The response is

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

indicated in changes in physiology, health, welfare and performance of ruminants. Physiological stress is resistance to the internal environment of the body in darkness of external stressors(40). Adverse environmental stressors like high temperatures or toxic gases make work for ruminants and make an influence their performance. The effects breathing and heart rate as some responses to any experiences of ruminants like increased decoction and sweating to reduce mouth respiration rate (41). Physiological stress responses malfunction or prevent stressors that are potentially harmful. The hypothalamus, a small region of the forebrain situated lower than the thalamus, maintains bodily condiments through the multi-system of brain. The brain detects these stressful signals, and the nodes make work for signals to the pituitary gland and apex to make signal of corticotropins (42). Corticosteroids, environmentally friendly in moderation to plan responses to stress, are circulating sent by the blood. These corticosteroids sting cells of the created glands and perceived hormone response (43) .Gonadal hormone is then unwanted in response to stressors, which insults reproductive performance and other actors of animals. Furthermore, handling stressors like transport, gathering, sale and shipment make work for the stressful reactions in animals. Animals make stress responses like social stressors, predator, fright or disturbance to environmental conditions like high temperatures (44).These stress responses are indicated in releases of the prefrontal gland, which include metabolites and sex steroids like estradiol, testosterone and progesterone. Stress hormones influence the behavior of ruminants by decreasing fertility, messing with performance, disease and health (45).

3.2. ***Environmental Stress***

The environment in which ruminants are raised can be a source of stress for the animals. Stress due to environmental conditions is called environmental stress. Ruminants are generally well adapted to the prevailing conditions in their specific ecology. However, factors such as stressful climatic and management practices can present challenges to their health and productivity (46).

Environmental temperature and humidity, air quality, space allowance per animal, density of livestock, sanitation, arrangement of feeds and water supply, housing type and location, and feeding methods are environmental factors that can influence the physiology, performance and health of the ruminants.It has been noted that there are species differences with regard to the performance response of cattle raised on practically the same tropical pasture fed on the same ration(21) .Physiologically-equally capable animals with the same genotype and age kept in a similar environment, yet managed differently respond differently to heat stress. Social stress that occurs when space per animal is inadequate, leading to scrambles for suet and drink gives the weaker animals little chance to eat (47)**.** In terms of management stress, there are sometimes overt incidences of stress of the order tissue injury during the processing of an animal for production or slaughter, but these occurrences are not under investigation. Most culled and slaughtered ruminants are sent for slaughter immediately after purchase so that factors that would make them go off feed can be minimized(48) .Handling and restraint of hauling stress-causing agents can be decided based on the scale of animal gathering or obvious excursion behaviors such as head shy, clumsy gait, trembling, unrest, and vocalization. Vocalization can be observed when driving on the road or when cattle are crowded into an interview room (49).

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

4. *Impact of Physiological Stress*

There are few biological factors that have a greater direct influence on the physiology and productivity of animals than temperature and water availability. On a global scale, the increase in temperature due to climate change is expected to result in a major reduction in the numbers of livestock produced, with the poorest effects expected in the tropics(50). It is also anticipated that such changes will lead to higher costs of animal food production and food security. While well documented and of increasing significance in the tropics, little research has been done on the effects of increased temperature, relative humidity, and reduced water availability on domestic animal productivity. Throughout history, ruminants and their non-ruminant counterpart have undergone physiological and morphological modifications to combat the effects of environmental constraints(51) .

These are termed adaptive responses. In ruminant livestock rearing regions such as the tropics, an impact of adaptational responses to environmental stressors has been adaptations to hot climates. Farm animals are expected to meet adequate physiological, nutritional, and environmental requirements to perform optimally. Conversely, performance may deteriorate as stressors overwhelm adaptive physiological control mechanisms .It has been recognized that environmental factors such as high ambient temperature, high relative humidity, and inadequate ventilation have a deleterious effect on the physiology, performance, and health of farm animals. Environmental variables deeply affect metabolism, production, reproduction, behaviour, and health of animals. Changes in body temperature and behaviour indicate that animals experience stress in response to environmental restrictions .A reduction in body weight gain, food intake, fertility rates, milk production, and increased mortality are direct indicators of management stress. Cattle and goats exposed to management stressors exhibited strong behavioral stress responses. These are marked by increased ear and tail position activities, changes in aggregation index, and increase in the frequency of browsing and pacing in goats, suggestive of increased cortisol secretion (52).

4.1. *Hormonal Responses*

The hypothalamus-pituitary-adrenal (HPA) axis is often the first physiological response to stressors. Stressors act on the hypothalamic paraventricular nucleus (PVN), increasing its activity and, in turn, the release of corticotropin-releasing hormone (CRH) and arginine-vasopressin (AVP). Additional factors regulating the release of ACTH are the epinephrine and norepinephrine released in the excitatory locus coeruleus (LC), increased levels of visfatin, and sex steroid hormones .Alternatively, some stressors, such as ablation of the thimerosal region, will activate the hypothalamic median eminence to release β-endorphin (BE) that will inhibit the release of corticotropin, from anterior pituitary, and so reduce the activity of the HPA axis.Biologically important stressors enhance renin-angiotensin-aldosterone system (RAAS) activity and directly increase corticosterone (CORT) through angiotensin II (ANGII). Stressors appear to act through altered activity in one or more epidermic populations in the hypothalamus and through distinct mechanisms depending on peptidergic population. Stressors may act to cause rapid changes in the release of substances from neurons and other cells(53).

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

University of Thi-Qar Journal of agricultural research

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

While generally adaptive, an adverse outcome may occur when stressors overwhelm the mechanisms that covary with the HPA system. Temporarily high levels of glucocorticoids are acceptable, but when this chronically occurs, it is termed an allostatic overload (54). The understanding that stressors affect bodily homeostasis in the areas of behavior, autonomic nervous system, neuroendocrine, and immune function has greatly increased. Harsh and prolonged exposure to a stressor may have directional adverse effects. The response of the organ may vary depending on its healing ability and duration of stressor exposure (55).

