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Prediction the onset of calving to decrease stillbirth rate in a Holstein-Friesian dairy farm

PhD thesis

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General summary

Calving is a critically important event in every dairy animal's life, perhaps the most important moment in the life cycle of dairy cows. The aim of calving management is to insure the dairy cow a good health to begin lactation, and to produce good quality replacement heifers. The risk of dystocia in dairy cows has been estimated to be 13.7% (Mee, 2008). Recent reports have shown that heifer calves in a very early experience in life can impact them even as mature animals where heifers born from a difficult birth had significantly lower milk production in their first lactation (Heinrichs, 2011).

Management concerning the transition period of dairy cows has been investigated by a large number of studies, which generally defined the period covering 3 weeks before parturition up to 3 weeks after giving birth.This period is critical in terms of health and production profitability of dairy cows as the effects of diseases in the transition period can extend far into their following lactation (Drackley, 1999, Mee, 2008; Mulligan and Doherty, 2008). Unfortunately, researchers have given little attention to the management of calving itself, beside the efforts done within our study (Kovacs et al., 2015; 2016a; 2016b; 2017), whereas the focus of bovine theriogenologists mainly given to the perceived decline in dairy cow fertility (Mee, 2008; 2013). Most researchers investigated and examined the detection and effects of calving difficulties or dystocia on the dams and their offspring. The incidence of stillbirth is one of the most investigated effects of dystocia on calves (Meijering, 1984; Chassagne et al., 1999; Meyer et al., 2001; Berglund et al., 2003). Stillbirth and perinatal morbidity incidence in dairy calves is greatly influenced by calving difficulties and is considered as a significant animal welfare and economic concern for the dairy industry given their impact on productivity, health, and reproduction (Meyer et al., 2000; Mee, 2008; 2013). Best management of prepartum cows, parturition, and newborn calf care arethought to be best accomplished through the implementation of simple protocols at the herd and cow levels (Mee, 2008). Prediction of the exact time calving would be highly important especially in small dairy farms where are no assistance available in day and night shifts, it determines if there is a need for human intervention and thus enables the rescue of the newborn calves and dams.

The aim of this thesis is to document the prevalence of calving management practice on Hungarian dairy farms through detecting the accurate time of calving and to examine the effects of a specific calving assistance management strategy of the health of the dam and the survival of newborn calves.

Materials and methods

In Experiment 1

Five days before the expected date of calving, a healthy pregnant cows (n = 257 including 92 nulliparous heifers) being in the precalving group pen were randomly selected for the study. Parity ranged from 2 to 5 for pluriparous cows (mean ± SD: 2.9 ± 0.3). An intravaginal thermometer (Vel'Phone, Medria, Châteaugiron, France) was inserted into the vagina an average of 7.4 ± 5.4 days before calving. Depending on the body size of the animals, different appendage kits were used for heifers (turquoise) and pluriparous cows (white) as it shown in the second experiment figure 1. Twenty intravaginal thermometers were used in the present experiment. After equipping the thermometer with the flexible appendages it was inserted into a vaginal applicator which was immersed into the povidone-iodine solution (Betadine®) for at least 2 min before cleansing and disinfecting the perineal area of the cow and gently inserting deep into the vagina. Once the thermometer had been placed into the vagina, the Vel'Phone sent information via SMS on its activation and the time (5 to 10 min) required for the temperature to rise above 36.4°C. From this time on two daily reports sent at 8 a.m. and 8 p.m. providing the temperature measured in each animal during the half-hour prior to sending the SMS. "*Possible calving in 48hr"* was created when at least one of the two algorithms, while in case of "*Expected calving in 48hr"*SMS both algorithms crossed their triggering threshold over a period of two hours. According to the producers' user manual the first algorithm calculates the absolute variation of the temperature that has dropped below 39°C after having previously risen above 39°C while the second algorithm calculates the relative variation of the temperature that has dropped close to 2°C after having risen close to 41°C.When a thermometer was expelled by the allantoic sac and observed its temperature falling below 36.0°C, an 'expulsion' SMS was sent.The onset of the second stage of labor was determined by this SMS for the cows. Forty-two cows were excluded from the later analysis because the thermometer was in the vagina for less than three days before its expulsion. Supervision of the dams during calving and the decision to move them into the maternity pen or to provide obstetrical assistance was made by the farm personnel (Kovács et al., 2016). Prepartum behavior of the animals was recorded with a closed-circuit camera system including two day/night outdoor network bullet cameras (Vivotek IP8331, VIVOTEK Inc., Taiwan) installed above the pre-calving group pen allowing the identification of the onset of calving restlessness, the appearance of the amniotic sac and the presence of dystocia.

