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Estimation of rectal temperature of pigs from the surface temperature

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Abstract
The objective of this study was to assess the relationship between the rectal temperature of pigs and surface temperatures estimated through non-invasive techniques, specifically utilising an infrared thermometer and thermal imaging. The trial involved six Large White Yorkshire and six crossbred pigs of six months of age from the Pig Farm, Instructional Livestock Farm Complex, Pookode, Wayanad, Kerala. The research was conducted for two months each, during the winter of 2022 and the summer of 2023. The animal parameters like rectal temperature and surface temperatures were recorded daily around 1 p.m., during the study period. Surface temperatures (in degrees Celsius) were determined by averaging the readings from six key points, including the head, shoulder, loin, back, inner ear, and tympanic region, using an infrared thermometer. Simultaneously, thermal images of the animals were captured within a maximum distance of 0.75 meters from the animals, using an infrared thermal imaging camera. During the summer season, pigs exhibited elevated rectal and surface temperatures of 39.42±0.02 °C and 36.42±0.07 °C, respectively, highlighting the influence of temperature fluctuations on their body temperature regulation. To evaluate the correlation between the non-invasive surface temperature measurements and the rectal temperature, Pearson's Coefficient of Correlation was computed for all the recorded surface temperature data. Notably, the shoulder temperature exhibited a strong correlation with a coefficient of 0.613 in relation to rectal temperature, at a significance level of $p<0.05$. These results provide valuable insights into the relationship between surface and rectal temperatures in pigs. The regression equation for calculating rectal temperature was derived.
Rectal temperature = 42.66 - 0.085 (Surface body temperature of loin).

Keywords: Pigs, rectal temperature, surface temperature, infra-red thermography

1. Introduction
Rectal temperature is a commonly accepted method for determining core body temperature in animals and is commonly used to gauge overall health. However, accurately obtaining rectal temperature in pigs can be difficult due to their size, temperament, and stress reactions. In such cases, surface temperature measurements can provide a convenient and non-intrusive means of estimating core body temperature in pigs (Zhang *et al*., 2019) [7].

Measuring the rectal temperature of pigs using surface temperature is a crucial component of animal health management, particularly in the realm of agriculture and veterinary care. Keeping tabs on the body temperature of pigs is essential for maintaining their welfare, as it offers valuable information on their overall health and can assist in identifying potential problems at an early stage (Koch *et al*., 2023) [2].

Many researchers and practitioners rely on a variety of tools and technologies to accurately measure surface temperature, including a popular technique known as infrared thermography. This method allows for non-invasive temperature readings by detecting an object's infrared radiation. By using this data to compare surface and rectal temperatures in different scenarios, a dependable model can be created for estimating the rectal temperature of pigs based on their surface temperature (Usamentiaga *et al.*, 2014) [6]. By adopting this non-invasive method for monitoring pig health, a wide range of industries can benefit, from commercial farming to research institutes and veterinary clinics. This approach allows for swift detection and handling of health concerns, ultimately leading to enhanced pig well-being and performance.

2. Materials and Methods

The experiments were conducted at the Pig Farm of the Instructional Livestock Farm Complex (ILFC), Pookode, located in Wayanad district of Kerala. Six female Large White Yorkshire (LWY) and six female crossbred (50% LWY x 50% Landrace) pigs of approximately six months of age maintained at Pig Farm, ILFC, Pookode, Wayanad were included in the study. The experiment was conducted in winter season (November-January) of 2022 and summer season (March-May) of 2023. The study period was two months.

Every day at approximately 1 p.m., we diligently recorded important animal data, specifically their rectal temperature (RT) and surface temperatures (ST). This involved taking measurements at six critical points on the animals: the head, shoulder, loin, hip and inner ear. Achieving precise surface temperature readings was crucial in our data collection, so we utilized an infrared thermometer. Placed at a distance of 0.75 meters from the pigs, it ensured consistent and dependable results. In addition, the implementation of an infrared thermal imaging camera enabled us to capture thermal images of the animals (FLIR TG165).

