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RELATIONSHIPS BETWEEN THE QUALITY OF THERMOGRAPHIC IMAGE AND THE MEASURE OF SKIN TEMPERATURE ON PIGLETS

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ABSTRACT

In order to evaluate the influence of the quality of the thermal image in assessing piglet's skin temperature, 576 images of back and 576 images of belly from 192 subjects were examined. Images were recorded using a FLIR P640 camera at 37, 45 and 55 days of age. Thermal images were analysed with software which calculates minimum, average, and maximum values of skin temperature. The quality of the images was evaluated subjectively by a reviewer assigning a rating of "excellent", "good" or "fair" on the basis of the available surface for measuring and on the presence of dirt or wet skin area. Average and minimum skin temperatures of both sampling areas were significantly reduced with the decrease of thermal image quality, while maximum value was less affected by the image quality. This latter measure seems more suitable for thermographic assessment of piglet's skin temperatures.

Key words: piglets / skin temperature / thermography / thermal image quality

1 INTRODUCTION

In the last two decades, infrared thermography has been applied to detect surface body temperature of animals (Mitchell, 2013). Briefly, this technique is based on detection of thermal energy emitted by a body, with the signal being converted into an electronic signal, which in turn is processed by software to produce digital images. The imaging is produced using different colour scales to highlight the areas that have different temperatures, thus obtaining a representation of the thermal gradient of the examined body with an accuracy of 0.1 °C. Infrared thermography does not require any contact and is therefore a completely non-invasive technique that allows recording measurements on subjects difficult to reach or to approach, or moving subjects. In livestock, this technique is used for mass screening aimed at the early diagnosis of diseases characterized by an increase of body temperature (Schaefer and Cook, 2013), as well as for the detection of stressful treatments increasing body temperature of animals (Cook and Schaefer, 2013) or for assessing the effects of environmental conditions (Knizkova *et al.*, 2002). Actually, there are few studies on the use of infrared thermography in pig farming and it is interesting to evaluate some practical aspects related to its application. The aim of this study was to evaluate the relationship between the quality of thermal images and the measures of piglets skin temperatures recorded on the back and on the belly areas.

2 MATERIALS AND METHODS

In this study 192 female and castrated piglets (Duroc × (Landrace × Large White)) divided into four groups of 48 animals balanced for sex were examined at the experimental farm of the Dept. of Agricultural and Food Sciences. Piglets of 30 ± 1 days of age (kg 7.6 ± 1.7 of live weight) were allocated in 12 boxes post-weaning having plastic slatted floor and an available surface of 0.20 m^2

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per subject. Thermal images of the back and belly were recorded at 37, 45, and 55 days of age using a hand-held thermal camera Flir P640 (Flir System SRL, Milan) positioning each piglet at 2 m of distance from the camera. Thermal images were recorded on piglets suspended for few seconds by their hind legs. Before the use, the thermal camera was calibrated on the basis of environmental temperature and relative humidity of the room where the piglets were examined. The emissivity of the piglet's skin was set at 0.98. In total, 576 images were recorded on the back and on the belly, respectively. Five images of each sampling area were illegible and were discarded. The remaining were analyzed by the software Therma Cam Researcher Pro 2.9 (FLIR System, Milan) in order to obtain minimum, average and maximum temperatures of the skin sampling area. The former corresponds to the temperature of the pixel with the lowest value; the second corresponds to the average temperature of the pixels and the third to the temperature of the pixel with the highest value. The skin selected area was a rectangle including a standardized portion of the back and belly (Fig. 1). On the back, the short sides were drawn following the junction of the shoulder behind the interscapular space and the stifles profile, respectively. The major sides were drawn connecting the extremities of the short sides, avoiding including the pixels of the image's background. On the belly, the short sides were drawn connecting the armpits and the inguinal profile, respectively, while the major sides were drawn connecting the previous ones, without include pixels from background. The quality of the thermal images was evaluated subjectively by a single reviewer assigning as "excellent", "good" or "fair" on the basis of the following characteristics: "excellent", the image does not display any dirt or wet spots, the area is fully visible, easily identifiable and the trunk has no torsion; "good", the image is smeared with dirt or wetlands and trunk has a partial rotation that change the shape of the selected area, even if back and belly are clearly detectable; "fair", the image includes patches of evident dirt and the trunk is rotated to right or left with the consequences that the selected area on back or on belly is not easily drawable. Data were processed with a mixed model for repeated analysis using Proc Mixed procedure of SAS (SAS, 1996) considering rating of thermal images, group of piglets and sex as fixed factors, thermal measures at three different ages within group as repeated factor and piglet within group as random factor.

