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ScienceDirect
Theriogenology 72 (2009) 372–377
Theriogenology
www.theriojournal.com

Assessment of pregnancy in the late-gestation mare using digital infrared thermography

S. Bowers [a], S. Gandy [b], B. Anderson [a], P. Ryan [a], S. Willard [a,b,*]

[a] Department of Animal and Dairy Sciences, Mississippi State University, Mississippi State, MS 39762, USA
[b] Department of Biochemistry and Molecular Biology, Mississippi State University, Mississippi State, MS 39762, USA

Received 8 September 2008; received in revised form 4 March 2009; accepted 28 March 2009

Abstract

The objective of this study was to investigate use of digital infrared thermal imaging (DITI) to determine whether surface temperature gradient differences exist between pregnant and nonpregnant mares as a noncontact method to determine pregnancy status. On the day measurements were collected, each pregnant mare (n = 10; beginning at 292.4 ± 1.4 d of gestation) was paired with a nonpregnant mare (n = 17). Ambient temperature, DITI measurements (left and right flank, wither temperatures [i.e., animal surface control] and background temperature), and rectal temperatures were obtained every 7 d for 5 wk before parturition and for 3 wk after parturition. There were no differences ($P > 0.10$) in temperature of the left and right side within groups; therefore, data were pooled. Pregnant mares had a higher ($P < 0.01$) flank temperature than that of nonpregnant mares (36.0 ± 0.2 °C vs. 34.2 ± 0.2 °C, respectively). Moreover, the difference (2.4 °C) in flank temperatures between the pregnant and nonpregnant mares was greater when the ambient temperature was <19 °C. Flank and wither temperatures were positively correlated ($R = 0.72$; $P < 0.01$) and were positively correlated with ambient temperature ($R = 0.48$ and 0.64, respectively; $P < 0.01$). However, wither temperatures (skin control site) did not differ ($P > 0.10$) between pregnant and nonpregnant mares. In conclusion, late-gestation mares had higher flank temperatures than those of nonpregnant mares, regardless of environmental conditions, however discriminating abilities were greater when ambient temperature was lower. We inferred that DITI may have value in confirming mid- to late-gestation pregnancies in some species by noncontact means, as observed in the mare.

Keywords: Equine; Horse; Infrared thermography; Pregnancy diagnosis

1. Introduction

Digital infrared thermal imaging (DITI) is a noninvasive diagnostic technique that is used to detect symmetry and asymmetry of surface temperature gradients. The temperature of the skin is ~5 °C cooler than the body core, as heat is often dissipated through the skin by evaporation and other means [1] to balance internal and external temperature. Therefore, thermal imaging is the most efficient and noninvasive technique for the study of temperature distribution by measuring bilateral anatomic sites and identifying significant differences among thermal images [2]. The surface of the skin is a highly efficient radiator, and it is possible to detect infrared emissions from the skin and create a thermal map of temperature distribution by noninvasive means [3]. Variations in skin temperature result from changes in tissue perfusion and blood flow [4], and because there is a high degree of thermal symmetry in

* Corresponding author. Tel.: +1 662 325 2640;
fax: +1 662 325 8664.
E-mail address: swillard@ads.msstate.edu (S. Willard).

0093-691X/$ – see front matter
doi:10.1016/j.theriogenology.2009.03.005

the normal body, subtle abnormal temperature asymmetry can be easily identified and may relate to underlying abnormalities or changes in physiology [3].

In livestock, DITI has been applied in the diagnosis of foot and leg problems in cattle and horses [5–8], for assessing fertility in bulls and rams [3,9–12], for characterizing the responses of cattle to hot-iron and freeze branding [13], for monitoring heat load in dairy cattle [14], and for evaluating thermal comfort in poultry [15]. Moreover, use of DITI in domestic livestock has led to new approaches to study wildlife or other captive exotic species that cannot be handled [16]. In 2002, personnel at the Frankfurt and Leipzig Zoological Gardens used thermography to detect late gestation in a single giraffe [17]. However, they stated that additional research was required to define the working conditions, constraints, and limitations of using thermography in pregnancy detection [17]. Earlier work by this same group detected heat signatures in the abdomen of a gravid black rhinoceros and Grevy zebra; these heat signatures were not present in nonpregnant animals of the same species [18]. Recently, thermography has also been used to detect pregnancy in the giant panda; however, this study also had a limited number of animals (n = 2) [19]. In addition, thermal imaging of the control animals (domestic bitch) was less informative and did not definitively diagnose pregnancy [19]. Finally, use of thermography to detect pregnancy in dairy heifers has also been investigated but did not result in discrimination between pregnant and nonpregnant animals [20].

