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Infrared Thermography in Livestock Farming: A Non-Invasive Tool for Precision Health and Reproductive Management

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ABSTRACT

Efficient livestock production is fundamentally dependent on timely detection of health disorders and optimization of reproductive performance. Conventional diagnostic techniques, although widely practiced, are often invasive, labor-intensive, and limited in detecting early physiological changes. Infrared Thermography (IRT), a non-invasive imaging technique, has emerged as a promising tool for real-time monitoring of physiological and pathological conditions in livestock. It operates by detecting infrared radiation emitted from body surfaces and converting it into thermal images that reflect underlying metabolic activity, blood flow, and inflammatory responses. This article provides an overview of the principles and applications of IRT in livestock farming, including estrus detection, mastitis diagnosis, thermal stress evaluation, and welfare monitoring. Scientific evidence indicates that IRT enhances reproductive efficiency, enables early disease detection, and improves animal welfare. The integration of IRT with precision livestock farming technologies offers a scalable and data-driven approach for improving productivity and sustainability in livestock farming.

***Keywords**: Infrared thermography, Thermal imaging, Estrus Detection, Mastitis, Precision Livestock Farming*

INTRODUCTION

Livestock production systems are undergoing a paradigm shift toward precision-based management, where real-time monitoring of animal health and reproduction is important for maximizing productivity. Reproductive inefficiency, delayed disease diagnosis, and environmental stress are among the major constraints affecting dairy and pig production systems globally. Traditional diagnostic approaches such as visual estrus detection, rectal thermometry and laboratory-based diagnostics are often subjective, time-consuming, and require handling of animals, which may induce stress and alter physiological responses. Infrared Thermography (IRT) has emerged as a powerful, non-invasive diagnostic tool that allows rapid and contactless assessment of animal health and reproductive status. The technique is based on detecting infrared radiation emitted by body surfaces and translating it into thermographic images. Since temperature variations are closely linked to physiological processes such as blood flow, inflammation, and metabolic activity, IRT provides valuable insights into animal health and productivity (Bewley et al., 2008; Montanholi et al., 2015).

First applied in veterinary science during the 1960s, IRT experienced limited uptake due to the high cost and poor resolution of early cameras. Advances in uncooled microbolometer detector technology have since reduced camera costs by more than 90%, while improving thermal sensitivity to below 0.05°C. Useful advancements in sensor technology, image processing, and artificial intelligence have further enhanced the applicability of IRT in livestock farming. Contemporary veterinary applications span mastitis detection in dairy cattle, reproductive monitoring in swine, lameness diagnosis in horses and ruminants, welfare assessment under heat stress, and automated on-farm surveillance integrated with milking robots and identification systems. It is increasingly being used as a tool for early disease detection, reproductive monitoring, and welfare assessment, thereby contributing to improved farm management and economic efficiency (Stewart et al., 2007). IRT has the ability to provide stress-free, contactless, and accurate monitoring of animals, making it particularly suitable for large-scale and automated farming systems. This review critically appraises its prospects, potential applications and methodological gaps that must be bridged before IRT can be adopted as a standardized diagnostic tool in livestock practice.

Principles of Infrared Thermography

Infrared thermography operates on the principle that all objects with a temperature above absolute zero (0 K) emit infrared radiation across a spectrum determined by their surface temperature. This radiation lies within the electromagnetic spectrum between visible light and microwave radiation. The intensity of emitted radiation is directly proportional to the temperature of the object and is governed by physical laws such as Planck's radiation law and the Stefan–Boltzmann law. Thermal cameras capture this radiation and convert it into visual thermograms, where each pixel represents a temperature value. Biological tissues like mammalian skin and mucous membranes have high emissivity (approximately 0.98), making them suitable for accurate thermographic measurements (Stewart et al., 2007; Montanholi et al., 2015). Temperature variations detected through IRT are indicative of changes in blood circulation, metabolic activity, and inflammatory processes. Healthy animals display bilateral thermal symmetry across corresponding body regions. Disruption of this symmetry—a thermal "hot spot" or asymmetry—is the primary diagnostic indicator in veterinary thermography. Regions of particular clinical relevance include the udder quarters (mastitis), the periocular area (fever correlate), the coronary band and hoof (laminitis, foot rot), the perineum and vulva (estrus), and limb joints (synovitis, arthritis). The non-contact nature of IRT eliminates the need for physical restraint, thereby reducing stress-induced variability in measurements. However, accurate interpretation requires standardized conditions, including controlled environmental temperature, absence of direct sunlight, and proper camera calibration.

