

Beat the Heat: Protecting Buffalo Bull Fertility During Hot Weather

Apeksha Ukey^{1a}, Vikas Diwakar^{2b}, Shubham Nagre^{1c}, Akash Patil^{1c}

^a Assistant Professor, Department of Veterinary Physiology

^b Assistant Professor, Department of Animal Genetics and Breeding

^c Assistant Professor, Department of Animal Nutrition

¹Shourabh College of Veterinary Science, Kheda, Hindaun City, Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India.

² Sanskaram College of Veterinary and Animal Science, Jhajjar, Haryana, India

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Abstract

Seasonal variations in temperature and humidity can influence the reproductive performance of buffalo bulls, particularly under tropical and subtropical climatic conditions. Heat stress may interfere with testicular temperature regulation, sperm development, oxidative balance and semen quality, ultimately affecting breeding efficiency. Buffaloes are particularly vulnerable to direct solar radiation and prolonged heat exposure because of their dark skin and relatively limited sweating capacity. Scientific studies have demonstrated associations between environmental heat stress, scrotal temperature and changes in sperm characteristics. However, the magnitude of these effects varies with breed, individual adaptability, management and climatic conditions. This article explains the physiological mechanisms through which seasonal changes affect buffalo bull fertility and discusses practical measures, including shade, ventilation, cooling, balanced nutrition and regular semen evaluation, that farmers can adopt to protect reproductive performance. Understanding seasonal reproductive patterns can help livestock owners make informed breeding decisions and improve the long-term productivity of buffalo herds.

Keywords: Buffalo bulls; heat stress; reproductive management; semen quality; seasonal variation

Introduction

A healthy breeding bull is one of the foundations of a productive buffalo herd. In dairy farming, successful reproduction supports regular calving, herd replacement and continued milk production. Farmers understandably pay close attention to the health and fertility of female buffaloes, but the bull's contribution is just as important. A bull with poor semen quality may reduce breeding success even when females are healthy and management is otherwise satisfactory.



Environmental conditions, especially temperature and humidity, can influence reproductive performance. Reviews of heat stress in dairy cattle and buffaloes describe effects on physiological function and fertility, making seasonal management an important part of herd care (Dash et al., 2016).

Why do seasons matter for buffalo bulls?

Buffalo bulls experience substantial changes in their surroundings through the year. During hot, dry weather, high air temperature and direct sunlight increase the heat load on the animal. During hot, humid weather, the body may find it harder to lose heat through evaporation. Cooler weather usually reduces this environmental challenge, although housing, exercise, nutrition and the animal's health also matter. Temperature should not be considered in isolation. Relative humidity, solar radiation, air movement and the availability of shade all influence the animal's ability to maintain thermal balance. A bull standing in direct sunlight or housed in a poorly ventilated shed may experience greater heat strain than an animal kept in shade with good airflow. Buffaloes are particularly vulnerable to solar heat because their dark skin absorbs radiation and their capacity for evaporative cooling is relatively limited. Marai and Haebe (2010) reviewed how heat stress can influence buffalo physiology, feed intake and other biological functions. When heat load rises, buffaloes respond through changes such as faster breathing, seeking shade or water, and altering activity. These responses help the body maintain a safe temperature, but prolonged heat can increase physiological strain. If the animal eats less or cannot recover from heat overnight, the challenge may continue for days. Reproductive function can be affected alongside other body functions.

How can heat stress affect reproduction?

Keeping the testes cool

Sperm production works best when the testes remain cooler than the body's core. The scrotum, its skin, blood vessels and associated heat-exchange mechanisms help maintain this temperature difference. Prolonged heat exposure can challenge these mechanisms and raise scrotal or testicular temperature. Research using scrotal infrared thermography in buffaloes has explored the relationship between thermal profiles and semen characteristics, suggesting that temperature monitoring can be a useful research and management tool (Ahirwar et al., 2018). The effect of heat may not be seen in the very next semen sample. Sperm cells develop through several stages before they are ejaculated. If developing cells are affected by heat, changes in motility, viability or morphology may become apparent later. For this reason, one normal semen sample does not necessarily rule out a seasonal problem, and one poor sample should be interpreted alongside repeat examinations and the bull's history.



Hormones and sexual behaviour

Normal reproduction depends on coordination between the hypothalamus, pituitary gland and testes. Luteinising hormone stimulates Leydig cells in the testes to produce testosterone, which supports libido and reproductive function. Follicle-stimulating hormone and testosterone also contribute to the regulation of sperm production. Heat stress may influence endocrine function, but the direction and size of any change can vary with the severity and duration of exposure, nutrition, age and individual tolerance. Reduced sexual activity should therefore be assessed carefully rather than automatically attributed to hot weather.

Oxidative stress and sperm cells

Sperm membranes contain polyunsaturated fatty acids that are vulnerable to oxidative damage. The body naturally produces reactive oxygen species, and small amounts are involved in normal sperm function. Problems arise when their production exceeds the antioxidant defences that control them. This imbalance is called oxidative stress. It can damage sperm membranes and interfere with motility, viability and the ability of sperm to fertilise an egg. Dash et al. (2016) discuss oxidative stress among the mechanisms through which heat stress may impair reproductive performance in dairy cattle and buffaloes. Research is also examining molecular responses to heat stress. Kumar et al. (2024) studied genome-wide DNA methylation patterns in relation to heat stress and altered semen quality in Murrah buffaloes. Such work helps researchers investigate whether seasonal stress is associated with changes beyond the immediate physical condition of sperm. These findings should be understood as part of a developing area of research, not as a reason to assume that every bull exposed to summer heat will become infertile.

