PREDICTION THE ONSET OF CALVING TO DECREASE STILLBIRTH RATE IN A HOLSTEIN-FRIESIAN DAIRY FARM

Ali Ismael Choukeir

PREDICTION THE ONSET OF CALVING TO DECREASE STILLBIRTH RATE IN A HOLSTEIN-FRIESIAN DAIRY FARM

Ali Ismael Choukeir

Budapest, Hungary

2021

Promoter: Dr. Ottó Szenci PhD, DSc, Diplomate ECBHM

Copromoter: Dr. Levente Kovács PhD

CONTENTS

Chapter 1

GENERAL INTRODUCTION

Ali Ismael Choukeir

University of Veterinary Medicine Budapest, Department of Obstetrics and Food Animal Medicine Clinic, 2225 Üllő – Dóra major, Hungary

General Introduction

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, 2008d). 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, 2004a,b; 2008b; Mulligan and Doherty, 2008). Unfortunately, researchers have given little attention to the management of calving itself, beside the efforts done within our study (Kovács et al., 2015; 2016a,b; 2017), whereas the focus of bovine theriogenologists mainly given to the perceived decline in dairy cow fertility (Mee, 2008d; 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, 2008d; 2013). Best management of prepartum cows, parturition, and newborn calf care are thought to be best accomplished through the implementation of simple protocols at the herd and cow levels (Mee, 2008a,b,c). 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.

Literature review

Management of dairy cows around calving involves many aspects of technologyincluding the housing and environmental conditions as well the feeding strategies for periparturient dams; i.e. Moving dams into individual maternity pens or group pens that provide adequate space, ventilation, soft non-slip flooring, and feeding and drinking equipment; Dams in group calving pens should also be monitored and managed for aggressive behavior (Cook & Nordlund, 2004; Mee, 2004a).

Physiology of parturition

In cattle, parturition occurs after a physiological gestation length of 270 to 290 days, which is dependent on the breed (Richter & Götze, 1993). Primiparous dams, female fetuses, and multiple births are known to decrease gestation length (Fisher & Williams, 1978; Nogalski et al., 2012; Dhakal et al., 2013). Some researchers suggest that the optimal gestation duration in Holstein cows is between 275 and 277 days after conception because calves continue to grow rapidly in weight and length near the end of gestation, which may increase the chances of calving difficulties (Hansen et al., 2004; Jackson et al., 2004).

Hormonal aspects of parturition and stages of labour

The onset of labour is provoked by a series of hormonal changes in the dam and in the fetus. Glucocorticoids secreted by the fetal adrenal cortex have been found to be synchronizing factors of the fetal development and maturation as well the onset of parturition (Bazer & First, 1983; Jenkin &Young, 2004). The increased production of corticosteroid by the fetus stimulates the production of estrogens in the dam's placenta, placental estrogens themselves stimulating the production of prostaglandins (Squires, 2003). In brief, the initiation of parturition is a result of a drop in maternal plasma progesterone, an increase in estrogens and prostaglandin metabolites, and a spike in prolactin concentrations (Thatcher et al., 1980; Lye, 1996; Noakes et al., 2009). Placental relaxin and oxytocin are also involved to allow the relaxation of the pelvic ligaments and vulva, and to increase myometrial contractions (Noakes et al., 2009).

The calving process is commonly divided into three separate stages: onset of parturition, fetal expulsion, and fetal membranes expulsion.

The first stage is defined as the onset of parturition, which prepares the birth canal and the fetus for expulsion (Jackson, 2004; Mee, 2008b; Noakes et al., 2009). More precisely, stage one of parturition is considered to be the time between the onset of myometrial contractions, cervical dilation, pelvic ligament relaxation and the emergence of the amnion or fetal hooves in the vagina (Mee, 2008b; Noakes et al., 2009). The fetus also assumes its birth posture during this stage (Jackson, 2004). The duration of stage one of calving is difficult to determine because there are usually very few, if any, visible external signs (Mee, 2008b). Generally, researchers report that the duration of stage one is approximately 6 to 12 h, depending on the exact definition of its onset, and the timing is highly variable among cows (Hickson et al., 2008; Mee, 2008b; Noakes et al., 2009). A specific investigation of uterine muscular activity found that myometrial activity increased about 12 h before the start of cervical dilation for calving (Engelen et al., 2007).

