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Review Article

Climate Change - Impact on Poultry Production

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Abstract

Climate change is one of the most serious problems facing the world today, and it is mostly driven by greenhouse gas emissions, which produce warming of the atmosphere and represent a threat to agriculture, socioeconomic development, and feed sustainability. Poultry production is one aspect of agriculture that has been significantly influenced by climate change. Climate change has an impact on poultry birds because of the range in thermal conditions, which affects the animal's physiological and behavioural activity. Poultry production is most effective when the temperature is comfortable. Understanding how to manage environmental conditions is critical to effective poultry production and welfare. Current poultry production practices include large numbers of birds reared together, making them more prone to heat stress. Heat stress not only causes inconvenience and a high mortality rate for birds, but it also leads to poorer or lost production, reducing profitability. Climate change has an impact on the following aspects of poultry production: meat and egg production and quality, a decrease in reproductive and immunological response and disease outbreaks. Furthermore, mitigation is crucial for reducing the future impacts of climate change, and there are a number of possible strategies. The study aims to review the impact of heat stress on poultry productivity and suggest mitigation techniques.

Keywords: Climate Change; Poultry Production; Heat Stress; Impacts; Mitigations

Introduction

Climate change and global warming have affected numerous countries in recent decades as a result of greenhouse gas (GHG) emissions such as water vapor (H2O), carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). Climate change has an impact on poultry birds because of the range in thermal conditions, which affects the bird's physiological and behavioural activities. Production in poultry birds is typically at its peak in bearable heat conditions [1]. The adverse impacts of increased environmental temperature due to climate change on the poultry industry include lower feed intake, weight gain, and meat quality in broilers, as well as low egg production and egg quality, an increase in feed conversion ratio, and a high mortality rate in laying hens. Climate change may also affect feed grain supply and disease transmission [2,3].

An increase in global average surface temperature might have several effects on livestock production, including changes in the production and quality of feed crops and pasture, as well as biodiversity, water availability, and animal health, growth, and reproduction. As a result, the purpose of this article is to discuss some of the effects of heat stress on poultry and to look into measures to reduce the influence of climate change on poultry production.

Thermoregulatory mechanism of poultry birds

Domesticated gallinaceous birds (chickens) have significantly higher internal body temperatures (106°F to 108°F) than mammals (97°F to 102°F) [4]. The dry season, when daily temperature reach extremes, has a significant impact on poultry output. Poultry are not well suited to high ambient air temperatures because they lack sweat glands in their skin and hence do not benefit greatly from natural evaporative cooling, though there is some direct diffusion of water through the skin tissue. Only the head appendages (e.g., comb) are densely packed with blood arteries and can serve as direct heat loss sites, implying that chickens have few alternatives for heat removal in warm temperatures. Domestic poultry is clearly less tolerant of heat than cold, and it is much more likely to die from heat stress (hyperthermia) than from stress caused by low temperature (hypothermia). They must dissipate heat in different ways to keep their body temperature around 105°F. Radiation, conduction, convection, and evaporation all help to remove body heat into the surrounding environment [5]. The quantities of heat lost owing to seasonal changes depend on the temperature difference between the bird and its surroundings [6]. The goal of poultry house ventilation is to maintain a high or low air velocity in the house so that the birds can regulate their body temperature via heat loss.

Response of heat stress in poultry

Behavioural response

As the ambient temperature rises, chickens spend more time drinking than eating, spreading their wings to regulate their body temperature, walking less and sleeping more [6]. The birds begin to adjust their activity in order to facilitate heat exchange or to eliminate surplus heat, which has an impact on productivity. The birds get fatigued, lose hunger, and begin to withdraw their wings from their bodies in order to expel excess heat through water vapor. They seek out secluded areas with the lowest temperatures and stick to cold joints. This is exacerbated if the temperature rises in tandem with the humidity, as it now does in our country. As a result, the bird's ability to evaporate decreases, increasing the risk of overheating. Birds also use physiological channels, such as the conversion and flow of blood from internal organs to skin [7]. When the temperature falls below 29 °C, the bird's thermal capacity drops, resulting in a decrease in feed conversion efficiency. Large and overweight birds are more susceptible to stress and mortality than smaller birds. The optimal range of the bird begins to conduct many mechanical procedures to keep its temperature constant and can be explained below

- Birds try to move away from each other.
- Move to cold surfaces, such as walls or places with air masses and cold currents.
- Remove the wings from the body to reduce the insulation and stripping any areas of the skin without feathers.
- Reduce the temperature of the fatty cover under the skin.
- The flow of blood to the skin of the limbs, especially comb and wattles.
- Reduce movement and reduce food consumption.
- Increasing water consumption.
- Eliminate excess heat through intense panting.