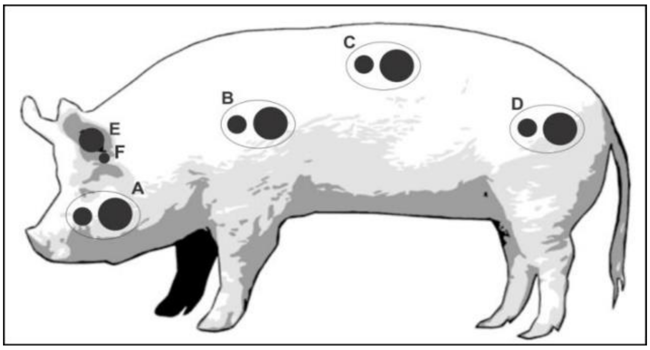

Fig 1: Skin surface regions assessed in piglets: head (A), shoulder (B), loin (C), ham (D), ear (E), and tympanic (F)

Fig 2: Recording of rectal temperature and surface temperature

After capturing both rectal temperature (RT) and surface temperature (ST) data, we used SPSS software for correlation analysis to investigate the connections between these two values. From there, we delved deeper by running regression statistics to uncover potential correlations between rectal temperature and surface temperature recordings. Ultimately, we arrived at a regression equation that serves as a predictive tool for estimating rectal temperature based on surface temperature readings.

3. Results

The rectal temperature of the pigs was recorded daily and the average rectal temperature was 39.08±0.03 ℃ in winter and 39.42±0.02 ℃ in summer, respectively. For crossbred pigs, the respective values were 39.10±0.02 ℃ in winter and 39.42±0.02 ℃ in summer. Animals exhibited higher rectal temperatures ($p<0.01$) during the summer season compared to the winter.

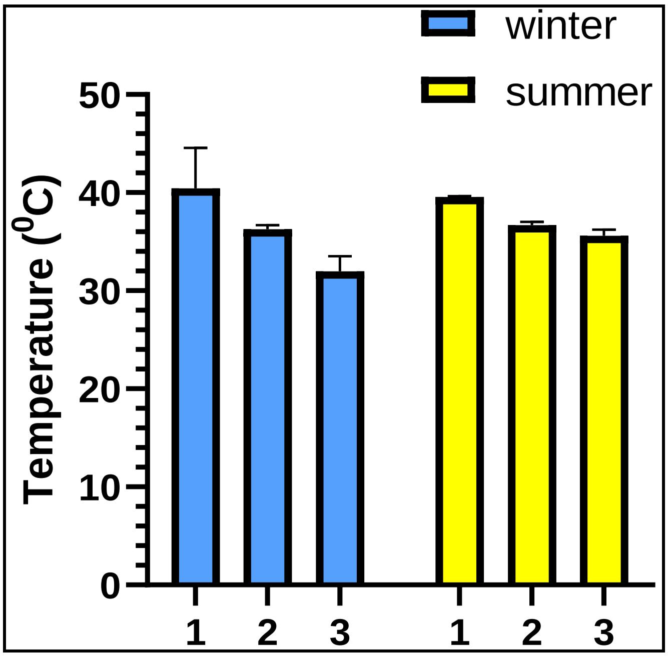

Fig 3: 1. Rectal Temp, 2. Surface Temp, 3. IR

Surface temperature of different points was recorded and the average surface temperature of the pigs 34.74±0.22 ℃ in winter and 36.42±0.07 ℃ in summer and for crossbred pigs, the readings were 34.66±0.13 ℃ in winter and 36.36±0.09 ℃ in summer.

