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CLINICAL APPLICATION OF INFRARED-THERMOGRAPHY IN INFLAMMATION DIAGNOSIS IN MEGA-HERBIVORES

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Abstract

After a brief introduction into the method of infrared-thermography, 11 case reports are presented. In these case reports a short history of the case, the infrared-thermographic findings, the procedures after evaluation and a short discussion. A general discussion rounds up the paper.

Zusammenfassung

Nach einer kurzen Einführung in die Methode der Infrarot-Thermographie werden 11 Fallbeispiele präsentiert. Jedes dieser Beispiele beinhaltet eine kurze Anamnese, die Untersuchungsergebnisse mittels Infrarot-Thermographie, die daraus folgenden Maßnahmen und eine kurze Diskussion. Anschließend folgt noch eine allgemeine Diskussion.

Résumé

Après une brève introduction à la méthode de thermographie infrarouge, 11 rapports de cas sont présentés. Une brève histoire du cas, les résultats de la thermographie infrarouge, les mesures prises après évaluation, et un bref commentaire sont fournis. Une discussion générale conclut la totalité de l'article.

Key words: infrared-thermography, thermography, infrared, elephant, black rhinoceros, giraffe, hippopotamus, lameness, pododermatitis, traumatology.

Introduction

Infrared-thermography is a non-invasive method. With an infrared-camera, the body surface temperature of an animal is measured from a distance and the thermoprofile of this animal is then displayed as a thermogram. No direct animal contact or immobilisation is necessary. In this work a thermogram is defined as an infrared-picture of a detail or a whole animal with its surroundings. The thermoprofile of an animal can give information on or hints about certain aspects of the animals health status, e.g. on it's current general thermoregulation or local temperature changes (2, 5, 6, 7, 15).
It is necessary for the investigator to have a clear understanding of the technical aspects of this method and its limitations (3, 7, 15). This, in order to make the application of infrared-thermography in veterinary medicine plausible, realise its potential, and discover pathological alterations while preventing inaccurate diagnosis and/or false interpretations of clinical findings. In addition, the investigator should have a modern working knowledge of thermoregulation, anatomy, morphology, physiology and pathological physiology of the animals to be investigated. Infrared-thermography is not a new form of colour photography. Technical information and many aspects of thermoregulation in zoo and wild animals are discussed in two Ph.D. theses (7, 10).

In megaherbivores such as giraffes, rhinos, elephants and hippos it is often very difficult to observe locations of injured areas on limbs, especially when no external lesions are visible. Here thermography can help locating the area and extend of the injury (7). As heat radiation is one of the five cardinal symptoms of an inflammation, infrared-detectors can localise this heat area, if the heat is radiated from close to the surface of the animal. This phenomenon has been intensely used in horse medicine (11, 12, 13, 16, 17, 18, 19, 20, 21, 22).

Material and Methods

For this investigation an infrared camera from the company FLIR (Forward looking Infrared) was used. The following models were used:

- Thermovision 470
- Thermovision 570
- Vetcam 695
- Thermacam 695 (includes a digital camera)

All images were captured during a standing or slow moving position of the animal. All animals were adapted to the ambient temperature for at least two hours, before image capture, unless specified otherwise. For each image a reference ambient temperature and relative humidity were recorded separately. If possible, the other animals of the zoo group were used as references. If this was not possible, reference images from the database were used.
The infrared images were then analysed using the computer program IRWin 522 or Reporter 2000, both specific software programs for analysing infrared images.

Results

In case reports the application of infrared-thermography in zoo animal medicine is demonstrated. As a non-invasive method infrared-thermography allows the investigating vet to get a quick picture of the location and extend of an alteration on the animals limbs. All colour infrared images for these case reports can be obtained from the author.

Inflammation diagnosis in elephants

Case report 1

Weaving in an Asian elephant
In this case, an Asian elephant *Elephas maximus* showed intense heat radiation over all joints in the hind and most joints of the front legs. This elephant had been chained over many years. In recent years it was only chained during the training sessions. The infrared-images revealed, however, the lasting damage done to the joints of this old elephant. As soon as the elephant starts to weave while chained, the heat radiation shows over these joints. It is interpreted as originating from the none physiological sideways movement of the joints, which in elephants is not normal to this extreme, as elephants normally move their limbs forward, and fare less often sideways. This heat radiation could be observed even four hours after the elephant was released from the chains and moving freely on the outside enclosure. Unfortunately chaining is still used in many institutions and in some zoos the only way to keep elephants (1). This case report indicates the necessity to investigate the effect of chaining in an intense study, as does also the next case report.