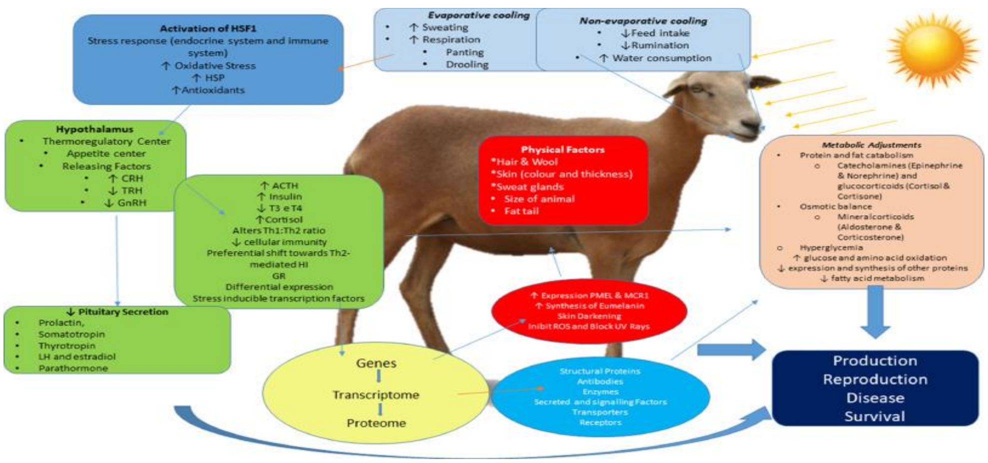

Fig. 2: Pathway of reaction to heat stress in small ruminant (17)

4.2. *Immune Function*

The innate (non-specific) immunity is the first line of defense against a disease, while the adaptive immunity is a defense mechanism that takes a longer time to develop. Depending on the species involved, innate immune cellular response occurs due to the activity of monocytes, macrophages, dendritic cells, and granulocytes, and the cells interact with other mediators like immunoglobulins, add cell and organ products (i.e, cytokines) to modulate inflammation and immunity. The main cells involved in the non-specific (innate) immunity of ruminants are the polymorphonuclear leucocytes (neutrophils) and mononuclear cells (macrophages) (56). Mononuclear cells act strongly in chemotaxis and phagocytosis, their functional state depending on different mediators to which they are exposed. Macrophage activity may be modulated by stress: for instance, the activation of the HPA axis causes an increase in plasma cortisol concentrations, and this has a depressor effect on macrophage cell populations both in humans and in laboratory animals (57).Elevated concentrations of plasma non-esterified fatty acids derived from lipomobilisation are also able to inhibit the proliferation of some lymphocyte sub-populations. In ruminants, stressors may depress the immune functions: a number of studies positively correlated the association of high production level to the incidence of health disorders with depression of some cellular functions (58).

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

Bovine mononuclear cellular function was investigated in vitro in a number of experiments using temperature as a heat stressor. Polyenoic fatty acids exerted an in vitro modulating effect on the phagocytic activity and the production of reactive oxygen species (ROS) in goat neutrophils (59).The phagocytic activity is compatible with an equilibration between of ROS burst and apoptosis in these cells. In bovines, heat stress elicits different responses in peripheral blood mononuclear cells (PBMC) at 39 and at 41°C. Heat shock effects and its interactive effects with some stressors with the capability of activating the stress axis (elevated environmental temperature and the anti-inflammatory peptide apelin) were assessed in bovine PBMC (5). Heat shock impairs DNA synthesis and down-regulates gene expression for leptin and Ob-Rb receptor in bovine PBMC exposed to 41°C. The effects of heat stress on the immune functions in the transition period in dairy cows and the relation of these effects with certain diseases occurring in this period were also reviewed (60)**.**

4.3. ***Reproductive Health***

Stress is known to influence the normal reproductive processes in many mammalian species including ruminants like cattle and sheep during the heat stress (HS) period, follicular development, ovulation, oocyte fertilization, embryonic development, uterine environment, and embryo quality. In ruminants, normal functioning of the reproductive system is essential for the optimum herd fertility and successful breeding programs (61).The reproductive function can be depressed by a variety of factors and is one of the first systems to be affected by any stressor. An increase in fecal glucocorticoid metabolite concentrations measured in non-invasive faecal samples suggests that under HS, there is an increase in cortisol levels which more broadly illustrates that ruminants undergo physiological stress which can affect the reproduction processes in ruminants (62). Physiological (environmental) stress affects reproductive health, specifically the behavior (timing, estrus), physiology (follicular development, ovulation, size), and endocrinology (hormone concentrations) of ruminants. The review describes the wide-ranging impacts of physiological stress on reproductive health in ruminants and ways to mitigate exposure (63). The embryonic development and uterine environment of ruminants can be seriously compromised by HS. Several changes in the uterine environment have been identified due to HS. These include decreased uterine blood flow; decreased leptin concentrations; increased expression of endometrial inflammatory genes, and dysregulation of prostaglandin (PG) and interferon- (IFN-) pathways (24).The uterine microbiome is important in maintaining a healthy endometrium but can also influence fertility. Maternal stress predisposes the reproduction to abnormalities through its effects on the conceptus survival and development. Furthermore, increased mortality of early post-attachment embryos may occur after maternal stress. The involvement of this stress-induced pathway that impacts both the embryo and maternal environment has implications for the efficient management of ruminant reproduction during adverse climatic conditions(64) .Environmental conditions and management of ruminants affect their physiological well-being, productivity, and general health. Stressors must be managed to minimize or eliminate the detrimental effects of hot and humid weather conditions on reproductive performance, growth, feedlot performance, milk production, disease susceptibility, and meat quality(65). Farm animals in the tropics too often experience multiple environmental stressors (heat, humidity, rain, wind, and dust), and changes in management from farming practices can interact with these to cause further stress

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

impacts (27). Ruminants from temperate zones experience serious physiological and metabolic problems when forced to endure the climates of the Tropics. They require a much lower maximum air temperature for evaporative cooling to cope with the high temperature and humidity climates. Their efficiency of water absorption in the tract is limited. When forage or starter intake depresses, these animals enter metabolic stress. Compared to other livestock species, ruminants seem to be more affected under tropical conditions. They are more susceptible to tropical diseases, foot-rot, mastitis, fertility problems, endometritis, and milk fever as a consequence of the stressors (66). Shade or shelter significantly protects farm animals in the tropics. Conventional set-ups inadequately provide shade compared to a more natural feature. A paddock width of 40 m can better facilitate shade than 5 m. Grazing on cooler slopes can be extremely beneficial. Open yards and barns can be cooled with evaporative air coolers. Underutilized Porto and shaded yards and pens need to be assessed and improved (67). Existing shade plants greatly benefit farm animals and should be retained. Which plants help only after damage has occurred needs urgent research. In gain barns or extensive setups, stressful aviary pens with fans and misters may relieve heat stress exposure. Varieties of grasses that stay cool can make farms cooler. Applying urea fertilization to high cationic-pH soils in humid tropics increases plant sodium and modulates tree canopy microclimates. Effective tropical bush-farming management strategies and dash-tanks are needed for shelter against environmental stressors (68).