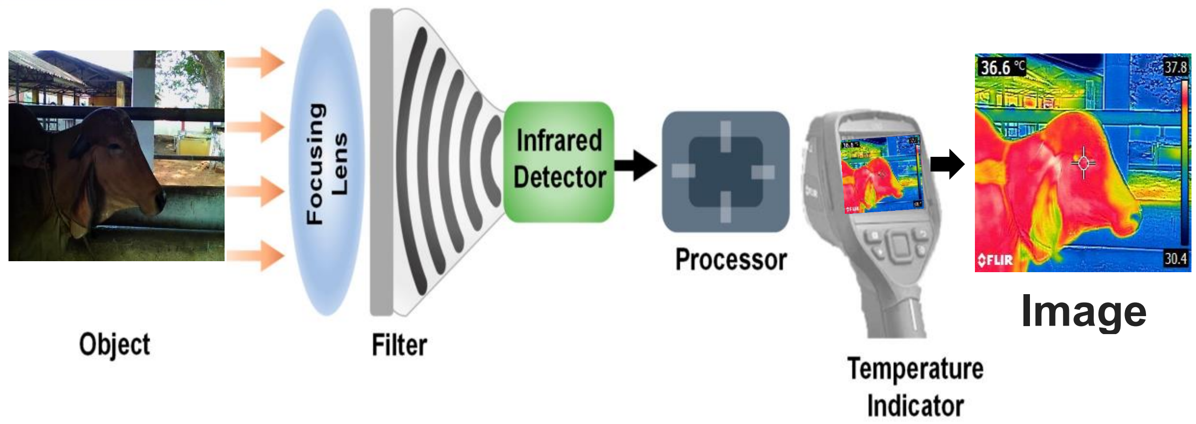

Figure 1: Diagrammatic representation of Infrared Thermographic Imaging Process in Livestock System

Applications of Infrared Thermography in livestock farming

1**. Estrus Detection and Reproductive Monitoring**

Accurate detection of estrus is critical for improving conception rates and reducing calving intervals in livestock (Diskin and Sreenan, 2000). Infrared thermography provides a reliable method for detecting estrus by identifying temperature changes associated with hormonal fluctuations (Hurnik et al., 1985; Talukder et al., 2014). Elevated estrogen levels during estrus increase blood flow to reproductive organs, resulting in a measurable rise in vulvar temperature (Talukder et al., 2015). Studies in cattle, buffalo, and goats have demonstrated significant increases in surface temperature during estrus, with strong correlations between thermographic readings and hormonal profiles. These thermal patterns can indicate reliable timing of artificial insemination, thereby improving fertility outcomes. Unlike conventional methods that rely on behavioral observation, IRT provides objective and quantifiable data. Its application in reproductive management reduces labor dependency, improves breeding efficiency, and minimizes non-productive days.

2. Mastitis Detection and Udder Health Monitoring

Mastitis remains one of the most economically significant diseases in dairy cattle (Halasa et al., 2007). Early detection is essential to prevent production losses and maintain milk quality (Seegers et al., 2003). Inflammatory processes associated with mastitis lead to increased blood flow and elevated udder surface temperature, which can be detected using IRT (Polat et al., 2010; Berry et al., 2003). Research indicates that thermographic imaging can detect temperature differences of 1–2.5°C between healthy and infected udder quarters, enabling early identification of subclinical mastitis (Polat et al., 2010). Studies have reported sensitivity and specificity values of approximately 0.80 and 0.81 for mastitis detection using IRT (Colak et al., 2008). IRT can be integrated with automated milking systems and RFID-based identification technologies to enable continuous monitoring of udder health (Bewley et al., 2008). This approach reduces reliance on manual inspection and enhances herd-level disease management.

