Review Article ISSN 2766-2624

Advances in Earth and Environmental Science

Effects of Environmental Temperature on Cattle Physiology

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Submitted : 10 Aug 2025 ; Published : 11 Oct 2025

Citation: Raza, M. A. (2025). Effects of Environmental Temperature on Cattle Physiology. *Adv Earth & Env Sci; 6*(4):1-4.
DOI : https://doi.org/10.47485/2766-2624.1076

Abstract

Dairy animals respond to environmental temperatures in different ways. Both high and low temperatures affect the animal's performance variably but stress the animal resulting in reducing the overall productive and reproductive performance. Heat stress is more adverse and comparatively difficult to manage. Stress impact post-absorptive energy and lipid metabolism by impairing liver function and enforce stress by depressing the immune system. The whole mechanism reduces performance of animal. Similarly, extreme cold weather compromises the performance by lowering the energy levels but impact is obviously lesser than the heat stress. Temperature enforce the changes in hormone release interfering the reproductive health in female, while scrotal exposure to the high environmental temperature enforce low sperm production in bulls.

Introduction

Stress is the response provoked when a threat is observed by a living being that reduces the physiological performance of a particular individual. Stress adversely affect the performance of dairy herd. Dairy animals are highly sensitive to stress that directly influence the breeding efficiency by changing follicular development and embryo growth by reducing in metabolic activities. In addition to other factors, environmental temperature is most important stress factor that adversely effects on physiological performance, but the most affected is the decrease in fertility and milk production. Extent of heat is generally measured through the temperature humidity index (THI). October to March is considered the non-heat stress period during which ideal reproductive performance is achieved, while May to June is critical. In addition to genetics, most of the variations in the fertility are determined by environment and nutrition (Dash et al., 2016). Stressors activate the central nervous system (CNS) to transmit signal (Bhimte et al., 2021). Data revealed the calving to conception interval may be as high as 157 days in Friesian cows (Saleem et al., 2006). Physiological response reduced when body temperature is increased due to high environmental temperature causing problem in heat tolerance (Girma & Gebremariam, 2019). Reduced efficiency in dairy animals causes heavy economic losses. Nutritional and management strategies are helpful to reduce the influence of stress. Generally, hot seasons of the year are accompanied by significant losses for dairy farmers (Skliarov et al., 2022). Similarly, the animal, which are exposed to extreme cold are likely to face cold stress or hypothermia. Serious illnesses, tissue problems and mortality observed. Energy requirement is increased in severe cold causing difficulty in maintaining body heat through body reserves. Increased feed allowance may compensate the severity of cold weather. However, feed consumption is limited to feeding capacity of cattle. In such cases supplemented feed is required to compensate increased energy requirement (Vining, 1990).

Environmental Temperature Effects

Climatic conditions directly affect the animal because they prefer to stay in open area exposing themselves to Humidity, direct sunrays and environmental temperature (Toghdory et al., 2022). Cold, heat, humidity, rain snow and wind are main stressors affecting the reproductive system by involving the CNS. In high yielders, high metabolic rate is disturbed due to heat stress and aggressively affect the reproductive system causing loss of time because of reduction in fertility parameters. High or low environmental temperature stress are interconnected but affect differently depending upon seasonality and latitude of intensity. Heat stress is most studied of all climatic stressors.

High Environmental Temperature

Environmentally induced hyperthermia is called heat stress (Thoriya et al., 2024). Wind, humidity and direct sunlight are basic environmental factors compromising reproduction by reducing estrous behavior that alters follicular development and inhibiting embryonic growth. Corpus luteum reduced in diameter due to heat stress leading to less production of progesterone compromising conception rate and pregnancy. Low prolactin is also observed under heat stress causing leading to economic losses to the farmer.

Exposure to heat is related to disturbance of physiological mechanism of body including rapid respiration, excessive salivation and adverse effects on reproductive performances. Healthy animals may adopt themselves by maintaining their body temperature (Cooke et al., 2011). The temperature above 35°C cause reduction of milk production and reproductive performances. In some cases, even disturbance in milk composition is observed due to metabolic stress. It is widely accepted that the levels of milk components, similar to the physiochemical properties, can fluctuate extensively over the year (Chen et al., 2014). Non-fat solids percentage is highest in winter and lowest under humid environments, however, temperature has not much effect solid not fat (Pacheco et al., 2021). Somatic cell count in milk observed highest in moderate environmental temperature. Extreme summer season also found reducing the protein components of milk due to less feed intake and reduced metabolic activities. Nonaka et al. (2008) observed heat stress reducing acetate production and increased propionate and butyrate production, resulting change in rumen function and animal consume less roughages due to change in pH. Animals attempt to cool down by panting, which can lead to increased water loss and electrolyte imbalances. Dairy animals desire shade, increase water intake, and reduce activity levels during hot periods, that ultimately lessen the effects of environmental heat. Air flow may reduce the effect by reducing the shed temperature with the support of sprinklers and fans. Dairy breeds are more sensitive to heat stress.