Based on video recordings, the start of obstetrical assistance was considered when at least one person assisted the cow using a calving rope or a calf puller. Calving assistance by trained farm personnel was performed at the latest within 90 min after the appearance of the amniotic sac in the vulva as described previously by Kovács et al. (2016). Type of calving (single or twin calving), presentation of the calf (anterior or posterior), presence of dystocia (without or with obstetrical assistance), gender and weight of the calf, time of day (8 a.m. or 8 p.m.), season (summer with calvings in June, July and August vs. fall with calvings in September, October and November), parity (nulliparous or pluriparous cows), gestation length and the retained foetal membranes (RFM) diagnosed 12 to 24 hr after calving were also recorded

In Experiment 2

Five days before the expected date of calving, a healthy pregnant cows (n = 257 including 57 nulliparous cows) being in the precalving group pen were randomly selected and an intravaginal thermometer (Vel'Phone, Medria, Châteaugiron, France) was inserted into the vagina (experimental group). Depending on the size of the cow two appendage kits were used for heifers (turquoise) and multiparous cows (white) (Figure 1).

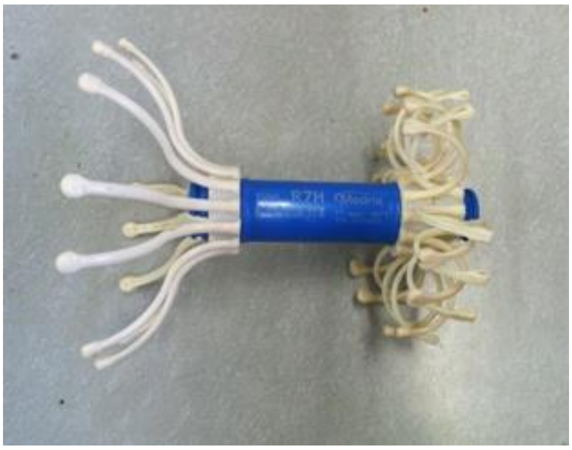

Figure 1. Intra-vaginal thermometer (11.5 cm x 2.2 cm) used for multiparous cows

At the same time, 116 healthy pregnant cows (including 37 nulliparous cows) served as control (control group). Parity for the experimental and the control group ranged from 2 to 5 for multiparous cows (mean ± SD: 2.9 ± 0.3 in the experimental group and 3.1 ± 0.2 in the control group). The mean ± SD body condition scores using the 5-point scoring system (Hady et al., 1994) following calving were 3.1 ± 0.2 for nulliparous cows and 3.3 ± 0.2 for multiparous cows in the experimental group and 3.4 ± 0.2 for nulliparous cows and 3.1 ± 0.3 for multiparous cows in the control group. Once the thermometer had been placed into the vagina, the Vel'Phone sent information via SMS on the expulsion of the device. The onset of the second stage of labor was determined by the ‘expulsion’ SMS for the experimental cows. Control animals were also kept in the precalving group pen; however, the beginning of the second stage of labor was controlled by the farm personnel by checking the animals every 60 minutes (Schuenemann et al., 2011).