3. Thermal Stress Assessment and Reproductive Performance

Environmental stress, particularly heat stress, significantly affects livestock productivity and reproductive efficiency (Hansen, 2009). Elevated temperature-humidity index (THI) levels lead to physiological disturbances, including reduced feed intake, altered hormonal balance, and impaired spermatogenesis. Infrared thermography has been used to assess thermal stress by measuring surface temperatures of body regions such as the scrotum, eye, and flank (Stewart et al., 2007; Montanholi et al., 2008). Increased surface temperature indicates heat stress and reduced thermoregulation capacity. Studies have shown strong correlations between thermographic measurements and environmental conditions, highlighting the utility of IRT in monitoring thermal stress (Montanholi et al., 2008). Since spermatogenesis requires temperatures lower than core body temperature, even slight increases in testicular temperature can negatively impact semen quality. IRT thus provides a rapid, non-contact means of pre-breeding soundness evaluation, complementing the conventional semen morphology and motility assessments. Its application is particularly relevant in farming enterprises where the reproductive performance of a single male influences a large number of offspring. IRT also aids in early detection of heat stress, enabling timely management interventions such as cooling systems and altered breeding schedules.

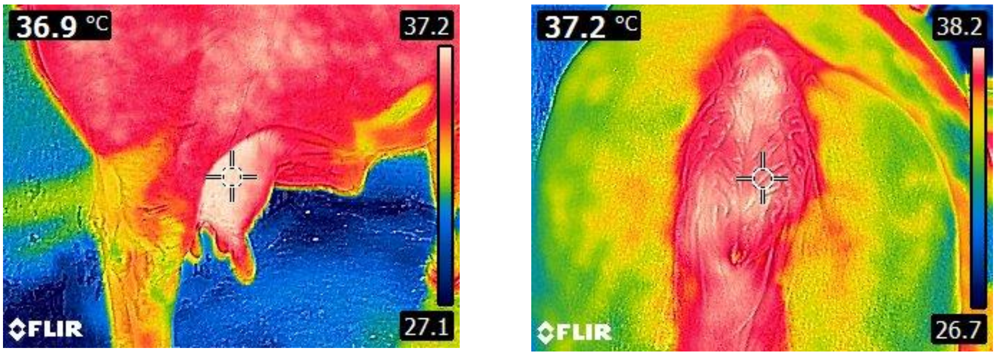

Figure 3: Thermographic images of udder and vulvar areas of dairy cow showing surface temperature distribution across different regions

4. Disease Diagnosis and Lameness Detection

Infrared thermography is an effective tool for detecting various diseases and injuries in livestock (Alsaaod and Büscher, 2012). Inflammatory conditions such as lameness, joint disorders, and tissue injuries result in localized increases in temperature due to enhanced blood flow (Eddy et al., 2001). These changes can be identified through thermographic imaging before clinical signs become visible. IRT has been widely used in veterinary medicine for diagnosing orthopedic disorders in horses and cattle, as well as for monitoring healing processes (Turner, 2001). Early detection of such conditions reduces economic losses and improves animal welfare.

5. Animal Welfare and Behavioural Monitoring

Animal welfare is a key component of sustainable livestock production (Broom, 2011). Infrared thermography provides a non-invasive method for assessing stress and discomfort in animals (Stewart et al., 2007). Changes in eye temperature and body surface temperature are indicative of stress responses and can be monitored using thermal imaging. IRT is also used to evaluate housing conditions, ventilation efficiency, and thermal comfort in livestock facilities (McManus et al., 2016). By identifying areas of heat accumulation or poor airflow, farmers can optimize environmental conditions to improve animal comfort and productivity.

