The Impact of Climate Change on Egyptian Livestock

Subjects: Veterinary Sciences

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Egypt is one of the hottest countries in the world, and extreme climate events are becoming more frequent, which is consistent with the warming of the planet. The impact of this warming on ecosystems is severe, including on livestock production systems. Under Egyptian conditions, livestock already suffer heat stress periods in summer. The predicted increases in temperature as result of climate change will affect livestock production by reducing growth and milk production because of appetite suppression and conception rate reductions and will increase animal welfare concerns. In severe cases, these effects can result in death.

Keywords: Egypt ; livestock ; climate

1. Introduction

The climate of a region is its typical or average weather pattern, and the following contents adopt the climate change definition of being “attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” [1]. This is not an entirely new phenomenon—the average surface temperature of the planet increased by about 1.1 °C in the 19th century. However, climatic extremes have recently increased in both magnitude and frequency [2][3][4][5], with further increases projected in the future [6][7][8].

Mediterranean ecological systems, including the agriculture and water cycles, are being drastically affected by climate change [9], with harmful effects on animal welfare and production, which are expected to increase in the future [10][11]. Egypt has a precarious economy, which depends, in part, on livestock production for income and food security. Even though the efficiency of land and water use is less for animal proteins than it is for plant proteins, those from an animal source are still favoured [12][13]. Food safety and security are key priorities in the coming century, and, with population increases, the demand for food production is also increasing, including demand for that of animal origin.

Extreme temperatures and low rainfall periods, which lead to drought, primarily affect crop production, but they also impair animal production functions such as milk yield and quality, egg yield, reproductive performance, and the behavioural and immune responses of animals, and they increase the incidence of diseases [14]. Tropical and sub-tropical countries face the biggest challenges to animal productivity from climate change, with reduced growth, reproduction, and milk production, and dramatic changes in physiological functions caused by heat stress [15]. In Egypt, a reduction in animal production by 25% over the course of this century as a result of global climate change is anticipated [16]. The best coping response to these adverse climatic conditions is the development of resilient management strategies and the genetic selection of heat tolerant livestock species [14]. In addition to the direct effects on livestock production, there are indirect effects because climate change and variability affect soil and pasture fertility [17].

Livestock themselves contribute to global warming through greenhouse gas (GHG) emissions and accounts for up to 18% of total emissions [18]. Climate change can also have a direct impact on livestock keepers and the goods and services on which they depend [19]. Thus, livestock production is under pressure due to the negative impact of these environmental implications, especially in terms of GHG emissions [20].

Heat stress directly and indirectly affects animal production and welfare. The major indirect effects are a reduction in feed and water intake and feed efficiency, a disturbance in mineral balances, enzymatic activities, and hormonal secretion, all leading to impaired immunity, which, together with reduced pasture availability, leads to more disease outbreaks [20]. In addition, there is also an impairment in productive and reproductive performance [15]. However, there are physiological and biochemical adaptations to heat stress to protect vital cell functions and that allow rapid recovery, especially in the case of moderately hypothermic conditions [21].

An industrial-based livestock system is potentially less affected by climate change than mixed farming and grazing systems. In grazing systems, there are direct effects of solar radiation and high temperatures on livestock, and drought causes major reductions in pasture growth [14]. In developing countries, there is a reliance on traditional systems of grazing livestock rather than intensive animal production systems due to a lack of capital for infrastructure [22][23][24]. Several adaptive technologies are being developed to cope with the challenges of climate change, including drought-tolerant fodder crops, the improved use of weather information by livestock keepers to make better management decisions, changes in the livestock species and genotypes used, and policy changes such as market and infrastructural development [19].

2. Climate Profile of Egypt

For at least the last decade, it has been acknowledged that Egypt is one of the countries that is the most exposed to climate change [25], which is largely due to the extent to which it relies on natural resources. It has been estimated that it is the fifteenth most vulnerable country to human-induced environmental change [26]. Climate change in Egypt is already evident in the form of lower precipitation rates, changing weather patterns, increased CO_2 in the atmosphere, methane and nitrous emissions, and sea level rise [18].

