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USE OF THERMOGRAPHY METHOD IN DIAGNOSIS OF HORSE DISEASES

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The paper is focused on the practical use of infrared thermography (IRT) in the diagnosis of clinical or subclinical forms of equine inflammation. The aim of the study was to verify the suitability of IRT for the early detection of areas with the potential existence of inflammation. The verification of findings was carried out through veterinary data (medical reports, radiographs). The study claimed the suitability of the IRT method for practical monitoring and detection of health problems, especially limb diseases – hooves, tendons, muscles (13 horses) as well as dermatological diseases (3 horses). The results showed that the most frequent occurrence of the disease, manifested by muscle and tendon overload and inflammatory processes, is on the limbs. The results claimed a significant difference between the measured temperatures and the typical temperatures of a healthy horse.

Keywords: non-contact temperature measurement; infrared camera; inflammatory disease; non-invasive diagnostic method

Infrared thermography (IRT) can detect and measure infrared radiation emitted spontaneously from any object that is at a temperature above absolute zero (Rosenmeier et al., 2012). Infrared thermography is a non-contact diagnostic method of measuring surface temperature. Temperature differences are indicated by a change in colour (Purohit and McCoy, 1980; Turner et al., 1986). Infrared thermography has a wide range of applications. In addition to medicine, it is used in construction (Junga et al., 2024), remote sensing (Rahimi-Ajdadi and Khani, 2022), and other scientific fields. The IRT of the body surface is a simpler procedure than the contact method of measurement, and this method is relatively easy and cheap. Infrared thermography can be successfully applied for assessing heat and methane production through the analysis of feet temperature and temperature difference between left and right flanks, respectively (Montanholi et al., 2008).

Infrared thermography is a method of measuring the heat radiated by the skin, which reflects subcutaneous blood circulation (Jones and Plassmann, 2002). It is also used as a method of evaluating stress reactions in animals. It has been proved that changes in surface temperature are related to emotional reactions. The use of IRT offers an objective non-invasive method of evaluating a horse's reaction to training methods. It is also a means of improving the welfare of a riding horse (Hall et al., 2011). The advantage of this imaging technique is that no penetrating radiation is used (Redaelli et al., 2014). Infrared thermography is also used in human medicine (Özdil and Yilmaz, 2021). The IRT classification of a healthy and arthritis affected knee thermogram achieved 92% accuracy (Bardhan et al. 2022). Infrared thermography can be used to detect a breast cancer (Mishra et al., 2023). Thermography is another alternative, being non-ionising, non-invasive, and able to detect abnormal breast conditions at an early stage. An accuracy of 94.4% was achieved

(Chebbah et al., 2022). Hanusová et al. (2016) observed the effect of different levels of vacuum on the mammary gland of dairy cows. To evaluate the degree of mammary gland trauma, they used the measurement of teat surface temperatures using a thermal camera. At the vacuum of 45 kPa, the temperature increase in the morning and afternoon milking was at an average of +2.44 K. At the vacuum of 40 kPa, the temperature increase was +1.93 K. Both temperature increases were statistically different ($P > 0.05$). Karas and Gálik (2004) described the principle of non-contact temperature measurement and its use in testing milking machines. Heat is a fundamental symptom of inflammation, caused by an increase in circulation and tissue metabolism (Head and Dyson, 2001; Van Hoogmoed and Snyder, 2002). Thus, by monitoring temperature fluctuation the development of inflammation in tissues can potentially be identified. Thermal images can be taken from a greater distance from the subject, avoiding temperature artefacts associated with capture and confinement (Stewart et al., 2005). This technique has been used in both human and veterinary medical research, primarily as a diagnostic tool to detect local inflammation caused by disease and injury (Schaefer et al., 2004).

This article serves to verify the suitability of infrared thermography as a low-cost non-invasive diagnostic tool for inflammatory diseases and acute injuries in horses. Demonstrating the suitability of the method consists in comparing specific cases monitored by, among other things, ultrasound diagnostics and X-ray methods. The comparison of thermographic measurements with conventional diagnostics aims to demonstrate the consistency of the diagnosis of disease. Unlike conventional methods, this method is time saving and horse friendly.