What changes should farmers look for in semen?

Semen quality is assessed through several characteristics, including ejaculate volume, sperm concentration, mass activity, progressive motility, viability and sperm morphology. For frozen semen, post-thaw motility and the integrity of sperm membranes and acrosomes are also important. These measures describe different aspects of semen quality and should be interpreted together. A satisfactory semen volume does not guarantee that sperm are moving well or that their shape is normal. Likewise, a single measure cannot provide a complete picture of fertility. In a study of 97,023 ejaculates from 197 bulls belonging to six buffalo breeds, Bhavé et al. (2020) examined semen production and quality under hot semiarid climatic conditions in India. This large dataset illustrates the importance of evaluating semen traits across animals and breeds rather than relying on a single observation. Seasonal observations from Murrah buffalo bulls at ICAR–National Dairy Research Institute, Karnal, found that fresh semen characteristics were generally less favourable during hot, dry and hot, humid periods than during autumn. Frozen semen quality



was least favourable in the hot, humid period, while autumn showed the most favourable results among the seasons studied. Sperm abnormalities were also more frequent during hot, humid weather, followed by hot, dry weather, winter and autumn. These observations reflect the bulls and conditions studied; they should not be treated as a universal ranking for every buffalo herd.

The practical lesson is to monitor semen quality across the year. Autumn may provide more favourable conditions in some settings, but climate, breed, management, nutrition, photoperiod and individual heat tolerance can change the pattern. Breeding programmes should rely on local records and professional semen evaluation, not on the calendar alone.

Why is hot and humid weather especially difficult?

High temperature increases the amount of heat an animal must lose. High relative humidity reduces the effectiveness of evaporative cooling, so the two conditions together can create a serious challenge. A buffalo bull in a crowded, poorly ventilated shed may remain uncomfortable even after the daytime temperature begins to fall. Warm nights can also limit recovery from the previous day's heat. Farmers should observe the animal as well as the weather. Faster breathing, seeking shade or water, reduced feed intake and unusual inactivity may indicate heat strain, although these signs can also occur with illness. Persistent changes, severe distress or a sudden decline in performance warrant veterinary attention.

Practical steps to protect bull fertility

1. Provide shade and comfortable housing

Protect bulls from direct sunlight with suitable shade or well-designed sheds. Roofing should limit heat accumulation, and ventilation should allow warm, humid air to escape. Avoid overcrowding and keep resting areas clean and dry. Shade is a basic, practical step that can reduce the animal's direct exposure to solar radiation.

2. Use cooling methods appropriately

Fans, sprinklers and access to bathing or wallowing facilities can help buffaloes lose heat when they are used appropriately. Water-based cooling should be combined with air movement and good drainage. In humid conditions, simply wetting the animal without sufficient airflow may be less effective. Choose a system suited to local climate, water availability, housing and hygiene.

3. Keep clean drinking water available

Fresh drinking water should be available throughout the day, especially during hot weather. Clean troughs regularly and check that all animals can reach the water easily. Water supports normal physiological functions and is essential when animals are coping with heat.



4. Maintain balanced nutrition

Heat stress can reduce feed intake, which may make it harder for a bull to meet its energy, protein, mineral and vitamin requirements. Provide a balanced ration suitable for the animal's body condition and workload. Avoid using antioxidant or other supplements as a substitute for shade, cooling and adequate feeding. Supplementation should be based on a nutritional assessment and advice from a veterinarian or animal nutritionist.

5. Monitor semen quality and breeding soundness

Periodic breeding soundness examinations can help identify problems in sperm motility, morphology and other reproductive traits. Where possible, compare results across seasons and keep records of collection dates, environmental conditions and semen findings. Repeat testing is particularly useful when a result is unexpectedly poor. Bulls used for natural service should also be assessed for general health, sound legs and feet, libido and ability to mate.

Do not overlook other causes

Heat is only one possible cause of reduced fertility. Infection, reproductive tract abnormalities, lameness, poor body condition, nutritional deficiencies and problems with semen collection, storage or insemination can also affect breeding success. A veterinarian should investigate persistent problems rather than assuming that season is the only explanation. Heat-stress mitigation and good husbandry are important components of reproductive management, but they work best alongside sound health care (Marai and Haebe, 2010; Dash et al., 2016).

Summary

Seasonal heat can challenge buffalo bull fertility by affecting testicular temperature regulation, sperm development and semen quality. Hot, humid conditions may be particularly difficult because high humidity reduces evaporative cooling. Seasonal observations in Murrah buffalo bulls at Karnal indicated less favourable semen characteristics during hot periods and comparatively better results in autumn under the conditions studied; local patterns may differ. Farmers can reduce heat load by providing shade, ventilation, suitable cooling, clean drinking water and balanced nutrition. Regular semen evaluation across seasons helps detect changes early, while veterinary assessment is needed to identify other causes of infertility. The most reliable approach is not to depend on season alone, but to combine good year-round management with local records and sound breeding decisions.

Conclusion

Seasonal changes can influence the reproductive performance of buffalo bulls through effects on testicular temperature regulation, sperm development, oxidative balance and semen characteristics. Hot, humid conditions can present a particularly difficult challenge, while



favourable environmental and management conditions may support better reproductive performance.

For farmers, the key message is simple: protect the bull from excessive heat, provide good nutrition and comfortable housing, and monitor semen quality regularly. These measures can help identify reproductive problems early and support more efficient breeding management. A healthy breeding bull is an important foundation of a productive buffalo herd. By understanding seasonal effects and adopting preventive management, livestock owners can help safeguard fertility and strengthen the long-term productivity of their dairy enterprises.

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