The Egyptian climate is characterized by warm days and cold nights. There are two main seasons: a mild winter (November–April) and a hot summer (May–October). The average temperature range in the coastal regions is between a 14 °C minimum in winter and a 30 °C maximum in summer. In the desert areas, the temperatures reaches 7 °C at night and 43 °C during the day in summer, while in winter, temperatures are as low as 0 °C at night and 18 °C during the day [27]. The annual mean air temperatures range from 20–22 °C in coastal region to 28–30 °C in the south-eastern corner [27].

A Global Rice Science Partnership report [28] compared two periods, from 1901–1950 and from 1951–2016. The report highlighted increases in the maximum temperature, about 0.6 °C and 0.4 °C in winter and summer, respectively, in lower Egypt, which was considered to be primarily due to the growth in urbanization in that region. The minimum temperature increases seen in winter ranged from 0.85 °C in Cairo to 0.50 °C in southern Egypt, and in summer, the increase seen in southern Egypt was 0.7 °C, while in the north, the increase was 0.45 °C. This temperature reversal between the two zones in the two seasons may be due to heat retention in the desert in the south in summer as well as to an absence of wind and rain.

The annual current average temperatures are 20 °C on the Mediterranean coast, 24 °C on the Red Sea coast, 25 °C in Cairo, and 26 °C in Aswan in the south [29]. The typical maximum temperatures for daytime in midsummer range from 30 °C in Alexandria on the Mediterranean coast to 41 °C in Aswan in the far south, while daytime midwinter maximum temperatures are 18°–23 °C. There was greater warming in summer (0.31 °C/decade) than in winter (0.07 °C/decade) between 1960 and 2003 [29].

Solar radiation (4500 KJ/m^2) is high during the entire year for all Egyptian zones, with extremes during the summer season and high humidity (50–75%) in the coastal region and low humidity in the very dry desert areas [30]. Farm animals experience climate stress for about 6 months of the year, causing various physiological and biochemical changes due to the increased heat production and reduced heat loss, manifesting in impaired health, production, and reproduction [31][32].

3. Climate Change Impacts on Livestock Production in Egypt

Livestock production contributes significantly to the national economy of the countries of the Near East and North Africa region, with increases from 186 million to 412 million head over the 40 years until 2010 [33]. Livestock production represents 24.5% of the agricultural Gross Domestic Product (GDP) [34][35]. In 1999, livestock production had contributed 27% of domestic agricultural production [36]. The main livestock production in Egypt is by small-scale farmers, with government farms contributing to less than 2% of the production [35]. Egyptian animal production depends on water buffaloes (70%) and cattle (30%) for annual milk-production and using males and barren females for meat production [37]. The buffalo population increased from 3,250,000 head in 1993 to 4,200,000 head in 2013 [38] due to an increased demand for buffalo products such as milk, cheese, and butter. However, the numbers of buffaloes and cattle have also been estimated as 3.5 and 5.01 million head, respectively, in 2016 [39]. In 2016, the buffalo herd contained 42% dairy buffalo cows, 32% buffalo heifers, 6% bulls, and 20% male calves.

In 2016, poultry meat production in Egypt was about 148,517 metric tons, which exceeded all other livestock meats, including beef and veal, buffalo meat, sheep and goat meat, camel meat, and others. Calf (buffalo and cattle) production increased to 1.93 million head in 2018 from 1.85 million head in 2017 [17]. A similar pattern of poultry dominance has been

seen in other countries in the region. In Algeria, chicken production was 137,235 metric tons in 2016, increasing to 138,500 in 2019. At the same time, cattle production, which was from 2,081,306 head in 2016 dropped to 1,780,591 head in 2019. In Tunisia, chicken production was 90,742 metric tons in 2016, increasing to 92,663 metric tons in 2019, while the cattle population was 646,100 head in 2016, increasing to 653,611 head by 2018. In Syria, chicken production was 16,600 metric tons in 2016, increasing to 18,498 in 2019; cattle production was 1,090,000 head in 2016, decreasing to 788,321 head in 2019 [38].