Case report 2

Overnight chaining in an African elephant
An African elephant *Loxodonta africana* was found to radiate more heat from the hip and knee joint of the right side as well al over the right carpal joint. From the investigation with a night vision video camera, it became clear, that this elephant, do to its size, could only sleep on his right body side, while being chained. Furthermore, there was no soft bedding material is this elephants stable for him to lei down on, so only bare concrete was available. The weight of the animal is therefore

placed on these specific joints during the whole night. Due to the chaining, there was no other way for this elephant to lei down. As the other side of the animal shows no signs of inflammation, the alterations on the right joints are most likely to be attributed to this inadequate holding facility. An enlargement of the stall should solve this problem at least partially, as it would allow the elephant to sleep on his other side as well.

Lameness evaluation in elephants

Case report 3
Shoulder injury in an Asian elephant
This Asian elephant *E. maximus* was observed walking in an abnormal way, but the origin of the lameness could not be found. The caretakers assumed that this elephant must have fallen while on the outside enclosure, but nobody observed this accident. Infrared-thermography revealed that the problem was in the right shoulder, exact in the elbow joint. The elephant was then treated on this joint by the local vet and the caretakers. In horse medicine thermography is often used in cases of unclear lameness (4, 20, 21, 22).

Case report 4
Hip injury in an African elephant
An African elephant *L. africana* was observe to move stiffly while walking on the outside enclosure. The senior caretaker assumed that the problem must come from the hip area. He had observed the mounting of this cow by the bull the day before. Infrared-thermography confirmed the assumption of the caretaker. The female elephant showed a localised intense heat radiation over the left ilio-sacral joint. The elephant was treated over several weeks by the local vet and followed-up with infrared-thermography for several weeks. A reduction of the heat area was found.

Case report 5
Carpal joint injury in an Asian elephant
During the establishment of the hierarchy in a group of female Asian elephants *E. maximus*, the elephants were separated through vertical bars for part of the day and during the night. A caretaker observed two elephants fighting through these bars. One of the elephants was found lame afterwards. The location of the injury, however, was not clear. Infrared-thermography detected the heat radiation area to be just above the carpal joint on the inside leg, hence most likely a soft tissue contusion was the cause. After the exact localisation the elephant was treated locally with good results.

Case report 6
Hind leg injury in an African elephant
An African elephant *L. africana* was found lame one day without anyone having observed an accident. This animal was the oldest individual of the group, with only young elephants below 6 years as companions. Hence, a hierarchical fight could be ruled out. Infrared-thermography revealed no changes in heat radiation over any joint, but a change in radiation over the skin connecting the left knee with the rump of the animal. This intensified heat radiation was visible from the side, the front and from under the animal. Hence it was inferred that the animal had no joint injuries but had acquired a muscle fibre rupture. As there was some ice on the ground of the outside enclosure it seemed most likely that the animal had slipped on this ice and overstretched and torn some of the adductor muscles in the left knee region. Local treatment improved the condition soon.

Foot problems in elephants

Case report 7
Pododermatitis in an Asian elephant
As is known from many elephants in captivity, they develop lesions on their toenails quite often (2, 8). There are multiple reasons for this. Often, however, the beginning of this problem goes by unnoticed, and hence treatment only starts at a late age of the lesions. In the following case, the le-

sions were observed with infrared at an early stage, and altering therapies were followed up closely over a two-year period. As can be demonstrated with the infrared images, the first therapy was not successful. The inflammation of the nails increases to include the leg fare beyond the carpal joint at the end of the first year of observations. Then the treatment was changed to a more radical surgical removal of altered nail tissue and included also the use of stronger antiseptic solutions. After the second year, the infection was reduced, but kept coming back periodically, as infrared further observations revealed. Here again a lot of basic studies are needed in the future to establish the use of infrared-thermography in observing pododermatitis in elephants and also to evaluate the current treatment used.

Inflammation diagnosis in a rhino

Case report 8
Lameness evaluation in a black rhino
A lameness in the front left leg was observed in an old hook-lipped rhinoceros. No thorough investigation was possible without immobilisation. As the risk of immobilisation in this old animal was too great, infrared-thermography was used as preliminary diagnostic tool. Thermography revealed the problem not to be in the front left foot, where there was a slight increase of heat radiation, but instead in the right knee area. A severe heat area was observed over the knee joint and the femoral bone. It was inferred that a muscle fibre rupture (*Musculus biceps femoris*) was the reason for the lameness. The observed lameness in the front left leg was compensatory. This case shows, that infrared-thermography is a valuable tool in the observation of the complete body surface of an animal and that hidden injuries can be detected, if they are located close to the surface (9, 17, 18).

