

Infrared Thermographic Assessment of Cold Stress and Growth Performance in Romanian Spotted and Romanian Brown Calves

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Abstract

Infrared thermography (IRT) represents a non-invasive method for detecting temperature variations on the surface of an animal's body. By capturing infrared radiation emitted by the animal and converting it into thermal images, IRT enables the early identification of health and physiological disturbances. The aim of the study was to test the ability of Romanian Spotted (RS) and Romanian Brown (RB) calves to adapt to cold thermal stress. In this respect, 20 calves (10 RS and 10 RB) were included, having recorded the dynamic of the body temperature at the nose (BTN) and eye (BTE) and average daily gain (ADG) according to environmental temperature (ET) and calves' breed. Data were collected between January and March 2025, being expressed as average and standard deviation. Thermal images were collected twice daily, during the morning and afternoon, from a distance of 0.5 to 2 meters, using a FlirOne mobile infrared camera. Comparisons were performed using one-way ANOVA, with the categorical factor being the calves' breed. Decisions about the acceptance or rejection of statistical hypotheses were made at the 0.05 level of significance. No significant differences ($p>0.05$) were observed for BTN (23.24 ± 3.14 °C vs. 24.3 ± 2.86 °C for RS and RB) or BTE (33.4 ± 2.44 °C vs. 33.9 ± 2.97 °C for RS and RB). The ET proved to be an influential factor for both BTN and BTE. No significant difference was recorded for ADG according to the calves' breed (0.818 vs. 0.784 kg/day for RS and RB, $p>0.05$). ET significantly influenced ADG in both breeds, with a value of ADG of 8.84% from January to February compared to February to March (35.15%, $p\leq 0.001$). In conclusion, both breeds included in the study possess comparable abilities to adapt to their environment.

Keywords: cattle, cold stress, infrared thermography, temperature measurements, weight gain.

1. Introduction

Stress is a state that inhibits the expression of typical behaviour and the productive capabilities of animals. It negatively impacts their well-being and limits their growth and development. Cows, as homeothermic organisms, must sustain a stable body temperature of 38°C. When the animals are within the thermo-neutral zone, they do not have to spend additional energy to regulate their body temperature. However, when temperatures drop below the lower critical

temperature, this leads to cold stress, which negatively impacts the productivity and metabolic efficiency of cows. Specifically, for each degree decrease in temperature below the lower critical threshold, the energy demands rise by 1% for animals with a dry coat and by 2% for those with a wet coat [1]. Infrared thermography (IRT) is an innovative, non-invasive technique that safely visualizes thermal profiles. The application of the thermographic method extends beyond industrial use, finding significant roles in both human and veterinary medicine, particularly for diagnostic purposes. In their study, Schaefer et al. (2004) [2] utilized IRT to identify calves affected by the bovine viral diarrhoea virus. They discovered that changes

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in eye temperature exhibited greater consistency than alterations in other anatomical sites. Furthermore, significant variations in eye temperature were noted several days to a week ahead of the appearance of other clinical indicators of infection [3]. Research indicates that the lower critical temperature (LCT) for newborn dairy calves lies within the range of 8°C to 13°C. When temperatures dip below this threshold, calves must consume more dietary energy to regulate their body temperature. Consequently, if they are provided with the same volume of milk as in more temperate conditions, there will be a reduced amount of energy available for their growth [4]. In clinical practice, temperature is regularly monitored and is a vital diagnostic resource for determining an animal's health status and recognizing potential illnesses or physiological shifts. The most widely used and traditional technique involves rectal temperature assessment. The studies conducted have shown medium to strong correlations, indicating that eye or muzzle temperature measurements could be suitable replacements for core body temperature evaluations [5]. The aim of this study was to test the ability of Romanian Spotted (RS) and Romanian Brown (RB) calves to adapt to cold thermal stress.

2. Materials and methods

All experiments were performed in accordance with relevant guidelines and regulations. The experimental procedures and protocols were approved by the Ethical Committee, and the experimental design was in accordance with the EU Directives 2010/63/EU on Experimental Animal Protection [6] and 2008/119/EC on protection of calves [7].

The present study was carried out at the Research and Development Station for Bovine Arad, located in the Western Plain of Romania, and took place between January and March 2025. The study focused on two breeds, Romanian Spotted (RS) and Romanian Brown (RB), and included 10 calves of each breed. Both calf experimental groups were managed under identical rearing conditions. New-born calves were separated from their dams within the first hour after birth and kept in individual maternity barn pens up to 3 days of age. Between 4 and 48 days of age, calves were kept in individual hutches on straw bedding with free access to the resting area (2 m²/head) and moving area (2.3 m²/head). The administration of

the suckling calf's diet consisted of maternal colostrum for the first 3 days and raw milk from its own dam for the next 4 days. From the eighth day of age, raw milk was administered from the tank. The dairy diet was offered in two equal meals per day (7 am and 7 pm). In parallel, starting from the 4th day of life, calves receive *ad libitum* water and concentrated feed administered until the age of 48 days.

Infrared thermography measurements were obtained using a thermal camera Flir One Edge Pro camera (Teledyne FLIR LLC, Wilsonville, USA) [160 × 120 (19,200 pixels), temperature range -20°C - 120°C (-4°F - 248°F)] wirelessly connected to a smart device. The Flir One employs advanced sensor technology to transform heat emitted by all objects into colour images. These images enable users to detect temperature variations as small as a fraction of a degree. The body temperature measured at the nasal region (BTN) and at the lacrimal caruncle of the eye in the orbital region (BTE), as well as the average daily gain (ADG), in relation to environmental temperature (ET) and experimental groups were collected. The thermal images were measured twice daily, during the morning and afternoon, from a distance of 0.5 to 2 meters from the calves (Figure 1). The thermal images revealed that the warmest section of the animal's surface was indicated by a fixed spot representing BTE, in contrast to BTN, which was indicated by a spot that was movable, resulting in 240 records (20 calves x 3 months x 2 readings/day x 2 measurement traits).

