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Predicting farrowing of sows housed in crates and pens using accelerometers and CUSUM charts

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ABSTRACT

Piglet mortality is a continuing problem in modern pig production. It is high especially during the first few days after birth and can be reduced by supervision of farrowing.

There is currently a trend to move towards housing without crates due to animal welfare concerns. Thus, automatic systems that can predict farrowing equally well in different housing systems would have wider applicability than ones developed for crated systems only. A method that works with same parameters in different housing systems would be easier to maintain and reuse in different conditions. The aim of this study was to develop a new accelerometer based system to measure sow activity before farrowing. This data was then used to build a model to predict the approach of farrowing, based on increased activity, within 24 h before the start of farrowing.

We used a wireless 3D accelerometer to measure the activity of sows in order to detect farrowing. The accelerometer collars were attached to neck collars of 29 sows farrowing in crates and 33 sows farrowing in pens. We expected sows in pens to show higher activity, but a similar rise in the level.

We used a single model to detect farrowing in both crates and pens. A dynamic linear model was used to model the activity of the sows before farrowing and to extract trend component from seasonal components and a CUSUM chart was used to detect activity increase.

The model detected a rise in activity on average 13 ± 4.8 h (mean ± standard deviation) before farrowing in sows housed in crates and pens with sensitivity of 96.7% and specificity of 100%. The fact that we were able to use a single model with a constant set of parameters gives indication that the method has potential to become a robust indicator of farrowing in different housing systems, even though pre-farrowing activity was higher in sows housed in pens than in crates.

1. Introduction

Mortality of piglets is a continuing problem within modern pig production: total pre-weaning mortality levels (including still-births) were between 21% and 24% in the Scandinavian countries in 2013 (Anon, 2014). Piglet mortality is high especially during the first few days after birth (Marchant et al., 2000), and can be reduced by supervising farrowing, and acting timely in case problems occur (Andersen et al., 2009). It is crucial both for reducing the number of stillborn piglets, and for the vitality of the surviving piglets that the farrowing progresses smoothly: A prolonged farrowing could lead to an increase in asphyxia, which is a major cause for stillbirth. Also, piglets with reduced vitality are in greater danger of getting crushed by the sow (Kirkden et al., 2014). Efficient supervision of farrowing on-farm is, however, challenging to realize, partly due to the fact that manual detection of approaching farrowing is difficult and time consuming.

Farrowing induction by administration of prostaglandin is widely used to synchronize farrowing. However, even when using farrowing induction, there is a great variation in actual farrowing time (Straw et al., 2008; Decaluwé et al., 2014), making it challenging to adjust the time of piglet delivery in order to facilitate supervision of farrowing. With increasing unit size of piggeries, it becomes increasingly difficult to supervise animals individually.

Sows increase their activity level due to nest building behaviour, independent of farrowing housing, within approximately 12–24 h before farrowing (Jarvis et al., 1997; Oliviero et al., 2008; Yun et al., 2014). This increase in activity is due to the high motivation of sows to build a nest prior to farrowing. Nest building is a hormonally induced behaviour (Algers and Uvnäs-Moberg, 2007), which can be used as an indicator of approaching farrowing. It is, however,

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difficult to visually recognize this stage in sows without spending a lot of time in the farrowing unit. Crated sows with restricted access to nest building materials are less active during this phase (Yun et al., 2014) than sows in pens, thus further increasing the difficulty to visually recognize the nest building phase. However, automated systems have the potential to detect the increase in activity preceding farrowing. Such systems could either be utilized to alarm the caretaker, making supervision of farrowing more precise and efficient, or they could be connected to other automatic systems, aiding the care of sows and piglets around farrowing. Such systems could include the automatic onset of additional heat sources for the piglets (Malmkvist et al., 2006), or, if the system detects changes early enough before farrowing, even automatic delivery of additional nest building material to promote nest building activity in sows.

