Current Options for Measuring the Surface Temperature of Dairy Cattle in a Stable Technology: Review

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Abstract

Regular measurement of the body surface temperature can help to assess the health status of animals. There are many technological possibilities of contactless temperature measurement of body surface. The important thing is to find the right part of the body whose temperature will point to the first possible symptoms and immediately react to the first signs of the disease. Disagreements about how to measure body surface temperature and accuracy of the method can occur when different measures are used. We review work showing possibilities of contactless surface temperature measurements using 1) thermography, 2) electronic transponders and 3) other possibilities of measuring the body surface temperature of dairy cattle. For example, when we scan the surface temperature with the thermal imager there can operate in individual animals confounding factors such as the nature or degree of muscular coat, which may significantly affect the results.

Keywords: health status, surface temperature, thermography, dairy cattle

1. Introduction

With the rising demand of the already large cattle industry, new techniques are being employed to aid the tracking and monitoring of cattle herds [1]. Additional benefits can be realized from this class of technology, such as the ability to identify the presence of disease early and thereby prevent its spread [2]. Body temperature is an important parameter for assessing animal stress [3]. Dairy pastoralists and veterinarians have used body temperatures, most commonly rectal temperatures, in detection and management of febrile disease and changes in the state of cows (oestrus, heat stress, and onset of calving) for many years [4]. During the last years, several passive radiofrequency identification devices have been tested to electronically identify domestic ruminants, including injectable transponders in different body locations [5], rumen boluses [6,7], ear tags [8] and leg bands [9].

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2. Infrared thermography

Infrared thermography (IRT) is a temperature measurement tool based on the ability of all objects to emit characteristic infrared radiation as a function of their temperature [10,11]. Infrared thermography (IRT) is a non-invasive technique that detects the infrared radiation emitted by any surface or object generating a thermogram on which the colour gradient reflects differences in the emitted heat [12-15]. The temperature values in the images are strongly related to the emissivity of the object, which is defined as the relative ability of a surface to emit and absorb radiation [16]. Method thermography found a variety of applications not only in the industry, but also in human and veterinary medicine, particularly for diagnostic purposes [17-20]. It has been used in veterinary science for lameness [21] and mastitis

[22] in dairy cows. It has also been reported that IRT can be used to detect changes in vulvae temperatures between oestrus and diestrus cows [23, 24].
[25] dealt with observation of surface temperature using infrared thermography as an alternative method to investigate the environmental and physiological processes related to thermal comfort. He designated with the thermal imager area of extremities as the best indicator of thermal comfort. [26] have examined possibility of using infrared thermography as a non-invasive tool for early detection of pathologies limbs cows. The temperature of the limbs and the skin is largely dependent on the amount of blood flowing through the peripheral vasculature [27]. E.g. inflammation heat generated is transferred overlying skin due to increased blood flow through the capillaries and is dissipated as infrared energy [19].
Using IRT can recognize changes in peripheral blood flow and the resulting changes in heat loss, so this method can be a useful tool for measuring stress to the animals [28, 29].

2.1 Temperature of eye

It has been suggested that IRT temperatures of the lacrimal caruncle region of the eye may correlate with core body temperature, in essence serving as a proxy for core body temperature [30, 12]. The use of IRT to measure eye temperature is rapid, relatively easy, and less invasive compared to alternative methods of body temperature measurement such as rectal thermometers, tympanic infrared thermometers, thermal microchips, and rumen boluses [31, 32]. [33] argues that by measuring the eye is possible to determine whether the animal is stressed or not.

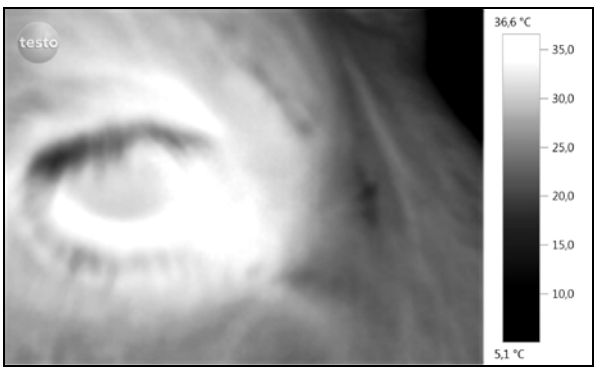

Figure 1. Thermal image of the eye

Also studies by [34] and [28] showed that the temperature of the eye can be a good indicator of stress. [35] used the infrared camera for the identification of bovine viral diarrhoea in calves. They found that elevated temperatures of eyes were more consistent than in other areas. Significant changes in the temperature of the eye occurred several days before other clinical symptoms.

2.2 Temperature of udder

[36] used a thermal imager to examine the effects of environmental factors on the daily temperature fluctuations of udder. They found that the imager has a potential as a tool for early detection of mastitis when combined with monitoring of environmental factors. Radiated heat emitted by the udder can be detected with IRT, but IRT was not suitable for early detection of subclinical mastitis [37]. Also [38] and [39] confirmed that the surface temperature of udder caused by mastitis infection increased before other clinical symptoms.