Advantages and limitations in IR thermography

Infrared thermography (IRT) offers several key advantages in livestock production by providing a rapid, non-invasive, and contactless means of assessing animal health and physiological status. One of its primary strengths is the ability to monitor real-time changes in body surface temperature, which reflect underlying processes such as inflammation, blood flow, and metabolic activity. This enables early detection of diseases like mastitis, lameness, and thermal stress, often before clinical signs become visible. By minimizing the need for physical handling, IRT significantly reduces animal stress and improves welfare, which is particularly important in sensitive or high-producing animals. Additionally, the technology is well-suited for large-scale herd management, as it allows simultaneous screening of multiple animals with minimal labor input. Its application in reproductive management, especially for estrus detection, further enhances breeding efficiency. Overall, IRT serves as a valuable precision tool that supports proactive, efficient, and welfare-oriented livestock management.

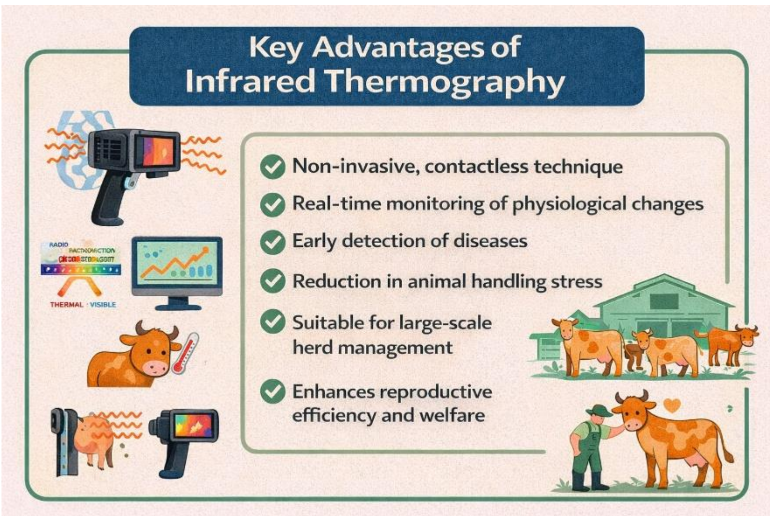

Figure 2: Major advantages of IR Thermography in livestock systems

Despite its significant advantages, practical application of IRT in livestock systems is constrained by certain technical, environmental, and operational factors. One of the primary limitations is the strong influence of environmental conditions on thermal readings. Ambient temperature, relative humidity, wind speed, and solar radiation can alter surface heat dissipation, leading to variability in thermographic measurements. Hence, standardization of imaging conditions—such as shaded environments, consistent camera distance, and controlled timing—is essential for reliable interpretation. Animal-related factors also introduce variability. Differences in hair coat thickness, skin pigmentation, subcutaneous fat, and cleanliness can significantly affect emissivity and heat emission patterns. In species like cattle and buffalo, mud contamination or dense hair coats may obscure thermal signals, reducing diagnostic sensitivity. Similarly, physiological factors such as stage of lactation, age, stress status, and circadian rhythms can influence baseline temperature, necessitating careful interpretation within biological context rather than relying on absolute thresholds.

Another major constraint is the requirement for technical expertise in data acquisition and interpretation. Thermographic images are not self-explanatory; they require trained personnel to distinguish between physiological and pathological heat variations. The lack of universally standardized protocols across species and applications further complicates reproducibility and large-scale adoption. Additionally, IRT is primarily a screening and monitoring tool rather than a definitive diagnostic method. While it is highly effective for early detection of abnormalities such as inflammation or heat stress, it must be complemented with confirmatory diagnostic tests for accurate disease diagnosis. Addressing these limitations through standardization, training, and technological innovation will be critical for wider adoption.