Inflammation diagnosis in giraffes

Case report 9
Polyarthritis in giraffe
A giraffe was observed with severe joint problems over many years. The animal seemed stiff in the joints at times. During such times the crackling sounds in the joints were intensified. As the treatments did not improve the conditions, it was decided that euthanasia was the only solution. Two weeks before this took place it was possible to conduct an thermographic investigation on this animal. Thermography revealed severe inflammations over all joints in the front legs and in all joints of the back legs down to the hock joint. The joints distal from the hock showed no increased heat radiation. Necropsy confirmed the inflammations of the joints (23), as observed in infrared-thermography.

Case report 10
front leg injury in a giraffe
This very recent case concerns a giraffe with an increased heat radiation in the front left leg, but without an observed lameness. Periodically this animal shows this heat increase, sometimes emitted over the whole front left leg, sometimes only over the distal parts of the leg, sometimes disappearing altogether. This animal has scissor claws in the front left leg. Currently this reappearing increased heat radiation is followed using infrared-thermography and the debate continues whether or not to immobilise this animal in order to correct these claws. The newest findings will be discussed in the presentation.

Inflammation diagnosis in a hippopotamus

Case report 11
Front leg injury in a hippopotamus
One day the male hippopotamus suddenly showed a lameness of the front right leg. No accident was observed previously. The animal was so severely injured that he would not come out of the water at feeding times. In order to localise the problem infrared-thermography was used. The ani-

mal was given a strong painkiller and later on allowed to come out of the water. The minute the animal came out of the water, the radiation over the right carpal joint started to increase disproportional from that over his other legs or that of the females. Within minutes the carpal joint was “red-hot” compared with the “green” colour of the other legs. A temperature difference of more then 3,0 °C were measured 15 minutes after the hippo came out of the pool. In a horse a temperature difference of 3,0 °C or more is always considered pathological (12), even but differences of 1,0 °C are often considered pathological already (18). A second infrared investigation 11 days later revealed that the leg has not improved yet. The carpal joint still shows a tremendous increase of heat radiation beginning to show up the minute the animal comes out of the water and feeds on land. Here the discussion has to be continued whether or not another treatment should be applied to this animal, or whether the giving of painkillers actually hinders the healing of the leg. As the animal continues to utilise the leg, then without pain, maybe this hinders the healing process.

Discussion

The application of infrared-thermography has led to good results in detecting processes, which were associated with local or general changes in surface temperatures. For instance in the areas of joint inflammation, in traumatology, in localising the area of the origin of a lameness, or in the supervision of a healing process in an elephant with pododermatitis. An earlier investigation of an elephant with pododermatitis showed the same good results using infrared-thermography (2). Infrared-thermography enables the investigator to detect pathological processes in an early stage, and allows an evaluation of the applied therapy. This was already found to be very valuable in racehorse medicine in Great Britain (9, 16, 20), but also in pigs good results were achieved (14) or even in dogs (4). Even in companion animals, when other technique do not solve the case, infrared-thermography may help lead the investigator to investigate areas he/she missed before (4).
The great potential of using infrared-thermography in lameness evaluation was discovered in horse medicine in the United Kingdom a long time ago (11, 12, 13, 17, 18, 19). On racecourses this technique is often used as a preventative method for detecting of potential problems before they manifest themselves in form of a visible lameness. In lameness evaluation it is essential to evaluate both sides with the infrared-camera under the same conditions and within a close time frame. In horse medicine the legs of the animals are placed parallel to each other and then infrared-images are taken from the front an the back of the legs. This is the easiest way of investigation, as it allows direct comparison between both hind- and forelegs. In horse medicine it is easier to detect slight temperature changes then in zoo animals. Artefacts from uneven weight distribution over the legs can be minimised in horses by placing the legs exactly next to each other (17, 18, 19). This is not possible in zoo animals. Therefore temperature changes in zoo animals should only be evaluated if they are more then 1,0 °C different and continue to be there even if the animal shifts the weight from one lag to the other. Temperature differences of less then 1,0°C difference require a lot of experience from the investigator when interpreting infrared-images (7).
Infrared-thermography seems to be a valuable diagnostic tool in localising areas of tissue injuries or other forms of inflammations. Infrared-thermography can, however, not identify the cause of the injury, e.g. an infection or a simple distortion. If this information seems absolutely necessary than other conventional diagnostic tools have to be used. In case of lameness evaluation in Megaherbivores infrared-thermography seems to be an indispensable tool already today, as it can give information on the localisation of a problem that can be obtained with almost no other means (7).

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