

# Effects of Climate Change on Animal Breeding Objectives

Hasan Önder

**Abstract**— The pressure of climate change on the livestock sector is increasing. When the climate change affect livestock sector, livestock sector also affect the climate change. The solution of this situation needs new approaches for livestock sector components such as feeding, husbandry and breeding. This review mainly focused on changing animal breeding objectives versus climate change effects. The problems related to the climate change the livestock sector face to face can be summarized as production performance, reproductive physiology, metabolism and the immune system. In that case, animal breeding objectives mainly covers these problems. Even the problems related to measuring the phenotypes relevant to adaptation must be overcome, animal breeding for climate change adaptation or mitigation will not be fundamentally different from existing breeding strategies. We focused on the animal breeding for enteric methane production, productivity and feed efficiency, disease resistance, and heat resistance.

**Keywords**— Adaptation, Animal breeding, Climate change, and Heat stress

## I. INTRODUCTION

The climate is one of the most important factors affecting life styles on earth [1]. The combination of elements such as temperature, air movement, barometric pressure, radiation, humidity, precipitation and ionization creates the climate [2]. The climate, which is formed by the effects of factors such as temperature, precipitation, humidity and wind in a particular region, affects the existence of living things, the geographical distribution and abundance of plant and animal species, the chemical structure of oceans, seas and lakes, and the formation of soil [1] [3]. In many parts of the world there can be differences in climatic zones, the reason for these differences is latitude, winds, evaporation conditions, water availability, altitude, proximity to mountains [2] [4].

The change that occurs in the climate system as a result of natural factors or human activities is defined as “climate change” [5]. Climate change (CC) is a global fact that threatens our planet with global warming, droughts, flooding, and depleting natural resources. CC will directly impact livestock, farming systems, and human and animal health [6]. Climate change is a natural phenomenon that has occurred throughout history. In recent years, the term 'climate change' has mostly been used to describe changes in the Earth's climate. These changes started from the pre-industrial period (from about 1850) primarily by human activities. The use of

fossil fuels, which causes a relatively rapid increase in the CO<sub>2</sub> concentration in the world's atmosphere, and the removal of forests are the biggest reasons for these changes [2] [7]. Climate change includes not only rising average temperatures, but also extreme weather events, changing wildlife populations and habitats, sea level rise, changes in river flows and water levels, and many other effects. While precipitation is increasing in some parts of the world, others are experiencing severe droughts, increasing the risk of wildfires, crop loss and drinking water shortages [8]. Scientific evidence indicates that climate change has already affected the ecosystem in a diverse set of sectors, particularly in agriculture, which is the main source of rural livelihood. It is also a global challenge for humans and their socio-economic activities, health, livelihood, and food security. These negative impacts, combined with socio-demographic pressure, often contribute to food insecurity and poverty, increasing their vulnerability in the end [6] [9] [10].

Climate change can directly and indirectly affect livestock and animal nutrition. Heat stress results from inability to dissipate enough heat to maintain homeothermy of the animals. High ambient temperature, relative humidity and radiant energy compromise ability to dissipate heat of the animals. Ruminants, pigs and poultry are susceptible to heat stress due to their species-specific characteristics such as their metabolic rate and growth, high yield levels, rumen fermentation, sweating disorder and skin insulation. The indirect effects of climate change on livestock are changes in crop and forage production and quality, decrease in pasture/rangeland quality as a result of decrease in biodiversity and decrease in water availability. The direct effects are on the feed and water consumption, growth, milk, meat, egg, wool/hair and honey yield and product quality of the animals [2].

It is widely recognized that identifying the impacts of climate change and determining the adaptation strategies to combat the effects is crucial to developing realistic and applicable action plans and policies that farmers can adopt [6] [11].

Improving lifetime productivity focused on the needed Improvement of efficiency of animal production which can be achieved by improving not only productivity but also by improving health, reproductive performance, length of productive life span, and robustness of animals, which refers to the ability of animals to handle variation in the environment and face climate change. The quality of animal products refers not only to the food safety and taste but also to animal welfare

Hasan Önder is with the Ondokuz Mayıs University, Department of Animal Science, 55139, Atakum, Samsun, Türkiye

[12].