5.1. *Heat Stress*

Several studies have been conducted to evaluate the physiological consequences of heat stress on the reproductive performance of various classes of livestock, including ruminants (69)**.** This review presents a summary of reproductive indices sensitive to ambient conditions, with a particular emphasis on the research on beef and dairy cattle, swine, sheep, and goats (70). The concept of temperature-humidity index (THI) was developed to describe the suspected thermal effect of temperature and humidity on livestock(71). Architecturally or environmentally controlled systems that require ventilation or air conditioning to maintain proper animal conditions are often designed using THI models. Various studies have examined the thermal state of animals under these conditions, but few have considered the physiological changes in the animals themselves. Performance is the end result of the integration of the physiological, environmental, nutritional, and managerial factors within the species being evaluated. Performance indices could result from direct behavioral or physiological reactions to changing environment. In livestock production systems where ventilation methods rely on natural forces, an understanding of the heat load pattern and physiological response of the species can greatly minimize future loss of production. Reproductive indices of livestock sensitive to ambient temperature and humidity, along with their physiological responses from previous relevant attempts, will be reviewed (44). As ambient temperature exceeds 21ºC, various production limitations can result in unacceptable economic consequences of livestock. Heat stress during late gestation of the dam has been implicated as contributing factor to increased calf mortality, increased culling rates, and decreased milk production of beef cows. In control herds, 85% of fresh cows were successfully dried off as compared with only 32% in the hours after the breakdown. In another study of the same herd, 270 management interventions occurred in 62 days following the breakdown in one silo. Proactive defense measures against the feed system breakdown included: feeding three weeks of feed costs, replacing available

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

high moisture corn, decanting silage into piles prior to freezing conditions, use of an elevator to push feed from a pile into a mix wagon, and securing hay from neighboring producers to stretch rations during repairs (72).

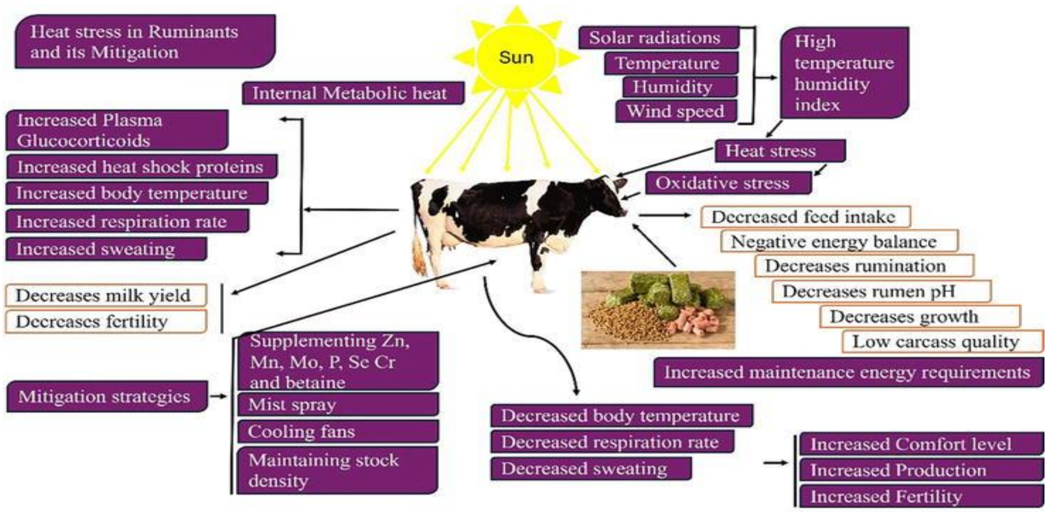

Fig. 3: Heat stress effects in cattle and its modulations (72)

5.2. ***Cold Stress***

Increasing cold stress affects some physiological variables in cattle. Cold stress occurs when the environmental temperature is below the lower critical temperature (LCT) of the animals. Cold stress conditions lead to a decrease in rectal temperature in Bos taurus cattle, while Bos indicus has a more stable rectal temperature. In sheep, a decrease in body temperature due to heat loss due to cold stress is reported (73). Coats of sheep have been observed to be wet after exposure to cold weather conditions, which could be an efficient way to decrease energy expenditure by keeping the core body temperature constant. However, colder temperatures increase rates of shivering which, while inhibiting food intake, also increases metabolic heat production (74). shivering which, while inhibiting food intake, also increases metabolic heat production.The cold stress effect on some metabolic variables in cattle has been investigated. In lambs, exposure to low ambient temperature decreases plasma glucose concentration on the 2nd day but increases on the 7th day of exposure. However, for 40 kg feedlot lambs, there is no difference in plasma glucose concentration on the 1st day between temperature treatments (75). In contrast, on the 30th day, plasma glucose concentrations are higher in thermal neutral conditions compared to cold stress conditions. The inverse is true for plasma glucose on the 30th day, with concentrations being higher in cold stress conditions than in thermal neutral conditions (76). Cattle sweat glands are more efficient than Bos taurus, secreting more sweat fluid per gland and more than Bos taurus, Bos taurus if stressed and capable of sweating, have higher concentrations of calcium after exposure to cold stress, while Bos indicus have a very limited response to

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

stress (77). More research is required for testing the effects of different cold intensities and durations in dairy goats to support limited information on the metabolic status of dairy goats during cold exposure. Adverse effects of excessive cold exposure on feed intake, milk production, milk fat, and somatic cell score have been documented in dairy cows (78)**.** Nevertheless, little information is available on how cold stress affects metabolic variables such as plasma β hydroxy dodecanedioic acid, free fatty acids, non-esterified fatty acids, plasma glucose, and urea nitrogen. The simultaneous determination of these metabolites in blood serum has been studied in cattle (79).

