Impact of Climate Change in Livestock Reproduction and Mitigation Strategies

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OPEN ACCESS

Keywords

Climate, Heat stress, reproduction, livestock, buffalo

How to cite this article:

Nistane, S., Lakhanpal, D., Sahu, U. K., Biswas, N., Suryawanshi, S. P. and Srivastava, N. 2026. Impact of Climate Change in Livestock Reproduction and Mitigation Strategies. *Vigyan Varta* 7 (09): 117-120.

ABSTRACT

Climate change is gradually affecting livestock health, productivity, and reproductive efficiency through rising temperatures, altered rainfall, droughts, floods, and other environmental stresses. Heat stress adversely affects both female and male reproduction by disrupting hormonal balance, estrus expression, ovarian function, embryo development, spermatogenesis, and semen quality. Buffalo bulls are particularly vulnerable because their spermatozoa are highly susceptible to oxidative damage caused by increased reactive oxygen species. These reproductive losses can compromise sustainable livestock production and food security. Effective adaptation measures include genetic selection for heat tolerance, provision of shade and cooling systems, nutritional management, antioxidant supplementation, and reproductive interventions such as hormonal synchronization and fixed-time artificial insemination. Integrating these approaches can improve thermotolerance, reproductive performance, and climate resilience in livestock production systems.

INTRODUCTION:

Climate change refers to long-term changes in environmental factors such as temperature, humidity, solar radiation, wind patterns, and rainfall. Livestock are becoming increasingly vulnerable to extreme weather conditions, including severe heat waves, floods, and droughts, which can reduce productivity and, in extreme cases, result in animal deaths (Gaughan and Cawsell-Smith, 2015). Global surface temperatures during 2011–2020 were approximately 1.1°C above the 1850–1900 baseline (IPCC, 2023). Similarly, India experienced an average temperature rise of around 0.7°C from 1901 to 2018, with temperatures expected to continue increasing throughout the twenty-first century (IMD, 2018).

Climate change affects livestock directly through increased air temperatures, altered humidity and precipitation, and more frequent droughts and floods, and indirectly through reduced feed and water availability, changes in vector- and food-borne diseases, and alterations in microbial populations (Lacetera, 2019). Therefore, implementing effective adaptation and mitigation measures is crucial for ensuring sustainable livestock production.

Effect on reproduction: Heat stress adversely affects reproductive functions in both male and female livestock by disrupting reproductive processes and altering the hypothalamic–hypophyseal–ovarian axis. Heat-stressed cows often show weak or reduced estrus due to decreased estradiol secretion from dominant follicles under low LH conditions. During summer, conception rates in dairy cows may decline by 20–27%, as heat stress disrupts ovarian function and embryo development, ultimately reducing reproductive efficiency (Naqvi *et al*., 2012). Thus, implementing effective heat mitigation measures is crucial for mitigating thermal stress and reducing associated fertility losses.

Effects on female reproduction: When body temperature rises above 40°C, developing ovarian follicles may become damaged and non-viable. Heat stress impairs oocyte growth and maturation, while increasing ACTH and cortisol secretion (Roth *et al*., 2007). Temperatures of approximately 41°C can adversely affect bovine oocyte quality and impair their ability to undergo normal meiotic maturation (Barati *et al*., 2008).

Heat stress can increase circulating prolactin levels, leading to acyclicity and infertility (Singh *et al*., 2013). It may also elevate FSH secretion by disrupting the negative feedback from developing follicles, thereby impairing reproductive efficiency in dairy animals. High environmental temperatures can shorten and weaken estrus, while increasing the occurrence of anestrus and silent heat in farm animals. Heat stress also reduces estrogen secretion, and low estradiol levels can suppress estrous behavior, ovulation, gamete transport, conception, and ultimately fertilization (Wolfenson *et al*., 2000). During summer, decreased estradiol concentrations at estrus may be a contributing factor to the poor expression of estrous behavior in Indian buffaloes (Upadhyay *et al*., 2009). Thermal stress adversely affects embryonic development and survival in dairy animals. It causes embryonic mortality by disrupting protein synthesis, inducing oxidative cellular damage (Wolfenson *et al*., 2000) and reducing interferon-tau production, thereby impairing the maternal recognition of pregnancy (Bilby *et al*., 2008).

Effect on male reproduction: Normal sperm production depends on the testes being maintained at a temperature approximately 2–6°C below the body's core temperature.

Thermal stress-induced hyperthermia of the testes can impair semen quality and alter biochemical parameters, which may ultimately compromise fertility in bulls. Heat exposure may cause degeneration of the testicular epithelium and increase the production of morphologically abnormal spermatozoa (Garcia-Oliveros *et al*., 2022). Variations in environmental conditions across seasons may affect testicular volume, hormonal patterns, sexual behavior, and semen quality, ultimately influencing male reproductive potential. Heat stress can lower testosterone levels in bulls during the early period of heat exposure and may also reduce the levels of luteinizing hormone (LH), which is important for normal reproductive function. Long-term heat stress may reduce glucose availability and disrupt the normal regulation of reproductive hormones by affecting pathways involving leptin and gonadotropin-releasing hormone (GnRH).

