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# ASSOCIATION BETWEEN FOOT SKIN TEMPERATURE (FST) AND LOCOMOTION SCORING (LS) IN DAIRY CATTLE

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**Abstract**

The health status of the hoof in dairy cattle is crucial for their overall well-being and productivity. Hoof diseases and lesions can lead to lameness, decreased milk production, and economic losses for dairy farmers. Traditional methods of assessing hoof health involve manual inspection and trimming, which can be time-consuming and subjective. This research article explores the potential use of a phone-connected infrared camera as a non-invasive and objective tool for assessing the health status of the hoof in dairy cattle, by investigating the association between foot skin temperature (FST) and locomotion scoring (LS) in a group of Romanian Black Spotted dairy cows. LS was carried out using the mobile app developed by the Wisconsin University (Locomotion Scorer). The thermograms were collected during afternoon milking and processed using the FLIR software. Overall, 73.9% of the cows were scored as non-lame, while 13.04% presented signs of foot lesions. The highest temperature observed in the interdigital area, in the lame group, by thermography, was T°=36.5°C. In conclusion, monitoring hoof health status in dairy cattle is essential for ensuring their well-being and productivity. The use of an infrared thermal camera for the assessment of foot surface temperature has shown promise as a noninvasive tool for evaluating hoof health.

**Key words**: infrared termography; lameness; locomotion score; dairy cattle

## INTRODUCTION

Foot diseases, including foot rot and digital dermatitis, are prevalent in dairy cattle and can have a significant impact on animal welfare and productivity (Chapinal *et al*., 2013). Research efforts have focused on investigating the etiology, risk factors, diagnosis, and control of foot-related lameness in dairy cattle (Warema *et al*., 2021). It has been demonstrated that foot disorders in dairy cattle have a heritable component, indicating a genetic predisposition to these conditions Koenig et al, 2005; Oberbauer *et al*., 2013). Furthermore, modeling approaches have been used to assess the welfare impact of foot disorders in dairy cattle, highlighting the importance of pain intensity and clinical foot disorders in determining the welfare of the animals (Bruijnis *et al*., 2012).

Hoof health in dairy cattle is influenced by various factors, including nutrition and genetics. Langova *et al*., (2020) reviewed the impact of nutrients on hoof health in cattle and highlighted the role of minerals such as calcium, iron, copper, zinc, iodine, selenium, molybdenum, and chromium in hoof development and disease.

Genetic factors also play a significant role in hoof health. Genetic selection for hoof health traits can accelerate the rate of genetic gain in lameness in dairy cows. Ring *et al*., (2018) discussed the opportunities to enhance claw health through genetic selection and highlighted the importance of routine recording of claw health status for genetic evaluation. Furthermore, Solano *et al*., (2016) conducted a study to estimate the genetic parameters for hoof lesions and their relationship with feet and leg traits in Canadian Holstein cows. They found that there were significant genetic correlations between hoof lesions and feet and leg conformation traits, indicating that genetic selection for improved feet and leg conformation could lead to better hoof health

Monitoring hoof health status in dairy cattle is crucial for ensuring the well-being and productivity of the animals. Lameness, which is often caused by hoof disorders, is a complex condition that is challenging to detect and manage (Flowers and Weary, 2006). Traditional methods of assessing hoof health, such as locomotion scoring and visual inspection, have limitations in terms of accuracy and objectivity.



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One promising approach to assess hoof health is the use of infrared thermal cameras to measure foot surface temperature. This method allows for non-invasive and real-time monitoring of the temperature distribution on the hooves, which can provide valuable insights into the presence of hoof pathologies and potential lameness issues (Stokes *et al*, 2012; Warema *et al*., 2021).

This research article explores the potential use of a phone-connected infrared camera as a non-invasive and objective tool for assessing the health status of the hoof in dairy cattle, by investigating the association between foot skin temperature (FST) and locomotion scoring (LS) in dairy cattle.

