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Monitoring individual sows' activity & detecting the onset of parturition

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The use of 3D accelerometers for monitoring the types of activity a sow performs in farrowing house, and the onset of parturition, gives satisfying results in terms of sensitivity and specificity.

Perspectives include: monitoring the occurrence of illness, of problems around the onset of farrowing, and of animal welfare in general.

An experiment carried out in January 2011 using accelerometers placed on an ear chip gave promising results for further application of the suggested methods.

2008

Farrowing house where the activity of 19 sows were monitored

Experimental sow wearing an accelerometer fitted on a neck collar

2011

An experimental sow wearing an ear tag with accelerometer

The accelerometer placed inside its box, beside a sow's ear tag

Phase 1 - Modeling and monitoring activity types

Five types of activity were chosen to describe the behavior of sows :

HA: High active behavior, corresponding to feeding and rooting activities
MA: Medium active behavior, corresponding to standing, sitting or lying sternally
L1: Lying on one side and passive, where the sow is sleeping /resting
L2: Lying on the other side and passive, where the sow is sleeping /resting
LS: Lying sternally and passive, where the sow is sleeping /resting

Each activity is modeled using a separate *multivariate dynamic linear model (DLM)* .
The classification method is based on a *Multi Process Kalman Filter (MPKF)*.

The classification method correctly classified:
✓ 75 to 100% of each activity type
✓ 96 to 100% of the categories active (HA+MA) vs. passive (L1+L2+LS)

Illustration of the output of the classification method applied on two series of 24 hours is shown below.

Two days prior farrowing (left): three periods of high activity (HA) are distributed around feeding time.

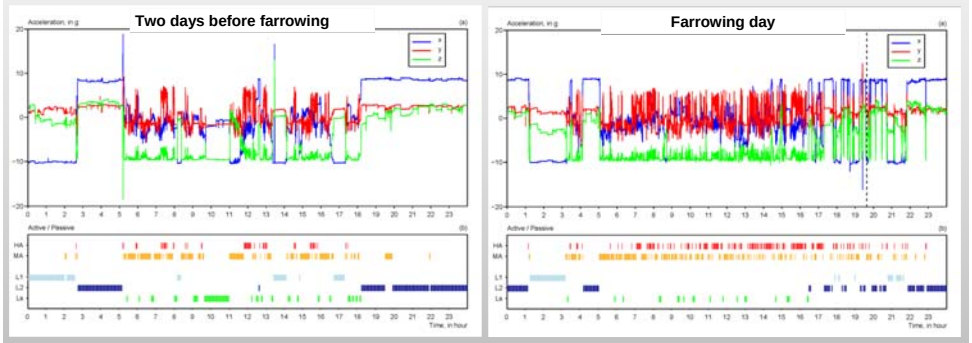
Farrowing day (right): the period of high activity (HA) is stretched outside the feeding time, and is almost continuous from early morning to two hours prior farrowing.

The classification method was thereafter applied on the acceleration series collected for the 19 sows.

Results indicate that there is a marked
✓increase of active behaviors (HA and MA, p < 0.001)
✓decrease of lying laterally (L1 and L2) behaviors starting 20 to 16 hours before the onset of farrowing

During the last 24 hours before parturition
✓the averaged time spent lying laterally in a row decreases
✓the number of changes of activity types for HA and MA increases

These behavioral changes occur for sows both with and without bedding material, but are more marked when bedding material is provided.



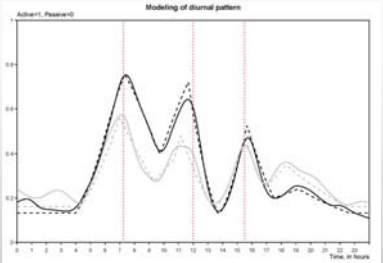
Application of the classification method. For both days, the top part shows 3D-acceleration measurements; bottom part: 2 min series classified as activity types (HA, MA, L1, L2, LS). Farrowing day: the onset of farrowing is indicated by the vertical dotted line.

Phase 2 - Modeling sows' diurnal pattern and monitoring the onset of farrowing

Based on the qualitative series obtained from the classification method, two methods are suggested to model and monitor sows activity, and detect the onset of parturition.
A total of 19 sows were monitored: 9 sows were provided with straw (group S), and 10 sows did not receive straw (group NS).
Both methods use an optimized threshold value to catch the increase of activity preceding farrowing.

First method
Modeling and monitoring diurnal variation using DGLM

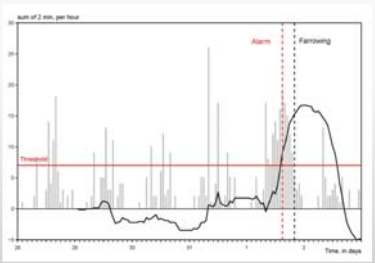
Explorative plots of 2 minutes activity shows a regular diurnal pattern of active (value=1) vs. passive (value =0) categories of behavior around feeding times. The diurnal pattern is modeled and included in a *dynamic generalized linear model (DGLM)*, where individual variations between sows are taken into account.



Modeling of the diurnal pattern of active behaviors. Solid lines: smoothed lines of 2 min classified observation for the group S (black, 9 sows) and NS (grey, 10 sows). Dotted lines: model describing the diurnal pattern for the group S (black) and NS (grey). Vertical dotted lines: feeding times (7.15am, 12.00pm, 15.30pm).

Second method
Modeling of activity using a cumulative sum based on daily variations

The second method is based on monitoring differences of activity at a given hour, from day to day, and monitor their *cumulative sum* (shown below as solid line).



Detection method for parturition based on a cumulative sum of hourly differences of HA for sow 1. In bars: hourly sum of 2 min HA. Solid line: cumulative sum of hourly differences of HA. Vertical black: onset of farrowing. Horizontal red: optimized threshold monitoring the excess of activity; vertical red: detection of parturition, when the cumulative sum excesses the threshold.

Best results in terms of sensitivity and specificity are observed for the cumulative sum method, using individual sows' variance and monitoring High Active (sensitivity = 100%; specificity = 100%) and Total Active behaviors (sensitivity = 100%; specificity = 95%).

Results of the DGLM method indicate a sensitivity of 100% and a specificity of 89% in average for both group S and NS. Observing the occurrence of alarm times, the DGLM method allows

✓earlier detection of farrowing: 15 hours before the onset of farrowing, for both groups, as compared to 9-12 hours for the other methods
✓a better distribution of alarms: most alarms occur in the interval 6-18 hours before parturition.

Experimental set up

Individual sows were monitored in a farrowing house of a production herd, in 2008. Sows were kept in crates and dry-fed three times daily. Sows were monitored from their entrance into the farrowing house. Half the individuals received 0.5 kg bedding materials every second day (Group S); the rest received no bedding material (Group NS). Sows' activity was measured using a three-dimensions accelerometer (LIS3L02DS from STMicroelectronics), at four samples per second, at a range 0-2g. Each accelerometer was fixed on a board and put in a curve shaped air tight box .The boxes containing the accelerometers were fixed on a neck collar, and fitted on each experimental sow. The sows were video recorded 24 h a day using 12 cameras (TVCCD-140IR from Monakor). Acceleration data from 19 sows were available: 9 sows from Group S and 10 sows from Group NS. Video recordings helped to determine which type of activity sows were performing at a given time and the exact onset of farrowing for each experimental sow.