The second stage of calving is defined as the expulsion phase, from the first sight of the amnion or fetal hooves, until the calf is expelled (Jackson, 2004; Mee, 2004a). Normally, the duration of the second stage is around 90 minutes for primiparous animals and 45 minutes for multiparous animals, but the duration is highly variable among animals (unassisted calving varying from 10 minutes to 6 hours) and dependent on the occurrence of dystocia (Mee, 2004a; Noakes et al., 2009).

The term "dystocia" comes from the Greek word "dys" means "difficult", and "tokos", meaning "birth". Dystocia may be broadly defined as a difficult parturition requiring "more assistance than what is desirable" (Meijering, 1984; Mee, 2008d). Overall, the duration of calving is usually longer in primiparous animals and negatively correlated with the number of abdominal contractions (Hickson et al., 2008; Schuenemann et al., 2011). Dystocia or difficulty of parturition is the main cause of prolonged calving process (Mee, 2004a).

Finally, the third stage of calving is the dehiscence and expulsion of the fetal membranes, and is considered to be of an acceptable length if it is completed within12 h (Noakes et al., 2009; Beagley et al., 2010).

Reasons for dystocia

The reason for dystocia can either be in the dam or in the foetus. Three main different complexes can be considered responsible for dystocia:

- expulsion factors,
- adequacy of the birth canal,
- size and disposition of the birth canal

In cases in which one or more of these problems occur, the cow will suffer from dystocia. Thus, obstetrical help is needed to protect the health of both the dam and the calf (Taverne & Noakes, 2009).

Prevalence of dystocia

The prevalence of dystocia ranged from 28.6% (Meyer et al., 2001) to 51.2% (Lombard et al., 2007) in heifers and from 10.7% (Meyer et al., 2001) to 29.4% (Lombard et al., 2007) in multiparous dams in the United States.

Economic effects

Dystocia has a negative effects on the dam and the newborn calf, the tremendous economic consequences of dystocia are numerous (Mee, 2004a; McGuirk et al., 2007; Tenhagen et al., 2007; Taverne & Noakes, 2009):

- increased stillbirth rate,
- increased neonatal mortality,
- increased mortality rate of the dam,
- reduced productivity of the dam,
- reduced subsequent fertility and increased chance of infertility in the dam,
- increased likelihood of puerperal disease in the dam,
- increased likelihood of subsequent culling in the dam,
- veterinary costs.

In the last few decades, the sensitivity of the economic consequences of dystocia have increased, which is the reason for the high number of investigations recently performed in this field. The total financial impact of dystocia varies a lot from country to country as well as between various investigations. In the U.K., investigations in the last decade (McGuirk et al., 2007) showed that the total cost was dependent on the severity of dystocia. The consequences of dystocia are dependent on its severity. In control case studies, effects concerning the reproductive performance, culling rate, milk yield and calf viability were correlated to the severity of dystocia (Tenhagen et al., 2007).

Signs of the onset of parturition

The observation of the onset of calving is very important in order to accurately monitor progress and provide assistance in a timely manner when required (Mee, 2004a; 2008b; Schuenemann et al., 2011). Unfortunately, this remains a difficult task to accomplish in dairy cattle because the animals are highly variable in the physical and behavioural signs they express for impending calving; the ability of observers to detect and interpret these signs are also highly variable (Wehrend et al., 2006; English et al., 2015; Kovács et al., 2015). In fact, approximately 10 to 20% of animals, particularly primiparous dams, will enter the second stage of calving without showing any visible signs of stage one (Berglund & Philipsson, 1987; Mee, 2008b). It is generally recommended to observe cows every 3 to 6 hours after stage 1 has been detected, and discreetly every 30 minutes once stage 2 is in progress, to provide good calving supervision (Mee, 2008b).