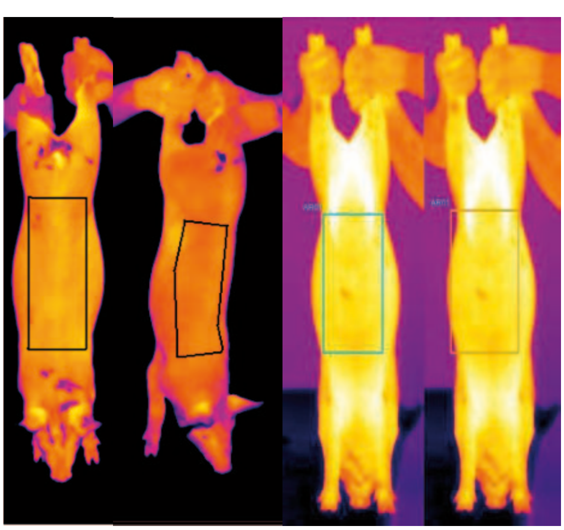

Figure 1: *Selected area of measure of back and belly thermal images*

3 RESULTS AND DISCUSSION

Distribution of thermal images between quality classes is shown in Table 1. There was a difference in the class distribution between back and belly images. Only 29% of images recorded on the back were included in the class "excellent", whereas more than 40% were included in the "good" and 30% in the "fair" classes, respectively. At the opposite, more than 60% of the belly images were classified as "excellent" and only 11% were classified as "fair". The different distribution of the dorsal and ventral images between classes of quality could be related to the likelihood that the back becomes more dirty due to contact with other piglets and/or with the cage's wall, while the belly has less possibility to became dirty, especially in boxes with slatted floor. Furthermore, the twist of the trunk and the consequent reduction of the sampling area for assessing the skin temperature seem to exert more negative effect on the quality of dorsal than ventral measures. In Table 2, least squares means and standard errors of minimum, average and maximum of the back and belly skin temperatures were reported for each quality class of thermal images. The minimum value recorded on the back significantly decreased ($P < 0.05$) according to the reduction of image's quality, falling of about one degree by class. Moreover, the minimum value presented the largest variability in all quality classes. Its

Table 1: *Distribution of back and belly thermal images into three classes of quality*

Quality classes of thermal images	Back		Belly	
	No.	%	No.	%
Excellent	166	29.1	346	60.6
Good	230	40.3	161	28.2
Fair	175	30.6	64	11.2

Table 2: *Least squares means (LSM) and standard errors (SE) of the minimum, average and maximum skin temperatures recorded on piglet's back and belly into different quality classes of thermal images*

	Quality class of thermal images					
	Excellent		Good		Fair	
	LSM	SE	LSM	SE	LSM	SE
Back:						
- minimum value	33.37[a]	0.12	32.41[b]	0.10	31.43[c]	0.11
- average value	36.11[a]	0.05	35.88[a]	0.04	35.30[b]	0.05
- maximum value	37.29[a]	0.04	37.24[a]	0.03	37.12[b]	0.04
Belly:						
- minimum value	33.03[a]	0.12	32.71[b]	0.10	32.67[b]	0.12
- average value	36.67[a]	0.06	36.47[b]	0.05	36.39[b]	0.06
- maximum value	38.80	0.05	38.69	0.04	38.71	0.05

[a-b] Different letters within the same row differ significantly ($P < 0.05$)

standard error was twofold those observed for average and maximum values. Differences between quality classes of thermal images were found for the average value of selected areas. In the class "fair", it was found significantly lower ($P < 0.05$) than those observed in the other two classes, showing differences between 0.5 and 0.7 °C, respectively. Similarly, the maximum value was significantly lower in the "fair" class ($P < 0.05$), even if the differences with the other classes were smaller and ranging from 0.12 to 0.17 °C. Minimum, average and maximum values recorded from thermal images of belly presented similar trends to those observed for the corresponding values recorded on the back, showing a decrease of skin temperature according to the reduction of the quality class. The minimum value of the "excellent" class was significantly higher ($P < 0.05$) than those recorded in the two other classes. Similarly to the corresponding values measured on the back, the minimum values recorded on the belly presented a large variability, showing standard errors twofold higher than those observed for the average and maximum values. The average values were significantly higher ($P < 0.05$) in the "excellent" class compared to those found in the other two classes of quality, while there were not differences between classes of thermal image quality for the maximum values. As expected, the superficial temperatures recorded on the belly were slightly higher than those measured on the thermal images of the back, because the latter are more influenced by the variation of environmental conditions. On the back, and a lesser extent on the belly, minimum surface temperature was found to be significantly affected by the quality of the thermal images. The latter value, consisting of a single pixel in the selected area, can be influenced by a very small spot of dirt that is able to shielding the heat radiation coming from the skin and to decrease the reading value. The measure of maximum value of skin temperature was lesser influenced by the quality of thermal image and, although consisting of a single pixel, it cannot affected by spots of dirty and/or by wet areas. In fact, they reduce the thermal radiation from the skin and the corresponding pixels are not taken into account during the assessment of maximum value of thermal images.

4 CONCLUSIONS

The thermographic analysis on back and belly of piglets requires special attention because it is exposed to the influence of factors that can reduce the quality of thermal images. Dirty and wet areas, more often present on the back, decrease minimum and average values of skin temperatures assessed by the analysis of the thermal images. At the opposite, the maximum value is not affected by these factors and, therefore, it can be used as reference for thermographic surveys on piglets. The quality of the thermal image is essential for reliability of information obtained from the infrared thermography. Therefore, standardization of recording conditions and knowledge of the variation sources of thermal radiation are aspects that should not be overlooked in the application of thermography in pig farming.

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