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Climate Change affecting the Livestock Production

Sandeep Singh[1], Simran kaur[2] and Santosh Kumar[3]
[1]Ph.D. Research Scholar, Department of Animal Production, Rajasthan College of Agriculture, MPUAT, Udaipur -313001
[2]M. Sc. Scholar, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur -313001
[3]M. Sc. Scholar, Department of Plant Pathology, Rajasthan College of Agriculture, MPUAT, Udaipur -313001

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Abstract:

Globally, the climate is changing, and this has implications for livestock. Climate affects livestock growth rates, milk and egg production, reproductive performance, morbidity, and mortality, along with feed supply. Simultaneously, livestock is a climate change driver, generating 14.5% of total anthropogenic Greenhouse Gas (GHG) emissions. Climate change may manifest itself as rapid changes in climate in the short term (a couple of years) or more subtle changes over decades. The ability of livestock to adapt to a climatic change is dependent on a number of factors. Acute challenges are very different to chronic long-term challenges, and in addition animal responses to acute or chronic stress are also very different. The extents to which animals are able to adapt are primarily limited by physiological and genetic constraints. Animal adaptation then becomes an important issue when trying to understand animal responses. The focus of animal response should be on adaptation and management. Adaptation to prolonged stressors will most likely be accompanied by a production loss, and input costs may also increase.

Keywords: livestock production; adaptation; mitigation

Introduction

Livestock products and services play an important role for humans. Globally, livestock occupy about 26% of the ice-free land with one-third of the cropland being used for feed production. Livestock production generates nearly 40% of global agricultural gross domestic product (GDP). Livestock provide 33% of the global protein and 17% of the global calories consumed. Production creates substantial employment opportunities for rural households. Additionally, livestock are a major provider of food, nutritional security, livelihood, and income in developing countries.

The interaction between ongoing climate change and demands for increasing livestock production makes it challenging to increase production while lowering climate impacts and Greenhouse Gas (GHG) emissions. Addressing such challenges requires an understanding of climate change effects on livestock production, as well as the effect of both adaptation and mitigation actions.

Impact of Climate Change on Livestock Production

The climate is changing, exhibiting higher temperatures, increasing precipitation variation, and more frequent extremes. This is driven by increasing carbon dioxide (CO2) concentrations. Such changes have been found to alter livestock and associated feed production. We will follow Collier and broadly divide the impacts into direct and indirect effects: Direct effects refer to climate and CO2 impacts on livestock thermoregulation, metabolism, immune system function, and production. Indirect effects derive from the influence of climate on feed production, water availability, and pest/pathogen populations.

1. Direct Effects

The thermal environment is the major climatic factor that affects animal production. This involves a combination of air temperature, humidity, and air movement [9]. The relationship describing the best conditions of these is often referred to as the thermal comfort zone. In this zone, animals exhibit optimum performance and minimal energy expenditure. When conditions rise above this zone, extra energy is required to maintain thermoregulation and production processes become less effective. Animals suffer from thermal stress when the environmental temperature deviates outside the thermal comfort zone. The phenotypic response of animals to an individual source of stress can be called acclimation.

Heat stress is more problematic and has a greater effect than cold stress. Climate change is also almost certainly increasing temperatures and, in association, increasing heat stress and lowering cold stress. Therefore, heat stress has been the dominant topic within the discussion of thermal stress. Heat stress has been found to have negative effects on livestock. The estimated annual U.S. livestock industry loss caused by heat stress falls between $1.7 and $2.4 billion. Heat stress occurs when animals are not able to dissipate sufficient heat to keep homeothermy. This has been found to lead to increased respiration, pulse, and heart rate, along with increased body temperatures. In turn, this can result in reduced feed intake, milk production, and reproduction efficiency, as well as changes in mortality and immune system function. Below, we discuss these impacts in more detail, with emphasis on animal performance rather than underlying biological mechanisms.

1.1. Feed Intake

Reduced feed intake is one response to high environmental temperatures. Ruminants experience reduced appetite, gut motility, and rumination under increased heat stress. Lactating dairy cows exhibit a reduction in feed intake as ambient temperatures rise above 25–26 ◦C and show more rapid declines above 30 ◦C. Goats are less susceptible to heat stress than other ruminants. However, their voluntary feed intake declines when the ambient temperature is more than 10 ◦C above their thermal comfort zone.