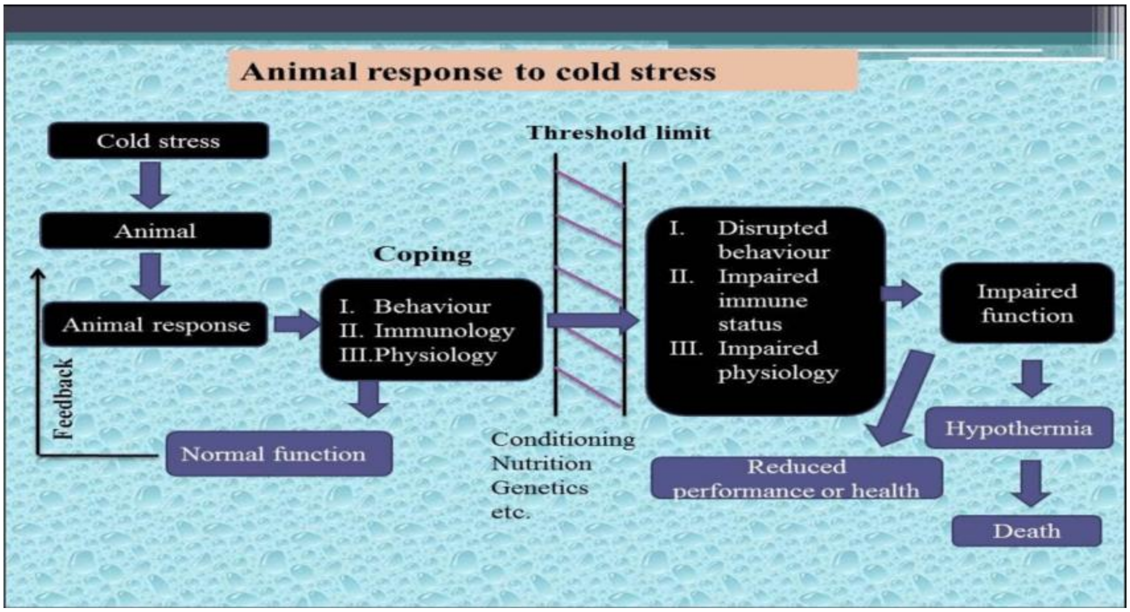

Fig. 4: Diagrammatic representation of animal's response to cold (80)

5.3. Nutritional Stress

Ruminants are well-adapted to poor and variable feed resources; however, they can experience nutritional stress when food availability is severely compromised. Incidental stressors, such as adverse weather conditions and the presence of predators, can compound the effects of limited forage availability and feed quality (81). Nutritional stress in ruminants can elicit direct and indirect physiological responses. When forage quality declines, there is a predictable sequence of resource reaction patterns, including alterations in behavior, intake, and rumen function that, when considered together, form a continuum of potential nutritional stress from mild to severe conditions (82). Mild levels of nutritional stress can lead to altered feeding behaviors while maintaining normal feeding levels. Chronic mild environmental conditions such as increased stocking density can lead to altered distribution of feeding activity while not altering overall levels of feeding activity (83). When resource quality starts to be marginal, foraging and rumination activity can be increased at the expense of rest periods, but intake rates are reduced. An altered gastrointestinal microbial

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

population leads to altered short-chain fatty acid production and microbial protein supply, exacerbating any intake minimization effects and digestive inefficiencies. These physiological changes can result in the compromised productivity of milking or breeding ruminants (34). Fuel supply normally exceeds substrate disposal and utilization, and fatty acids are an important substrate for cellular respiration. However, when exposure to genetically imposed levels of nutritional stress is chronic, the physiological capacity for regulation of metabolism with body lipid oxidation is compromised, leading to chronic subclinical ketosis in dairy cows or increased body condition loss in beef cows. Evidence is presented that the physiological responses of feed-restricted ewes, lambs, and angora goats to short-term restrictive intake at pasture are those expected. Nutritional stress can have economic consequences on farm profitability for marketing rims, ewes, and/or lambs as prime lamb production systems (84).

6. *Behavioral Responses to Stress*

There are a number of strategies that prey species or prey populations employ to avoid predation, several of which have demonstrable animal welfare consequences. In many of these strategies, detecting and assessing the risk of danger may be more important than avoiding detection. Warnings, scream, and alarm calls, often in the form of squeals, yelps, and hollers are very effective ways for prey and predators to communicate without direct confrontation, and promote modification of behavior in order to avoid unwanted interactions. Alarm calls give other members of the flock or herd prior knowledge that enhances survival, while the communication between hunting animals facilitates the catch of prey. Many prey species respond to the proximity of their predator with increased vigilance or alertness. This is often followed by changes in the use of habitat, which may be associated with higher levels of insecurities or risk. Contact with the predator may elicit a number of higher levels of stress. This results from physical changes and psychological changes that develop as coping strategies. Domesticated animals are not exempt from such management procedures and situations. Techniques derived from ethology and animal welfare research are critical to understanding the requirements of an animal for welfare in the farming, slaughter, housing, and transport situations. In traditional practices meat quality was improved by the absence of stressors. However, it is often not appreciated that animals' welfare can alter dramatically in less than a minute (85). Shifting scales from high-med-low levels of determinants, and also distance from farm in space and/or time, affects an animal's welfare as seen from the closer perspective of whom assess it. Biases in averages of welfare measures encountered at such different levels include the onset and looking for herding, slaughter and ex-situ treatment. This gives rise to some long-term statistics of unpicked welfare accidents, which are rare for, and may consequently be fairly regarded as negligible from this distance (86) .

Conclusions Production efficiency of ruminant animals is highly compromised by the immeasurable effect of physiological and environmental stress, especially in the tropics. Routine stresses should, therefore, be monitored and managed by farm supervisors and animal caretakers to minimize its impact on production efficiency and enhance the improvement of the animal protein supply in the tropics.

References:

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

1-Kotsampasi, B., Karatzia, M.A.,Tsiokos, D.,Chadio,S.(2024). Nutritional Strategies to elleviated stress and improve welfare in Dairy Ruminants. *Animals*, 14(17):2573; https://doi.org/10.3390/ani14172573.

2-Sejian, V., Silpa, M. V., Reshma Nair, M. R., Devaraj, C., Krishnan, G., Bagath, M., Chauhan, S. S., Suganthi, R. U., Fonseca, V. F. C., König, S., Gaughan, J. B., Dunshea, F. R., and Bhatta, R. (2021). Heat Stress and Goat Welfare: Adaptation and Production Considerations. *Animals*, 11(4): 1021. https://doi.org/10.3390/ani11041021.