Future prospects

The future of infrared thermography in livestock farming is closely aligned with the evolution of precision livestock farming and digital agriculture. With rapid advancements in artificial intelligence (AI) and machine learning (ML), thermographic data can now be analyzed automatically to identify patterns associated with disease, estrus, or stress. These technologies enable the development of predictive models that can detect subtle physiological changes well before clinical symptoms appear, thereby facilitating proactive herd management.

One of the most promising developments is the integration of IRT with sensor-based monitoring systems. Combining thermal imaging with wearable sensors (e.g., activity trackers, and temperature loggers) allows for multi-parameter assessment of animal health. Such integrated systems can provide real-time alerts for conditions like mastitis, lameness, or heat stress, significantly reducing response time and improving treatment outcomes. The emergence of portable and smartphone-compatible thermal cameras is expected to democratize access to this technology. These devices offer sufficient resolution for field-level applications and can be easily used by veterinarians and farmers with minimal training. In developing countries, this could be particularly transformative by enabling low-cost, on-farm diagnostics and reducing dependency on centralized laboratory facilities.

Another important area of advancement is the application of IRT in reproductive biotechnology. Continuous thermal monitoring of reproductive organs can improve estrus detection accuracy and optimize timing of artificial insemination. Integration with automated breeding systems and herd management software can further enhance reproductive efficiency and genetic progress. In addition, ongoing research is focusing on improving the sensitivity and specificity of thermographic diagnostics through advanced image processing, spectral analysis, and calibration techniques. As these innovations mature, IRT is likely to transition from a supportive diagnostic tool to a core component of smart livestock management systems. Overall, IR thermography holds immense potential to revolutionize livestock health monitoring by enabling non-invasive, real-time, and data-driven decision-making, thereby contributing to sustainable and efficient animal production systems.

CONCLUSION

Infrared thermography represents a transformative advancement in livestock health and reproductive management. Its ability to detect subtle physiological changes in a non-invasive and rapid manner makes it an important tool for modern animal husbandry. Applications ranging from estrus detection and mastitis diagnosis to welfare monitoring highlight its versatility and importance. When integrated with precision farming technologies, IRT has the potential to transform livestock systems by enabling early diagnosis, improving reproductive efficiency, and enhancing overall productivity. With continued methodological refinement and protocol standardization, IRT holds considerable promise as a high-throughput, stress-free diagnostic support in modern precision livestock farming. Adoption of this technology, along with proper training and standardization, will play a crucial role in achieving sustainable, profitable and precision livestock farming.

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REFERENCES

Bewley, J. M., Grott, M. W., Einstein, M. E., and Schutz, M. M. (2008). Impact of intake water temperatures on reticular temperatures of lactating dairy cows. Journal of Dairy Science, 91(10), 3880–3887.

Montanholi, Y. R., Lim, M., Macdonald, A., Smith, B. A., Goldhawk, C., Schwartzkopf-Genswein, K., and Miller, S. P. (2015). Technological, environmental and biological factors: referent variance values for infrared imaging of the bovine. Journal of Animal Science and Biotechnology, 6(1), 1-16.

Stewart, M., Webster, J. R., Verkerk, G. A., Schaefer, A. L., Colyn, J. J. and Stafford, K. J. (2007). Non-invasive measurement of stress in dairy cows using infrared thermography. Physiology and Behavior, 92, 520–525.

Diskin, Michael G., and Sreenan, John M. (2000). Expression and detection of oestrus in cattle. Reproduction Nutrition Development, 40(5), 481–491.

Hurnik, J. Frank, Webster, A. B., and DeBoer, S. (1985). An investigation of skin temperature differentials in relation to estrus in dairy cattle using a thermal infrared scanning technique. Journal of Animal Science, 61(1), 109–113.

Talukder, S; Kerrisk, KL; Ingenhoff, L; Thomson, PC; Garcia, SC; Celi, P. (2014). Infrared technology for estrus detection and as a predictor of time of ovulation in dairy cows in a pasture-based system. Theriogenology, 81 (7): 925-935.

