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Infrared Thermography for Enhanced Livestock Health and Welfare

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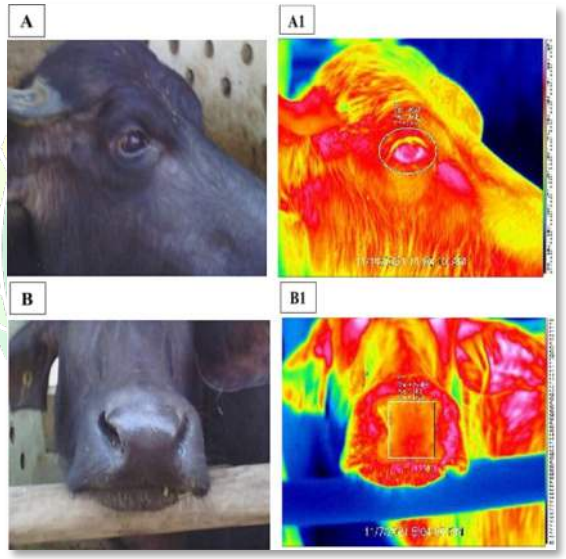
An animal's body temperature is closely linked to its metabolic and physiological activities, serving as a primary indicator of its overall health. Accurate monitoring of thermal fluctuations is essential for identifying diseases, environmental stress, and specific reproductive stages. Traditionally, livestock health assessment relied on physical examinations and invasive procedures such as rectal temperature and heart rate measurements (Stewart et al., 2008). Although cost-effective, these methods require physical restraint, which induces stress and may lead to measurement errors (Soerensen and Pedersen, 2015; McManus et al., 2016).

Moreover, conventional diagnostic approaches depend on visible clinical symptoms such as lethargy or altered gait, which typically appear only at advanced stages of disease. To overcome these limitations, modern agricultural systems are increasingly adopting remote sensing technologies within the framework of Precision Livestock Farming (PLF). Among these, infrared thermography (IRT) has emerged as a revolutionary non-invasive diagnostic tool (Redaelli et al., 2014).



IRT detects natural infrared radiation emitted by the animal's body and converts it into a visual thermogram, reflecting microvascular circulation and metabolic activity in real time. Its contactless nature eliminates handling-induced stress and provides highly accurate physiological data (Lokesh Babu et al., 2018; Zhang et al., 2019). By enabling early, subclinical detection of diseases and stress conditions, IRT significantly enhances animal welfare and farm productivity.

Physiological Principles of Infrared Thermography (IRT)

All objects above absolute zero emit infrared radiation (Zaninelli et al., 2018). Infrared thermal imagers capture this radiation using non-contact sensors (Godyń and Herbut, 2018). Instead of directly measuring temperature, IRT translates these emissions

into thermograms that represent surface temperature patterns.

These thermal patterns reflect underlying tissue metabolism and blood flow. For example, inflammation or infection leads to vasodilation, creating localized "hot spots," whereas reduced circulation appears as cooler regions. Since IRT is entirely non-invasive, it ensures accurate data collection without stress-induced alterations in physiological responses.

Applications of Infrared Thermography in Livestock

1. Viral Disease Detection

IRT is an effective tool for early detection of viral infections. In Bovine Respiratory Disease (BRD), thermal changes in orbital, nasal, and auricular regions can be detected 48–72 hours before clinical signs appear. Early detection improves recovery rates and reduces antibiotic use. IRT is also useful in detecting infections caused by pathogens such as Mycoplasma bovis, Coronavirus, Parainfluenza-3, and Bovine Respiratory Syncytial Virus. Additionally, it aids in diagnosing bluetongue in sheep and rotavirus infections in calves.

2. Mastitis Detection

Mastitis, a major issue in dairy production, causes inflammation of the mammary gland leading to reduced milk yield. While clinical mastitis is visible, subclinical mastitis requires laboratory analysis. IRT provides a rapid, non-invasive screening method by detecting increased udder surface temperature due to inflammation. Routine thermal scanning during milking helps in early identification and intervention.

3. Lameness and Hoof Health Detection

Lameness is a critical welfare and economic concern in livestock. IRT helps detect inflammation in the distal limbs and coronary band. Temperature differences between limbs can predict lameness up to two weeks before visible symptoms appear. It is widely used in cattle, sheep, swine, and poultry for hoof health assessment.

4. Environmental Stress and Thermoregulation Assessment

Livestock are highly sensitive to environmental stress, which affects immunity, productivity, and feed efficiency. IRT evaluates thermoregulation by monitoring heat dissipation from regions such as the eyes, ears, and muzzle. It helps farmers optimize housing conditions, ventilation, and cooling systems. Additionally, IRT is useful in transport and abattoirs for rapid stress assessment.

5. Oestrus Detection

Accurate estrus detection is essential for reproductive efficiency. While wearable sensors are commonly used, they can be expensive and uncomfortable. IRT offers a non-invasive alternative by detecting temperature variations caused by hormonal changes during the estrous cycle, enabling precise identification of reproductive stages.

6. Testicular Abnormality Detection

IRT is valuable in assessing male reproductive health. Since spermatogenesis requires lower testicular temperatures, thermal imaging helps detect abnormalities caused by heat stress or inflammation. Elevated scrotal temperatures are associated with

reduced sperm quality, making IRT an effective tool for screening breeding males.

Economic Viability and Return on Investment (ROI)

The cost of thermal imaging technology has decreased significantly, making it accessible to farmers. Modern devices, including smartphone attachments, are affordable and user-friendly.

The return on investment is achieved through:

- Early disease detection and reduced veterinary costs
- Optimized drug usage and reduced antibiotic dependence
- Improved animal productivity and reduced culling rates

Overall, IRT supports sustainable and profitable livestock management practices.

Conclusion

Infrared thermography has evolved into a practical and highly sensitive diagnostic tool in livestock management. Its non-invasive nature aligns with modern animal welfare standards, while its ability for early disease detection provides significant economic benefits.

The integration of IRT into routine farm practices shifts livestock management from reactive to proactive approaches. With advancements in automation and machine learning, IRT is expected to play a central role in precision veterinary medicine and smart farming systems.

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