Physiological response

When the temperature changes, poultry birds have many physiological changes that allow them to alter their thermal balance to the surroundings [8]. The optimal temperature range for laying hens is 20 to 24 °C, and 18 to 20 °C for broilers. Chickens' body temperatures began to rise when the ambient temperature exceeded 30 °C, especially if the rate of increase was rapid. The physiological response to heat stress in birds involves the functional integration of multiple organs to meet the metabolic needs of birds attempting to disperse heat and maintain equilibrium. The chicken response involves heightened activity of the hypothalamus, pituitary gland, and adrenal gland. A series of physiological steps to counteract this stress begin by increasing the rate of breathing from 250 to 260 times per minute, resulting in huge levels of carbon dioxide and hence bicarbonate in blood plasma [9]. In turn, the decreased concentration of hydrogen ions causes an increase in plasma pH, a condition known as alkalosis. The hypothalamus begins to encourage the secretion of hormones that suppress urinary incontinence, and the urine becomes waterer. Corticosteroids are also released, which causes electrolyte, sodium, potassium, and bicarbonate losses. Some organs, including the brain and circulatory system, are also damaged, increasing the strain on the heart and blood arteries. The rate of urine incontinence is determined by water consumption. Finally, bird's immunity is greatly weakened, particularly the reduction of immunoglobulin in the blood, making the flock more susceptible to disease. All previous manifestations of high temperature have an impact on the flock, causing symptoms such as bird swings with peripheral spasms, low body weight, increased predation disease, decreased egg production, decreased cortex quality, decreased fertility and poor semen quality and in severe cases even death. Many studies have shown that birds can adapt to heat stress and their tolerance to this burden as well as low mortality, if exposed to high temperatures early in life, and this adaptation is reflected in increased rates of fatigue, low body weight and a lack of water lost by evaporation, depending on a variety of factors such as strain type, average body weight, quantity of drinking water available, and quantity of production.

Immune response

The immune system's functions are broadly characterized as (i) innate immunity and

(ii) adaptive immunity. Innate immunity is the germ line's non-specific, first line of defense against invading diseases. Antimicrobial components found in mucosa, perspiration, tears, saliva, and other body fluids prevent bacteria from entering the body for the first time. Heat stress directly or indirectly promotes illness incidence in animal hosts. Directly high temperatures promote the long-term survival of organisms outside their host. Chronic heat stress indirectly suppresses bird's immune system making them more prone to disease. Heat stress lowers the relative weight of lymphoid organs such as the spleen, thymus, and cloacal bursa. This could be attributed to glucocorticoid-induced lympholysis and redistribution of lymphocytes from systemic circulation to other tissues. natural killer cells are key components of the innate immune system, found in both systemic circulation and lymphoid tissues such as lymph nodes, spleen, and bone marrow. They are involved in the killing of tumor cells and infectious organisms such as bacteria, fungus, and viruses. Chronic heat stress lowers the cytotoxic activity of splenic natural killer cells. The inhibition could be due to increased glucocorticoid effect in immune cells [10]. Heat stress alters immunological functioning through cytokine interactions. Stress-induced glucocorticoids suppress pro-inflammatory cytokines, which are essential to activate an innate immune response via the inhibitory route. Heat stress activates the hypothalamic-pituitary adrenal axis, which then releases glucocorticoids. Glucocorticoids, in their natural pulsatile release, stimulate the release of pro- inflammatory cytokines. However, a persistent elevation in glucocorticoid levels inhibits the majority of immune cytokines. The stress-related immune responses in poultry species demonstrated that acute stress is advantageous to both the bird and its immune system. Chronic stress lowers the immune response by shifting the T helper cell response to T regulatory cells and producing TGF-β, a regulatory cytokine [11].

