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Variations in the vulvar temperature of sows during proestrus and estrus as determined by infrared thermography and its relation to ovulation

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A B S T R A C T

The prediction of ovulation time is one of the most important and yet difficult processes in pig production, and it has a considerable impact on the fertility of the herd and litter size. The objective of this study was to assess the vulvar skin temperature of sows during proestrus and estrus using infrared thermography and to establish a possible relationship between the variations in vulvar temperature and ovulation. The experimental group comprised 36 crossbred Large White × Landrace females, of which 6 were gilts and 30 were multiparous sows. Estrus was detected twice daily and the temperature was obtained every 6 hours from the vulvar area and from two control points in the gluteal area (Gluteal skin temperature [GST]). A third variable, vulvar–gluteal temperature (VGT) was obtained from the difference between the vulvar skin temperature and the GST values. The animals were divided into two subgroups: group A consisting of 11 animals with estrus detected at 6:00 AM, Day 4 postweaning, and group B comprising seven animals with estrus detected at 6:00 AM, Day 5 post-weaning. Both groups showed a similar trend in the VGT. The VGT increased during the proestrus, reaching a peak 24 hours before estrus in group A and 48 hours before estrus in group B. The VGT then decreased markedly reaching the lowest value in groups A and B, respectively, 12 and 6 hours after estrus. Although the time of ovulation was only estimated on the basis of a literature review, the matching between the temporal variations of the VGT values and the predicted time of the peak of estradiol secretion that ultimately leads to the ovulation processes suggests that the VGT values represent a potential predictive marker of the ovulatory events.

1. Introduction

In recent decades, productivity of the pig industry has increased dramatically, supported by major investments in new techniques that maximize the genetic potential of the herds. In reproductive management, artificial insemination, estrus synchronization, and ultrasonography for pregnancy diagnosis are now widely used. However, determining the optimal time to inseminate still relies on a relatively subjective evaluation of behavioral and physical signs of the sow. Because the best fertility results are achieved when artificial insemination is performed during the 24 hours before to ovulation [1–3], the development of a technique

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that could accurately predict its occurrence under field conditions would be of particular value. This would allow not only a more precise insemination time and, thus, an increase in the fecundation rate but also a decrease in the number of inseminations per animal and fewer post-ovulatory inseminations.

Several studies have tested the applicability of ultrasonography to detect or predict the occurrence of ovulation, but the protocols are usually time-consuming and require trained staff [4–6]. Moreover, even if using ultrasonography has enabled ovulation to be detected, it is not able to predict it in advance [7,8]. Other authors have found a relationship between the electrical resistance of the vaginal mucus and the day of estrus [9,10], but the results show a considerable variation among animals and between different measurement locations in the vagina [10,11].

More recently, infrared thermography was used to detect changes in the vulvar skin temperature (VST) of sows during the periovulatory period [12,13]. A significant decrease in the vulvar temperature before ovulation was reported, but it remained unclear whether the temperature peaks observed occurred exclusively in the vulvar region or as a reflex response to a rise in body temperature. Moreover, although several authors have reported temperature fluctuations in mammals related to the circadian rhythm [14–16], these were not taken into account in these previous studies because the measurements were only taken at 12-hour intervals.

Infrared thermography is a modern, noninvasive, and safe technique that measures the temperature of a surface, based on its emission of infrared radiation. It has been shown that estrogen administration can induce an increase in vaginal blood flow measured through a rise in vaginal thermal conduction [17,18]. The increased local blood flow linked to rising plasma estrogens is reflected by vulvar reddening and swelling that have been widely reported as typical signs of estrus in the sow [19,20]. Infrared thermography has the potential to evaluate these physiological changes by monitoring the evolution of the VST. The aim of this study was to detect variations of VST in sows and gilts during the periovulatory period, to establish a relationship between these temperature fluctuations and ovulation, and, ultimately, to evaluate the applicability of this method to predict ovulation under field conditions.

2. Materials and methods

2.1. Animals and housing

This study took place in the Groupement d'intérêt économique (GIE) Villefranche Grand Sud located in Villefranche de Rouergue, France, from January 25, 2012, to February 2, 2012. The experimental group comprised a total of 36 female sows, of which 30 were multiparous sows with mean parity of 4.1 $\pm$ 2.3 and lactation length of 28.3 $\pm$ 0.7 days and 6 were gilts of around 249 days of age. The females were crossbred Large White $\times$ Landrace, housed individually in stalls measuring 2 $\times$ 0.60 meters with controlled temperature and humidity. To synchronize the gilts, each one received an oral daily dose of 20 mg (5 mL) of altrenogest (Altresyn, Ceva Santé Animale, Libourne, France), for 14 days, until 2 days before weaning the sows. The day when the sows were weaned was defined as Day 0 of the study.

The room temperature was set at 19 °C and monitored by the electronic ventilation system's thermostats. However, the temperature was recorded every time when thermal imaging was carried out and double-checked with an independent thermometer placed inside the room.

2.2. Detection of estrus

Starting Day 1, estrus was detected twice daily (morning and afternoon) by a single person using a 2-year-old Duroc boar. It was based on the recognition of typical signs such as standing reflex and ear pricking. The animals detected in the morning were recorded as starting estrus at 6:00 AM, whereas the ones detected in the afternoon were recorded as starting estrus at 12:00 PM.

2.3. Infrared thermography

Temperature measurements of the VST and GST were done using an infrared thermal camera (Fluke TiR 9 Hz Thermal Imager, Fluke Corporation, Everett, WA, USA) every 6 hours at midnight, 6:00 AM, 12:00 PM, and 6:00 PM from Day 1 to Day 7. These thermograms were systematically obtained at a distance of 1 m from the rear end of the animal, with a 90° incidence. A pink dot was drawn on each gluteal region, so all the temperature records were obtained from the same location as shown in Figure 1A. For each measurement, two sequential thermograms were recorded, downloaded, and visualized with SmartView 2.0 (Fluke Thermography, Plymouth, MA, USA). The VST records were estimated by drawing a polygonic area delimited around the vulva, and the GST was taken in a circle in each gluteal spot. The recorded VST was defined by the mean temperatures from the polygon area, whereas the GST came from the overall mean of the two gluteal measures as represented in Figure 1B. If the image quality of the first thermogram was poor, it was discarded and the readings were obtained from the second thermogram.

Because these temperature variables were susceptible to both exogenous and endogenous factors, a third variable was created based on the difference between the VST and the GST. This allowed us to differentiate an increase in the VST due to body temperature (related to a febrile state for example), from an increase occurring exclusively in the VST (which would lead to a subsequent increase in the vulvar–gluteal temperature (VGT)).

In order to assess the repeatability of this method applied to the measurement of the VGT, the measurements of the VST and the GST were carried out five times at 5 minutes intervals on a sample group of four females at Day 0.

2.4. Statistical analysis

Data were entered in an Excel database (Microsoft Excel, 2010, Microsoft Corporation, USA). Records from two animals (one sow and one gilt) were discarded as the animals had not shown any sign of estrus during the study. The repeatability of the method to measure VGT infrared temperature was estimated by calculating a repeatability index