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Effect of Global Warming on Livestock Production and Reproduction: An Overview

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Abstract

Global warming refers to the increase in the earth's average temperature due to the accumulation of green house gases in the atmosphere. Due to global warming, there is a climate change which poses alarming challenge to the development of livestock sector in India with an anticipated rise in temperature between 2.3 and 4.8°C together with increased precipitation. This causes thermal stress to animals. Effect of thermal stress on animal health mainly includes reduction of production and reproduction traits in animals. Reduction in milk production is one of the major economic impacts of thermal stress in dairy cattle. Heat stress is of major concern for the poultry industry because of the resulting poor growth performances and high mortality rates. Over all, heat stress reduces the reproductive and productive performance of livestock by various means and thus in this review, we presented a brief note of various production and reproduction parameters affected due to global warming.

Keywords: *Global warming, production, reproduction*

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INTRODUCTION

Livestock play a major role in the agricultural sector in developing nations and the contribution of Indian livestock sector in total GDP was nearly 4.11% (19th Livestock Census, 2012). India's livestock sector is one of the largest in the world comprising 56.7% of world's buffaloes, 12.5% cattle, 20.4% small ruminants, 2.4% camel, 1.4% equine, 1.5% pigs and 3.1% poultry population (19th Livestock Census, 2012). India contributes 16–17% of world's milk that comes from its 304 million bovine populations [1]. The existing livestock feeding system in the country is based mainly on crop residues such as straw and green fodder, supplemented by small quantities of low-cost compound feed. It has been reported that climate change poses alarming challenge to the development of livestock sector in India with an anticipated rise in temperature between 2.3 and 4.8°C over the entire country, together with increased precipitation due to global warming.

Global warming refers to the increase in the earth's average temperature due to the accumulation of green house gases in the atmosphere. Since the early 20th century, earth's mean surface temperature has increased by about 0.8°C (1.4°F), with about two-thirds of the increase occurring since 1980. Scientists have envisioned that increase in average global temperature above 2°C may be beyond the bearable limit of present-day societies causing extended and widespread societal and environmental disruptions [2]. Warming of global climate has multifaceted effects in many natural, economic and social systems including ecosystem, agriculture, animal and human health, soil, water resources etc. across

the world and these effects will most probably be continued for centuries in future effecting both of animal and human populations [3]. Global warming causes an increase in temperature and thus causes thermal stress to animals. Effects of thermal stress on animal health mainly include reduction of production and reproduction traits in animals and a brief note on effect of heat stress due to global warming is discussed below.

EFFECTS OF HEAT STRESS DUE TO GLOBAL WARMING

Effect on Milk Production

Thermal stress adversely affects the milk production and its composition which causes more economic losses to the dairy farmers. Holstein cows were having more prominent effect as compared to Jersey cow that resulted in decreased milk yield [4–6]. Thermal stress causes decreased hepatic glucose synthesis as well as low NEFA level in blood which leads to reduced glucose supply to the mammary glands which is largely responsible for the decline in milk synthesis. Furthermore, high environmental temperature causes decreased feed consumption that causes reduction in milk yield [7]. Quantifying direct environmental effects on milk production is difficult as milk production is also strongly affected by other factors such as nutritional management that may or may not be directly linked to environmental factors [8–9]. However, reported declines in the productions of milk and fat have been seen as a direct result of high environmental temperatures. This may be because heat stress has negative effects on the secretory function of the udder [10]. McDowell *et al.* suggested that milk production is reduced 15%, accompanied by a 35% decrease in the efficiency of energy utilization for productive purposes, when a lactating Holstein cow is transferred from an air temperature of 18 to 30°C [11]. Milk fat, solids-not-fat, and milk protein percentage decreased by 39.7, 18.9 and 16.9%. In addition, Johnson attributed 3–10% of the variance in lactation milk production to climatic factors [9].

Differences in the physiological responses of cattle to the form and duration of heat stress have been reported and differences have also been noted in productive responses. Cows maintained under similar temperatures during the day but at 25°C at night did not decrease milk production beyond that normally expected under temperate conditions [12]. The point on the lactation curve at which the cow experiences heat stress is also important for the total lactation yield. Cows are less able to cope with heat stress during early lactation. Heat stress at the initiation of lactation negatively impacts the total milk production.

