ARTICLE IN PRESS
BIOSYSTEMS ENGINEERING XXX (2017) 1–6

Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/issn/15375110

Research Note

Prediction of calving in dairy cows using a tail-mounted tri-axial accelerometer: A pilot study

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ARTICLE INFO

Article history:
Published online xxx

Keywords:
Cattle
Accelerometer
Parturition
Monitoring

Dystocia and stillborn calves are recurring problems for dairy farms, leading to high costs. By implementing a real-time monitoring system, problems could be reduced by supporting farmers to detect the onset of parturition and to intervene in case of dystocia. The hypothesis of this study was that the onset of parturition is detectable through analyses of the movement pattern of the dam's tail, recorded by a tri-axial accelerometer that was fixed on the upper part of the cow's tail. Cows (n = 5, approx. 1 week before calving) were housed in single straw-bedded boxes. Animal behaviour was video-recorded (24 h/d) and evaluated by encoding the events ‘frequency and duration of tail raising 5 h pre-partum’, ‘rupture of the amniotic sac’ and ‘expulsion of the calf’. In parallel, the accelerometer data collected from two days before calving to parturition were analysed. We developed an algorithm to detect the tail raising and created a decision function based on the frequency and duration of the tail raising. Exceeding the threshold led to a birth alarm. In each of the evaluated calvings, the alarm was triggered a short time before the expulsion of the calves, at 33, 32, 121, 6 and 71 min for cows 1 to 5, respectively. These preliminary results indicate that an accelerometer to detect tail movements may be useful to predict parturition. Further research is required to refine the algorithm and the decision function, to analyse predictability of dystocia and to develop a real-time alarm system under field conditions.

1. Introduction

Modern dairy farmers face many challenges. Structural changes and a shift towards intensive livestock farming are a way of ensuring optimised use of limited resources (Barkema et al., 2015), but lead to less time available per animal. Maintaining healthy livestock is the key to a productive farm, keeping high standards of animal welfare and fulfilling consumers' demands (Cembalo et al., 2016). Precision dairy farming technology offers the opportunity to focus on individual animal needs and challenges by using e.g. sensors and real-time wireless technologies (Stangaferro, Wijma, Caixeta, Al-Abri, & Giordano, 2016a,b,c).

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https://doi.org/10.1016/j.biosystemseng.2017.11.010

In the last two decades, the perinatal mortality of dairy calves has increased and ranges between 2% and 10% (Kayano, Kadohira, & Stevenson, 2016; Mee, 2008a). Dystocia contributes to up to half of the perinatal mortalities in cattle (Meyer, Berger, Koehler, Thompson, & Sattler, 2001). Ninety per cent of calves that die during parturition were alive at the beginning of parturition (Mee, 2008b,c). Environment and management are important factors. Implementing an optimised calving management system, particularly by improving supervision during parturition, can help to prevent perinatal mortality (Mee, 2004). Villettaz Robichaud, Pearl, Godden, LeBlanc, and Haley (2017a) pointed out that giving early assistance to cows during calving as a routine did not negatively influence calves' stillbirth risk, vigour at birth, or transfer of passive immunity. With late intervention, calves had a significantly higher risk of stillbirth. Early calving intervention had no impact on average daily gain, health, or survival in dairy heifer calves up to weaning at 7 weeks of age (Villettaz Robichaud et al., 2017b).

Numerous behavioural changes can be observed in the dam around parturition e.g. increased number of lying bouts (Titler et al., 2015), increasing duration of walking and tail raising (Miedema, Cockram, Dwyer, & Macrae, 2011b), as well as reduction of rumination time (Clark et al., 2015; Pahl, Hartung, Grothmann, Mahlkow-Nerge, & Haeussermann, 2014). Four systems for calving detection are currently available: inclinometers and accelerometers detecting tail raising and changes in activity; abdominal belts monitoring uterine contractions; vaginal devices detecting vaginal temperature and expulsion of the calf or allantochorion [reviewed by Saint-Dizier & Chastant-Maillard, 2015]. However, the high individual variability of these changes is still limiting the sensitivity and specificity of automatic assistance systems predicting or monitoring parturitions in dairy cows.