Material and Methods

The study evaluates the diagnostics results of 16 horses of the same stable. The horses were stabled in a stable with individual boxes. During the experimental infrared thermographic measurements, a series of thermograms (12 thermograms per horse) of selected body parts were taken for each horse. The individual body parts measured were selected to minimise possible measurement errors. Thermograms were then evaluated. Thermograms with temperature anomalies were then selected and interpreted. The objectification of findings was carried out by comparing the results of IRT measurements with information on the clinical condition of the horses listed in the medical reports. The IRT measurements were performed in accordance with the standards of IRT in veterinary medicine (Purohit and McCoy, 1980). During the measurements, apparent surface temperature values were obtained in the body surface area of interest (hooves, joints, muscles and tendons, eyes, skin). The values of detected apparent surface temperatures were then statistically evaluated.

The IRT measurements were performed using a FLUKE Ti32 thermal camera (FOV: 45°). Boundary conditions were measured using an OMEGA HH11 contact thermometer, KIMO AMI 300 multifunction equipment (air velocity, air temperature, relative humidity). Reflected temperature was determined using Lambert reflector. Distance was determined using a Leica DISTOtm A5 laser EDM device. Emissivity was considered at a value of 0.98. Measurements were made inside the stable, in the same place, with the horses at rest. The threshold value of temperature difference was chosen to be 1 °C (Turner et al., 1983).

Result and Discussion

Measurements were carried out inside the stable under the following conditions. Air temperature value was 7.8 °C; relative humidity 53.9%; air velocity 0.25 m·s⁻¹; the distance of the measured object 1.0 m. The following text presents the results

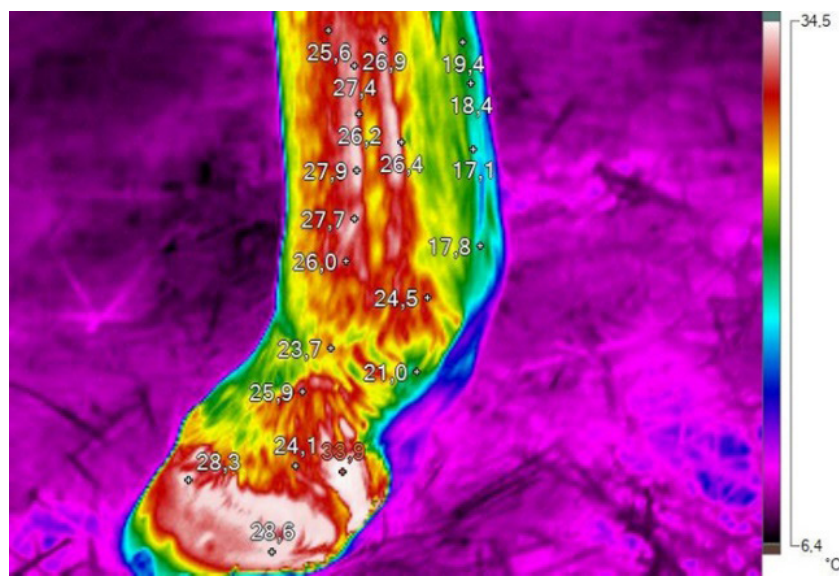


Fig. 1 Thermogram of front limb

of experimental measurements and the interpretation of detected temperature anomalies for the most interesting objects from the total sample of 16 horses.

Object 1

Figures 1 and 2 show the thermograms of the limbs, documenting the occurrence of health problems. The detected temperature anomalies correspond to the veterinarian's diagnosis, established based on the X-ray images of the front limb (Fig. 3). The result of measurement corresponds to the clinical report of the veterinarian. An overload of

the pelvic part of the limb was found in the horse as a result of the relief of the limb indisposed by the injury. According to the evaluation of X-ray images and the expertise of the veterinary clinic, the occurrence of higher values of surface temperatures in this area occurs when there is an injury or an acute stage of emerging degeneration. The correlation of the use of IRT with X-ray imaging was presented by Eddy et al. (2001).

The maximum temperature of the right front (RF) area is 33.9 °C. The average value of temperatures in the evaluated RF area is 27.4 °C.