There are a few earlier studies reporting successful attempts to predict farrowing: Oliviero et al. (2008) used movement sensors to measure pre-farrowing activity, Manteuffel et al., 2015 used light barriers, while Cornou and Kristensen (2014) and Oczak et al. (2015) showed that accelerometers can be used to measure activity during the peripartum period. Aparna et al. (2014) used combinations of different sensor-based input and showed that a combination of water consumption and activity measurements gave a good result. However, these studies included only one type of farrowing system: pens (Aparna et al., 2014) or crates (Oliviero et al., 2008; Cornou and Kristensen, 2014), not making it possible to assess if the system is applicable in different systems. Currently, due to animal welfare concerns, there is a trend to move towards housing without crates, thus automatic systems should be able to predict farrowing equally well in different housing systems. In addition, developing a method that works with the same parameters in different housing systems would be very important for the practical application of such a system as the need to collect reference data for modelling is smaller, there is less need to adapt the systems in different farms, and as the results can be expected to be more robust.

The aim of this study was to develop a system to detect farrowing in sows, using accelerometers for measuring activity, and a model to detect the related changes to predict the approach of farrowing within 24 h before the start of farrowing. We hypothesized that, as sows show in increase in activity before farrowing both when housed in pens or crates, the same model could be used in both housing systems. However, we did expect sows in pens to show a higher level of pre-farrowing activity than sows in crates.

2. Materials and methods

2.1. Animals and management

The experiment was conducted on a commercial farm in Finland. A total of 62 crossbred sows (Finnish Yorkshire × Finnish Landrace; parity 5.2 ± 3.6) were randomly selected to take part in this experiment. Sows and gilts (hereafter sows) were moved to the farrowing rooms from a group housing gestation unit between 2 and 6 days before expected parturition. The rooms had either 20 farrowing pens equipped with conventional crates, or 10 farrowing pens without crates. The steel farrowing crates measured 220 × 75 cm and the pens 240 × 240 cm (Fig. 1). A shovelful of sawdust on the floor was provided in both housing system every day. All pens had a partly slatted plastic floor, covered with a rubber mat. The sows were allowed ad libitum access to water from a nipple drinker and were fed three times a day via an automatic dry feeding system. The ventilation system was based on under pressure and the temperature in all the rooms was automatically controlled to approximately 21–22 °C before parturition.

2.2. Measurements

We used a wireless 3D accelerometer to measure the activity of sows in order to detect farrowing. The accelerometer was based on an accelerometer developed in our previous studies measuring animal movements (Pastell et al., 2009; Hokkanen et al., 2011) and used the same radio and protocol, but the accelerometer chip was replaced with improved digital version (MMA8451Q, Freescale Semiconductor, Austin, Texas, USA). The accelerometer measured 5 × 5 × 2.5 cm in its casing and used a 950 mA h coin cell battery (CR2477N). Raw data from the sensors was transmitted via a receiver to a computer and stored to data files with dedicated logging software. We used a sample rate of 20 Hz and measurement range of ±2 g with motion trigger that caused the sensor only to transmit data when there were changes in the acceleration as compared to previously transmitted data. The motion trigger was used in order to extend the battery life. Farrowing times of the sows were registered from video. The accelerometers were attached to a neck collar as seen on Fig. 1.

The accelerometer collars (commercial animal collar, modified to for sensor attachment), with the sensor located on top behind the sows head were attached to neck of 29 sows farrowing in crates and 33 sows farrowing in pens. Small amount of surgical tape was used to attach the collars behind sows' ears when they were housed in crates. The initiation of farrowing, defined as the expulsion of the first piglet, was coded from video recorded during the whole experiment using surveillance cameras (Tracer TS 6030PSC IR) with the resolution of f 352 × 288 pixels (MPEG-4 codec) and frame rate of 12 frames per second.

2.3. Model to predict farrowing

We developed a single model to detect farrowing in both crates and pens. The model was based on detecting increased activity

Fig. 1. The farrowing crate (left) and pen (right) used in the study. The accelerometer is attached to the neck collar of the sow.