In 2017, the human population was about 104 million, with 56.7% living in rural areas and 43.3% living in urban areas [39]. By 2020, the population had reached 120 million, with the growth rate anticipated to be unchanged. It is expected to increase to 151 million in 2050, with the urban share becoming 56.5% [40]. Although livestock numbers in the last 20 years have increased, this increase is not adequate for the requirements of the increased population, especially in terms of dairy products. Only in the poultry sector has a steady increase in numbers been evident, increasing by about 4% per year [39], which is more than sufficient to cater for the annual human population increase of 1.9%, but this growth may not be sustainable in the future. Numbers of ruminant livestock have declined, and a decrease of about 10% has been seen in sheep and buffalo since about a decade ago, which is probably due to the pressure of urbanization, drought, and diminishing feedstocks. Livestock production (principally from cattle, buffalo, sheep and goats, and camels) contributes to about 37.5% of agriculture production [41].

Livestock production and health is challenged both directly and indirectly by climate change. With higher temperatures, livestock health and production are challenged by heat stress, metabolic disorders, oxidative stress, and immune suppression, together with an increased incidence of diseases. The indirect effects are related to the multiplication and distribution of parasites and infectious pathogens and the impact on feed availability [42]. The direct impact of climate change on livestock is influenced by the ability of animals to exchange heat with their environment [34]. If animals lack the ability to dissipate environmental heat, they suffer from heat stress. There are various detrimental effects of heat stress on livestock, with the most important economic impact being on reproduction and milk production in dairy cows. Heat stress has a direct adverse effect on milk production, growth, feed intake, reproductive efficiency, and disease incidence in dairy cows [43]. When the environmental temperature rises above the thermal comfort zone, it adversely affects the growth and productivity of animals in both intensive and extensive production systems. In addition to the reduction in milk production, it leads to a reduction in sperm quantity and quality and a decline in female fertility and embryo quality.

Heat stress also decreases the body weight of beef cattle due to decreased feed intake and feed conversion efficiency [17]. Additionally, dairy cattle in heat stress have a particular stance, with a lowered head, backward-facing ears, and a vertical tail [44]. An increase in the ambient temperature could also reduce forage digestibility in ruminants because of the greater lignification of the plant [45]. A negative correlation has been found between ambient temperature and degradability, in which the potential degradability of plants was decreased in tropical and arid climates by 0.55% compared to cold and temperate climates, for each 1 °C increase in ambient temperature.

Farm animals have behavioural strategies to attempt to mitigate the impact of heat stress. Birds respond to heat stress by extending their wings, holding them away from their body, increasing their respiration rate, which has the potential of leading to exhaustion, in an attempt to reduce the heat load through water vapor cooling. Other strategies include looking for isolated places to lower their body temperature, moving away from each other, less activity, decreasing feed intake, and increasing water consumption [46]. The negative effects of climate change on poultry production are mostly direct, reducing weight gain and meat quality in broilers and the rate of egg production, egg quality (especially thin and breakable eggshells), egg weight and size, and a high mortality rate in laying hens [46]. There are also indirect effects reducing growth and reproduction, in particular through the enhanced growth of toxin-producing fungi in feed or by reducing the bird’s ability to cope with other stressors. Moreover, immunity is reduced in birds exposed to heat stress, including a weak immune response to vaccines, which lowers the birds’ resistance to infectious diseases.

A temperature increase of 1 °C above the ideal temperature leads to a reduction in the feed consumption of laying hens by 1.6%, while the amount of energy consumed reduces by about 2.3% [46]. The egg weight also decreases at rate of 0.07–0.98 g/egg for every 1 °C rise, which can be attributed to the decrease in calcium availability because of the reduction in the food consumption. When temperatures increase to above 30 °C, feed consumption and egg production reduce by 5% and 1.5%, respectively. Approximately one half of this reduction in food consumption occurs when the temperature is elevated from 21 to 38 °C.

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