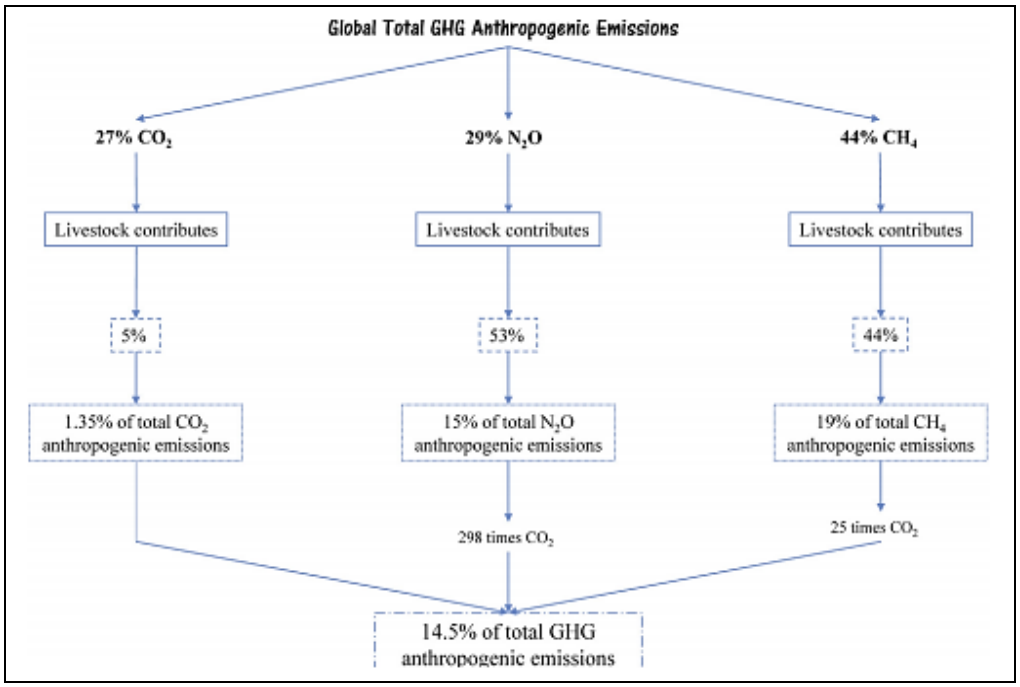

Fig. 1: *Contribution of Livestock to the Total GHG Anthropogenic Emissions. [Rojas-Downing et al]*

Furthermore, thermal stress during 60 days prepartum period negatively affects postpartum milk production and cows calved during summer produce less milk as compared to other seasons [13]. Summer temperatures in the Mediterranean region generally are above the TNZ of dairy cows and result in heat stress. At 40°C, dietary intake may decline by as much as 40% [14]. Heat stress causes the rostral cooling center of the hypothalamus to stimulate the medial satiety center which inhibits the lateral appetite center, resulting in reduced dietary intake and consequently lower milk production [15]. Animals in a highly productive state, such as high-producing dairy cows, have feed intakes and metabolic rates that may be two to four times higher than at maintenance [16].

Effect on Meat Production

Worldwide, beef cattle are generally reared outdoors with consequent exposure to natural conditions and are only maintained in housing systems to a limited extent. Beef cattle are particularly vulnerable not only to extreme environmental conditions, but also rapid changes in these conditions. In particular, fatter cattle (fat under the skin provides an insulation layer trapping heat inside the animal), cattle with a heavier hair coat (more insulation) and darker coated animals (black and dark red cattle) are very sensitive to heat. The Scientific Committee on Animal Health and Animal Welfare suggested that the higher threshold temperature for beef cattle is 30°C with relative humidity below 80% and 27°C with relative humidity above 80% [17]. Temperatures between 15 and 29°C do not seem to exert any influence on growth performance. In contrast, above 30°C, adverse effects are recorded in daily weight gain. Mitlöhner *et al.* reported a reduction of daily dry matter intake and average daily gain, carcass weight loss, lower fat thickness and an increase in disease incidence in steers kept under high environmental air temperature and solar radiation [18]. Nardone reported that in the Mediterranean area during dry month, breeds of cattle, sheep and goats' body standard sizes get reduced at remarkable level [19]. 5 to 6 month old female Holstein Friesian calves were exposed to hot condition which caused lower wither height, oblique trunk length, hip width (35, 26, and 29% respectively) and body condition score as compared to calves that are kept under thermoneutrality conditions [20]. Therefore, these evidences indicate that global warming could be a risk cause for reduction in average carcass weight, particularly in ruminants. Kadim *et al.* found that beef meat quality gets deteriorated during the hot season (average temperature of 34.3±1.67°C and 48.8+7.57% RH) [21].