3-Napolitano, F., De Rosa, G., Chay-Canul, A., Álvarez-Macías, A., Pereira, A. M. F., Bragaglio, A., Mora-Medina, P., Rodríguez-González, D., García-Herrera, R., Hernández-Ávalos, I., Domínguez-Oliva, A., Pacelli, C., Sabia, E., Casas-Alvarado, A., Reyes-Sotelo, B., and Braghieri, A. (2023). The Challenge of Global Warming in Water Buffalo Farming: Physiological and Behavioral Aspects and Strategies to Face Heat Stress. *Animals* ,13(19): 3103. https://doi.org/10.3390/ani13193103.

4-Soldado, D., Bessa, R. J. B., and Jerónimo, E. (2021). Condensed Tannins as Antioxidants in Ruminants-Effectiveness and Action Mechanisms to Improve Animal Antioxidant Status and Oxidative Stability of Products. *Animals*.11(11): 3243. https://doi.org/10.3390/ani11113243.

5-St-Pierre, N. R., Cobanov, B., and Schnitkey, G. (2003). Economic losses from heat stress by US livestock industries. Journal of Dairy Science, 86(E. Suppl.), E52–E77. https://doi.org/10.3168/jds.S0022-0302(03)74040-5.

6-Mader T. L. (2014). Bill E. Kunkle Interdisciplinary Beef Symposium: Animal welfare concerns for cattle exposed to adverse environmental conditions. *Journal of animal science*, 92(12): 5319–5324. https://doi.org/10.2527/jas.2014-7950.

7-Steele, M. A., Penner, G. B., Chaucheyras-Durand, F., and Guan, L. L. (2016). Development and physiology of the rumen and the lower gut: Targets for improving gut health. *Journal of dairy science*, 99(6): 4955–4966. https://doi.org/10.3168/jds.2015-10351.

8-Pokhrel, B., and Jiang, H. (2024). Postnatal Growth and Development of the Rumen: Integrating Physiological and Molecular Insights. *Biology*, 13(4): 269. https://doi.org/10.3390/biology13040269.

9-Chilliard, Y., Doreau, M., Veissier, I., and Bocquier, F. (2010). Guest editorial: Ruminant physiology; digestion, metabolism and effects of nutrition on reproduction and welfare. *Animal,* 4(7): 977. https://doi.org/10.1017/S1751731110000959.

10-Liu, Y., Min, Q., Tang, J., Yang, L., Meng, X., Peng, T., and Jiang, M. (2023). Transcriptome profiling in rumen, reticulum, omasum, and abomasum tissues during the developmental transition of pre-ruminant to the ruminant in yaks. *Frontiers in veterinary science*, 10: 1204706. https://doi.org/10.3389/fvets.2023.1204706

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

11-Cholewińska, P., Czyż, K., Nowakowski, P., and Wyrostek, A. (2020). The microbiome of the digestive system of ruminants - a review. *Animal health research reviews*, 21(1): 3–14. https://doi.org/10.1017/S1466252319000069

12-Cholewińska, P., Górniak, W., and Wojnarowski, K. (2021). Impact of selected environmental factors on microbiome of the digestive tract of ruminants. *BMC Vet Res*. 17(1):25. doi: 10.1186/s12917-021-02742-y.

13-Cammack, K. M., Austin, K. J., Lamberson, W. R., Conant, G. C., and Cunningham, H. C. (2018). RUMINANT NUTRITION SYMPOSIUM: Tiny but mighty: the role of the rumen microbes in livestock production. *Journal of animal science*, 96(2): 752–770. https://doi.org/10.1093/jas/skx053.

14-Qianrige, Roh, S., Kim, D. H., Shishido, T., and Ogura, S. I. (2023). Effects of Rumen Fermentation Characteristics on Stress-Related Hormones and Behavior in Sheep. *Animals*, 13(23): 3701. https://doi.org/10.3390/ani13233701.

15-Hatt, J. M., Codron, D., Richter, H., Kircher, P. R., Hummel, J., and Clauss, M. (2021). Preliminary evidence for a forestomach washing mechanism in llamas (Lama glama). *Mamm Biol. 101(6):*941-948. doi: 10.1007/s42991-021-00142-1.

16-Tardiolo, G., La Fauci, D., Riggio, V., Daghio, M., Di Salvo, E., Zumbo, A., and Sutera, A. M. (2025). Gut Microbiota of Ruminants and Monogastric Livestock: An Overview. *Animals,* 15(5): 758. https://doi.org/10.3390/ani15050758

17-McManus, C. M., Lucci, C. M., Maranhão, A. Q., Pimentel, D., Pimentel, F., and Paiva, S. R. (2022). Response to heat stress for small ruminants: Physiological and genetic aspects. *Livestock Science*, 263:105028. https://doi.org/10.1016/j.livsci.2022.105028

18-Jiang, B., Qin, C., Xu, Y., Song, X., Fu, Y., Li, R., Liu, Q., and Shi, D. (2024). Multi-omics reveals the mechanism of rumen microbiome and its metabolome together with host metabolome participating in the regulation of milk production traits in dairy buffaloes. *Frontiers in microbiology*, 15: 1301292. https://doi.org/10.3389/fmicb.2024.1301292

19-Xu, Q., Qiao, Q., Gao, Y., Hou, J., Hu, M., Du, Y., Zhao, K., and Li, X. (2021). Gut Microbiota and Their Role in Health and Metabolic Disease of Dairy Cow. *Frontiers in nutrition*, 8: 701511. https://doi.org/10.3389/fnut.2021.701511.

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

20-Morgavi, D. P., Rathahao-Paris, E., Popova, M., Boccard, J., Nielsen, K. F., and Boudra, H. (2015). Rumen microbial communities influence metabolic phenotypes in lambs. *Frontiers in microbiology*, 6: 1060. https://doi.org/10.3389/fmicb.2015.01060

21-Kim, S. H., Ramos, S. C., Valencia, R. A., Cho, Y. I., and Lee, S. S. (2022). Heat Stress: Effects on Rumen Microbes and Host Physiology, and Strategies to Alleviate the Negative Impacts on Lactating Dairy Cows. *Frontiers in microbiology*, 13: 804562. https://doi.org/10.3389/fmicb.2022.804562.

