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Detecting oestrus by monitoring sows' visits to a boar

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ABSTRACT

This paper suggests a method for automatic detection of sows returning to oestrus in the gestation department. The detection is based on monitoring of sows' visits to a boar, where the duration and frequency of visits are modelled separately and subsequently combined. The hypothesis is that it is possible to reduce the response time and the number of false alarms compared to previously published attempts. The duration of visits to a boar is defined as seconds per hour the sow is near the boar – logarithmically transformed. The duration is modelled with a multiprocess dynamic linear model with first order Markov probabilities. The indicator of oestrus is the probability of the model describing oestrus, $P(M_{OE})$, and it is monitored with a threshold value. The frequency of visits to a boar is defined as number of visits per 6 h. A dynamic generalised linear model with two built-in diurnal periods is applied. The indicator of oestrus is the relative deviation from the forecasted frequency, which is monitored with a threshold value. The probability, $P(M_{OE})$, and the relative deviation from the forecasted frequency are combined by means of Bayes Theorem. The combined probability of oestrus is monitored with a threshold value as well. Results indicate that the specificity is superior compared to previously published attempts. The model describing duration alone yields the most satisfactory specificity – 99.4% per sow day, which is considerably greater than previously published studies. Furthermore, this model detects 87.4% of the sows entering oestrus, which is slightly lower than previous attempts. The response time of the models is 1 h for the duration model and the combined model and 6 h for the frequency model. This is better than previous attempts. Even though the specificity is greater, the proportion of false alarms on a day-to-day basis is still too high (91.0%), which is due to the very large proportion of the sow days defined as non-oestrus. In order to improve the specificity of the detection method, it is suggested to combine the detection method in the present study with other information sources about oestrus.

1. Introduction

Group housing for pregnant sows has become more prevalent in the EU since 2003. Group housing is often more labour intensive (Rasmussen and Duus, 2003), and the labour associated with group housing tends to be perceived as more strenuous (Backus et al., 1997). Part of the labour associated with group housed sows is reproduction management. Usually, a sow is serviced in a separate mating department approximately 5 days after weaning. It is then transferred to the gestation department, where it stays until a few days before expected farrowing, which is 115 days after service. However, some sows that are transferred to the gestation department will return to oestrus either because they did not conceive at first service or because they abort during gestation. In practice, between 5 and 25% will return to oestrus depending on the efficiency on the individual farm. Detecting those sows in the gestation department is a challenge, because the loose sows are often housed in very big groups. A well optimised reproduction management makes it possible to reduce the averaged number of non-productive days (days, where the sows are neither pregnant nor lactating) by servicing non pregnant sows in the gestation section the first time they re-enter oestrus. Reduced non productive days entail both a better utilisation of the production capacity and reduced feeding costs per produced litter. These factors combined make optimal reproduction management one of the most important means of reducing costs (Korthals, 1999). Currently, reproduction management is performed by daily routines, where the ultimate sign of oestrus is when the sow is susceptible to weight applied on the back (the back pressure test). These daily routines are time consuming and demand a well trained staff. Automation of oestrus detection is one option for improvement of labour conditions and for optimisation of reproduction management of group housed sows. Automated oestrus detection means that the sows are monitored automatically in order to inform the staff of sows entering oestrus. In a review article by Cornou (2006), it is

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concluded that measurements of the sow's visits to a boar pen show the best results compared to other automated methods for oestrus detection.

Detection of oestrus by monitoring the sows' visits to a boar is an inexpensive and widely investigated method for automatic oestrus detection (Houwers, 1988; Buré and Houwers, 1989; Bressers et al., 1991, 1995; Korthals, 1999). There are two ways to monitor visits to a boar; one is to have a detection area, which means that there is an area separated from the rest by a passageway. In this detection area, the sow can obtain contact with the boar. By monitoring when the sow passes the passageway it is possible to monitor frequency and duration of the visits (Bressers et al., 1995). The second way of monitoring visits to a boar is a so-called ticket window. This method does not require a separate area for detection, but instead offers the sow a narrow window to obtain contact with the boar (Bressers et al., 1995). Bressers et al. (1995) concluded that there was only little difference in the efficiency of the two methods.

Buré and Houwers (1989) observed an increasing frequency of visits to a boar 3 days before peak of back pressure test score. The authors observed that the frequency reached a basic level 2 days after peak of back pressure test score. Bressers et al. (1991) defined a variable containing both frequency and durations of visits per day (Boar Visiting Index – BVI) and compared it to a fixed threshold value. The authors were able to detect 96% of the oestrus cases and classified 93% of the sow days defined as non-oestrus correct (Bressers et al., 1995).