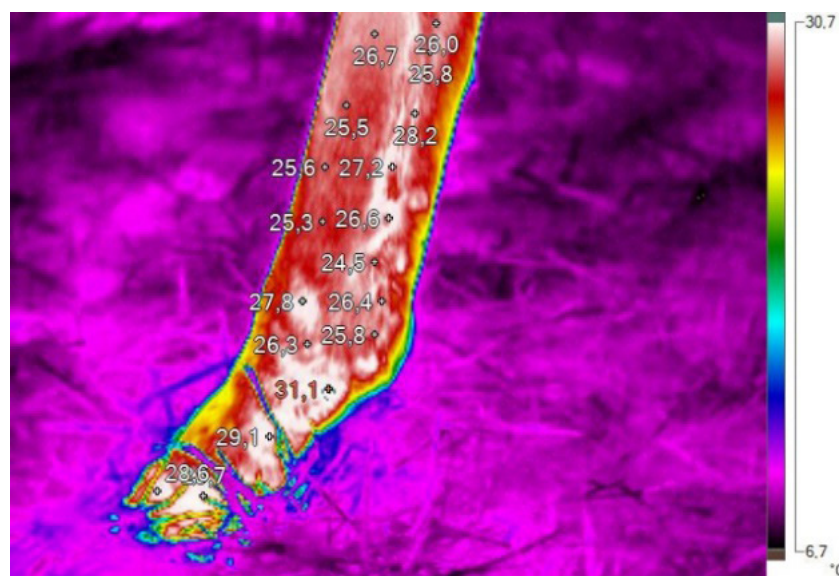


Fig. 2 Thermogram of hind limb

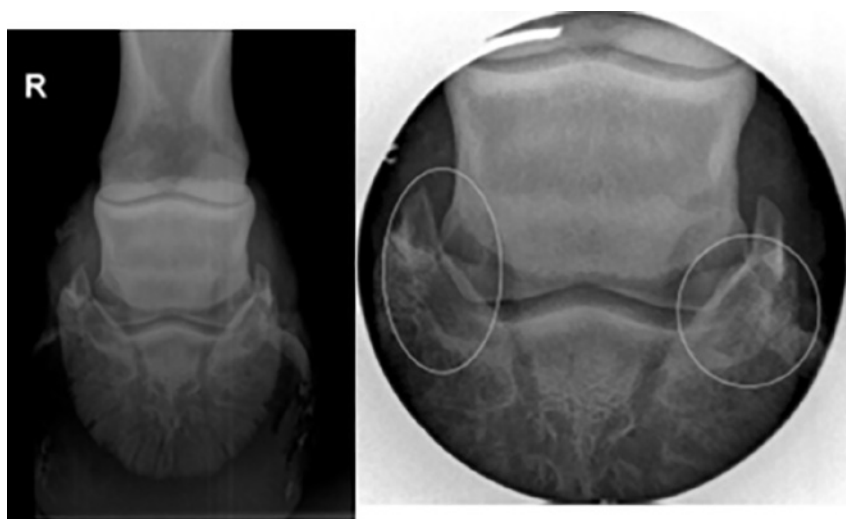


Fig. 3 X-ray image of the hind limb

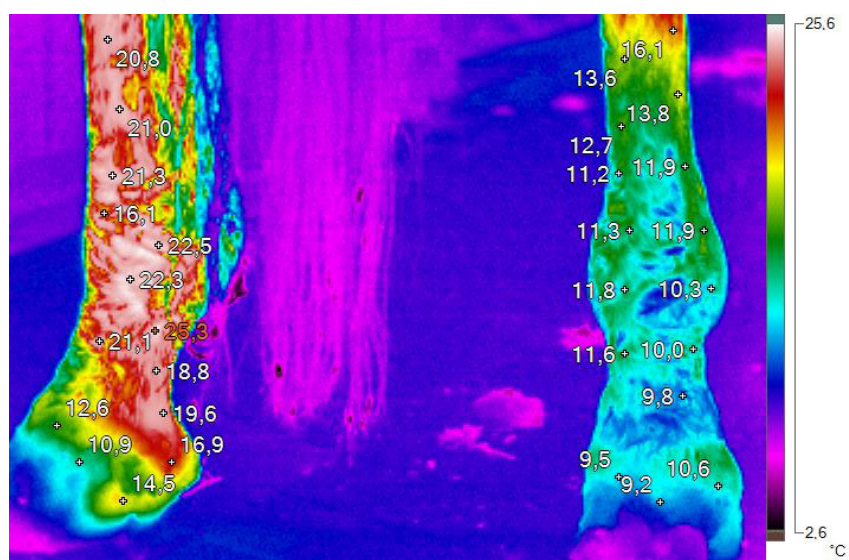


Fig. 4 Thermogram showing hind of tendon limb damage

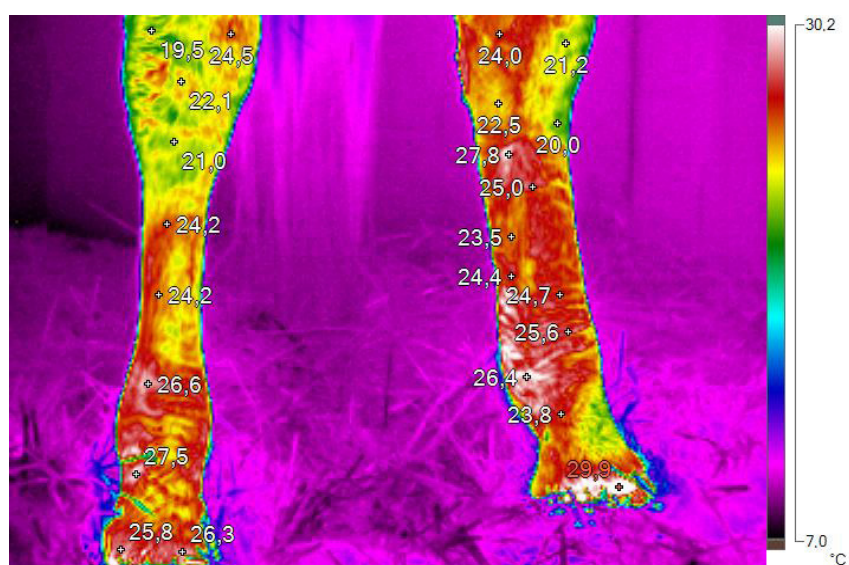


Fig. 5 Thermogram of the limbs showing the problematic metacarpal area

The maximum temperature of the right rear (RR) area is 31.1 °C. The average value of temperatures in the evaluated RR area is 29.7 °C.

Object 2

The left hind limb is shown on the thermogram in Fig. 4. The figure shows higher surface temperatures indicating probable inflammation. The veterinarian diagnosed tendon damage and associated inflammation by sonographic examination. Fonseca et al. (2006) also present the use of the IRT method and ultrasound examination in their work. Thermography was used to map the lesioned areas of this region and ultrasonography for lesion characterisation. Thermography associated with ultrasonography was shown to be efficient in the diagnosis of the thoracolumbar lesions of these horses. Comparable foot health problems in dairy cattle are presented by Stokes et al. (2012). The IRT method correctly identified 80% of feet with lesions.

The maximum temperature is 25.3 °C. The average value of temperatures in the evaluated area is 22.0 °C.

Object 3

The horse has a damaged metacarpal bone. It is quite common in horses. This condition occurs due to excessive pressure and tension. This causes damage to the metacarpal ligament between the third metacarpal bone and the metatarsal bone. On the thermogram in Fig. 5, there is a clear manifestation of higher surface temperatures in the metacarpal area. It clearly signals a health problem. Soroko et al. (2013) present comparable facts in their work. The threshold value of temperature difference indicative of subclinical inflammation was found to be 1.25 °C.

The maximum temperature is 29.3 °C. The average value of temperatures in the evaluated area is 24.0 °C.

Object 4

Horse skin is sensitive to external factors. These factors include allergens, UV radiation, mechanical damage, etc. From the thermogram in Fig. 6 and Fig. 7, there are visible