The onset of the second stage of labor was determined based on the presence of mucus (blood around the perineum) and/or the onset of amniotic sac appearance outside the vulva for the control animals. Supervision of the dams during calving and the decision to move them into the maternity pen or to provide obstetrical assistance was made by the farm personnel. In both groups, calving personnel moved cows to the maternity pen if the calving would have been disturbed by group mates or if assistance was required as described previously by Kovács et al. (2016). Ten minutes after moving cows to the maternity pen (either experimental or control animals), cows were examined to check the presentation of the calf. When a maldisposition was evident (e.g. appearance of one foot outside the vulva), obstetrical assistance was performed by the calving personnel.

The start of obstetrical assistance was considered when at least one person assisted the cow using a calving rope or a calf puller. Calving assistance by the farm personnel was performed at the latest within 90 minutes after the appearance of the amniotic sac in the vulva as described previously by Kovács et al. (2016). Presentation of the calf (anterior, posterior), live body weight of the calf, calving difficulties, number of personnel providing assistance at birth, and the delay of the second stage of labor were recorded using a 1 to 4 scale (Score 1 = eutocia, no assistant needed; Score 2 = delay in the second stage of labor and/or calving assisted by one person without the use of mechanical traction (light dystocia); Score 3 = mechanical traction of a calf with a calf puller or assistance by more than one person (severe dystocia); Score 4 = severe dystocia surgery needed as suggested by Meyer et al. (2001), Lombard et al. (2007)and Schuenemann et al. (2011). Sixteen (experimental group) and three animals (control group) were excluded from the study due to twin calving, which will be evaluated in another paper. For statistical analysis, dystocia was used as a dichotomous variable (dystocia score was one or larger than one/cows needing or not needing assistance). Stillbirth was recorded in case of death of a calf after an at least 260-day gestation during calving or in the first 24 h of postnatal life (Szenci, 2003; Mee, 2009). Postpartum diseases such as RFM and clinical (puerperal) metritis (CM) were also recorded. Each cow was examined 12 to 24 h after calving for RFM and until Day 20 after calving for Grade 2 CM as described previously by Buják et al. (2018). CM was diagnosed when fetid red-brown watery uterine discharge, atonic enlarged uterus, and pyrexia (> 39.5 °C) were found (Sheldon et al., 2009).

1.3 **Results and Discussion**

In <u>Experiment 1</u>

Several remote devices are available for dairy farmers to record decreases in body or vaginal temperatures for the prediction of the onset of calving. However, only a few authors reported on changes in vaginal temperature around calving in beef cattle based on Medria thermometers (Ricci et al., 2018) and dairy cows (Chanvallon et al., 2012).

The sensitivity of receiving the "possible calving in 48 hr" SMS message was 40% (Chanvallon et al., 2012) while the sensitivity of the "expected calving in 48 hr" SMS message was 82.9%, respectively. In contrast, our sensitivity results for possible and expected calvings in 48 hr SMS messages were only 21.1% and 62.4%, respectively, while the positive predictive value of the SMS messages were 10.3% and 75%, respectively. Sakatani et al. (2018) used another temperature sensor in 625 beef cattle which recorded the vaginal temperature every 5 min and every 4 hr the moving average temperature was calculated automatically. An alert (Alert 1) was issued when the temperature difference was higher than the threshold (0.4ºC). The duration (mean ± SD) between the alert and the beginning of the second stage of labor (broken of allantoic sac) was 21:59 ± 7:07 and the sensitivity of this alert was 88.3%.

To increase the accuracy of measuring the vaginal temperature Ricci et al. (2018) has suggested to use the intravaginal temperature 38.2ºC as a cut-off value to predict calving within 24 hr because it can be more accurate (sensitivity: 86% vs. 66%) than a 0.21ºC decrease during the last 24 hr before calving. Authors found similar changes to our findings as in their study the mean vaginal temperature decreased from 38.65ºC to 38.12ºC between 48 and 60 hr and 0 to 12 hr before calving, respectively.