Physical signs

Many studies have attempted to find a sign of imminent calving that would be objective, sensitive, and specific. Earlier research focused more on visible signs that could be easily recognized by human observers. For instance, Dufty (1971) found that palpation of the sacro-sciatic (pelvic) ligaments could correctly predict imminent calving in most cows and was the most efficient method compared to rectal temperature, udder size, and vaginal and udder secretions. The relaxation of the pelvic ligaments and udder fill were the most reliable and useful signs to accurately predict calving within the next 12 hours, but it was noted that these signs were greatly influenced by parity and breed (George & Barger 1974; Aitken et al., 1982; Berglund et al., 1987). A more recent study calculated that an increment of $\geq$ 5 mm in the relaxation of pelvic ligament measurements could accurately predict parturition within 24 h for 93% of the cows they observed (Schilling & Hartwig, 1984; Shah et al., 2006; Mortimer, 2009).

Due to the wide variation in both the onset and the progression of the external signs of imminent parturition, many other physical signs have, and are, being used to detect the onset of calving (Ewbank, 1963; Berglund et al., 1987; Mee, 2008b). Vulvar swelling and relaxation, udder enlargement, mammary secretions and displaced abdomen profile to the right side are signs that are used to follow the progress of cows toward preparation for parturition, but are not very predictive of the number of hours prior to calving (Dufty, 1971; Aitken et al., 1982; Berglund et al., 1987; Mee, 2004a). Teat enlargement, engorgement with colostrum, and shine have also been found to be reliable signs of calving within 4 days (Kharche et al., 1982). Vaginal secretions, especially bloody mucus, and abdominal contractions are signs commonly used, when observed, to detect cows undergoing stage one of parturition (Dufty, 1971; Hickson et al., 2008; Proudfoot et al., 2013).

Physiological signs

Physiological changes as parturition becomes imminent have also been used to predict the time to calving. Heart rate has been found to increase following the onset of the behavioural signs of calving and peak at the time of fetal expulsion (Kovács et al., 2015). A study found that plasma progesterone <1.3 ng/ml was a good indicator of calving occurring within 24 h (Matsas et al., 1992). Another study found that using a cut-off of inorganic phosphorus level of ≥ 11.8 mmol/l in mammary secretions can be used to predict calving within 72 h (Bleul et al., 2006). An increase in plasma estradiol-17β concentration of ≥ 0.20 ng/ml compared to the previous day has also been found to accurately predict calving within 24 h in a majority (85%) of cows (Shah et al., 2006).

Several recent studies have proved the value of body temperature changes as potential objectives and easily-measured indication of the imminent calving. A rumen temperature decrease measured continuously through wireless boluses, and a reduction of 0.3 to 0.5ºC in rectal temperature measured twice daily with a regular veterinary thermometer have both been found to be good predictors of parturition (Burfeind et al., 2011; Statham, 2015). A variety of vaginal temperature loggers have been tested to predict the onset of calving; generally studies found that a decrease≥0.3ºC indicated that parturition would take place within the next 24 h (Aoki et al., 2005; Burfeind et al., 2011; Ouellet et al., 2016).