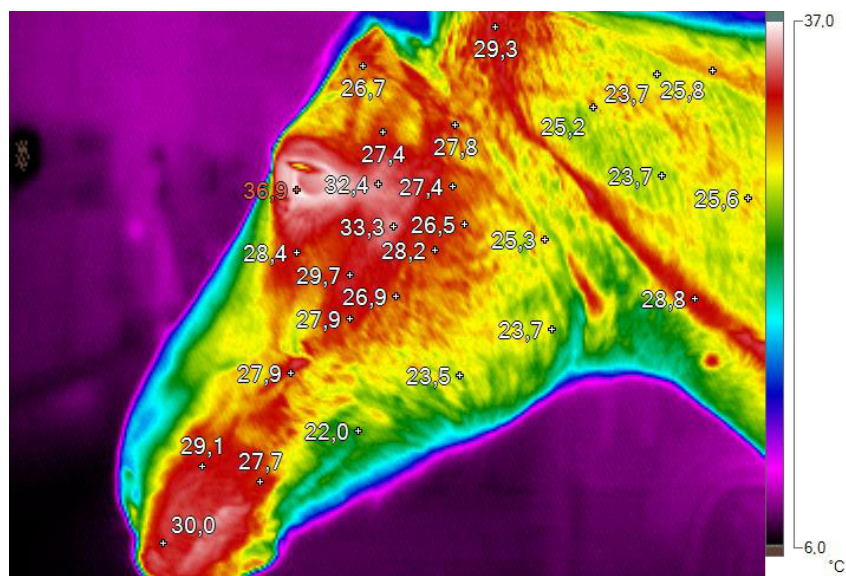


Fig. 6 Thermogram of the head with exposed areas and manifestations of dermatological problems

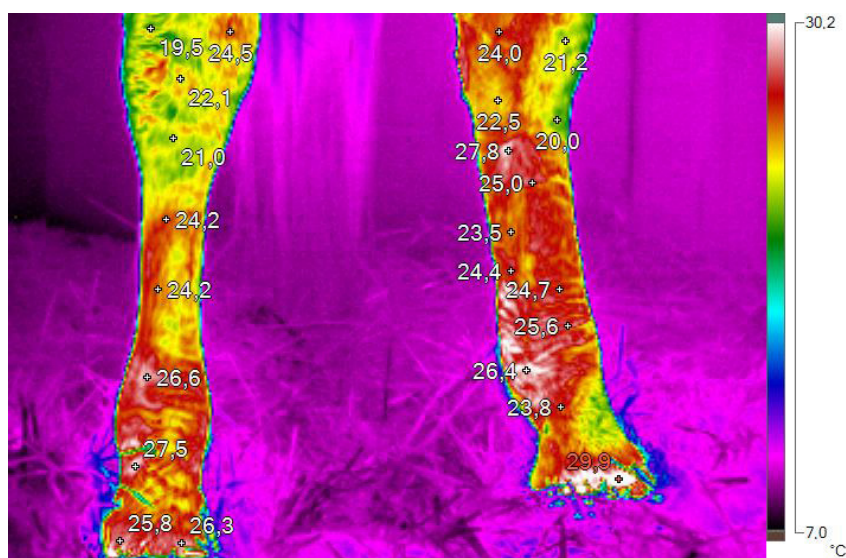


Fig. 7 Thermogram of limbs with the areas of health problems

areas on the head and hind limbs with a higher surface temperature signalling probably dermatological problems. The distribution of temperature in this area indicates skin disease. The variations of skin surface temperature are presented by Palmer (1983). Comparable dermatological problems in horses are presented by McGreevy et al. (2012). A zone with a higher surface temperature in the area of the crown, where the hoof tissue is formed and grows, can signal a metabolic disorder in this area (the formation of a lower quality horn and the consequent greater susceptibility to the formation of hoof abscesses). Comparable use of IRT for early detection of digital dermatitis in dairy cows is presented by Alsaad et al. (2014). The optimal value of temperature difference for disease detection was determined to be 0.99 °C, and 89.1% of sick cows were indicated.

The maximum temperature is 33.3 °C. The average value of temperatures in the evaluated area is 28.4 °C.

The maximum temperature of the right rear (RR) area is 27.5 °C. The average value of temperatures in the evaluated right rear area is 23.0 °C. The maximum temperature of the left rear (LR) area is 27.8 °C. The average value of temperatures in the evaluated left rear area is 24.4 °C.

Statistical evaluation

Statistical evaluation was performed for the health problems of the legs, which are the most common in horses. For this reason, 13 horses were tested. Based on thermographic measurements, a total of 6 horses were identified as showing thermal abnormalities on their limbs due to their disease. Subsequently, this assumption was clinically confirmed by a veterinary examination. This type of problem did not occur in the other measured horses (7 horses). In summary, a total of 14 legs where this type of problem occurred (sample *P*) and 38 legs where this problem did not occur (sample *N*) were identified. The maximum temperature in the area evaluated was then determined from the thermographs. These values were then statistically analysed.

Table 1 Results of exploratory analysis

Data sets	Arithmetic average (°C)	Median (°C)	IQR (°C)	Standard deviation (°C)	Coefficient of variation (%)
P	28.7	28.6	3.7	2.1	7.3
N	24.1	24.1	3.7	2.2	9.1

P – results of IR measurements in feet with tendon overload problems; N – results of IR measurements in feet without such problems; IQR – inter quartile range

TIBCO Statistica 14 software was used for statistical data processing. The *t*-test was used to test hypotheses for independent data sets. Shapiro-Wilk test was used to test the hypothesis whether the data sets were from a normal distribution. Hypothesis testing was performed at the level of significance $\alpha = 0.05$.