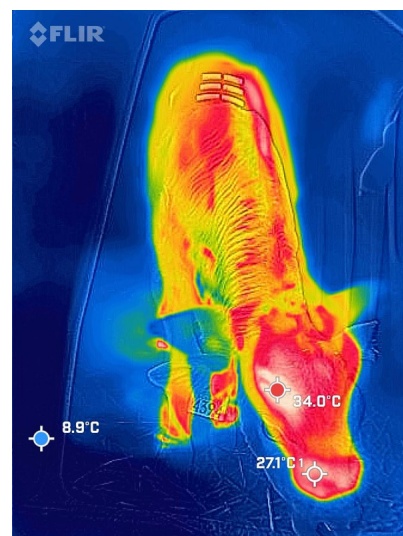


Figure 1. Infrared thermography measurements at the nasal and orbital regions in a dairy calf

In order to clean data for human recording errors and outliers, Grubbs' test (Grubbs, 1969) [8] was performed in a univariate data set characterised by a normal distribution. In the current data set, more than one outlier was recorded, the Tietjen-Moore test (Tietjen & Moore 1972) [9] being applied in order to reject them. Comparisons were performed using one-way ANOVA, with the categorical factor being the environmental temperature. Comparison between body temperatures related to calves' breed and months was assessed using the one-way ANOVA protocol. Differences were assessed using Tukey's test. All the statistical processes were carried out using the software package Statistica (Hill & Lewicki, 2007 [10]). Decisions about the acceptance or rejection of

statistical hypotheses were made at the 0.05 level of significance.

3. Results and discussion

No significant difference was recorded for ADG according to the calves' breed (0.818 vs. 0.784 kg/day for RS and RB, respectively, $p > 0.05$) (Table 1). ET significantly influenced ADG in both breeds, with a value of ADG of 8.84% from January to February, compared to February to March (35.15%, $p \leq 0.001$). No significant differences ($p > 0.05$) were observed between breeds (Table 2) for BTE ($33.4 \pm 2.44^\circ\text{C}$ in RS and $33.9 \pm 2.97^\circ\text{C}$ in RB) neither for BTN ($23.24 \pm 3.14^\circ\text{C}$ in RS and $24.3 \pm 2.86^\circ\text{C}$ in RB). ET proved to be an influential factor for both BTN and BTE.

Table 1. Means (\pm SE) for average daily gain (kg/day) in Romanian Spotted (RS) and Romanian Brown (RB) dairy calves during the cold stress period

Breed	Mean	SE	Coef. Var. (%)	Min.	Max.
RS	0.818 ^a	0.11	18	0.631	1.112
RB	0.784 ^a	0.09	20	0.584	1.054

Column with different superscript differs significantly at $p \leq 0.05$

Table 2. Means (\pm SE) for orbital and nasal IRT data ($^\circ\text{C}$) during the experimental period of cold weather exposure

IRT	Breed	Mean	SE	Coef. Var. (%)	Min.	Max.
Orbital (BTE)	RS	33.4 ^a	2.44	16	31.19	34.68
	RB	33.9 ^a	2.97	17	31.4	35.11
Nasal (BTN)	RS	23.24 ^a	3.14	14.7	20.1	25.26
	RB	24.3 ^a	2.86	19.4	21.13	26.44

Column with different superscript differs significantly at $p \leq 0.05$

The impact of cold stress on cattle is substantial, affecting numerous facets of their health and productivity. Low temperature exposure induces modifications in their haematological and biochemical profiles, thereby affecting their metabolic functions and immune system responses. On a cellular basis, cattle undergo adaptations through modifications in gene expression and protein synthesis to uphold homeostasis. To address these challenges, it is imperative to implement robust management strategies, which may include improving shelter conditions, refining nutritional approaches, and providing optimal health care [11]. Cold stress elevates metabolic rates, resulting in livestock expending additional energy to sustain body temperature, potentially leading to a decline in body condition [12]. Cold stress represents a critical environmental challenge that markedly affects cattle,

with wide-ranging implications for both their physiological well-being and overall productivity. Exposure to suboptimal temperatures initiates a cascade of adaptive responses, including significant alterations in haematological and biochemical profiles. These changes reflect disruptions in metabolic homeostasis, characterized by modified energy utilization and thermoregulatory demands [13]. Moreover, cold stress compromises the efficiency of the immune system, rendering animals more susceptible to infectious diseases and inflammatory conditions [14]. The cumulative impact of these physiological disturbances can lead to reduced growth performance, diminished reproductive efficiency and lower milk yield, ultimately resulting in economic losses for the livestock industry [15].

4. Conclusions

In conclusion, both breeds included in the study exhibit comparable adaptive capacities to environmental conditions, indicating a similar level of physiological and behavioural resilience to cold stress. This finding suggests that genetic selection and local acclimatization have equally contributed to the development of effective thermoregulatory mechanisms and the maintenance of homeostasis. The results highlight the potential of both breeds to perform under variable climatic conditions, positioning them as valuable assets in sustainable livestock production systems. Furthermore, the study emphasizes the importance of adopting tailored herd management strategies that consider not only genetic differences, but also ecological contexts and region-specific stressors.

Acknowledgements

This work was supported by a grant of the Romanian Ministry of Agriculture and Rural Development through the project ADER 7.1.9/2023.

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