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Effect of climate change on reproduction and milk production performance of livestock: A review

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Abstract
Climate change is a long-term shift in the statistics of the environmental variables of a particular region. Various climate model projections suggest that by the year 2100, mean global temperature may be 1.1–6.4°C warmer than in 2010. Livestock production is adversely affected by detrimental effects of extreme climatic conditions. Reproductive processes are affected by thermal stress. Low estradiol level during summer season in buffaloes may be responsible for silent heat. 80% of estrus remains unnoticed during summer. When the body temperature exceeds 40°C developed follicles suffer damage and become non-viable. Conception rates of dairy cows may drop up to 20–27% in summer. Seasonal variations affect testicular volume, hormonal profiles, sexual behavior and semen quality that affect the reproductive performance of males. Summer heat stress declined semen quality parameters. Up to 50% drop in milk production in dairy animals is due to reduced feed intake and rest due to metabolic adaptations to heat stress as heat stress. Hot and humid climate not only affects quantity but also effects quality of milk too.

Keywords: Climate, conception, estradiol, milk, reproduction

Introduction
Climate change is a long-term shift in the statistics of the environmental variables such as temperature, humidity, radiation, wind and rainfall of a particular region. Climate change may appear as rapid changes in climate in the short period or may appear over decades. Generally climate change is associated with an increasing global temperature. Various climate model projections suggest that by the year 2100, mean global temperature may be 1.1–6.4°C warmer than in 2010. The difficulty facing livestock is weather extremes e.g. intense heat waves, floods and droughts. In addition to production losses, extreme events also result in death of livestock [1]. Animals Livestock systems occupy about 30% of the earth's terrestrial area directly supporting the livelihoods smallholding farmers in the developing countries [2]. Therefore livestock production is a key factor of world agriculture. Human populations around the globe largely depend on domestic animals for multiple purposes such as meat, fat, milk, and other dairy products, eggs and wool as well as other purposes such as transport, draft, and provision of fertilizers. However livestock production is adversely affected by detrimental effects of extreme climatic conditions. As a result adaptation and mitigation have played a major role to overcome the detrimental effects of climate changes in livestock production [3]. Climate change directly influence on animal performance: growth, milk production, wool production and reproduction [4]. Extreme climatic and seasonal fluctuations in herbage quantity and quality will affect the well-being of livestock, and will lead to declines in production and reproduction efficiency [5]. Impact of climate change can be direct or indirect. The direct effects of climate change include high temperature and change in rainfall pattern, which could result into the increased incidence of existing vector-borne diseases and macro-parasites, accompanied by the appearance and circulation of new diseases. The indirect effects are bestowed by changes in feed resources associated shortage of feed arising from the increasingly demands of food, feed and fuel production, and use of land [6].

Effect on reproduction
Reproductive functions of livestock are highly susceptible to climate changes and both female and males are affected adversely. Heat stress also negatively affects the reproductive performance of animals [7]. Reproductive processes are affected by thermal stress. The high rise in temperature and high intensity of radiant heat will directly affect reproductive rhythm via hypothalamic-hypophyseal–ovarian axis.

The main factor from hypothalamus regulating ovarian activity is GnRH and the gonadotropins i.e. FSH and LH from anterior pituitary gland [8]. Heat stressed cows often have poor expression of oestrus due to reduced estradiol secretion from the dominant follicle developed under low luteinizing (LH) hormone environment. Conception rates of dairy cows may drop up to 20–27% in summer. Poor reproductive performance due to heat stress alters the ovarian function and embryonic development by reducing conception rate and the resulting embryo [9]. Low estradiol level during summer season in buffaloes may be responsible for poor expression of estrus (silent heat) in this species [10]. That is why the expression of estrus and conception rate is recorded low during summer in crossbred cattle and buffaloes. Therefore, heat mitigation measures and strategies need to be adopted not only to reduce thermal stress but also to prevent fertility losses and other health consequences on animals.

Effects on female reproduction

Reproductive performances of dairy animals are influenced by high environmental temperature and depend up on the intensity of heat stress. Heat stress during pregnancy slows down growth of the foetus and can increase foetal loss, although active mechanisms attenuate changes in foetal body temperature when mothers are thermally stressed.

