The Detection of Rectal Temperature in Dairy Cattle by Using Infrared Digital Laser Thermometer

Deteção da Temperatura Retal em Bovinos Leiteiros Usando Termômetro Digital a Laser Infravermelho

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Abstract

Heat stress in dairy cattle can jeopardize several physiological functions, including milk production, reproduction and immune function. The objectives of this study were to correlate body surface temperature (BST) and rectal temperature (RT) of dairy cows by using an infrared digital laser thermometer as well as to determine the ideal emissivity. Ten dairy cows were maintained under a covered area for three consecutive days. BST and RT measurements were taken at 8 am, 1 pm, and 4 pm every day. Thermal readings were carried out at four distinct anatomic locations: the face, ribcage, rump, and mammary gland at 0.95 and 0.50 emissivity. The temperatures and anatomic locations of thermal measurements were evaluated by ANOVA and the means were compared using the Tukey Test at 5%. Emissivity at 0.50 did not establish a significant (P>0.05) correlation between BST and RT, while a significant correlation (P<0.05) was obtained at 0.95 emissivity. Therefore, emissivity at 0.95 was used to assess the variables. The following equation was established: \( RT = 0.143 \times BST + 33.534 \), which was found to be significant with a determination coefficient of 82%. The results of this study suggest that the utilization of infrared digital laser thermometer with emissivity of 0.95 directed at the middle region of the ribcage can be efficient to estimate the rectal temperature of dairy cows.

Keywords: Animal Well-Fare. Emissivity. Heat Stress. Thermoregulation.

1 Introduction

The effects of high environmental temperature on farm animals, previously considered limited to tropical areas, were extended to the temperate climate areas in response to the rise of global temperature (POLSKY; VON KEYSERLINGK, 2017). Thermal comfort and animal welfare are essential conditions for the production, productivity, and profitability of livestock exploitation (CRUZ et al., 201; LEME et al., 2005). St-pierre et al. (2003); Liu et al. (2019) estimated annual losses of $897 million by the US dairy industry, due to reduction in milk production and animal reproduction. This is a concern, especially for dairy cattle, considering that most of the territorial Brazil is in the tropical region, with a predominance of high temperatures and a high incidence of solar radiation (AZEVEDO et al., 2005).

Heat stress in dairy cattle can jeopardize a variety of physiological functions, including milk production, reproduction and immune function. Most of the negative effects of heat stress on animal performance are consequences of physiological adaptations or the animal’s difficulty maintaining its homeothermy (DIKMEN et al., 2013).

Among physiological parameters, body temperature and its fluctuations are key indicators of animal health and welfare (GODYŃ et al., 2019). Rectal temperature is an indicator of deep body temperature and there are several methods to evaluate temperature differences by obtaining samples from various body anatomic locations, to understand how temperature varies in different parts / organs and how
they change in response to physiological, behavioral, and environmental parameters (MCCAFFERTY et al., 2015).

A low-cost radiometric method used to measure temperatures at a distance was based on sensors that recorded the radiation released by a body having its emissivity as a parameter. Emissivity is a dimensionless number between zero and 1 relative to the ratio of radiant energies emitted by two bodies of the same dimension, wavelength range, geometric shape, focus conditions, and temperature, being the numerator any surface and the denominator a blackbody (SILVA, 2014). The term blackbody implies a structure that does not reflect radiation. At the same temperature, blackbodies emit the same amount of radiation for all wavelengths (SILVA, 2014). Therefore, if the emissivity of a body is known and the amount of radiation emitted at a given wavelength range \(E\) is measured, it is possible to estimate the surface temperature (SILVA, 2014). Consequently, the use of infrared thermometers would greatly facilitate the estimation of body temperatures under field conditions.

Studies have used infrared thermography to demonstrate that increased foot temperature is associated with lameness and foot lesions (NIKKHAH et al., 2005; STOKES et al., 2012). Lin et al. (2018) have evaluated the surface environmental temperature adjusted of the cows’ hind feet adjusted to the surface temperature aiming at verifying it the differences among the cows’ hind feet would enhance the lameness detection. These authors have concluded that the results of infrared thermometry demonstrated an association between elevated foot temperature and lameness, but further improvements to this detection technique will be required before it can be implemented as a management tool for detecting cows that may benefit from this technology.

Studies that assess the cattle’s rectal temperature, without the discomfort caused by rectal introduction of thermometers, will greatly contribute to the animal’s welfare and allow for the evaluation of the heat stress level that is suffered by the animal, indicating the need for environmental corrective measures. This study evaluated the temperature of irradiated surfaces of several anatomic regions of dairy cattle using infrared digital thermometry and compared these results with rectal temperature and determined the best correlation obtained at 0.95 and 0.50 emissivity.

2 Material and Methods

2.1 Study location and animals

The experiment was carried out at Fazenda Realeza, city of Araputanga, Mato Grosso, Brazil. Ten crossbred (5/8 Holstein x 3/8 Gir) dairy cows, with an average production of 15 liters of milk / cow / day were used. All animals were supplemented with corn silage and concentrate with 20% crude protein (CP) being provided 1 kg for every 3.0 kg of milk produced, with ad libitum access to water. All cows were evaluated three times a day: at 8 am, 01 pm and 04 pm, for three days, to determine the rectal temperature (RT) and the body surface temperature (BST) during three consecutive days.

2.2 Temperature determinations

BST evaluation was performed at specific anatomic locations: 1) left masseter muscle of the face; 2) left rib, between the 7th and 9th intercostal space; 3) middle left rump, between the ischium and ileum bones, and 4) at the middle region of the left mammary gland (between the anterior and posterior quarters). Thermal measurements were taken at emissivity of 0.95 and 0.50.