## II. THE EFFECTS OF CLIMATE CHANGE ON LIVESTOCK

The heat dissipation capacity of animals due to high temperature and humidity is exceeded and there is an increase in body temperature beyond physiological limits, this situation is called heat stress [2]. Extreme heat in the summer can adversely affect grazing animals and cause nutritional imbalances. In the arid and semi-arid tropics, insufficient and poor quality feed is the most important factor in animal nutrition. Heat stress may cause deterioration in rumen physiology, decrease in rumination, rumen activity and reticulo-rumen motility, metabolic disorders, slowdown of digestive transit rate and decrease in production performance. Since heat stress causes an increase in lactic acid concentrations in ruminants, it reduces the animal's production, energy availability and lowers the rumen pH, the rumen water content rises, and accordingly the osmotic pressure of the rumen fluid decreases [2] [13].

Decreased feed intake due to heat stress may result in a decrease in metabolic body weight, and as a result, the animal may enter physiologically negative energy balance, and then is decrease in body condition score of the animal [2] [14]. Problems related to the availability of water will affect the water needs of animals, the growth of forage crops and the livestock sector using the crops grown. Approximately 8% of global human water use belongs to the livestock sector. While the water requirements of heat-stressed animals increase by two to three times compared to thermoneutral conditions [2] [15].

Biological, physical and chemical environmental conditions or climate have a direct effect on animals. Extreme temperatures adversely affect production performance (growth, meat, milk, egg production, etc.), reproductive physiology, metabolism and the immune system [1]. For example, the decrease in milk yield occurs when the average daily temperature rises above 26 °C. Changes in environmental factors such as ambient temperature, relative humidity, wind speed and solar radiation cause stress in lactating cattle, and heat stress negatively affects both the quantity and quality of milk. It was determined that milk yield decreased by 33% at 35 °C and 50% at 40 °C [2] [14]. In many studies, hot and humid environments will cause temperature stress in livestock as well as infectious diseases and changes in many physiological functions associated with a decrease in feed consumption, deterioration in health, reproductive efficiency and productivity while animals are trying to cope with temperature changes in the process of adaptation to climate change, behavioral and metabolic changes such as sensitivity to disease [1] [16] [17].

## III. ANIMAL BREEDING OBJECTIVES FOR CLIMATE CHANGE

In general, animal breeding aims to genetically improve the next generation in order to increase the quantity and quality of economic traits in certain environments. Traditional genetic improvement in farm animals has successfully predicted breeding values using phenotypes and pedigree information. Unlike traditional animal breeding methods, genomic

selection can estimate breeding values more accurately, nowadays [18].

The problems related to the climate change the livestock sector face to face can be summarized as production performance, reproductive physiology, metabolism and the immune system. In that case, animal breeding objectives mainly covers these problems. Even the problems related to measuring the phenotypes relevant to adaptation must be overcome, animal breeding for climate change will not be fundamentally different from existing breeding strategies [1] [19].

Despite the livestock sector contributing only 25% to greenhouse gas (GHG) emissions (Hoffmann, 2010), public discussion focuses on enteric methane (CH<sub>4</sub>) fermentation in ruminants. To reduce CH<sub>4</sub> excretion in ruminants, reducing number of livestock, increasing efficiency and optimization of rations and feed additives or other technologies may be primarily solutions. In general, CH<sub>4</sub> output increases with the higher dry matter intake that is linked to high performance. However, the production pathways of different animal products differ in their GHG emissions and this may influence the future emphasis given to different production systems. For beef cattle, intensive feedlot systems give rise to less CH<sub>4</sub> per unit of meat produced than do extensive grazing systems, because CH<sub>4</sub> decreases as the proportion of concentrate in the diet increases, and because of faster growth rate and shorter time to market. Milk protein can be produced with less CH<sub>4</sub> emission than beef; CH<sub>4</sub> emission per kg of milk declines as production increases, but with a diminishing rate. In a life-cycle-assessment of global GHG emissions per kg of fat and protein corrected milk (FPCM), Gerber and Vellinga [20] found that intensive and mixed farming dairy production had lower emissions than grassland-based systems [19].