Table 1: Correlation coefficient of different points surface temperature

RT	Head	Shoulder	Loin	Hip	Ear
r	0.282	0.296	0.613	0.203	0.175
P-value	0.351	0.326	0.034*	0.507	0.568

RT- Rectal Temperature, r– Coefficient of correlation

The highest correlation can be observed between the rectal temperature and loin regions, with a significant coefficient of 0.613. This suggests a strong and positive relationship between these two variables, and the statistical significance of this correlation (P-value = 0.034) adds to the credibility of this connection. Our analysis has produced a valuable predictive tool in the form of a regression equation that helps to estimate rectal temperature using surface temperature measurements. This equation effectively captures the numerical connection between these parameters, enabling precise predictions. It is essential for the equation to incorporate coefficients for both the intercept and the surface temperature variable in order to provide a formula that can accurately estimate rectal temperature in pigs based on measurements taken in the loin region.

Rectal temperature = 42.66 - 0.085 (Surface body temperature of loin).The correlation calculation for IR max yielded a meagre correlation coefficient of 0.247. This suggests a weak correlation between the variables being examined, namely IR max and the parameter being studied.

Fig 4: IR image of pig

4. Discussion

The fluctuations in rectal temperature between winter and summer seasons for both groups of pigs serve as a clear reminder of the impact of environmental elements on these animals body temperature regulation. With a P-value of less than 0.01, the noticeably higher rectal temperatures during the summer are in line with expectations, highlighting the animals innate ability to adapt to warmer conditions. In the study by Renaudeau *et al*. (2010) [5], pigs were examined, revealing a correlation between elevated environmental temperatures and an increase in core body temperature. Likewise, Godyń *et al*. (2020) [1] conducted a comparable investigation involving pigs, determining that exposure to heat stress resulted in a rise in rectal temperature. This correlation is further supported by the parallel rise in average surface temperatures for both groups of pigs, solidifying the notion that ambient temperature is a key influencer of pig's body temperature.

There appears to be a compelling correlation between rectal temperature and the loin region, with a strong coefficient of 0.613 and a significant P-value of 0.034. In the context of our study, the incorporation of both season and time points in the optimal model yielded a determination coefficient of 0.613. Notably, this value demonstrates a 40% increase compared to the determination coefficient of 0.432 observed by Metzner *et al*. (2014) [3] in their investigation, which focused on the relationship between rectal temperature (RT) and the average surface temperature (ST). This underscores the enhanced explanatory power of our model in capturing the complex dynamics associated with these temperature variables. This points to a potential physiological link between core body temperature and the distinct anatomical features of the loin (Mostaço *et al*., 2015) [4]. It is possible that this correlation is reflective of heightened metabolic activity or increased heat production in the loin, indicating a need for further exploration into the underlying mechanisms at play.

5. Conclusion

Overall, our study sought to delve into the connection between rectal temperature (RT) and surface temperature (ST) in pigs, taking into account differences in seasons and specific areas of the body. Our findings demonstrated notable changes in rectal temperature throughout the seasons, with a notable increase during the summer months.

One noteworthy finding of our study is the strong connection between rectal temperature and the loin region, indicating a possible physiological relationship between core body temperature and specific anatomical characteristics. Our optimized model, which took into account both season and time points, significantly enhanced its ability to explain this correlation with a determination coefficient of 0.613 – a remarkable 40% increase from a similar study by Metzner *et al*. (2014) [3]. This highlights the efficacy of our model in capturing the complex dynamics of rectal temperature and skin temperature, and emphasizes its potential as a valuable tool for monitoring the health of pigs.

According to the study, there is a clear need for more research to fully understand the connection between core body temperature and its impact on the loin region in pigs. Interestingly, there were also moderate positive correlations observed in the head and shoulder areas, suggesting potential localized thermoregulatory responses. While these correlations were not deemed significant by statistical measures, they still raise important questions that require further investigation. Overall, our study provides valuable insights into the non-invasive monitoring of pig health, with potential implications for a range of industries including commercial farming, research institutions, and veterinary clinics.

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