Hogs exposed to heat stress exhibit increased body temperature, and their feed intake decreases by 10.9% when temperatures increase from 20 to 35 ◦C. Such impacts persist beyond the period when the hogs are exposed to heat stress. Hence it is suggested that feeding in early morning hours could help avoid reduced feed intake.

Poultry animals also exhibit reduced feed intake when exposed to high temperatures. An increase in ambient temperature from 21.1 to 32.2 ◦C has been found to lead to a 9.5% drop in feed intake for birds from the post-hatch period to 6 weeks of age. The reduction in feed intake causes decreased feed conversion efficiency and daily weight gain.

More generally, across all the livestock types, heat-stress-related decreased feed intake leads to decreased milk, meat, and egg production, which in turn leads to further sectoral losses.

1.2. Animal Production:

Milk and Others Studies indicate that the dairy industry suffers greater heat-stress-related economic loss than does the other U.S. livestock sectors. Under heat stress, dairy cows reduce feed dry matter intake and this explains approximately 35% of the decrease in milk production. Meanwhile, as high-producing dairy cows are larger and emit more metabolic heat than lower-producing breeds, the most productive breeds exhibit more sensitivity to heat stress. As a consequence, milk production declines as heat-stress-caused metabolic heat production increases. In addition to milk production, hot and humid environments also affect milk composition.

Meat production has been found to be affected by heat stress for all major commercial livestock types. Heat-stressed ruminants exhibit reduced body size, carcass weight, and fat thickness and lower meat quality. Small ruminants, such as goats and sheep, have been found to be more adapted to a hot and humid environment. However, feedlot cattle have been found to be more vulnerable due to their being raised with greater exposure to rough radiant surfaces and fed high-energy diets.

Similar to ruminants, hogs exhibit reduced carcass weight and meat quality when exposed to a high temperature. Under high ambient temperature, they have also been found to exhibit reduced average daily gain of 9.8% when compared to thermo-neutral animals.

Chickens exposed to heat stress increase energy expenditure to maintain thermo-neutral conditions at the expense of growth. Heat-stressed broilers exhibit reduced weight gain, feed conversion rates, protein concentration, and breast muscle weight. For laying hens, egg shell strength, daily feed intake, egg mass, and egg production are more sensitive to heat stress compared to other traits. In addition, significant declines in egg shell quality and egg production are observed in breeders. The reduction in egg quality and production caused by heat stress can be mediated by alterations in dietary calcium.

1.3. Reproduction

Heat stress affects reproduction for both sexes. For females, heat stress reduces estrous period and fertility while increasing the incidence of anestrous and embryonic death.

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For males, there are declines in semen quality, testicular volume, and quantity of fertile sperm. Significant seasonal differences in reproductive performance in both sexes have been reported.

Although poultry reproduction is also affected by heat stress, birds may exhibit a difference in performance compared to mammals. Male broilers are reported to be more sensitive to heat-related infertility than female broilers. For layers, environmental stress could delay the process of ovulation, reduce yolk quality, and affect hatchability.

1.4. Disease and Parasite Stress

Many factors, including species, breed, geographical location, disease characteristics, and animal susceptibility, contribute to the effects of climate change on livestock health. In terms of animals themselves, the immune system is their major body defense that protects them from environmental stressors and other noxious insults. Heat stress can negatively affect immune functions via cell-mediated and humeral immune responses. As a result, periods of hot weather can cause livestock to be more vulnerable to diseases and raise the incidence of certain diseases (such as mastitis), leading to an increased potential of morbidity and death.

In addition, heat stress could affect the health condition of livestock through other functional pathways. For example, growing hogs may suffer from intestinal injuries if exposed to acute heat for several hours. Broilers and laying hens are also reported to experience intestinal micro-biota alterations under heat stress.

Simultaneously, increased temperature and altered precipitation may accelerate the incidence of pathogens and parasites. Although the effect of pathogens and parasites on livestock is generally regarded as an indirect effect, it is covered in this section since it is usually discussed in conjunction with animal health. This would affect the distribution and abundance of vector-borne pests and introduce new diseases. These may increase the potential for morbidity/mortality and associated economic loss. Compared to other impacts, climate change effect on livestock disease is more difficult to estimate and predict due to the nature of disease and climate-change-driven alterations to livestock. Such impact assessment is even more challenging in developing countries.