## MATERIAL AND METHOD

*Data Collection*

This study was carried out in March–April 2023 and data were collected from a number of 23 dairy Romanian Black Spotted cows reared in a semi-intensive system and milked twice per day, in a dairy farm located in the northeast of Romania. Prior to capturing the digital images, the hooves of the cattle were not subjected to any washing or cleaning procedures. This deliberate omission was made to ensure that the infrared thermography (IRT) devices used for lameness detection would not be compromised in their usefulness. A cut-off temperature value of 27 °C was used to define foot lesions of hind feet, as described previously by Stokes *et al*., 2012.

*Clinical assessment of the locomotion score*

Assessment of locomotion score required the observation of well-described gait and postural features, while cows were moving on a level surface. Visual observation of the cows was carried out after milking, because cows with claw horn lesions, such as sole ulcers, exhibit the most noticeable locomotor irregularities after milking. Scoring was carried out using the mobile app developed by the Wisconsin University (Locomotion Scorer). The software allows the locomotion scoring using a 4-category scale and provides images, video, and vocal explanations for evaluation. A graphical and numerical overview of the cows' scores was provided once the evaluation was completed (https://www.vetmed.wisc.edu/fapm/svm-dairy-apps/locomotion-scorer/).

*Foot skin temperature*

The thermograms were generated using an infrared thermo-graphic phone-connected camera (Flir One Pro, Flir Systems). Thermograms of each cow's target region were acquired from 0.5 m distance during afternoon milking. The designated area was the heel bulbs and below in the hindfoot. The temperature reflected by the environment was 20 °C. The images were processed using the ThermaCAM software (FLIR Systems, USA).

*Data processing*

A total of 97 hind foot thermograms were acquired throughout the four days of data collection. However, upon analysis, it was determined that 7 of them did not meet the required quality standards for inclusion in this research. The exclusion was mostly attributed to the designated region not being completely visible or being blurry within the thermograms.

*Statistical Analysis*

The highest recorded temperature from each thermogram was exported to Microsoft Excel (Microsoft, USA) and associated with the locomotion score (LS) of the corresponding cow. Cows with LS values of 2 and 3 were categorized as lame. The statistical analysis was conducted using GraphPad Prism 9 software, developed by GraphPad Software in San Diego, CA, USA.

## RESULTS AND DISCUSSIONS

In recent years, there has been a growing interest in the use of infrared thermography (IRT) as a non-invasive tool for assessing the health status of cattle, particularly hoof health. Several studies have demonstrated the potential of IRT in detecting various health conditions in cattle, such as udder health status, respiratory disease, lameness, and foot lesions. These cameras have been employed to study the relationship between an animal's physiology and surface temperature, as well as to analyze metabolic heat loss (Warema *et al*., 2021). By capturing thermal images of the hooves, it is possible to detect abnormalities in temperature distribution that may indicate the presence of foot diseases or injuries (Alsaaod and Büscher, 2012).

For instance, studies by Zaninelli *et al*., (2018), Byrne *et al*., (2018), and Alsaaod *et al*. (2015) have investigated the application of IRT in evaluating the health status of dairy cows, sheep, and cattle, respectively. These studies have shown promising results in using IRT for the early detection of health issues, including hoof lesions, lameness, and respiratory diseases.

Lameness in dairy cattle is a common health problem that affects animal welfare, milk production, and longevity. One of the traditional methods of assessing lameness is visual observation grading, which uses a locomotion score to compare healthy and unhealthy cows on a scale of 0 to 4, with 0 being a healthy cow and 5 being a severely sick cow.

In our study, 73.91% of the analyzed cows did not exhibit any signs of foot injuries and were

graded as normal, with score 0, white 13.04 of the cows received 2 score, indicating the debut of hoof lessions (Table 1).

Although the assessment of locomotion score is a method that has been routinely used in dairy farms globally, it relies on subjective gait scoring systems, which can be time-consuming and prone to human error.

Table 1.