22-Bionaz, M., Vargas-Bello-Pérez, E., and Busato, S. (2020). Advances in fatty acids nutrition in dairy cows: from gut to cells and effects on performance. *Journal of animal science and biotechnology*, 11(1): 110. https://doi.org/10.1186/s40104-020-00512-8

23-Jin, Y., Fan, Y., Sun, H., Zhang, Y., and Wang, H. (2021). Transcriptome Analysis Reveals Catabolite Control Protein A Regulatory Mechanisms Underlying Glucose-Excess or -Limited Conditions in a Ruminal Bacterium, Streptococcus Bovis. *Frontiers in microbiology*, 12: 767769. https://doi.org/10.3389/fmicb.2021.767769

24-Matthews, C., Crispie, F., Lewis, E., Reid, M., O'Toole, P. W., and Cotter, P. D. (2019). The rumen microbiome: a crucial consideration when optimizing milk and meat production and nitrogen utilization efficiency. *Gut microbes*, 10(2): 115–132. https://doi.org/10.1080/19490976.2018.1505176

25-Hernández, J., Benedito, J. L., Abuelo, A., and Castillo, C. (2014). Ruminal acidosis in feedlot: from a etiology to prevention. *The Scientific World Journal*, 2014: 702572. https://doi.org/10.1155/2014/702572

26-Ellett, M. D., Rhoads, R. P., Hanigan, M. D., Corl, B. A., Perez-Hernandez, G., Parsons, C. L. M., Baumgard, L. H., and Daniels, K. M. (2024). Relationships between gastrointestinal permeability, heat stress, and milk production in lactating dairy cows. *Journal of dairy science*, 107(7): 5190–5203. https://doi.org/10.3168/jds.2023-24043

27-Razzaghi, A., Ghaffari, M. H., and Rico, D. E. (2023). The impact of environmental and nutritional stresses on milk fat synthesis in dairy cows. *Domestic animal endocrinology*, 83: 106784. https://doi.org/10.1016/j.domaniend.2022.106784

28-Antanaitis, R., Džermeikaitė, K., Krištolaitytė, J., Ribelytė, I., Bespalovaitė, A., Bulvičiūtė, D., Palubinskas, G., and Anskienė, L. (2024). The Impacts of Heat Stress on Rumination, Drinking, and Locomotory Behavior, as Registered by Innovative Technologies, and Acid-Base Balance in Fresh Multiparous Dairy Cows. *Animals,* 14(8): 1169. https://doi.org/10.3390/ani14081169

29-Čukić, A., Rakonjac, S., Djoković, R., Cincović, M., Bogosavljević-Bošković, S., Petrović, M., Savić, Ž., Andjušić, L., and Andjelić, B. (2023). Influence of Heat Stress on Body Temperatures Measured by

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

Infrared Thermography, Blood Metabolic Parameters and Its Correlation in Sheep. *Metabolites*, 13(8): 957. https://doi.org/10.3390/metabo13080957

30-Chauhan, S. S., Zhang, M., Osei-Amponsah, R., Clarke, I., Sejian, V., Warner, R., and Dunshea, F. R. (2023). Impact of heat stress on ruminant livestock production and meat quality, and strategies for amelioration. *Animal frontiers*, 13(5): 60–68. https://doi.org/10.1093/af/vfad046

31-Giannone, C., Bovo, M., Ceccarelli, M., Torreggiani, D., and Tassinari, P. (2023). Review of the Heat Stress-Induced Responses in Dairy Cattle. *Animals*, 13(22): 3451. https://doi.org/10.3390/ani13223451

32-Ghassemi Nejad, J., and Sung, K. I. (2017). Behavioral and physiological changes during heat stress in Corriedale ewes exposed to water deprivation. *Journal of animal science and technology*, 59: 13. https://doi.org/10.1186/s40781-017-0140-x

33-Oke, O. E., Uyanga, V., Iyasere, O., Oke, F., Majekodunmi, B., Logunleko, M., Abiona, J., Nwosu, E. U., Abioja, M. O., Daramola, J., and Onagbesan, O. (2021). Environmental stress and livestock productivity in hot-humid tropics: Alleviation and future perspectives. *Journal of Thermal Biology,* 100, 103077. https://doi.org/10.1016/j.jtherbio.2021.103077

34-Dong, X., Chen, J., Zhou, Z., and Hu, R. (2024). Editorial: Nutrition regulation and stress in ruminant. *Frontiers in veterinary science*, 11: 1456709. https://doi.org/10.3389/fvets.2024.1456709

35-Joy, A., Dunshea, F. R., Leury, B. J., Clarke, I. J., DiGiacomo, K., and Chauhan, S. S. (2020). Resilience of Small Ruminants to Climate Change and Increased Environmental Temperature: A Review. *Animals*, 10(5): 867. https://doi.org/10.3390/ani10050867

36-Woo, J. S., Lee, N. K., Lee, H. G., and Park, K. K. (2024). Effects of heat stress on performance, physiological parameters, and blood profiles of early-fattening Hanwoo steers in climate chambers. *Animal bioscience*, 37(1): 142–150. https://doi.org/10.5713/ab.23.0274

37-Kim, W. S., Nejad, J. G., Park, K. K., and Lee, H. G. (2023). Heat Stress Effects on Physiological and Blood Parameters, and Behavior in Early Fattening Stage of Beef Steers. *Animals*, 13(7): 1130. https://doi.org/10.3390/ani13071130

38-Inbaraj, S., Sejian, V., and Ramasamy, S. (2019). Role of environmental stressor-host immune system–pathogen interactions in development of infectious disease in farm animals. *Biological Rhythm Research*, 53(5): 707–724. https://doi.org/10.1080/09291016.2019.1695084

39-Loor, J. J., Lopreiato, V., Palombo, V., and D'Andrea, M. (2023). Physiological impact of amino acids during heat stress in ruminants. *Animal frontiers*, 13(5): 69–80. https://doi.org/10.1093/af/vfad052

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

40-Caceres, S., Moreno, J., Crespo, B., Silvan, G., and Illera, J. C. (2023). Physiological Stress Responses in Cattle Used in the Spanish Rodeo. Animals, 13(16), 2654. https://doi.org/10.3390/ani13162654

41-Horst, E. A., Mayorga, E. J., and Baumgard, L. H. (2025). International Symposium on Ruminant Physiology: Integrating our understanding of stress physiology. *Journal of dairy science*, S0022-0302(25)00076-1.https://doi.org/10.3168/jds.2024-25794

42-Chen, Y., Arsenault, R., Napper, S., and Griebel, P. (2015). Models and Methods to Investigate Acute Stress Responses in Cattle. *Animals* ,5(4): 1268–1295. https://doi.org/10.3390/ani5040411

43-de Kloet, E. R., Karst, H., and Joëls, M. (2008). Corticosteroid hormones in the central stress response: quick-and-slow. *Frontiers in neuroendocrinology*, 29(2): 268–272. https://doi.org/10.1016/j.yfrne.2007.10.002

44-Fernandez-Novo, A., Pérez-Garnelo, S. S., Villagrá, A., Pérez-Villalobos, N., and Astiz, S. (2020). The Effect of Stress on Reproduction and Reproductive Technologies in Beef Cattle-A Review. Animals, 10(11): 2096. https://doi.org/10.3390/ani10112096.

