Infrared Thermography: Sick Domestic Animals

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Contributor: Daniel Mota-Rojas

Infrared thermography (IRT) has proven to be a reliable method for the early detection of pathologies affecting animal health and welfare that represent economic losses for farmers. However, the standardization of protocols for IRT use is still needed.

Keywords: febrile response ; hyperthermia ; infectious process ; pathogen ; thermoregulation ; thermogenesis ; thermoregulatory behavior ; animal welfare ; Bubalus bubalis ; Water buffalo ; domestic animals ; farm animal welfare

1. Introduction

Fever is a cardinal symptom that occurs when homeostasis is altered due to the presence of infectious or non-infectious stimuli, which is why it is recognized as a hallmark of disease [1][2][3].

Regarding fever, a wide variety of questions have arisen to define whether it is a mechanism that should be treated or not, and their answers are based on the findings obtained at the neurophysiological level, related to the hypothalamic control of fever and the development of thermoregulatory responses [4]. Despite this, some still question whether their study helps measure pathologies, in spite of the fact that scientific evidence indicates that it can be used for their detection [2][4]. However, given the scarcity of quantitative, studies of non-invasive tools that allow us to understand and interpret the pathophysiological processes of fever in farm animals are still valid [5][6].

Concerning this issue, infrared thermography (IRT) has proven to be a reliable auxiliary method that allows for the early detection of pathologies that, in addition to affecting animal health and welfare, represent economic losses for farmers [7]. However, the standardization of the protocols for the use of this tool is still needed, so that, together with the complete understanding of the physiological and behavioral responses involved in the febrile process, it is likely to have timely solutions to serious problem situations [7][8].

For this reason, the present review aims to describe and analyze the pathophysiological mechanisms of the febrile process, the mechanisms of heat loss in an animal with fever, and recent scientific findings when studying farm animals with infrared thermography.

2. Pathophysiology of Fever and Adverse Effects

It is essential to mention that the hypothalamus is considered the biological thermostat of the organism and has stipulated stable temperature ranges, according to each species, which keeps the heat loss and production adjusted [9]. During fever, neurological, endocrine, immunological, and metabolic changes occur that cause an increase in the stable temperature range, allowing the core body temperature to rise significantly to stop the invasion of the offending agent and restrict the damage to the organism [10].

In general, the effects or complications of fever are observed in organisms exposed to higher temperatures and for extended periods [9].

Concerning systemic complications, prolonged exposure to elevated temperature induces alterations in the permeability of the digestive tract that allow the passage of microorganisms, mainly bacteria, to extraintestinal sites, such as blood and mesenteric lymph nodes [11]. This process called intestinal bacterial translocation corrupts the integrity of the gastrointestinal barrier to induce the presence of toxins that act as stimuli to secrete cytokines with inflammatory potential; likewise, due to the damage to the gastrointestinal structure and cell death, the presence of free radicals increases, and these free radicals participate by evoking oxidative stress that synergistically contributes by increasing cytotoxicity to cell death [12].

One of the systems that suffer the most remarkable alterations due to fever is the neurological one. At elevated temperatures, the ranges depend on the species; the hypothalamus loses the ability to coordinate temperature regulation, compromising various brain structures to the point of causing multi-organ dysfunction and irreversible brain damage [13]. In addition, the existence of a relationship between increased temperature and ischemic infarcts that exacerbate late neuronal death of cortical cells, cerebellar granular cells, and the dorsal root ganglion has been reported, causing neurological deficit [14]. Likewise, it is known that, at high temperatures, cellular swelling originates due to the alteration in cell membrane transport and neuronal death that becomes noticeable shortly after the end of prolonged fever [15].

3. How Does an Animal with a Fever Thermoregulate? (Neurophysiological Responses to Temperature Control)

In response to cold or heat, the brain triggers a series of thermoregulatory responses to coping with changes in body temperature. These responses include autonomic effectors, such as thermogenesis, vasodilation, and sweating, as well as behavioral mechanisms that trigger flexible, goal-oriented actions, such as seeking heat or cold, nest building, postural extension [16].

It is worth mentioning that some species have specialized thermoregulatory organs that allow heat to dissipate more quickly. Examples of them in mammals are the rat tail and the rabbit ears. Both areas of bare skin have an extensive network of blood vessels responsible for the rapid exchange of heat with the environment when the vasodilation process begins [16]. In the case of birds, the bill stands out, because, given its high vascularity, it functions as a thermal window for heat exchange with the environment [17][18][19][20]. Scientific studies indicate that the size of the avian bill influences the rate of heat loss, since species with long bills, such as Ramphastos toco , can lose up to 60% of the heat through this structure [20], while in species with small bills, such as Melospiza melodia , the total loss of body heat through its surface can represent up to 10% [17][21].

Even though sweating proves to be an efficient mechanism for the dissipation of body heat excess, it should be considered that this response can lead to the development of deficiencies of sodium chloride and some trace minerals, such as Ca and Fe, which, depending on their severity, can be fatal [22][23][24][25].

They also come to present the behavior of placing the bill within the plumage, since, given its function as a thermal window, doing so could help isolate the bill from environmental heat to prevent it from continuing to gain heat. However, research is still needed to confirm the development of this behavior as a means of insulation against heat, as well as against cold [21].

4. Importance of IRT in the Detection of Sick Farm Animals

IRT is considered a noninvasive remote sensing method that is useful for evaluating the temperature of animals [26][27][28][29][30] and, more specifically, measure changes in heat transfer and blood flow [31], since variations in thermal patterns are the result of blood flow that intervenes in the amount of radiated heat [32][33].

The authors conclude that the thermal imaging camera is a valuable tool to detect changes in the surface temperature of the udder during clinical mastitis, before the results of milk sampling, but after the development of local signs of mastitis. Therefore, thermography can be used to detect mastitis, at least the clinical one, with fever or other febrile diseases.

On the contrary, the bovines of the VT group presented lower temperature increases (0.5 °C in the preclinical stage, 5.7 °C in the clinical stage, and 5.2 °C in the post-clinical stage), which could reflect a lower inflammatory response, a product of the partial protection of the vaccine, because 38.1% developed viremia and foot lesions.

In the study, they obtained images of the ocular surface by focusing the camera on the orbital area, which includes the eyeball and part of the skin that surrounds the eye socket, since they started from the argument that this area, together with the lacrimal gland, is favorable for measuring variations in temperature due to its sensitivity to changes in thermoregulation.

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