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Application of infrared thermography on lactating sows

One of the most important disease indicators in livestock is the rectal temperature. This procedure is, compared to the infrared thermography, more time consuming and needs animal contact. The infrared thermography is a contactless and non-invasive method to detect the body temperature. Regarding to animal welfare the infrared thermography is a good method to detect the body temperature. A trial with sows in farrowing crates under practical conditions has shown that the body regions eye and back of the ear are appropriate localisations to record the body temperature using infrared thermography. Therefore the infrared thermography can provide an essential contribution to disease prevention and can improve the welfare of lactating sows.

Keywords
Infrared thermography, sow, fever, localisation

Abstract
Landtechnik 68(4), 2013, pp. 228–231, 2 figures, 1 table, 12 references

Puerperal diseases with sows such as the mastitis metritis agalactia complex (MMA) are common phenomena [1]. In most cases this disease is accompanied by fever [2]. Timely introduction of targeted preventive action depends on early recognition of symptoms. The possibility of continuous monitoring of sows' body temperatures, especially in the farrowing department, is therefore of great importance. This would play a role, not only in good economic results and associated profit, but also in animal welfare. Rectal temperature measurement is the accepted practice in commercial farming. However, this method is mostly associated with stress for the animals and is also time consuming.

In previous trials with sows the conclusion already reached is that IR thermography offers the possible utilisation of body surface temperature recording for early identification of disease [3].

In a further study it was reported that fever could be detected with a sensitivity of 74.6 % using IR measurement on the eye with ponies [4]. With consideration of influencing factors such as climate, circadian rhythms or surface dirt in the analysis of the measurement results, the results indicate that IR thermography certainly offers a possibility for early recognition of temperature increases and therefore of diseases [5]. In other studies [5; 6] the areas which are most suitable for recording body temperature of farm animals non-invasively have already been investigated. To be clarified in the trial presented here is the most suitable IR technique and whether the eye and back of auricle are suitable for adoption as surface localisation for temperature measurement of pigs.

Animals, materials and methodology

The trial took place on a pig production farm with 340 breeding sows (Large White x German Landrace) and 17 000 feeding pigs. One week ante partum sows were penned in the farrowing station where the measurements took place. All the sows were in conventional farrowing crates with a length of approximately 2.25 m. Each farrowing pen was 1.80 m wide and 2.40 m long. The animals had free access to water. Feeding took place twice daily. Feed was individually rationed after farrowing.

The trial was divided into two parts.

The first part was carried out with 15 sows. On days one to four 10 sows were examined twice daily (in total eight measurements per sow and localisation). On days three and four 5 further sows were examined twice daily (in total four measurements per sow and localisation). In the second part of the trial 30 sows were observed over a period of four days, each sow being examined every second day.

In both parts of the trial temperature measurements were between feeding times. An examination took about 10 minutes per sow and always followed the same sequence:

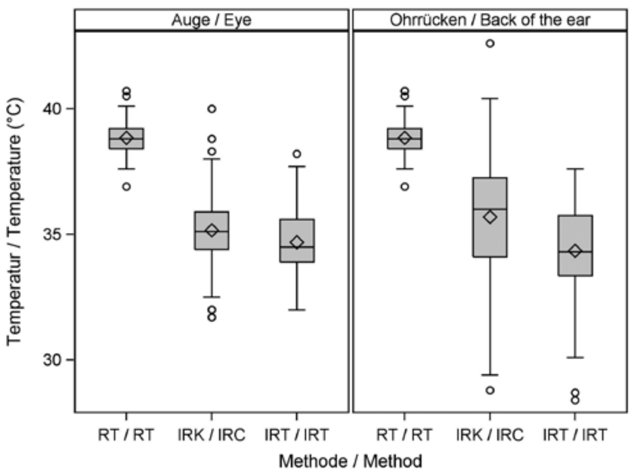
1. Measurement of rectal temperature (RT) with a microlife VT 1831 digital thermometer (ApoNorm, Hillscheid, Germany)
2. Measurement of body surface temperature with an infrared camera (IRC) (PI 160, Optris, Berlin, Germany)
3. Measurement of body surface temperature with an infrared hand thermometer (IRT) (Raytek, Berlin, Germany).