45-Sze, Y., and Brunton, P. J. (2020). Sex, stress and steroids. *The European journal of neuroscience,* 52(1): 2487–2515. https://doi.org/10.1111/ejn.14615

46-Webster A. J. (1983). Environmental stress and the physiology, performance and health of ruminants. *Journal of animal science*, 57(6):1584–1593. https://doi.org/10.2527/jas1983.5761584x

47-Shu, H., Guo, L., Bindelle, J., Fang, T., Xing, M., Sun, F., Chen, X., Zhang, W., and Wang, W. (2022). Evaluation of environmental and physiological indicators in lactating dairy cows exposed to heat stress. *International journal of biometeorology*, 66(6): 1219–1232. https://doi.org/10.1007/s00484-022-02270-w

48-Jurkovich, V., Hejel, P., and Kovács, L. (2024). A Review of the Effects of Stress on Dairy Cattle Behavior. *Animals*, 14(14): 2038. https://doi.org/10.3390/ani14142038

49-Becker, C. A., Collier, R. J., and Stone, A. E. (2020). Invited review: Physiological and behavioral effects of heat stress in dairy cows. *Journal of dairy science*, 103(8): 6751–6770. https://doi.org/10.3168/jds.2019-17929

50-Baumgard, L. H., and Rhoads, R. P. (2012). Ruminant Nutrition Symposium: ruminant production and metabolic responses to heat stress. *Journal of animal science*, 90(6): 1855–1865. https://doi.org/10.2527/jas.2011-4675

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

51-Sun, F., Zhao, Q., Chen, X., Zhao, G., and Gu, X. (2022). Physiological Indicators and Production Performance of Dairy Cows with Tongue Rolling Stereotyped Behavior. *Frontiers in veterinary science*, 9: 840726. https://doi.org/10.3389/fvets.2022.840726

52-Wein, Y., Vaidenfeld, O., Sabastian, C., Bar Shira, E., Mabjeesh, S. J., Tagari, H., and Friedman, A. (2024). The Effect of Environmental Enrichment on Selected Physiological and Immunological Stress-Related Markers in Dairy Goats. *Biology*, 13(11): 859. https://doi.org/10.3390/biology13110859

53- Yaribeygi,H., Panahi,Y., Sahraei,H., Thomas P. Johnston,T.P., Sahebkar,A.(2017). THE IMPACT OF STRESS ON BODY FUNCTION: A REVIEW. EXCLI J, 16:1057-1072. doi: 10.17179/excli2017-480

54-Botía, M., Escribano, D., Martínez-Subiela, S., Tvarijonaviciute, A., Tecles, F., López-Arjona, M., and Cerón, J. J. (2023). Different Types of Glucocorticoids to Evaluate Stress and Welfare in Animals and Humans: General Concepts and Examples of Combined Use. *Metabolites*, 13(1): 106. https://doi.org/10.3390/metabo13010106.

55-Nagel, C., Trenk, L., Aurich, C., Ille, N., Pichler, M., Drillich, M., Pohl, W., and Aurich, J. (2016). Sympathoadrenal balance and physiological stress response in cattle at spontaneous and PGF2α-induced calving. *Theriogenology*, 85(5): 979–985. https://doi.org/10.1016/j.theriogenology.2015.11.009

56-Hulbert, L. E., and Moisá, S. J. (2016). Stress, immunity, and the management of calves. *Journal of dairy science*, 99(4): 3199–3216. https://doi.org/10.3168/jds.2015-10198.

57-Niu, X., Ding, Y., Chen, S., Gooneratne, R., and Ju, X. (2022). Effect of Immune Stress on Growth Performance and Immune Functions of Livestock: Mechanisms and Prevention. *Animals*, 12(7): 909. https://doi.org/10.3390/ani12070909

58-Gupta, S., Sharma, A., Joy, A., Dunshea, F. R., and Chauhan, S. S. (2022). The Impact of Heat Stress on Immune Status of Dairy Cattle and Strategies to Ameliorate the Negative Effects. *Animals*, 13(1): 107. https://doi.org/10.3390/ani13010107.

59-Cartwright, S. L., McKechnie, M., Schmied, J., Livernois, A. M., and Mallard, B. A. (2021). Effect of in-vitro heat stress challenge on the function of blood mononuclear cells from dairy cattle ranked as high, average and low immune responders. *BMC veterinary research*, 17(1): 233. https://doi.org/10.1186/s12917-021-02940-8

60-Velichko, A. K., Petrova, N. V., Kantidze, O. L., and Razin, S. V. (2012). Dual effect of heat shock on DNA replication and genome integrity. *Molecular biology of the cell*, 23(17): 3450–3460. https://doi.org/10.1091/mbc.E11-12-1009.

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

61-Hansen P. J. (2019). Reproductive physiology of the heat-stressed dairy cow: implications for fertility and assisted reproduction. *Animal reproduction*, 16(3): 497–507. https://doi.org/10.21451/1984-3143-AR2019-0053

62-Dobson, H., and Smith, R. F. (1995). Stress and reproduction in farm animals. *J Reprod Fertil Suppl*. 49: 451–461.

63-Dovolou, E., Giannoulis, T., Nanas, I., and Amiridis, G. S. (2023). Heat Stress: A Serious Disruptor of the Reproductive Physiology of Dairy Cows. *Animals,* 13(11):1846. https://doi.org/10.3390/ani13111846

64-Song, P., Liu, C., Sun, M., Liu, J., Lin, P., Wang, A., and Jin, Y. (2022). Oxidative Stress Induces Bovine Endometrial Epithelial Cell Damage through Mitochondria-Dependent Pathways. *Animals*, 12(18): 2444. https://doi.org/10.3390/ani12182444.