Behavioural signs

Many of dairy cows' routine behaviours have been found to be altered around the time of parturition. Cows, especially multiparous animals, often seek isolation around the time of calving (Edwards, 1979; Lidfors et al., 1994; Mee, 2004a; Proudfoot et al., 2014). Tail raising behaviour has been found to be a very reliable indicator that calving will take place in the next few hours (Aitken et al., 1982; Mee, 2004a; Miedema et al., 2011a). A prolonged elevation of the tail by 30 to 45º has been generally observed within 4 h of the second stage of parturition (English et al., 2015).Restlessness is the most commonly observed sign of imminent calving, with heifers going through their first parturition often exhibiting this sign earlier than multiparous cows (Wehrend et al., 2006; Von Keyserlingk & Weary, 2007; Mee, 2008b). A wide variety of definitions and/or component behaviours of restlessness have been used as predictors of the onset of calving (Aitken et al., 1982; Berglund et al., 1987; Wherend et al., 2006). Lying, standing and walking are the most frequently used indicators of restlessness, but increased frequency of pawing/scraping with the forefeet, shifting weight on the hind legs, rubbing against walls, turning of the head towards the abdomen, urination and defecation have also been noted (Mee, 2004a; Wehrend et al., 2006). Lying and standing by dairy cows around calving have been explored in terms of total time, number of bouts, and steps taken when standing. Generally, cows spend less time lying on the day of calving compared to the previous day or series of days, depending on the study (Huzzey et al., 2007; Jensen, 2012; Ouellet et al., 2016). Dams have also been found to change position between lying and standing more frequently and to take more steps on the day of parturition (Miedema et al., 2011a,b; Titler et al., 2015).

A decrease in feed intake and feeding time has also been noted in the days leading up to calving, with a particularly high drop on the day of calving (Dorshorst & Grummer, 2002; Schirmann et al., 2013; Büchel & Sundrum, 2014). Rumination time, measured visually or using automated equipment, has also been shown to decrease significantly on the day of calving, by up to 33% compared to several days prior to calving (Bao & Giller, 1991; Ouellet et al., 2016; Calamari et al., 2014; Clark et al., 2014).

References

Aitken, V. R., Holmes, R. J., & Barton, R. A. (1982). Calving behavior of single-suckled Angus cows and their calves born in the spring. Proc. of the New Zealand Society of Anim. Prod. 42:69- 71.

Aoki, M., Kimura, K. & Suzuki, O. (2005). Predicting time of parturition from changing vaginal temperature measured by data-logging apparatus in beef cows with twin fetuses. Anim. Repro. Sci. 86:1-12.

Bao, J., & Giller, P. S. (1991). Observations on the changes in behavioural activities of dairy cows prior to and after parturition. Irish Vet. J. 44:43-47.

Bazer, F. W., & First, N. L. (1983). Pregnancy and parturition. J. Anim. Sci. 57:425-460.

Beagley, J. C., Whitman, K. J., Baptiste, K. E., & Scherzer, J. (2010). Physiology and treatment of retained fetal membranes in cattle. J. Vet. Intern. Med. 24:261-268.

Berglund, B., & Philipsson, J. (1987). The influence of relative birth weight and certain other factors on calving performance in Swedish dairy cattle breeds. Anim. Reprod. Sci. 15:81-93.

Berglund, B., Philipsson, J., & Danell, Ö. (1987). External signs of preparation for calving and course of parturition in Swedish dairy cattle breeds. Anim. Reprod. Sci. 15:61-79.

Berglund, B., Steinbock, L., & Elvander, M. (2003). Causes of stillbirth and time of death in Swedish Holstein calves examined post mortem. Acta Vet. Scand. 44:111-120.

Bleul, U., Spirig, S., Hässig, M., & Kähn, W. (2006). Electrolytes in bovine prepartum mammary secretions and their usefulness for predicting parturition. J. Dairy Sci. 89:3059-3065.

Burfeind, O., Suthar, V. S., Voigtsberger, R., Bonk, S., & Heuwieser, W. (2011). Validity of prepartum changes in vaginal and rectal temperature to predict calving in dairy cows. J. Dairy Sci. 94:5053-5061.

Büchel, S., & Sundrum, A. (2014). Short communication: Decrease in rumination time as an indicator of the onset of calving. J. Dairy Sci. 97:3120-3127.

Calamari, L., Soriani, N., Panella, G., Petrera, F., Minuti, A., & Trevisi, E. (2014). Rumination time around calving: An early signal to detect cows at greater risk of disease. J. Dairy Sci.97:3635-3647.