Low Environmental Temperature

Animals exposed to cold face, hypothermia. Serious illnesses, injuries, everlasting tissue problems and ultimately death is observed if animals are not provided warm environment. The reason is difficulty in regulating body temperatures. Cattle on pastures are directly exposed cold stress associated with low temperature and relative humidity. Energy requirement is increased in such animals to maintain body reserves and body temperatures (Pires et al., 2022). Energy levels may be maintained by increasing the feed intake of cattle to compensate the effects of extreme cold (Braganca & Zangirolamo, 2018). Low environmental temperature reduces the overall performance of dairy animals.

How Environmental Stressor Affect the Performance

Feed intake is reduced due to heat stress reducing the productivity in terms of 10 to 25% low milk yield and body weight (Gaughan et al., 2008) and (Collier & Gebremedhin, 2015). Increase in somatic cell count with alteration in fat, protein, SNF and lactose reduces the milk quality. Cases of mastitis increase in summer (Bernabucci et al., 2010). High yielder animals are more sensitive to heat stress. Cattles are comfortable between (- 2 to (+) 20°C and body temperature above 35°C initiate stress reducing milk yield due to less feed intake. Dairy animals have shown alteration in duration of estrus due to high environmental temperature (De Rensis et al., 2021) and slow follicular development. It is also observed that heat stress interferes in the fetal growth. Hot and extreme cold weather disturb endocrine activity.

Puberty in male and female is affected in extreme weather conditions indicated by Sexual behavior and fertility (Edwards & Hansen, 1997). Heat stress reduces estradiol concentration in cattle near to ovulation disturb the LH surge causing delay in ovulation. However, FSH secretion increases under heat stress. Low LH surge may cause low levels of progesterone, cumulatively, resulting in reduction of the length and intensity of oestrus cycle (Garcia et al., 2007). Atresia is noticed during anestrus that is associated with the inadequate secretion of gonadotropins. Therefore, a cow may be in estrus, but will not express it due to her body's response to overheating. Thus the high environmental temperature is associated with reduced fertility due to its harmful impact on oocyte maturation and early developmental stages of embryo. hyperthermia is the main cause of low fertility during summer that lactating cow develop every day in summer (Khastayeva et al., 2021). Low concentration of estradiol in summer results in silent heat especially in buffaloes.

High-temperature results to increase secretion of Endometrial PGF-2α secretion is increased in heat stress causing threat to pregnancy maintenance leads to infertility (Bilby et al., 2008). Intrauterine activity in cow is compromised due to heat stress causing reduced blood flow to the uterus due to raised uterine temperature (Collier et al., 2017). Heat stress during 3-7 days of pregnancy reduced embryonic survival. The mean plasma prolactin concentration. Initial 3-11 days of embryo development are sensitive to heat stress is reduced gradually become stable with increase in days. During this phase of pregnancy, embryonic viability and development is decreased (De Vane, 2001). In addition, negative impact on ova quality, decreases the viability of young embryos. Embryos at morula and blastocyst stages are not effected with heat stress. Stress affects at embryonic stage varies from breed to breed with a moderate in Bos indicus and a greater negative effect in Bos Taurus. Buffaloes are categorized in greater negative effect, if not provided sufficient heat exchange system during summer. Buffaloes spending more time in water pond during day have shown lesser effects on fertility due to adjustment in body heat. In bulls, testes are located outside the body to maintain 2-6°C less temperature than the body temperature for production of fertile sperm. Increased testicular temperature results from thermal stress changes in seminal and biochemical parameters leads to infertility problems in bulls. Semen quality is abruptly reduced due to heat stress. It is observed that younger bulls are more sensitive to heat in sperm production.

Composition and production of milk is adversely affected by heat stress in high genetic animals (Bouraoui et al., 2002). More than 35°C of body temperature stimulates stress in lactating dairy cows (Berman, 2005) and milk yield decreased by reduction of feed intake due to metabolic disorders (Wheelock et al., 2010). Reduced feed intake drop in upto 50% of milk production (Baumgard & Rhoads, 2013). Heat stress during the dry period reduces mammary cell proliferation that ultimately reduces upto 35% milk production (Tao & Dahl, 2013). Milk quality is also reduced in humid environment. During summer season, there is lower milk fat and milk protein (Singh et al, 2013) but no effect on lactose in milk.

Conclusion

Environmental temperature significantly impacts dairy animals, primarily causing a decrease in milk production when temperature is too high due to reduced feed intake while other effects are impaired reproduction, increased respiration rate, and potential health complications, particularly in extreme heat conditions. Conversely, very cold temperatures can also negatively effect on animal health and productivity, although to a lesser extent than heat. Overall productivity of dairy animals is directly related to the environmental stress. In addition to gross changes, there is change in the milk composition and somatic cell count. These factors can be eliminated with better management practices to improve the performance of animals and profitability of farm.

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