All cows were maintained in a sheltered area and after 10 minutes, the RT was determined with the aid of a mercury clinical thermometer inserted into the rectum and maintained for one minute. The BST determination was done at the specific anatomic regions (mentioned above) using a digital infrared laser thermometer (Fluke 62 MAX, Washington, U.S.A), that was used placed approximately 50 centimeters distant from the animal, according to the manufacturer’s recommendations. BST was evaluated at 0.50 and 0.95 emissivity. Additionally, environmental temperature and relative humidity were monitored concomitantly with RT and BST, by a hygrometer (Incoterm Thermo-hygrometer, São Paulo, Brazil).

2.3 Statistical analyses

The surface temperatures of the regions measured (face, ribcage, rum and mammary gland) were compared by variance analysis, relating irradiated BST with RT, the effect at the different measurement regions for three days. The thermal measurements of all cows were done at 8 am, 01 pm and 04 pm, at 0.95 and 0.50 emissivity. The averages obtained were compared by the Tukey test with a 5% probability.

Temperature evaluation at different emissivity was performed by using the paired variance analysis comparing the dependent variable (the square of the difference between the estimated surface temperature and rectal temperature) with the independent variable (the adopted emissivity). The assumptions of the residual distribution adherence of models regarding the normal distribution was evaluated by the Kolmogorov-Smirnov test, while the heteroscedasticity was calculated by the Levene test.

The animal utilization in the research was approved (protocol # 005/2019) by the Animal Use Ethics Committee (CEUA), University of Cuiabá.

3 Results and Discussion

During this study, the average rectal temperature obtained was 39.0°± 0.6 °C, with a lower rectal temperature (P<0.05) identified when morning temperature readings were compared to those done in afternoon (Table 1). The results herein described are similar to those presented (ROCKETT; BOSTED, 2012). Maintenance of body
温度是由热损失和热增益的平衡决定的。这种生理参考值由测量直肠温度（DIRKSEN et al., 1993）获得。这些变量可以被外因所影响，如一天中的时间，测量时的环境温度等。这些因素，如一天中的时间，可能相互作用并导致在直肠温度的变化（BACCARI JUNIOR, 2001; CARVALHO, 1995）。

表1 - 平均值为所验证变量，按一天中的时间段和热测量温度，使用红外数字激光温度计， emissivity为0.95, 以确定牛的体表温度

<table>
<thead>
<tr>
<th>Variables Evaluated</th>
<th>Average Values</th>
<th>Time of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental temperature (°C)</td>
<td>26.5 ± 5.2</td>
<td>21.2 ± 1.9b</td>
</tr>
<tr>
<td>Relative humidity (%)</td>
<td>65 ± 19</td>
<td>86 ± 9b</td>
</tr>
<tr>
<td>Rectal temperature (°C)</td>
<td>39.0 ± 0.6</td>
<td>38.6 ± 0.3b</td>
</tr>
<tr>
<td>Facial temperature (°C)</td>
<td>38.0 ± 2.5NS</td>
<td>35.2 ± 0.9b</td>
</tr>
<tr>
<td>Ribcage temperature (°C)</td>
<td>38.4 ± 2.8NS</td>
<td>35.3 ± 1.1b</td>
</tr>
<tr>
<td>Rump temperature (°C)</td>
<td>38.7 ± 2.9NS</td>
<td>35.4 ± 1.2b</td>
</tr>
<tr>
<td>Mammary gland temp. (°C)</td>
<td>39.3 ± 2.7b</td>
<td>36.4 ± 1.3a</td>
</tr>
</tbody>
</table>

注释：**NS** 不显著 (P>0.05) 由 Tukey 测试; * (P<0.05) 由 Tukey 测试; ** Different letters in the same time represent significant difference (P<0.05) by Tukey test.

来源：资源数据。

显著差异 (P<0.05) 由 Tukey 测试，被识别出在0.50 emissivity时，BST由直肠温度决定。在脸、肋骨和臀部的比较中，直肠温度相对体表温度较高。这些结果表明， emissivity为0.50时，温度测量不精确。因此， emissivity为0.95时，直肠温度可用于评估所有动物的体温。相应地，直肠温度在0.95 emissivity下，用于评估所有结果的直肠温度（表1）。相似的结果为环境和直肠温度，被记录在AZÊVEDO; ALVES, 2009; FERREIRA et al., 2006; PERISSINOTTO et al., 2007)。

表中结果是通过非接触红外温度计测量的。这种非接触红外温度计可以用于测量牛的体表温度以及用于评估这些动物的热舒适和健康。在这些条件下，方法是有效的，可以用于确定奶牛的体温，同时可以用于研究热胁迫的影响。

恒定的环境温度被设置为26.5 ± 5.2 °C，单一环境温度为21.2 ± 1.9 °C，04 pm. 04 pm. 01 pm. 01 pm. 01 pm.

因此，直肠温度不仅用于评估牛的健康状况，同时也用于评估农场的热舒适和健康。这些因素相互作用，相互影响，可以影响动物的生存和健康。

4 Conclusions

红外数字激光温度计在测量直肠温度时，可以直接测量体表温度，同时也可以用于评估动物的热舒适和健康。这种方法在农场管理中具有重要的应用价值。
emissivity of 0.95 directed at the middle ribcage region of dairy cows, may be used to determine the rectal temperature in cattle. This methodology can help assess the thermal comfort of dairy cows, may facilitate management practices and reduce animal discomfort and stress due to the rectal introduction of the thermometer.

References