Why buffalo bulls deserve special attention: Buffalo spermatozoa show greater sensitivity to summer heat stress compared with other livestock species, partly as a result of their vulnerability to oxidative damage (Ahirwar *et al*., 2018). Heat stress enhances the generation of reactive oxygen species (ROS), which can damage the sperm plasma membrane, disrupt mitochondrial function, and ultimately reduce sperm quality. Buffalo spermatozoa are particularly vulnerable to oxidative damage due to the high concentration of polyunsaturated fatty acids in their membranes and their relatively limited antioxidant defense mechanisms (Nair *et al*., 2006).

Measures to Alleviate Heat Stress: Identification and selection of heat-tolerant animals, particularly breeds with smaller body size and lighter coats, can enhance climate resilience. Heat-shock genes associated with thermotolerance can serve as genetic markers for marker-assisted and genomic selection of heat-resilient, productive breeding animals.

Providing shade, sprinklers, ventilation, and cooling systems helps reduce heat stress in outdoor and indoor animals. Reproductive interventions can help mitigate climate change by improving livestock fertility and reproductive efficiency under heat stress. Antioxidants such as cysteine and taurine enhance sperm quality and cryopreservation success. Hormonal methods, including Ovsynch, GnRH, fixed-time AI, PRID and CIDR, improve conception rates. Nutritional management through reduced dietary fiber, increased fat, electrolytes, vitamins and selenium can reduce heat stress and support reproductive performance.

CONCLUSION:

Climate change poses a significant threat to livestock reproductive efficiency, particularly through heat stress. Integrating genetic selection, cooling, nutritional management, antioxidant supplementation, and reproductive technologies can improve thermotolerance, fertility, productivity, and overall resilience of livestock under changing climatic conditions.

REFERENCES

Ahirwar, M. K., Kataktalware, M. A., Pushpadass, H. A., Jeyakumar, S., Jash, S., Nazar, S., ... & Ramesha, K. P. (2018). Scrotal infrared digital thermography predicts effects of thermal stress on buffalo (Bubalus bubalis) semen. Journal of Thermal Biology, 78, 51-57.

Barati, F., Agung, B., Wongsrikeao, P., Taniguchi, M., Nagai, T., & Otoi, T. (2008). Meiotic competence and DNA damage of porcine oocytes exposed to an elevated temperature. Theriogenology, 69(6), 767-772.

Bilby, T. R., Baumgard, L. H., Collier, R. J., Zimbelman, R. B., & Rhoads, M. L. (2008). Heat stress effects on fertility:

Consequences and possible solutions. In The proceedings of the 2008 South Western nutritional conference.

Garcia-Oliveros, L. N., de Arruda, R. P., Batissaco, L., Gonzaga, V. H. G., Nogueira, V. J. M., Florez-Rodriguez, S. A., ... & Celeghini, E. C. C. (2022). Chronological characterization of sperm morpho-functional damage and recovery after testicular heat stress in Nellore bulls. Journal of Thermal Biology, 106, 103237.

Gaughan, J., & Cawdell-Smith, A. J. (2015). Impact of climate change on livestock production and reproduction. In Climate change Impact on livestock: adaptation and mitigation (pp. 51-60). New Delhi: Springer India.

Lacetera, N. (2019). Impact of climate change on animal health and welfare. Animal Frontiers, 9(1), 26-31.

Nair, S. J., Brar, A. S., Ahuja, C. S., Sangha, S. P. S., & Chaudhary, K. C. (2006). A comparative study on lipid peroxidation, activities of antioxidant enzymes and viability of cattle and buffalo bull spermatozoa during storage at refrigeration temperature. Animal Reproduction Science, 96(1-2), 21-29.

Naqvi, S. M. K., Kumar, D., Paul, R. K., & Sejian, V. (2012). Environmental stresses and livestock reproduction. In Environmental stress and amelioration in livestock production (pp. 97-128). Berlin, Heidelberg: Springer Berlin Heidelberg.

Roth, Z., Meidan, R., Braw-Tal, R., & Wolfenson, D. (2000). Immediate and delayed effects of heat stress on follicular development and its association with plasma FSH and inhibin concentration in cows. Reproduction, 120(1), 83-90.

Singh, M., Chaudhari, B. K., Singh, J. K., Singh, A. K., & Maurya, P. K. (2013). Effects of thermal load on buffalo reproductive performance during summer season. J. Biol. Sci, 1(1), 1-8.

Upadhyay, R. C., Ashutosh, R. V., Singh, S. V., & Aggarwal, P. (2009). Impact of Climate Change on reproductive functions of cattle and buffaloes. Global climate change and Indian Agriculture, 107-110.

Wolfenson, D., Roth, Z., & Meidan, R. (2000). Impaired reproduction in heat-stressed cattle: basic and applied aspects. Animal reproduction science, 60, 535-547.