For both infrared measurement techniques an emission factor of 0.985 was adjusted, which equals the emission factor for the human skin surface. Each infrared measurement took place with a distance of 30–40 cm between animal and measuring instrument. The IRC film was stored and later evaluated with analytic software (PI Connect, Optris, Berlin). Via the software it was later possible to establish measurement fields with their respective average and maximum temperature. The data recorded by the IRT measurements were noted for each animal immediately after the measurement, being average values over a measurement period of around 10 seconds. The measurement area represented, with a measurement distance of 30–40 cm, approximately 2 cm. The eye measurement area covered the eyeball and its surroundings whereby excess tear flow present on the eye was taken account of and avoided during measurements. The measurement on the back of the auricle took place on the transition area where the cartilaginous auricle meets the muscle immediately behind (*M. cutaneus colli*). Here too, the concern was to achieve a clean recording area of skin. Threshold value denoting an increased body core temperature for sows was selected as 39.5 °C [7] and in the case of IRT was also defined as 90 % quantile. The evaluation of the data took place using the statistical program SAS 9.3 (SAS Institute Inc., Cary, North Carolina). To present the results in graphical form Box-Whisker-Plots were completed for the first part of the trial. The data of the animal groups from the second part of the trial were graphically evaluated via the Bland and Altman method [8]. The influences of the IR measurement methods and the localisation on the fluctuation range between RT and the infrared temperatures were tested with a two-way factorial ANOVA model without interactions at a significance level of 5 %.

Results

With both localisations the measured infrared temperatures lay below the measured rectal temperatures and also showed a greater distribution (**Figure 1**). With back of auricle localisation average temperatures of all sows measured with the IRC lay nearer to the RT results compared with the results from the eye localisation, although the IRC recorded temperature range was greater from the back of the auricle. With both localisations the average IRT temperatures were just under 35 °C, whereby the range of readings from the eye was less than that from the back of the auricle.

Fig. 1



Comparison of the rectal temperature (RT) with the body surface temperatures, measured with an ifrared camera (IRC) or an infrared thermometer (IRT) at the eye and at the back of the ear of 15 sows (part 1 of the trial, n = 97 per box plot)

In **Table 1** temperature values from the second part of the trial are shown according to localisation and measurement method. The temperatures measured with the IRC were always higher than those taken with the IRT whereby the distribution range of the IRT temperatures was always smaller.

With IRC measurement of the body temperature on the back of the auricle 7 from 10 feverish sows (rectal temperature > 39.5 °C) were identified as such, whereby the 90 % quantile of the IR temperatures was 38.1 °C. The measurements on the eye with the IRC correctly identified 6 from 10 sows as feverish and the 90 % quantile of the IR temperatures in this case was 36.9 °C

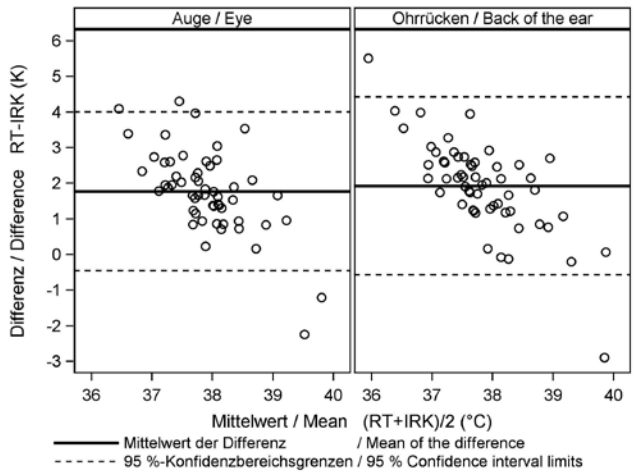
The Bland-Altman-Plot of the RT and IRC temperature differences against their arithmetic mean indicated that most values lay within the 95 % threshold. To be noted here, however, is the wide range of the individual animal temperatures. For both localisations the mean difference between RT and IRC temperatures was around 2 kelvins (**Figure 2**).