Another monitoring system available on the market is an electronic ear-tag (Smartbow GmbH, Weibern, Austria) that contains an accelerometer, collecting movement data from cows. This system was developed as a real-time monitoring tool providing localisation (Wolfger, Jones, Orsel, & Bewley, 2017), activity and rumination data from its subjects. The general aim of our project was assessing the feasibility of using such devices to predict and monitor parturitions. The objective of the study was to determine in particular the ability of the modified ear-tag accelerometer to record tail movements as an indicator of the onset of calving.

2. Material and methods

2.1. Animals and data collection

The study was conducted on the Teaching and Research Farm Kremesberg, University of Veterinary Medicine Vienna, Austria, between October 2015 and November 2015. One week before expected calving, calculated as 284 days after insemination, cows (n = 5) chosen at random were moved from a group pen and housed in a 17 m^2 straw-bedded single calving box. The dams had visual contact with the rest of the herd at all times. None of the cows had health problems during their pregnancy and delivered full-term live singleton calves. Aside from the daily stable routine, unnecessary distractions or examinations were avoided. The box was equipped with a camera system (IR Bullet Network Camera DS-2CD2632F-I(S), Hikvision, Hangzhou, China). The two infrared cameras enabled a reliable 24 h observation. The cameras were connected to a PC (Intel(R) Xenon (R), CPU 3.6 GHz, Windows 10pro) and client software (Hikvision iVMS-4200, Hikvision, Hangzhou, China) that allowed simultaneous recording of the two cameras. Recordings were stored on an internal 2 TB hard drive, in MPEG-4 format.

Table 1 provides an overview of the dairy cows and the births used in the experiment. All calves were presented in a physiological position and posture. In two cases (cows 2 and 3) the expulsion was assisted (<2 min light assistance without the use of mechanical traction). The second stage of labour was defined as the period between the rupture of the chorio-allantois and/or the amniotic sac and the expulsion of the calf.

2.2. Accelerometer

Immediately after moving into the calving box, we fixed a tri-axial accelerometer (Smartbow ear-tag) on the dam's tail. The thorn on the back was replaced by a plain lid to ensure a comfortable fit. The modified ear-tag sensor was originally designed to measure acceleration during the head movement of the cow in three axes (x-, y- and z-axis),

$$\boldsymbol{a} = \{a(t) | t \in T, a(t) = (a_x(t), a_y(t), a_z(t)) \in \mathbb{R}^3\} \quad (1)$$

The measured values ranged from −2 to +2 g and were recorded and stored 10 times per s (10 Hz). A button-cell battery (CR 2477) with 1000 mAh energy storage provided the energy for approximately four months use of each tag and allowed detailed data collection. The size of one accelerometer was 52 × 36 × 17 mm with a mass of 34 g. Figure 1 shows the attachment of the sensor. The accelerometer data measured by the sensor was sent to a Smartbow-Wallpoint (195 × 195 × 72 mm and weight 620 g) mounted on the wall of the stable and transmitted to Smartbow-Server (Intel Xeon 4-core5-2403 1.80 GHz). For this study, the tag was mounted on the upper part of the tail at a level corresponding to the ventral vulva commissure. It was fixed with tape (Leukoplast 2.5 cm × 5 m, BSN medical GmbH Hamburg, Germany) providing a secure, but not tight fit. Sufficient blood circulation was ensured by applying the high adherence tape as a figure eight bandage and using absorbent cotton as padding. Oedema or pressure marks were not found in any case. A self-adhesive bandage (HS Kohäsivbinde 10 cm × 4.5 m, Henry

Table 1 – Specification of births and the cows used in the experiment.

Cow	Breed	Lactation number	Gestation length (d)	Duration stage 2 of labour (min)
1	Brown Swiss	8	282	66
2	Simmental	1	286	119
3	Simmental	2	278	89
4	Simmental	6	283	25
5	Simmental	1	285	67