[11] Reported when the body temperature exceeds 40°C developed follicles suffer damage and become non-viable. It also reduces oocyte development by affecting its growth and maturation. It increases adrenocorticotropic hormone (ACTH) and cortisol secretion and blocks estradiol induced sexual behaviour. It also increases circulating levels of prolactin results to acyclicity and infertility [12]. Heat stress compromises oocyte growth in cows by altering progesterone, the secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) and dynamics during the oestrus cycle. However, secretion of FSH is elevated under heat stress probably due to inhibition of negative feedback mechanism from smaller follicles which ultimately affect the reproductive efficiency of dairy animals [13]. High environmental temperature reduces the duration and intensity of estrus, increases incidence of anestrous and silent heat in farm animals. Moreover, 80% of estrus remains unnoticed during summer [14] which further reduces fertility. Heat stress also decreases the secretion of estrogen and low estradiol secretion suppresses signs of estrus, ovulation, transport of gametes, conception rate and ultimately reduced fertilization [15]. Embryonic growth and survival rate is also affected by thermal stress in dairy animals and may cause embryonic death by interfering with protein synthesis [16]. Further, exposure to heat stress may affect early organogenesis and may also leads to various teratological defects [15]. The deleterious effects of heat stress in the embryo are most evident in early stages of its development. Alteration of glucose and lipid metabolism, liver function and oxidative status may be responsible for the increased sensitivity of heat-stressed animals to metabolic diseases with negative consequences on production, reproduction performances in intensive and extensive livestock production systems.

Effect on male reproduction

Semen concentration, number of spermatozoa and motile cells per ejaculate of bulls are lower in summer than in winter and spring. One of the important factors for good spermatozoa production is climate. Fertility of bulls is equally important as that of cow, for fertilization of oocyte to produce good, viable and genetically highly potential offspring. The temperature of the testis is 2-6°C lower than core body temperature. This 2-6°C lower temperature of the testis is important for the production fertile spermatozoa. If the testicular temperature is increased it may result thermal stress that directly affects seminal and biochemical parameters leading to infertility problems in bulls. [17] Reported seasonal effects on changes in testicular volume, hormonal profiles, sexual behavior and semen quality that affect the reproductive performance of males. [18] Studied seasonal influence on 19 Bos taurus bulls and found summer heat stress declined semen quality parameters. They also reported that younger bulls are more sensitive to elevated air temperatures during the summer seasons. Observed optimal semen qualities during winter, poor during summer and intermediate during rainy season and conclude that hot-dry or summer season adversely affect the various bio-physical characteristics of semen in Karan Fries bulls. Hence, heat stress significantly lowers conception as well as fertility rates per insemination of male and subsequently reduces male's fitness [19].

Effect on milk Production

Climatic changes greatly influence the behavior of animals due to neuroendocrine response to environmental variables that directly affect production and health status of animals. Climate change mainly affects the high producing animals particularly those high producing animals which are raised under tropical conditions, due to high air temperatures and relative humidity. One of the most important impacts of climate change is heat stress that adversely affects milk production and its composition, especially to those animals that have high genetic trait [20]. Environmental temperature above 35°C is enough to activate the stress response mechanisms in lactating dairy cows [21]. In response to heat stress dairy cows reduce feed intake leading to negative energy balance responsible for the drop in milk production [20]. Up to 50% drop in milk production in dairy animals is due to reduced feed intake and rest due to metabolic adaptations to heat stress as heat stress response markedly changes post-absorptive nutrient metabolism [22]. During the dry period (i.e. last 2 months of gestation) heat stress reduce mammary cell proliferation result in decreased milk production. Moreover, heat stress during the dry period negatively affects the function of the immune cell in lactating cows facing calving and also extended to the following lactation [23]. Hot and humid climate not only affects quantity but also effects quality of milk too. On comparing milk production during summer and spring in a dairy herd it was found that lower milk yield (-10%), and also lower casein percentages and casein number in summer (2.18 vs. 2.58% and 72.4 vs. 77.7% respectively) [24]. The fall in casein was due to the reduction in α-casein and β-casein percentages. No differences were found between the two seasons for κ-casein, α-lactoalbumin and β-lactoglobulin, whereas serum protein contents were higher in summer than in spring.

Conclusion

Human populations around the globe largely depend on livestock for multiple purposes such as meat, milk, and other dairy products and wool as well as other purposes such as transport, draft and provision of fertilizers. Different environmental variables like temperature, humidity, wind speed, radiations directly influence on production and reproduction performances of livestock. Among all these factors heat stress is the most important factor affecting

livestock. Climate change is not only responsible for decrease in reproductive efficiency like decrease oocyte and sperm viability, decrease conception rate, decrease fertility but also decrease milk production too in terms of quantity and quality both. Therefore, heat mitigation measures and strategies need to be adopted not only to reduce thermal stress but also to prevent fertility losses and other health consequences on animals.

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