Effects of heat stress on poultry

The rapid development of poultry production in many countries with warm climates has increased interest in studying the impact of environmental temperature as one of the consequences of climate change on poultry production, which is one of the most serious problems that can arise because it is the most important need for poultry. The growth achieved in the quality and quantity of bird production is dependent not only on the capabilities of the genetic and food quality provided to the birds, but also on the environmental factors surrounding it, which have a negative impact on productivity and the economic benefits envisaged. As a result, air temperature is regarded as one of the most critical external environmental elements, influencing the physiological, reproductive, and productive status of birds and creating ongoing stress. Birds exposed to high ambient temperatures develop behavioral, physiological, and immunological reactions that negatively impact their performance and productivity. A hot temperature can have a negative impact on chicken pperformance, resulting in heavy economic losses in poultry production due to stunted growth a decline in hen-day productivity [12], higher production costs, increased mortality due to weakened immunity and reproductive failure [13].

Meat production and meat quality

Climate change is characterised by a change in rainfall pattern and an increase in temperature. When there is a decrease in temperature due to an increase in rainfall, birds require more energy to maintain body temperature; however, when there is an increase in temperature, birds' energy and fat requirements reduce [14]. Heat stress reduces development rate and productivity due to a decrease in voluntary meal intake in birds [15]. It is clear that the reduction of growth and output in heat-stressed broiler birds is mediated by stress hormones, particularly corticosteroids. Climate change leads to decreased feed consumption and increased water usage. As the temperature rises, the bird must maintain a balance of heat production and heat loss, minimizing its feed intake. to minimize the heat generated by metabolism. Imik., *et al*., [16] revealed that climate change causes poor growth performance in broilers. The increase in temperature reduces glycerine and proline in carcass tissue. Heat-stressed bird carcasses exhibit coloration, dry muscle, increased blood density, and roughness of the skin [14]. Chronic heat exposure has been shown to have a deleterious impact on fat deposition and meat quality in broilers, which varies by breed [17]. Recent research indicated that heat stress is connected with a reduction in meat quality and chemical composition in broilers [18].

Egg production and egg quality

When the temperature becomes unbearable for the birds, heat stroke can develop, resulting in culling and mortality of the birds, consequently limiting egg output per laying flock [19]. A rise in ambient temperature considerably lowered the hen-day egg output of the heat- stressed flock [20]. Egg quality, both internal and external, has been observed to be altered by temperature owing to climate change, which can be ascribed to an imbalance in calcium- estrogen and decreased Haugh unit of the albumen [21,22]. Elevated environmental temperature reduced yolk size, ideal calcium deposit in the egg shell, and albumen consistency [21].

Reproductive performance

Climate change leads to lower production performance, reduced eggshell thickness, and increased egg-breaking [23]. Furthermore, climate change has been observed to induce a considerable decrease in egg weight (3.24%), eggshell thickness (1.2%), eggshell weight (9.93%), and eggshell percent (0.66%) [17]. Climate changes affect all stages of semen generation in breeder cocks [24]. Even though restricted high temperature promotes testicular growth in the early stages and promotes increased semen volume and concentration, a subsequent rise reduces reproductive capacity due to a decrease in seminiferous epithelial cell differentiation, which manifests itself in decreased semen quality and quantity over time

[25]. Ahaotu., *et al*., [26] observed that the fertility of broiler males decreased to 42% when exposed to a temperature of 32°C. Uzoma., *et al*., [17] demonstrated that due to climate change viable eggs during incubation resulted in differential tissue growth at various phases of incubation. The findings also revealed asymmetries in bone development in the early and late stages of embryo development. High ambient temperatures reduce egg fertility, hatchability, and chick quality in breeder stocks [19]. Climate change will have an impact on the synthesis and release of reproductive hormones (FSH, LH, progesterone, estrogen, and testosterone), resulting in a decline in the effectiveness of male gametogenesis (spermatogenesis) and female (oogenesis) in birds [27,28]. Heat-stressed cocks produce poor sperm concentration and quality. Immunity of the bird is decreased in heat stress circumstances [39].

Disease outbreak

Uzoma., *et al*., [17] observed that high temperatures have a significant impact on the occurrence of zoonotic diseases. Climate change may potentially increase insect vectors, lengthen transmission cycles, and boost the immigration of vectors and animals. According to Guis., *et al*., [30] reports, climate change will alter global disease distribution. Elijah and Adedapo [31]. reported also that climate change has also been affecting chicken feed consumption and disease outbreaks, which in turn affect poultry output (egg and meat) and production costs. Though, Gilbert., *et al*., [32] discovered that climate change factors had a direct effect on highly virulent avian influenza transmission and persistence in domestic birds, allowing for inferences regarding potential effects. Climate change and population growth have resulted in food-feed competition, which raises another problem about poultry production.