According to Lammoglia et al. (1997) vaginal temperatures were not affected by the gender of the calf, and there was no diurnal variation in body temperature from 48 to 8 hr before calving in beef cows. Ricci et al. (2018) reported that parity, dystocia, season and length of gestation did not affect the vaginal temperature from 60 hr before and up to calving. According to our results the vaginal temperature of dairy cows were significantly affected by parity, season (summer vs. autumn), time of day (8 a.m vs. 8 p.m.) and the 6-hr time intervals, whereas gender, birth weight of the calf, twinning, gestation length, foetal presentation, dystocia and presence of RFM did not affect it significantly. The present results can be explained with a diurnal rhythm (up to 0.5ºC) in the vaginal temperature during the last 120 hr before calving (Burfeind et al., 2011; Ouellet et al., 2016), hence, others did not confirm this precalving diurnal variation (Lammoglia et al., 1997; Ricci et al., 2018).

According to Chanvallon et al. (2012) the sensitivity of the thermometer to detect allantoic sac expulsion was 100% for both heifers and cows, which is consistent with our findings because no false alarms were detected during the trial. Similarly, no false alarm and no lack of alarm when using an intravaginal mechanical GSM device were recorded by Palombi et al. (2013). Sakatani et al. (2018) monitored 625 beef cattle and in four cases the sensors had fallen out together with the calf or they were malfunctioned and the sensitivity of predicting calving (Alert 2) with the appearance of the allantoic sac was 99.4%. It seems that the second stage of calving can be detected accurately by using intravaginal sensors either in dairy or beef farms.

It is important to mention that the intravaginal thermometer did not induce any pathological clinical signs except for a minor discomfort shown by some heifers (Choukeir et al., 2020). In contrast, when the intravaginal device remained inside the vaginal canal in some cases up to 20 days, no adverse effects were reported, and the animals did not exhibit any discomfort or vaginal discharge (Palombi et al., 2013; Ricci et al., 2018; Sakatani et al., 2018).

Our recent findings have supported the benefits of the Vel'Phonecalving monitoring system in terms of calving management and postpartum health because the risk of dystocia (Score >1) was 1.9 times higher, the prevalence of stillbirth was 19.8 times higher, the risk of retained fetal membranes (RFM) was 2.8 times higher and the risk of clinical metritis was 10.5 times higher in the control group than in the experimental group (Choukeir et al., 2020). By the authors' opinion, such smart sensor systems used in this study can support the routine reproductive management in a cost-effective manner in large-scale dairy farms where the "farm blindness" phenomenon is usual (Mee, 2013).

In <u>Experiment 2</u>

To the best of the authors' knowledge, apart from some preliminary results (Chanvallon et al., 2012) this is the first study presenting results on the effects of sensory detection of the second stage of labor on the progress and outcomes of calving in a large study population. According to Chanvallon et al. (2012) the sensitivity of the thermometer to detect calf expulsion was 100% for both heifers and cows, which is consistent with our findings because no false alarms were detected during the trial involving 241 animals. Similarly, no false alarm and no lack of alarm when using an intravaginal mechanical GSM device were recorded by Palombi et al. (2013). It seems that the second stage of calving can be detected accurately by using intravaginal sensors in a dairy farm.

It is important to mention that the intravaginal thermometer did not induce any pathological clinical signs with the exception of a minor discomfort shown by some heifers. In contrast, when the intravaginal device remained inside the vaginal canal for two consecutive weeks, Palombi et al. (2013) observed no adverse effects and the animals did not exhibit any discomfort or vaginal discharge.

The prevalence rate of dystocia can be 1.7 (Lombard et al., 2007)to 2.5 times (Meyer et al., 2001) higher in heifers compared to multiparous cows. In contrast, in our study parity did not influence the dystocia rate significantly because its rate between nulliparous and multiparous dams was 1.1 in the experimental group and 1.3 in the control group, respectively. In agreement with the results reported by Palombi et al. (2013), dystocia rate between the experimental and control groups was 1.4 in our study.