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1.5. Mortality

Mortality is an important heat stress impact that has significant associated economic loss. Studies on dairy cows and hogs show that added heat stress increases mortality rates. Hot and humid weather has been found to be more life threatening to cows and hogs compared to hot but dry conditions and a temperature higher than 37.7 ◦C with over 50% humidity were shown to be detrimental.

For poultry, the body temperature of birds is usually higher and more variable than that of mammals and they are more sensitive to rising temperature. Chickens can function normally up to ambient temperature of 27 ◦C or a body temperature of 41 ◦C, but an increase of 4 ◦C in body temperature would be lethal to them.

2. Indirect Effects

Livestock feed is mostly composed of forages and grain/oilseed crop product. Production of those items is affected by climate, as are water supplies, both through irrigation and soil moisture. Thus climate change indirectly imposes effects, mainly through its impacts on feed supply and water.

2.1. Forage Quality

Adequate nutrition is critical to weight gain, production, and reproduction, and forage is an important nutrition component for ruminants. As forage quality varies greatly within and between forage crops and nutritional needs vary among animal species, providing suitable feed to animals requires a balance. Most forage-quality studies have focused on digestibility, nutritive value, voluntary intake, and effects of anti-quality factors. Forages of higher digestibility supply more energy per unit dry matter (DM) consumed. Nutritive values reported by forage analysis usually include neutral detergent fiber (NDF); acid detergent fiber (ADF); crude protein (CP); and minerals, such as calcium (Ca), phosphorus (P), magnesium (Mg), and potassium (K). Quality can be affected by climate through increased temperatures and dry conditions, which cause variations in concentrations of water-soluble carbohydrates and nitrogen. Forage quality may also increase due to an increase in nonstructural carbohydrates resulting from elevated CO2 level. However, quality may also decrease since rising temperatures can increase lignin within plant tissues and therefore reduce digestibility.

2.2. Water

Water is scarce worldwide, and the magnitude of water scarcity depends on the supply relative to the demand. Agriculture is the single largest global water user, accounting for 69% of fresh water withdrawals. As human populations, incomes, and livestock product demand increase, water scarcity will likely grow in importance as a constraint on production agriculture. The livestock sector uses water for consumption by animals, growing feed crops, and product processing. It accounts for about 22% of the total evapotranspiration (ET) from global agricultural land and 41% of total consumptive water use.

Climate change is projected to change water availability and water usage in animal production. Rising temperatures are likely to increase per animal and per land area animal water consumption and irrigation water use. Water salination caused by sea-level rise is another concern. Competition for water between livestock, crops, and nonagricultural uses will increase in the coming decades, and it requires more efficient production systems to address water scarcity issue.

2.3. Seasonal Variation and Extreme Climate Events

Climate change may alter the seasonal pattern and variability of resource availability and crop yield, imposing further impacts on livestock production. As the frequency and duration of heat waves increase, animals will suffer from additional heat stress. Knee *et al*. found significant seasonal differences in cattle muscle glycogen and also that conditions with nutritious and abundant pastures coincide with better beef quality in spring and that worse pastures coincide with worse beef quality in summer. Moreover, changes in seasonal patterns of forage availability could bring additional challenges for grazing management and livestock management. Increasing risk of extreme drought threatens forage quantity, and adaptation strategies are required to cope with such extreme events. In addition, changes in snow melt timing alter water availability patterns during the year, which affects feed supplies.

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References

Food and Agriculture Organization of the United Nations (FAO). Livestock and Landscapes: Sustainability Pathways. Food and Agriculture Organizations of the United Nations. Available online: https://www.fao.org/3/ar591e/ar591e.pdf (accessed on 3 November 2021).

Rojas-Downing, M.M.; Nejadhashemi, A.P.; Harrigan, T.; Woznicki, S.A. Climate change and livestock: Impacts, adaptation, and mitigation. Clim. Risk Manag. 2017, 16, 145–163.

Reynolds, C.; Crompton, L.; Mills, J. Livestock and Climate Change Impacts in the Developing World. Outlook Agric. 2010, 39, 245–248.

Shukla, P.R.; Skea, J.; CalvoBuendia, E.; Masson-Delmotte, V.; Pörtner, H.O.; Roberts, D.C.; Zhai, P.; Slade, R.; Connors, R.; Van Diemen, R. IPCC, 2019: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems; Intergovernmental Panel on Climate Change (IPCC): Geneva, Switzerland, 2019.