Immunity

In recent years, various research in poultry has looked into the effects of climate change on immunological response. Overall, all investigations found that seasonal changes suppressed the immune systems of broilers and laying hens. Lower relative weights of the thymus and spleen have been identified in laying hens subjected to seasonal variations. Additionally, reduced lymphoid organ weights and liver weights have been recorded in broilers under climate change situations [33]. Decreased lymphoid organ weights have also been documented in broilers exposed to heat stress conditions. Broilers exposed to heat stress had lower levels of total circulating antibodies, as well as lower specific IgM and IgG levels [34].

Scarcity of poultry feed resource

Poultry producers depend heavily on cereal grains such as soybeans, maize, and sorghum; nevertheless, the availability of these feed grains to chicken farmers has been significantly hampered by climate change. This has increased strain on the poultry industry in the tropics. Due to changes in the pattern of rainfall and increase in temperature, the planting season has invariably been adjusted, affecting the production and availability of these grains to poultry farmers as needed [35]. Likewise, according to the Rosenzweig., *et al*., [36] reports, climate change is having a greater negative impact on crop output. The substitution of grains in animal feeding systems contributes significantly to the resolution of food-feed competition. Similarly, Hinrichs and Steinfeld [37] noted that the worldwide poultry industries have faced competition for feed components. Furthermore, the authors argued that feed competition necessitates the search for alternate feed sources, including by-products. The use of these by- products will fill feed availability gaps. According to Schnepf [38] observations, Feed cost rises have outpaced animal price increases, reducing the profitability of livestock and poultry producers in the United States, while feed grain demand has surpassed output.

Mitigations to overcome heat stress

- Proper ventilation: Ensure adequate ventilation in poultry houses to reduce heat buildup. Installing fans and exhaust systems can facilitate air circulation, helping to dissipate heat and maintain a comfortable environment for the birds.
- Water management: Implement efficient water management strategies such as providing cool, clean water at all times. Additionally, using evaporative cooling systems or misters can help lower ambient temperatures in the poultry house.
- Shade structures: Erect shade structures over outdoor areas where birds are kept to provide relief from direct sunlight. Natural shade from trees or artificial structures like awnings can significantly reduce heat stress.
- Dietary adjustments: Modify the birds' diet during hot weather by reducing feed intake or incorporating additives like electrolytes to help maintain hydration and electrolyte balance.
- Cooling pads: Install cooling pads or wetting systems in the poultry house to provide evaporative cooling. These systems can help lower the temperature and create a more comfortable environment for the birds.

- Timely management Practices: Schedule activities such as feeding, handling, and medication administration during cooler parts of the day to minimize stress on the birds during peak heat periods.
- Proper stocking density: Avoid overcrowding in poultry houses, as it can exacerbate heat stress. Maintain appropriate stocking densities to allow for better air circulation and reduce competition for resources.
- Monitoring and early detection: Regularly monitor bird behavior and health indicators such as panting, wing spreading, and reduced feed intake, which are signs of heat stress. Early detection allows for prompt intervention to mitigate the effects.
- Heat stress protocols: Develop and implement comprehensive heat stress management protocols that outline specific actions to take during hot weather conditions. Train staff on these protocols to ensure timely and effective implementation.
- Emergency preparedness: Have contingency plans in place for extreme heat events, including access to emergency cooling methods such as portable fans or misting systems, and protocols for relocating birds if necessary.

Conclusion

High summer temperatures have a greater impact on chicken production efficiency. Climate change has always had a negative impact on poultry production. Heat stress is one of the most significant environmental stressor affecting chicken production worldwide. Heat stress has a variety of adverse effects on broilers and laying hens, including lower growth and egg production as well as reduced chicken and egg quality and safety. However, a major reason for worry should be the deleterious impact of heat stress on poultry welfare. Climate change- related stress in birds can be reduced by using appropriate management practices. The plan should begin with the construction of sheds and includes feeding, disease prevention, and other management options in the future.

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