The objective of this study was to investigate use of digital infrared thermal imaging to determine whether differences in temperature gradients exist between late gestation and nonpregnant mares. The results of this study were intended to help develop a model to evaluate DITI for detecting pregnancy in wildlife and exotic captive species.

2. Materials and methods

2.1. Mares

Data collection began in March and continued through May, with 24-h ambient temperatures ranging from 4.2 to 28.9 °C. All mares were housed at the Leveck Animal Research Center (Equine Unit), Mississippi State University (MSU), on rye grass pastures and fed 1.4 kg of a commercial 10% protein sweet feed (All-stock Sweet 10; Country Acres Feed Co, Brentwood, MO, USA) once daily. The mares were vaccinated against rhinopneumonitis at 5, 7, and 9 mo of gestation. On each day of data collection (imaging), pregnant mares (n = 10; beginning at 292.4 $\pm$ 1.4 d of gestation) and nonpregnant mares (n = 17) were brought into an enclosed barn, and debris was removed from the coat. The mares were then normalized to environmental temperatures in the covered barn for at least 30 min prior to imaging. On each collection day, pregnant mares and nonpregnant mares were paired so that a nonpregnant mare was imaged first, between pregnant mares, and last. In addition, the mares were also matched according to three levels of coat color: light (palomino, gray), medium (chestnut, sorrel), and dark (black, bay). The same focal distance was maintained for each data collection with the camera distance ranging from 147.3 to 157.5 cm from the mare. Ambient temperature, DITI measurements (including left and right abdomen/flank and wither temperature [used as a skin control site; Fig. 1]) of the horse, background temperature (wall inside the barn behind where the mares were imaged), and rectal temperatures were obtained weekly for 5 wk prior to predicted parturition date and for 3 wk after parturition. The total number of images of the abdomen/flank for the right and left side combined were as follows: pregnant mares, 74 images; nonpregnant mares, 130 images; and foaled mares, 70 images. Thermal images were acquired using a Meditherm vet2000 (Compix Inc., Tualatin, OR, USA) with emissivity set at 0.96 (corrected for humidity and ambient temperature) and analyzed using Wintes Software (Compix Inc., Tualatin, OR, USA). Temperature (°C) was quantified using the maximum temperature of the abdomen/flank and wither.

This study was reviewed and approved by the MSU Institutional Animal Care and Use Committee and

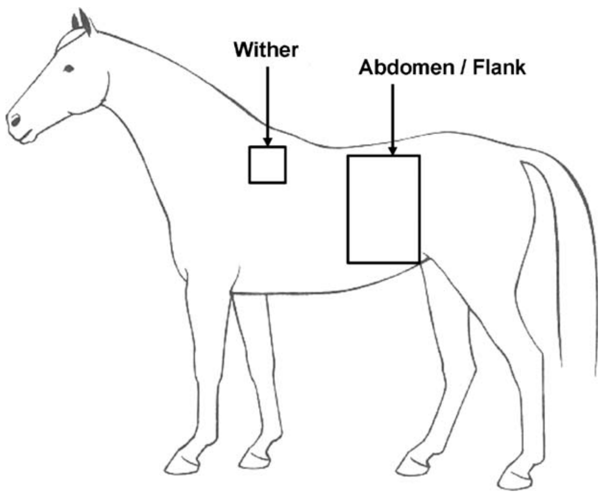

Fig. 1. Digital infrared thermal imaging measurements, including left and right abdomen/flank and wither temperatures, were obtained weekly for 5 wk prior to predicted parturition date and for 3 wk after parturition in mares.