Table 1

Minimum, arithmetic mean, maximum and range of the body temperatures, measured with a rectal thermometer (rectal temperature = RT), an infrared camera (IRC) and an infrared thermometer (IRT) at 30 sows (part 2 of the trial)

Lokalisation *Region*	**Methode** *Method*	**Minimum** *Minimum*	**Arithm. Mittel** *Arithmetic Mean*	**Maximum** *Maximum*	**Spannweite** *Range*
Rektal/*Rectal*	RT/RT	38,0	38,8	40,3	2,3
Auge/*Eye*	IRK/IRC	34,41	36,93	40,64	6,23
	IRT/IRT	32,97	34,69	36,01	3,04
Ohrrücken/*Back of the ear*	IRK/IRC	33,19	36,79	41,29	8,10
	IRT/IRT	32,73	35,19	37,54	4,81

Fig. 2



Bland-Altman-Plot for rectal temperatures (RT) and temperatures measured with an infrared camera (IRC) of 30 sows (part 2 of the trial, n = 58 per localisation)

Discussion

Rectal temperatures were in each case higher than the temperatures measured by the IR thermography method. This agrees with the results from Johnson et al. [4] and Traulsen et al. [3]. This was to be expected in that the IR thermography measured body surface temperature and not body core temperature.

Differences were also apparent between the IRC and IRT recorded temperatures. The IRC results showed less fluctuation compared with the standard procedure (rectal measurement with digital thermometer) than the IRT values. An explanation for this is that the IRC can measure the warmest point in the picture area while the IRT measures average temperatures of the area. Additionally, prevailing evaporation from the skin surface or skin condition might influence the IRT measurements more strongly. The measurements showed that the range of the IRT values was less than that of the IRC ones. Apparently, the average IRT values return a lesser distribution range than the maximum values recorded as IRC temperatures. Less variance between the individual measurements is, however, more important than the difference to the RT measurements if the aim is continuous monitoring of body temperature.

Using the IRC on the back of the auricle 7 from 10 feverish sows could be identified whereby the result from localisation on the eye was only 6 from 10 animals. These results agree in part with the results from Loughmiller et al. [9], Johnson et al. [4] and Schaefer et al. [10]. Thus Loughmiller et al. [9] reported that the detection of animals with fever is possible through measuring the body surface temperature. On anatomical and thermoregulatory reasons, the eye and the back of the auricle are especially good locations for conducting IR measurements. Additionally, procedural aspects also lead to the conclusion that these locations could be used. Because pigs have very few sweat glands thermoregulation is mainly achieved through increases in local blood circulation in the skin [11; 12]. Thus there are areas of the skin with low subcutaneous fat that are clearly very suitable as sites for measuring animal temperature.

The Bland-Altman-Plot showed that there were little agreements between the RT and the infrared temperatures. For this reason the measurement of the rectal temperature as reference value with clinically healthy animals cannot currently be replaced.

The distance between the infrared measuring instruments and the surface to be measured had strong influence on the measured temperature. Therefore a possibility for improving the method might involve further standardisation of the measurement distance and minimization of the spot of skin to be measured. This especially applies to the IRT. A further difficulty, and one which has to be considered in relationship with infrared thermography, are movements of the eye or auricle which can also have a considerable influence on the measuring precision. An animal-individual observation over a longer period could additionally contribute towards increasing the identification success rate.

Conclusions

Infrared measurements of temperatures with clinically healthy sows did not significantly agree with those measured by rectal thermometer. On the other hand, good results that agreed with measured rectal temperatures were achieved in some cases where the sows measured were clinically more obviously affected. The results show that once-only measurement of body temperature with the IRC or the IRT brought no satisfactory and reproducible results under practical farming conditions. Further investigations and developments are necessary to establish such methods under practical conditions. The localisations eye and back of auricle are suitable for IR thermography measurement, this approach being aided by the ease of reaching these body points with the device. Through its small variance range, the IRT appears to be well suited for continual monitoring of body temperature. But also the video-based IRC represents a very promising method in that this method allows a multiplicity of assessment possibilities compared with IRT.

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