Chassagne, M., Barnouin, J., & Chacornac, J. P. (1999). Risk factors for stillbirth in Holstein heifers under field conditions in France: A prospective survey. Theriogenology 51:1477-1488.

Clark, C. E. F., Lyons, N. A., Millapan, L., Talukder, S., Cronin, G. M., Kerrisk, K. L., & Garcia, S. C. (2014). Rumination and activity levels as predictors of calving for dairy cows. Animal 9:1-5.

Cook, N. B., &. Nordlund, K. V. (2004). Behavioral needs of the transition cow and considerations for special needs facility design. Vet. Clin. Food Anim. 20:495- 520.

Dhakal, K., Maltecca, C., Cassady, J. P., Baloche, G., Willliams, C. M., & Washburn, S. P. (2013). Calf birth weight, gestation length, calving ease, and neonatal calf mortality in Holstein, Jersey, and crossbred cows in a pasture system. J. Dairy Sci. 96:690-698.

Dorshorst, M. E., & Grummer, R. R. (2002). Effects of day relative to parturition and dietary crude protein on rumen fermentation in prepartum transition cows. J. Dairy Sci. 85:2290-2298.

Drackley, J. K. (1999). Biology of dairy cows during the transition period: the final frontier. J. Dairy Sci. 82:2259-2273.

Dufty, J. H. (1971). Determination of the onset of parturition in Hereford cattle. Australian Vet. J. 47:77-82.

Edwards, S. A. (1979). The timing of parturition in dairy cattle. J. Agri. Sci. Camb. 93:359-363.

Engelen, E. V., Taverne, M. A. M., Everts, M. E., Weijden, G. C. V., Doornenbal, A., & Breeveld-Dwarkasing, V.N.A. (2007) EMG activity of the muscular and stromal layer of the cervix in relation to EMG activity of the myometrium and cervical dilatation in PGF2α induced parturition in the cow. Theriogenology 67:1158-1167.

English, L., Murphy, J. P., & Mee, J. F. (2015). Development of a tail-mounted calving alarm in dairy cows – a pilot study. Cattle Practice 23:140-140.

Ewbank, R. (1963). Predicting the time of parturition in normal cow: a study of the precalving drop in body temperature in relation to the external signs of imminent calving. Vet. Rec. 75:367-371.

Fisher, L. J., & Williams, C. J. (1978). Effect of environmental factors and fetal and maternal genotype on gestation length and birth weight of Holstein calves. J. Dairy Sci. 61:1462-1467.

George, J. M., & Barger, I. A. (1974). Observations of bovine parturition. Proc. Aust. Soc. Anim. Prod. 10:314.

Hansen, M., Lund, M. S., Pedersen, J., & Christensen, L. G. (2004). Gestation length in Danish Holsteins has weak genetic associations with stillbirth, calving difficulty, and calf size. Livest. Prod. Sci. 91:23-33.

Hart, K. R. (2014). Investigation into the quality of colostrum and time between calving and administration. Cattle Practice 22:277-279.

Heinrichs, A. J., & Heinrichs, B. S. (2011). A prospective study of calf factors affecting first- lactation and lifetime milk production and age of cows when removed from the herd. J. Dairy Sci. 94:336-341.

Hickson, R. E., Lopez-Villalobos, N., Kenyon, P. R., & Morris, S. T. (2008). Duration of parturition and frequency of abdominal contractions in primiparous, 2-year-old Angus heifers and the relevance of body dimensions of calves to dystocia. Australian J. of Experimental Agriculture 48:935-939.

Huzzey, J. M., Veira, D. M., Weary, D. M., & von Keyserlingk, M. A. G. (2007). Prepartum behavior and dry matter intake identify dairy cows at risk for metritis. J. Dairy Sci. 90:3220- 3233.