Effect on Egg Production

Temperatures >30°C are conditions for heat-stress for birds [22]. Especially in the hot regions, heat stress is of major concern for the poultry industry because of the resulting poor growth performances (lower body weight gain and carcass yield) and high mortality rates [23]. Selection for rapid growth has been associated with increased susceptibility of broilers to heat stress [24]. Environmental temperatures above 30°C in the rearing area cause high mortality of broiler chickens or reduction in feed intake, body weight, carcass weight, carcass protein and muscle calorie content [25–27]. Feng *et al.* observed significant decrease initial pH and increased drip loss, and sheer force of breast muscle in heat-stressed broilers [28]. Heat stress reduces the reproductive performance of laying hens by interrupting egg production. This may be caused not only by a reduction in feed intake but also by a disruption of hormones responsible for ovulation and a decrease in responsiveness of granulosa cells to luteinizing hormone [29]. Significant reduction of body weight and feed consumption occur in heat-stressed hens. Egg production, egg weight, shell weight and shell thickness are considerably compromised by heat exposure [30]. Moreover, heat stress negatively affects the strength, weight, thickness, and ash content of the egg shell resulting in the increased egg breakage [31]. These responses may involve various aspects of calcium metabolism, including a reduction in free ionized calcium in the blood [32]. Recently, Franco-Jimenez *et al.* in Hy-Line Brown, W36, and W98 hens housed for 2 weeks at 22°C and exposed to 35°C heat stress for 2 weeks, and 2 weeks of recovery at 22°C, reported reduction in egg production, egg quality measures, and feed intake [33].

Effect on Livestock Reproduction

Reproductive functions of livestock are vulnerable to global warming. Reproductive

processes are affected by heat stress, over 50% of the bovine population is located in the tropics and it has been estimated that heat stress may cause economic losses in about 60% of the dairy farms around the world [34]. Heat stress due to high ambient temperature accompanied with excess humidity during summer months causes infertility in most of the farm species and have adverse effect on reproductive performance of farm animals [35]. During hot dry (April–June) and hot humid (July–September) seasons, the THI values exceeds 80 in most parts of India. In dairy cows, the conception rates may drop by 20–27% during summer. Heat stress also negatively affects reproductive function, such as poor expression and intensity of oestrus due to reduced oestradiol secretion from the dominant follicle developed in a low LH environment [36]. Heat stress causes, changes in ovarian function and embryonic development by reducing the competence of oocyte to be fertilized [14]. Buffaloes are more vulnerable to heat stress as compared to cattle which may be due to high thermal load in this species as a result of difficulty in heat dissipation due to unavailability of place for wallowing and lesser number of sweat glands [37]. A temperature rise of >2°C in buffaloes may cause negative impacts; this is due to low or desynchronized endocrine activities, particularly pineal-hypothalamo-hypophyseal-gonadal axis altering respective hormone functions [38], whereas in case of cattle, the effects of heat stress on fertility appear to carry into the autumn (October and November) even though the cows are no longer exposed to heat stress. Naqvi *et al.* reported that an increase in uterine temperature of 0.5°C above average is associated with a decline in conception rate of 12.8% [14]. Low temperature and THI during nights in summer (April and May) provide an opportunity to buffaloes to dissipate heat during night hours compared to day hours. Heat stress compromises oocyte growth by altering progesterone secretion, the secretion of LH, FSH and ovarian dynamics during the oestrus cycle. Heat stress has also been associated with impairment of embryo development and increase in embryonic mortality in cattle. Heat stress during pregnancy slows growth of the fetus and can increase fetal loss. Reproductive processes in male animal are very sensitive to disruption by hyperthermia with the most pronounced consequences being reduced quantity and quality of sperm production and decreased fertility (Figure 2).