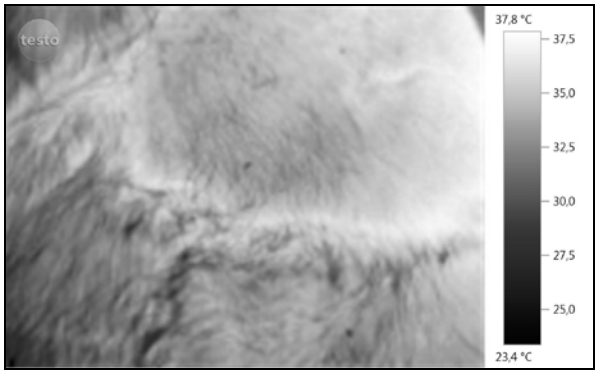

Figure 2. Thermal image of the udder

3. Electronic transponders

Transponders can be manufactured in several shapes such as the implantable variety, a glass capsule of a few millimetres in diameter and 12–32 mm in length. Other types are electronic ear tags for cattle and the so-called bolus transponders which can be swallowed by cows and goats and will remain in the gastrointestinal tract [40]. Advancement in sensor and battery technologies facilitated the development of more stable sensors, particularly those used for measuring body temperature [3]. The implementation of telemetric

systems to monitor core body temperature in cattle has recently attracted industry attention. Research shows that ruminal temperature (RT), measured via an intraruminal telemetric sensing device (bolus), can potentially be used to monitor the health of growing cattle [41, 42] and for the early diagnosis of bovine respiratory disease and bovine viral diarrhoea in cattle [43]. It also has the potential to predict parturition and oestrus in cattle [44, 45].
The telemetry system was used in the studies based on the specified resolution of temperature transmitters, overall accuracy of the system, and flexibility of taking measurements on both free roaming and housed animals. Transmitters were specified based on battery life and size of transmitters, and transmitting distance [2].

3.1 Rumen bolus

The ability to monitor physiological responses (e.g. temperature, fluid pH, heart rate), which can indicate diseases in livestock, via telemetric technology has great potential to increase timely disease detection, thus improving animals' health, productivity, and welfare [46]. Rumen boluses have proved to be easily administered and show a suitable long-term retention when properly designed and administered in sheep and cattle [47].
Work of [46] emphasizes that measuring ruminal temperature via radiotelemetry has the potential to detect fever and can be more practical than using vaginal or rectal telemetric devices.

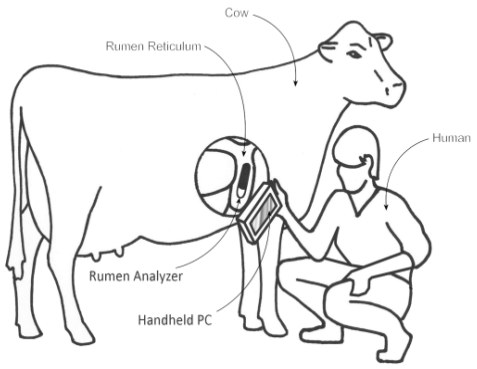

Figure 3. Rumen bolus [49]

3.2 Ear tag

Multiple temperature sensors were considered for measuring a cow's body temperature through the ear, anus, or within a bolus. Due to the fact that the nearest location from the ear tag to get a reading for the core body temperature is the ear canal, a probe inserted at least two inches into the ear was the most convenient and least invasive method [1].
[48] noted an innovative ear tag which detects a raised temperature pattern and alerts the stockperson up to 72 hours before the animal shows signs of respiratory disease.
There are some advantages and disadvantages of wireless networks. E.g. network setups can be done without fixed infrastructure. It is ideal for the non-reachable places such as across the sea, mountains, rural areas or deep forests. But it is not affordable for small farmers and there is lower speed compare to a wired network [2].

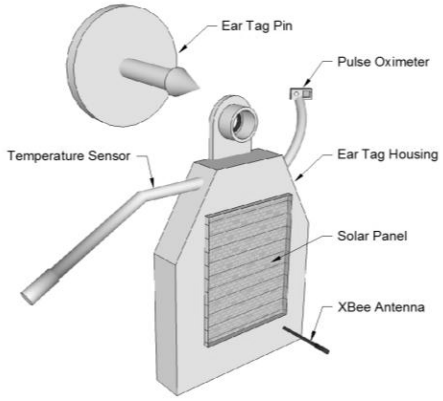

Figure 4. Ear Tag Diagram [1]

4. Conclusions

Experiments to measure body temperature of cattle have been made at different anatomical locations including rectum, ear (tympanic), vagina, reticulum-rumen, and udder (milk). Rumen temperatures have been shown to be effective measurements of core body temperature.
Examples given above demonstrate that the method of measuring the infrared camera can obtain important information, especially if they have exhausted the possibilities of conventional diagnostic methods. This method of measurement has value as a diagnostic tool for evaluating the function of the udder and can be a way for indirect and noninvasive teats and udder.

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