Jackson, P. G. G. (2004). Handbook of veterinary obstetrics, 2nd edition. Elsevier Limited. London. United Kingdom.

Jenkin, G., & Young, I. R. (2004). Mechanisms responsible for parturition; the use of experimental models. Anim. Reprod. Sci. 82-83:567-581.

Jensen, M. B. (2012). Behaviour around the time of calving in dairy cows. Appli. Anim. Behav. Sci. 139:195-202.

Kharche, K. G., Singh, H. N., & Thakur, M. S. (1982). Studies on symptoms and process of parturition in Gir cows. Cheiron 11:5-10.

Kovács, L., Kézér, F. L., Ruff, F., & Szenci, O. (2017). Rumination time and reticuloruminal temperature as possible predictors of dystocia in dairy cows. J. Dairy Sci. 100:1568–1579.

Kovács, L., Kézér, F. L., & Szenci, O. (2016a). Effect of calving process on the outcomes of delivery and postpartum health of dairy cows with unassisted and assisted calvings. J. Dairy Sci. 99:7568–7573.

Kovács, L., Kézér, F. L., Ruff, F., & Szenci, O. (2016b). Timing of obstetrical assistance affects peripartal cardiac autonomic function and early maternal behavior of dairy cows. Physiology and Behavior 165:202–210.

Kovács, L., Tőzsér, J., Kézér, F. L., Ruff, F., Aubin-Wodala, M., Albert, E., Choukeir, A., Szelényi, Z., & Szenci, O. 2015. Heart rate and heart rate variability in multiparous dairy cows with unassisted calvings in the periparturient period. Physiology and Behavior 139:281–289.

Lidfors, L. M., Moran, D., Jung, J., Jensen, P., & Castren, H. (1994). Behaviour at calving and choice of calving place in cattle kept in different environments. Appli. Anim. Behav. Sci. 42:11- 28.

Lombard, J. E., Garry, F. B., Tomlinson, S. M., & Garber, L. P. (2007). Impacts of dystocia on health and survival of dairy calves. J. Dairy Sci.90:1751–1760.

Lye, S. J. (1996). Initiation of parturition. Anim. Reprod. Sci. 42:495-503.

Matsas, D. J., Nebel, R. L., & Pelzer, K. D. (1992). Evaluation of an on-farm blood progesterone test for predicting the day of parturition in cattle. Theriogenology 37:859-868.

McGuirk, B. J., Forsyth, R., & Dobson, H. (2007). Economic cost of difficult calvings in the United Kingdom dairy herd. Vet. Rec. 161:685-687.

Mee, J. F. (2004a). Managing the dairy cow at calving time. Vet. Clin. Food Anim. 20:521-546.

Mee, J. F. (2004b). The role of micronutrients in bovine periparturient problems. Cattle Practice 12:95-108.

Mee, J. F. (2008a). Managing the calf at calving time. Proceeding from the American Association of Bovine Practitioners 41:46-53.

Mee, J. F. (2008b). Managing the cow at calving time. Proceeding from the American Association of Bovine Practitioners 41:35-43.

Mee, J. F. (2008c). Newborn dairy calf management. Vet. Clin. Food Anim. 24:1-17.

Mee, J. F. (2008d). Prevalence and risk factors for dystocia in dairy cattle: A review. Vet. J. 176:93-101.

Mee, J. F. (2013). Explaining unexplained bovine stillbirth: How to deal with 'farm blindness'. Vet. J. 197:120-121.

Meijering, A. (1984). Dystocia and stillbirth in cattle – a review of causes, relations and implications. Livest. Prod. Sci. 11:143-177.

Meyer, C. L., Berger, P. J.,& Koehler, K. J. (2000). Interactions among factors affecting stillbirths in Holstein cattle in the United States. J. Dairy Sci. 83:2657-2663.

Meyer, C. L., Berger, P. J., Koehler, K. J., Thompson, J. R.,& Sattler, C. G. (2001). Phenotypic trends in incidence of stillbirth for Holstein in the United States. J. Dairy Sci. 84:515-523.