65-Habeeb, A. A., Osman, S. F., Teama, F. E. I., and Gad, A. E. (2023). The detrimental impact of high environmental temperature on physiological response, growth, milk production, and reproductive efficiency of ruminants. *Tropical animal health and production*, 55(6): 388. https://doi.org/10.1007/s11250-023-03805-y

66-Morrison, S. R. (1983). Ruminant heat stress: effect on production and means of alleviation. *Journal of animal science*, 57(6): 1594–1600. https://doi.org/10.2527/jas1983.5761594x.

67-Das, R., Sailo, L., Verma, N., Bharti, P., Saikia, J., Imtiwati, and Kumar, R. (2016). Impact of heat stress on health and performance of dairy animals: A review. *Veterinary world*, 9(3): 260–268. https://doi.org/10.14202/vetworld.2016.260-268

68-Wrzecińska, M., Czerniawska-Piątkowska, E., and Kowalczyk, A. (2021). The impact of stress and selected environmental factors on cows' reproduction. *Journal of Applied Animal Research*, 49(1): 318–323. https://doi.org/10.1080/09712119.2021.1960842

69-Khan, I., Mesalam, A., Heo, Y. S., Lee, S. H., Nabi, G., and Kong, I. K. (2023). Heat Stress as a Barrier to Successful Reproduction and Potential Alleviation Strategies in Cattle. *Animals,* 13(14): 2359. https://doi.org/10.3390/ani13142359

70-Salihi, A., and Alsaadi, S. (2025). Effect of Spirulina Algae Powder and Folic Acid on Some Physiological Parameters During the Early Stages of Local ewe's Pregnancy in the Summer. *Egyptian Journal of Veterinary Sciences,* 56(7):1507-1512. doi: 10.21608/ejvs.2024.283832.2019

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383

https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

71-Nam, K. T., Choi, N., Na, Y., and Choi, Y. (2024). Effect of the Temperature-Humidity Index on the Productivity of Dairy Cows and the Correlation between the Temperature-Humidity Index and Rumen Temperature Using a Rumen Sensor. Animals, 14(19): 2848. https://doi.org/10.3390/ani14192848

72-Kausar, R. and Imran, S. (2024). Heat Stress Mitigation through Feeding and Nutritional Interventions in Ruminants. In book: Latest Scientific Findings in Ruminant Nutrition - Research for Practical Implementation [Working Title]. DOI: 10.5772/intechopen.1005594

73-Wang, S., Li, Q., Peng, J., and Niu, H. (2023). Effects of Long-Term Cold Stress on Growth Performance, Behavior, Physiological Parameters, and Energy Metabolism in Growing Beef Cattle. *Animals*, 13(10): 1619. https://doi.org/10.3390/ani13101619.

74-Young, B. A. (1981). Cold stress as it affects animal production. *Journal of animal science*, 52(1): 154–163. https://doi.org/10.2527/jas1981.521154x

75-Tüfekci, H., and Sejian, V. (2023). Stress Factors and Their Effects on Productivity in Sheep. *Animals*, 13(17): 2769. https://doi.org/10.3390/ani13172769.

76-Kasim, H. (2023a). Effect of Adding Omega-3 to Ration on Production and Physiological Performance of Awassi Ewes during Winter Season. *Egyptian Journal of Veterinary Sciences,* 54(4): 621-629. doi: 10.21608/ejvs.2023.199515.1461.

77-Kim, W. S., Ghassemi Nejad, J., and Lee, H. G. (2023). Impact of Cold Stress on Physiological, Endocrinological, Immunological, Metabolic, and Behavioral Changes of Beef Cattle at Different Stages of Growth. Animals,13(6): 1073. https://doi.org/10.3390/ani13061073

78-Broucek, J., Letkovicová, M., and Kovalcuj, K. (1991). Estimation of cold stress effect on dairy cows. *International journal of biometeorology*, 35(1): 29–32. https://doi.org/10.1007/BF01040960

79-Hu, L., Brito, L. F., Abbas, Z., Sammad, A., Kang, L., Wang, D., Wu, H., Liu, A., Qi, G., Zhao, M., Wang, Y., and Xu, Q. (2021). Investigating the Short-Term Effects of Cold Stress on Metabolite Responses and Metabolic Pathways in Inner-Mongolia Sanhe Cattle. Animals, 11(9): 2493. https://doi.org/10.3390/ani11092493.

80-Manzoor, A., Maqbool, I., Ganaie, Z.A., Afzal, I., Khan, H.M .and Zaffe, B. (2019). Mitigating winter vagaries in dairy animals: A review. International Journal of Veterinary Sciences and Animal Husbandry.4(1): 01-05. https://www.researchgate.net/publication/331224607

81-Alsaadi, S. A. A. and Abass, K. S., (2020). Benincasa hispida is an antioxidant of possible physiological importance: a comparative review. *Plant Archives*, 20(2): 2833–2838.

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 362-383
https://iasj.rdd.edu.iq/journals/journal/issue/18682 https://doi.org/10.54174/utjagr.v13i1.323

82-Freestone, P., and Lyte, M. (2010). Stress and microbial endocrinology: prospects for ruminant nutrition. *Animal*, 4(7): 1248–1257. https://doi.org/10.1017/S1751731110000674.

83-Alsaadi, S. A. R., Abdulazeez, S. T. and NOAMAN, H. A., (2025). The Bio-physiological Impact of Different Concentrations of Ginger Aqueous Extract in Awassi Ewes. *Egypt. J. Veter- Sci.* 56: 1099–1104, https://doi.org/10.21608/ejvs.2024.279035.1965.

84-Ibrahim, N. A., Alimon, A. R., Yaakub, H., Samsudin, A. A., Candyrine, S. C. L., Wan Mohamed, W. N., Md Noh, A., Fuat, M. A., and Mookiah, S. (2021). Effects of vegetable oil supplementation on rumen fermentation and microbial population in ruminant: a review. *Tropical animal health and production*, 53(4): 422. https://doi.org/10.1007/s11250-021-02863-4

85-Grandin, T., and Shivley, C. (2015). How Farm Animals React and Perceive Stressful Situations Such As Handling, Restraint, and Transport. *Animals*, 5(4): 1233–1251. https://doi.org/10.3390/ani5040409.

86-Ghasemi, F., Beversdorf, D. Q., and Herman, K. C. (2024). Stress and stress responses: A narrative literature review from physiological mechanisms to intervention approaches. *Journal of Pacific Rim Psychology*, 18:2024. https://doi.org/10.1177/18344909241289222 .

UTJagr This is an open access article under the CC-BY-NC-SA license (https://creativecommons.org/licenses/by-nc-sa/4.0/)