The resulting values of the exploratory analysis for both data sets can be seen in Table 1. The table shows that the values of arithmetic mean and median are very close in both cases, so it can be estimated that the data set comes from a normal distribution. Testing the hypothesis of whether the data in the data sets come from a normal distribution was done using Shapiro-Wilk test ($p_P = 0.47$ and $p_N = 0.19$). In this case, the hypothesis was not rejected, i.e., at the level of significance set, it can be assumed that the data sets in both cases come from a normal distribution. The homogeneity hypothesis of variance of the datasets was tested using Levene's test ($p = 0.8$). The homogeneity condition was met.

Therefore, the conditions for using the *t*-test were met. The *t*-test was used to test the hypothesis that there was no statistically significant difference between the data sets. This hypothesis was rejected at the specified level of significance, i.e., a statistically significant difference between the maximum measured values on the defined area of the thermogram in feet with problems (sample P) and in feet without such problems (sample N) can be assumed. The difference between temperatures was on average 4.6 °C (Table 1). The differences between the data sets are also evident from the box-plot graphical representation (Fig. 8).

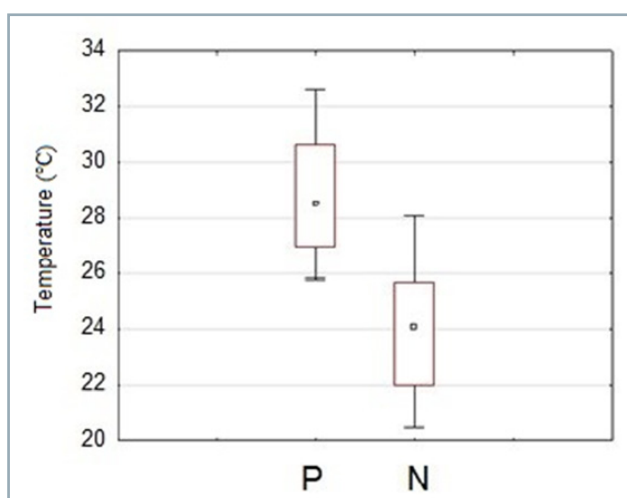


Fig. 8 Statistical analysis of measured temperature values on monitored surfaces using *t*-test ($p < 0.05$)

Conclusion

The non-invasive method of IRT is used to diagnose diseases and injuries in horses. It is a method applied worldwide, not only among veterinarians and veterinary physiotherapists, but also directly in breeding practice in the stable. This method is characterised by its speed, non-invasiveness (kind to animals), and provided the measurement is carried out correctly, it is also accurate and effective. The series of measurements described in this work clearly demonstrated the following. The method of infrared thermography can successfully diagnose health complications already at an early stage of development. This is also of great importance from the point of view of prevention and control of the course of treatment or the degree of effectiveness of the administered medication. From the point of view of rapid check-up diagnostics, this method can also be recommended for the diagnosis of acute injuries and also in the case of a basic examination when buying a horse. The results of the work confirmed the appropriateness of applying IRT. They are suitable for the diagnosis of orthopaedic problems, dermatological problems, and other health problems manifested by inflammatory processes, poor or excessive blood circulation, and related temperature manifestations. This method can be used from a practical point of view when diagnosing the suitability or unsuitability of the horse equipment. This issue is important for the comfort of both the horse and the rider. It also affects sports performance and possible health problems of the horse, mainly related to pain in the back area. The IRT method cannot fully replace other methods of veterinary diagnostics. However, this fast and relatively accurate diagnostic method significantly complements other investigative methods. It is very useful and effective for practical use in horse breeding. In this validation study of 16 horses, the objectivity of the infrared thermography method in breeding practice was demonstrated. Potential problem areas on the horse bodies showing temperature anomalies, which were determined by IR measurements, were subsequently successfully documented by veterinary reports showing clinical and subclinical forms of inflammation. Experimental measurements by IRT demonstrated limb disease (13 subjects) and dermatological disease (3 cases). The IRT method clearly demonstrated its suitability as a rapid indicator of the existence of clinical and subclinical forms of inflammation in horses.

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