Distribution of locomotion score and their percentage in the analyzed group

| | ***No. of scored cows*** | ***%*** |
|---|---|---|
| **1- Walks with even weight bearing and rhythm on all four feet, with a flat back. Long fluid strides possible** | 17 | |
| **2 - Steps uneven or strides shortened, but affected limb or limbs not immediately identifiable.** | 9 | |
| **3 - Uneven weight bearing on a limb is immediately identifiable and/or obviously shortened strides (usually with an arch to the center of the back).** | 6 | |
| **4 - Unable to walk as fast as a brisk human pace coupled with uneven weight bearing and shortened stride, with a back arch.** | 3 | |
| ***Total*** | ***45*** | |

Table 2.

Descriptive statistics of the results obtained from hoof assessment using thermography

| ***Category*** | ***Mean*** | ***Standard Deviation*** | ***Min value*** | ***Max value*** |
|---|---|---|---|---|
| Healthy cows group | 30.8 °C | 2.7 °C | 26.7 °C | 33.5 °C |
| Lame cows group | 35.3 °C | 3.6 °C | 34.1 °C | 36.1 °C |

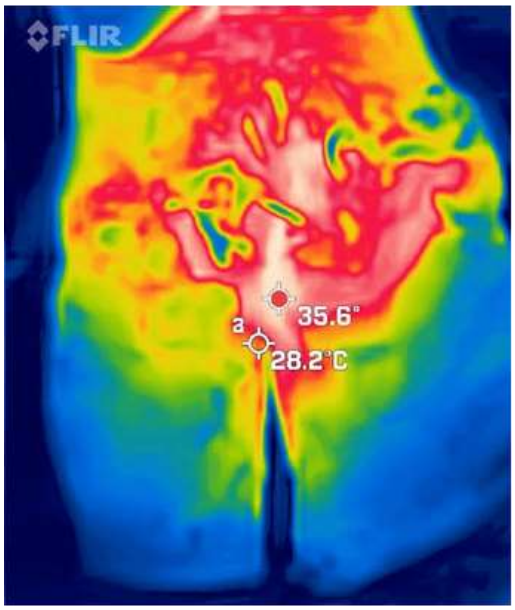


Figure 1 Infrared Thermal image of foot of the dairy cow exhibiting increased temperature in the interdigital area (T°-36.5°C) in a cows with score 3 (locomotion score). The red and blue hues of the scale correspond to the highest and lowest temperatures, respectivel

Our preliminary study showed a linear association between individual cow locomotion score and foot skin temperature. Cows with locomotion score above 2 and 3 exhibited higher skin surface temperature as compared to cows with score 1.

In recent years, there has been a growing interest in using objective measures, such as infrared thermography, to enhance lameness detection. Studies have shown that handheld infrared thermometers can be used to optimize lameness detection by analyzing foot-surface

temperatures and temperature differences between the hind feet of individual cows (Gelasakis *et al.*, 2021).

Our findings suggest that even a low-cost thermal imaging device, such as the one used in the study has the potential to serve as a tool for detecting lameness. If practitioners and vets were to use these devices more often, it might lead to higher rates of lameness identification and ultimately improve animal welfare.

## CONCLUSIONS

In conclusion, monitoring hoof health status in dairy cattle is essential for ensuring their well-being and productivity. The use of an infrared thermal camera for the assessment of foot surface temperature has shown promise as a noninvasive tool for evaluating hoof health. Infrared thermography (IRT) can detect surface heat emitted as infrared radiation and generate pictorial images without causing radiation exposure. Several studies have demonstrated the potential of IRT for the detection of lameness and other hoof lesions in dairy cattle. Hoof health is influenced by various factors, including nutrition and genetics.

Minerals and genetic selection for improved feet and leg conformation have been identified as important factors in hoof health. Other diagnostic methods, such as computerized claw trimming database programs, have also been used for monitoring hoof health in dairy herds. Overall, the combination of IRT and other diagnostic methods can provide valuable insights into the hoof health status of dairy cattle.

Further research is needed to validate the effectiveness and reliability of this approach in practical settings.

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