In harmony with the findings of previous studies (Palombi et al., 2013), the animals monitored by us experienced significantly less obstetrical assistance (39.4% vs. 55.8%), severe (Score > 2) dystocia (3.7% vs. 5.3%), stillbirth (0.8% vs. 10.6%), RFM (9.5% vs. 28.3%) and CM (11.6% vs. 31.9%) compared to the control cows. The differences in the stillbirth rate between our experimental and control groups might be explained by the standard operating procedure of the farm, i.e. that after detecting the second stage of labor the farm personnel had to finish calving assistance within 90 minutes. This agrees with the recommendations of Schuenemann et al. (2011)who suggested that calving personnel should start assisting cows 70 min after amniotic sac (AS) appearance (or 65 min after the appearance of feet). At the same time, it is also emphasized that the frequency of observation is critical for determining the appearance of the amniotic sac or the feet of the calf outside the vulva, therefore cows in the calving pen must be observed at least every hour in order to be able to detect the calving animal. Although there was no difference in predicting the second stage of calving by examining tail raising, stepping, clear and bloody vaginal discharge, turning the head toward the abdomen, and lying lateral with abdominal contractions between hourly observation and observation every 2 h, the area under the curve of examining the pelvic ligaments and teat filling changed only between 0.808 and 0.855 between 269 and 276 days of gestation which means that in some of the animals calving cannot be predicted accurately (Lange et al., 2017). Besides clinical behavioral changes, mainly bloody vaginal discharge and/or the appearance of amniotic sac and fetal feet in the vulva used to be detected in the daily practice. In this way the prompt onset of calving cannot be detected in time, especially in free stalls, which may cause a delay in obstetrical assistance. Delayed obstetrical assistance can increase the stillbirth rate (Saint-Dizier and Chastant-Maillard, 2015; Schuenemann et al., 2015). This may be one of the reasons why the prevalence of stillbirth in our control group (10.8% in heifer calving and 10.5% in cow calving) became higher. Somewhat higher stillbirth rates were reported for unmonitored heifers (16.7%) and cows (10%) in the calving barn also by Palombi et al. (2013).

Complications during calving may increase the risk for stillbirth, retained fetal membranes, clinical metritis and endometritis, and mortality and culling of the dam (Lombard et al., 2007). Depending on the severity of dystocia the total cost of loss may change between 150 to 600 EUR per cow (McGuirk et al., 2007). According to Saint-Dizier and Chastant-Maillard(2015) the initial investment of the Vel'Phone including 6 probes, receiver, GSM subscription can be done by the financial lost caused by 6 severe dystocia. Vannieuwenborg et al. (2017) have reported recently that an annual saving of 15 EUR per cow can be realized if calving monitoring devices are used in the farm.

Summary of main scientific results

1. **1.** The intravaginal temperature changes from 72 hr before and up to calving was significantly (*P*≤ .001) affected by parity, season (summer vs. autumn), the time of day (8 a.m. or 8 p.m.) and the 6-hr time intervals, while the gender, and the weight of the calf, twinning, gestation length, foetal presentation, dystocia and retention of foetal membranes did not affect it significantly.
2. **2.** The sensitivity of the SMS of expecting calving within 48 hr and the positive predictive value were 62.4% and 75%, respectively, while the sensitivity and the positive predictive value for the SMS of expulsion reached 100%.
3. **3.** The risk of dystocia, the prevalence of stillbirth, the risk of retained fetal membranes and the risk of clinical metritis was 1.9, 19.8, 2.8, and 10.5 and times higher in the control group than in the experimental group, respectively.
4. **4.** The prevalence of stillbirth was 7 times higher in cows with dystocia compared to cows with eutocia and the presence of dystocia and stillbirth increased the risk of RFM 4 and 5 times, respectively. The occurrence of RFM increased the risk of development of clinical metritis with a 22 times higher odds.
5. **5.** The use of calving alert systems not only facilitates controlling the time of parturition and providing prompt and appropriate calving assistance but also decreases the number of dystocia cases and improves reproductive efficiency, postpartum health of the dam and newborn calf survival.

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