Increasing productivity is a condition indispensable for all production systems because of the need to make to reduce the livestock sector's environmental footprint and efficient use of the available inputs. In addition to selection only for increased production, any selection that increases early maturity, fertility and longevity and reduces mortality tends to contribute to reducing GHG emissions per unit of output. The largest contributions in broilers came from improved feed conversion rate, and in pigs from improvements to growth rate and fertility. Genetic gain in milk performance has considerably reduced the environmental impact of dairy production [19] [21].

There are often genetic differences in responses to disease challenge. Some of this variation is caused by single genes and some by multiple genes each with small effect. There is potential for genetic improvement of disease resistance, and various commercial breeding programmes already include resistance to helminthosis, ticks, mastitis, *Escherichia coli* or scrapie. Breeding for disease resistance depends very much on the type of disease and the hosts resistance or tolerance mechanisms, the availability and costs of alternative treatment (e.g. vaccines, drugs) and the antimicrobial resistance of pathogens. In any case, the importance of molecular markers and marker assisted selection in such breeding programmes will increase [19]. Improvement on the disease resistance will

reduce the effect of livestock sector on climate change and the effect of climate change will decrease on livestock sector.

Although the direct effects of climate change on the animals are likely to be small as long as temperature increases do not exceed 3 °C [22], projections suggest that further selection for breeds with effective thermoregulatory control will be needed. This calls for the inclusion of traits associated with thermal tolerance in breeding indices, and more consideration of genotype-by-environment interactions ( $G \times E$ ) to identify animals most adapted to specific conditions (Hoffmann, 2010).

The correlations between breeding values are lower in high temperature countries, suggesting that heat stress plays an important role in  $G \times E$  [23]. Biologically important  $G \times E$  is assumed if the correlations between the performance of the same genotype in different environments are below 0.8 (Robertson 1959). A single breeding programme with progeny testing of sires in different environments and applying index selection to simultaneously improve performance in those environments is recommended for genetic correlations between environments higher than 0.6. At lower genetic correlations between environments, environment-specific breeding programmes are necessary to breed for special adaptability [19] [24].

Finocchiaro et al. [25] proposed the use of heat-resistant individuals in a sheep breeding programme as a main strategy to improve animal welfare and productivity in hot climates. Various physiological and blood parameters differ between local and exotic cattle breeds in Brazil [26]. Several Latin American cattle breeds with very short, sleek hair coats were observed to maintain lower rectal temperatures, and research in the major ‘slick hair’ gene, which is dominant in inheritance and located on Bovine Chromosome 20, is ongoing [27]. Collier et al. [28] suggest that there is some opportunity to improve heat tolerance through manipulation of genetic mechanisms at a cellular level [19].

#### IV. CONCLUSION

Climate change may lead to the neglect of the adaptation potential of local breeds in developing countries. Given the potential for significant future changes in production conditions and in the objectives of livestock production, it is essential that the value provided by animal genetic diversity is secured. This requires better characterization of breeds, production environments and associated knowledge; the compilation of more complete breed inventories; improved mechanisms to monitor and respond to threats to genetic diversity; more effective in situ and ex situ conservation measures; genetic improvement programmes targeting adaptive traits in high-output and performance traits in locally adapted breeds; increased support for developing countries in their management of animal genetic resources; and wider access to genetic resources and associated knowledge [19]. Even the animal breeding methodology not change, the new traits such as rectal temperature or some animal welfare traits will be more important in the future.

Studies on global warming have generally focused on the ways to reduce the problems that this will cause, based on the

modelling of climate data and scenarios. The climate parameters are sufficient to understand climate changes, but the researchers should also determine farmers’ perceptions [6].

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