Application of thermal imaging for cattle management

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Abstract

To study the possible application potential of thermal imaging for health and fertility diagnostics, series of thermal images of grazing suckler cows were taken over a period of several months. The initial results indicate that cows with hot udders can be monitored. On the other hand, it was not possible to determine pregnancy by means of changed skin temperature distribution. The skin temperature is dominated by the ambient conditions to which the cows are exposed and not by the changes due to gravidity. The oestrus cycle affects the core body temperature of cows and could produce partial changes in skin temperature as well. The measurement of core body temperature, activity and pudendum temperature by thermography from oestrus-synchronised cows proved that the temperature maximum during oestrus climax could be shown by thermal imaging.

Keywords: thermal imaging, suckler cows, hot udder, gravidity, oestrus

Introduction

Thermal imaging can be utilised in animal husbandry for the control of buildings (e.g. heat insulation), processes (e.g. air conditioning, eating behaviour), and state of animals (e.g. stress susceptibility or health state of animals). Fast and cost effective measuring methods are looked for to improve cattle management particularly in the fields of health and fertility diagnostics. Sickness, local inflammations, injuries and other changes of the state of animals may produce an increase of the core body temperature and/or a change of the skin temperature distribution. As the skin temperature is influenced by the intensity of blood circulation, gravidity of cattle might be visible in thermal images. The state of animals can be sensed by thermography, if increased skin temperature or a change of its distribution reflects the change of the state of animals. Therefore, grazing suckler cows, heifers at different gravidity states, and oestrus-synchronised cows were studied by thermal imaging. The aim of this study was to evaluate the potential of thermography for cattle management.

Materials and methods

Remote temperature measurement techniques utilise infrared radiation in the range of about 8 to 12 µm. Whereas for the measurement of static scenes like analysis of buildings scanning cameras with one image per second are suitable, FPA-cameras (Focal Plane Array) with a capability of 50 images per second must be used for dynamic scenes with animals. In the measurements here, a camera with a non-cooled micro-bolometer array was utilised, operating in the 10-micrometer waveband at a temperature resolution of about 0.1 K at 300 K. The suckler cows were on the pasture for the entire time. The heifers were in a free stall barn connected to a feedlot. Images were taken in the open stable and at the feedlot. For the oestrus study, six dairy cows were investigated at the Clinic for Bovine Obstetrics and Gynaecology, School of Veterinary Medicine Hannover (TiHo). Prostaglandin F₁₂α was applied to stimulate the artificial oestrus. The oestrus climax was evaluated by traditional measurements of the core body temperature and monitoring of animal activity.
Results and discussion

Thermal images and photos of grazing suckler cows on a pasture were collected for several months to study the practicability of monitoring cows at field conditions. It was found that cows with hot udder could be detected (fig. 1). However, as the skin is so well insulated, it makes it difficult to determine pregnancy by means of changed skin temperature distribution. There is no easily recognisable change in the skin temperature, which could be assigned to gravidity. Additionally, the black-white pattern in the visible range (photo below in fig. 2 and fig. 3) shows a similar pattern in the thermal image. This is valid for shadow (fig. 2) as well as for basking heifers in the sun (fig. 3). The differences in spectral emissivity (and thus the reflectivity; "black-white pattern") of the skin seem to range at first glance from the visible range (0.5 µm) to the thermal range (10 µm). Usually, the thermal emissivity of biological objects ranges between 0.90 and 0.99. Since the radiation interaction with the surrounding environment in connection with heat transfer from the body and cooling by transpiration and convection produces the skin temperature distribution, more detailed studies are necessary to determine the heat and radiation balance on the skin of animals.

During oestrus climax, the core body temperature of cows increases between 0.5 K and 1.0 K for a period of about 6 to 12 hours. An additional indicator of the oestrus climax is a maximum in activity of the cows. In an experiment at the School of Veterinary Medicine Hannover, the core body temperature, the activity and the pudendum temperature by thermography from six oestrus-synchronised cows was measured over a fortnight. The result was that thermal imaging could show the temperature maximum during oestrus climax.

Conclusions

Cows with hot udder can be easily detected by thermal imaging on pastures as well as in barns. Gravidity of heifers in natural ambience (pasture or barn) cannot be determined by simply monitoring with a thermal imager. The temperature distribution of the skin is mainly influenced by the black-white pattern of the cows (visible range) and by the heat exchange between skin and surrounding. Since the skin is a good thermal insulator, ambient conditions and not the minor changes in body temperature usually determine the skin temperature. In contrast, the external pudendum temperature follows the core body temperature, and infrared thermometry can be utilised for oestrus climax determination.