Korthals (1999) improved the above mentioned method by comparing BVI with a fixed value and an exponentially weighted moving average of previous levels of BVI for the individual sow. The author was able to detect 76.3% of the sow days defined as oestrus and classify 80% of the sow days defined as non-oestrus correctly. Note that the sensitivities of the methods described by Bressers et al. (1991) and Korthals (1999) are not comparable.

Only the approach described by Korthals (1999) considers both coincidental visits and the fact that the activity level of individual sows varies considerably. Another drawback of these methods is that they operate on a day-to-day level, causing the response time of the models to be rather slow. The response time of the model is important in that the sow only is in oestrus for 1–3 days. Furthermore, if only 80% of the sow days defined as non-oestrus are correctly classified, a normal gestation period of 115 days would result in 23 days with false alarms for a single sow. This indicates that the specificity of the existing methods is too low for use in a gestation section.

A way of obtaining low response time is to use shorter intervals than daily measurements. However, shorter intervals will entail greater fluctuations in the duration and frequency of the visits, creating a need for a model capable of distinguishing random fluctuations from systematic. State space models, as described by West and Harrison (1997), offer numerous filtering approaches.

In the literature, a variety of studies describe the use of automated monitoring systems based on state space models. Examples are given by Madsen et al. (2005), who implemented a dynamic linear model for modelling drinking patterns of young pigs, Cornou and Lundbye-Christensen (2008), who implemented a multiprocess dynamic linear model for modelling activity types from acceleration patterns and Thysen (1993), who implemented a multiprocess dynamic linear model for monitoring somatic cell counts in dairy production.

The aim of this paper is to implement an alarm system for detecting oestrus in sows in the gestation section by monitoring visits to a boar. The hypothesis is that state space models can reduce the number of false alarms and reduce the response time compared to previously published attempts.

The following section describes the experimental design and the characteristics of the raw data. Sections 3 and 4 describe the model design and parameter values regarding the duration and frequency of visits to a boar, respectively. The two models are combined in Section 5. Section 6 provides evaluation methods, whereas the obtained results are presented and discussed in Sections 7 and 8.

2. Data

All data were collected from the same commercial farm on Zealand, Denmark and data analyses have been performed with the statistical software R (R Development Core Team, 2009).

2.1. Experimental design

Two distinct data sets were used. The data used for creating the models (learning data) were from a controlled environment and consisted of measurements from 39 sows. The test data were used for testing sensitivity and specificity of the detection methods. A test period for an individual sow is here defined as a period of at least 14 days, where the sow is in the experimental gestation pens. The test data consisted of measurements from 3886 such test periods of a duration of at least 14 days. The measurements were collected in a less controlled environment than the learning data.

2.1.1. Learning data

Data were collected in three separate experiments that were conducted in 2005 (5 sows), 2007 (12 sows) and 2008 (24 sows), and total at 41 sows. The sows chosen were in their third or fourth parity, had no leg disorders and had reproduction cycles in prior parity of 145–147 days. Eight days after weaning oestrus, the sows were introduced to the experimental pen.

The data analysed were from 12–14 to 31–33 days after weaning (i.e. around the expected time of a return to oestrus). All sows were tested positive for weaning oestrus around day 5 after weaning with the back pressure test (Willemse and Boender, 1966), but only 17 of the 41 sows were serviced. The remaining 24 sows were to ensure that some sows entered oestrus during the data collection period. In order to identify oestrus, and thereby establishing a golden standard for when the sows were in oestrus, the back pressure test was conducted three times a day (7 a.m./2 p.m./9 p.m.) from day 21 after weaning. Two sows entered oestrus before or after the period of back pressure testing, which led to misinterpretations. These sows were omitted from further analysis. Thus, 39 sows remained. For a more detailed description see Cornou and Heiskanen (2007).

2.1.2. Test data

The test data were collected in the period October 2004 to June 2009. There were 3886 test periods (a period of at least 14 days in the gestation section); and 111 cases, where the sows entered oestrus and were serviced in the gestation section. All test periods were associated to a farrowing date in order to ensure correct date of service. Sows that were serviced during the first 3 days in the gestation section were omitted. No additional observations were made, which means that the data quality relies on ordinary registrations based on daily observations (e.g. back pressure test) performed by the staff of the farm. Sows included in the learning data were omitted from the test data.

2.2. Housing system and sensors

All sows were housed in a mechanically ventilated gestation section in pens containing approximately 120 sows. The boar pens were situated at the end of each pen, and contact to the boar could be obtained through a ticket window. The plan of the gestation