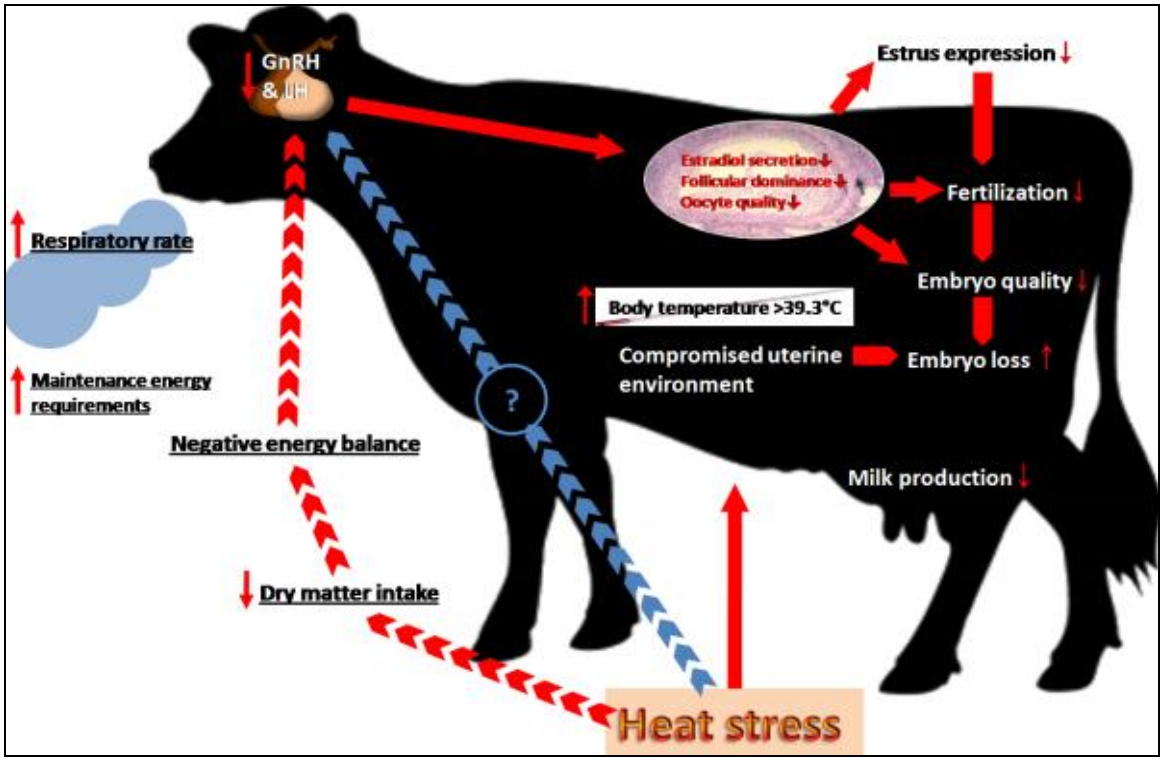

Fig. 2: *A Schematic Description of the Possible Mechanisms Generated by Heat Stress Which May Affect Reproduction in the Lactating Dairy Cow.*

Heat stress can act in more than one way to reduce fertility in lactating dairy cows. Heat stress can reduce dry matter intake to indirectly inhibit GnRH and LH secretion from the hypothalamo-pituitary system (dashed red lines). However, it is not clear if heat stress can also directly influence the hypothalamo-pituitary system (dashed blue line) to reduce GnRH and LH secretion. Heat stress can directly compromise the uterine environment (solid lines) to cause embryo loss and infertility.

CONCLUSION

Global warming by increasing the environmental temperature imposes thermal stress to animals. Thermal stress causes changes on various physiological, biochemical, hormonal and reproductive parameters effecting the production of animals. Therefore there is a need to develop new strategies to reduce the thermal stress like changes in housing, water management etc., especially during summer to protect from direct sunlight. Selection and raring of breeds that are tolerant to climate change can be also an alternative method to prevent the loss due to reduction of production in livestock.

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