Talukder, Shakil, Thomson, Philip C., Kerrisk, Kim L., Clark, Christine E. F., and Celi, Pietro. (2015). Evaluation of infrared thermography for predicting estrus in dairy cows. Journal of Dairy Science, 98(6), 3864–3875.

Halasa, Tariq, Huijps, Katinka, Østerås, Olav, and Hogeveen, Henk. (2007). Economic effects of bovine mastitis and mastitis management: A review. Veterinary Quarterly, 29(1), 18–31.

Seegers, Henri, Fourichon, Christine, and Beaudeau, François. (2003). Production effects related to mastitis and mastitis economics in dairy cattle herds. Veterinary Research, 34(5), 475–491.

Polat, B., Colak, A., Cengiz, M., Yanmaz, L. E., Oral, H., Bastan, A., Kaya, S. and Hayirli, A. (2010). Sensitivity and specificity of infrared thermography in detection of subclinical mastitis in dairy cows. Journal of Dairy Science, 93(8), 3525–3532.

Berry, R. J., Kennedy, A. D., Scott, S. L., Kyle, B. L. and Schaefer, A. L. (2003). Daily variation in udder surface temperature of dairy cows measured by infrared thermography. Canadian Journal of Animal Science, 83, 687–693.

Colak, A., Polat, B., Okumus, Z., Kaya, M., Yanmaz, L. E. and Hayirli, A. (2008). Short communication: Early detection of mastitis using infrared thermography in dairy cows. Journal of Dairy Science, 91(11), 4244–4248.

Hansen, P. J. (2009). Effects of heat stress on mammalian reproduction. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1534), 3341–3350.

Montanholi, Yuri R., Odongo, Nicholas E., Swanson, Kevin C., Schenkel, Flavio S., McBride, Brian W., and Miller, Stephen P. (2008). Application of infrared thermography as an indicator of heat and methane production. Journal of Animal Science, 86(6), 1528–1534.

Alsaaod, M., and Büscher, W. (2012). Detection of hoof lesions using digital infrared thermography in dairy cows. Journal of Dairy Science, 95(2), 735–742.

Eddy, Alan L., van Hoogmoed, Larry M., and Snyder, Jeffrey R. (2001). The role of thermography in the management of equine lameness. The Veterinary Journal, 162(3), 172–181.

Turner, Tracey A. (2001). Diagnostic thermography. Veterinary Clinics of North America: Equine Practice, 17(1), 95–113.

Broom, Donald Michael. (2011). A history of animal welfare science. Acta Biotheoretica, 59(2), 121–137.

McManus C., Candice B. Tanure, Vanessa Peripolli, Luiza Seixas, Vivian Fischer, Alexandre M. Gabbi, Silvio R.O. Menegassi, Marcelo T. Stumpf, Giovani J. Kolling, Eduardo Dias, João Batista G. Costa. (2016). Infrared thermography in animal production: An overview, Computers and Electronics in Agriculture, 123, pp: 10-16.

Sathiyabarathi, M., Jeyakumar, S., Manimaran, A., Pushpadass, H. A., Sivaram, M., Ramesha, K. P. (2016). Infrared thermography: A potential non-invasive tool to monitor udder health status in dairy cows. Veterinary World, 9(10), 1075–1081.

Sathiyabarathi, M. (2016). Investigation of body and udder skin surface temperature differentials as an early indicator of mastitis in Holstein Friesian crossbred cows using digital infrared thermography technique. Veterinary World, 9(12), 1386–1391.

Machado, N. A. F., Da Costa, L. B. S., Barbosa-Filho, J. A. D., De Oliveira, K. P. L., De Sampaio, L. C., Peixoto, M. S. M. and Damasceno, F. A. (2021). Using infrared thermography to detect subclinical mastitis in dairy cows in compost barn systems. Journal of Thermal Biology, 97, 102881.

Korelidou, V., Simitzis, P., Massouras, T., and Gelasakis, A. I. (2024). Infrared Thermography as a Diagnostic Tool for the Assessment of Mastitis in Dairy Ruminants. Animals, 14(18), 2691.