Miedema, H. M., Cockram, M. S., Dwyer, C. M.,& Macrae, A. I. (2011a). Behavioural predictors of the start of normal and dystocic calving in dairy cows and heifers. Appli. Anim. Behav. Sci. 132:14-19.

Miedema, H. M., Cockram, M. S., Dwyer, C. M., & Macrae, A. I. (2011b). Changes in the behaviour of dairy cows during the 24h before normal calving compared with behaviour during late pregnancy. Appli. Anim. Behav. Sci. 131:8-14.

Mortimer, R. G. (2009). Calving & handling calving difficulties. www.cvmbs.colostate.edu/ilm/projects/neonatal/Calving%20and%20Handling%20Calving%20DifDifficult.pdf. Consulted on 02/02/2016.

Mulligan, F. J., & Doherty, M. L. (2008). Production diseases of the transition cow. Vet. J. 176:3-9.

Noakes, D. E., Parkinson, T. J., & England, G. C. W. (2009). Veterinary reproduction and obstetrics (9th edition). Saunders Elsevier, Edinburgh, United Kingdom.

Nogalski, Z., & Piwcaynski, D. (2012). Association of length of pregnancy with other reproductive traits in dairy cattle. Asian-Aust. J. Anim. Sci. 25:22-27.

Ouellet, V., Vasseur, E., Heuwieser, W., Burfeind, O., Maldague, X., & Charbonneau, É. (2016). Evaluation of calving indicators measured by automated monitoring devices to predict the onset of calving in Holstein dairy cows. J. Dairy Sci. 99:1-10.

Proudfoot, K. L., Jensen, M. B., Heegaard, P. M. H., & von Keyserlingk, M. A. G. (2013). Effect of moving dairy cows at different stages of labor on behavior during parturition. J. Dairy Sci. 96:1638-1646.

Proudfoot, K. L., Jensen, M. B., Weary, D. M., & von Keyserlingk, M. A. G. (2014). Dairy cows seek isolation at calving and when ill. J. Dairy Sci. 97:2731-2739.

Richter, J., & Götze, R. (1993). Die normale Geburt. In: Grunert, E., & Arbeiter, K. (Eds.).Tiergeburtshilfe (4th ed.). Berlin Verlag Pail Parey, pp. 81-110.

Schilling, E., & Hartwig, H. H. (1984). Behaviour in cows before and during parturition. In: Unshelm, J., van Putten, F., & Zeeb,K. (Eds.). Proc. Int. Congress on Applied Ethology in Farm Animals, Kiel, pp. 391-394.

Schirmann, K., Chapinal, N., Weary, D. M., Vickers, L., & von Keyserlingk, M. A. G. (2013). Short communication: Rumination and feeding behavior before and after calving in dairy cows. J. Dairy Sci. 96:7088-7092.

Schuenemann, G. M., Nieto, I., Bas, S., Galvao, K. N., & Workman, J. (2011). Assessment of calving progress and reference times for obstetric intervention during dystocia in Holstein dairy cows. J. Dairy Sci. 94:5494-5501.

Schuenemann, G. M., Bas, S., Gordon, E., & Workman, J. D. (2013). Dairy calving management: Description and assessment of a training program for dairy personnel. J. Dairy Sci. 96:2671-2680.

Shah, K. D., Nakao, T., & Kubota, H. (2006). Plasma estrone sulphate (E1S) and estradiol-17β (E2β) profiles during pregnancy and their relationship with the relaxation of sacrosciatic ligament, and prediction of calving time in Holstein-Friesian cattle. Anim. Reprod. Sci. 95:38-53.

Squires, E. J. (2003). Applied animal endocrinology. CABI Publishing, CAB International. Oxon. United Kingdom.

Statham, J. M. E. (2015). Predicting oestrus and parturition in cows. Cattle Practice 23:74-97.

Taverne, M. A. & Noakes, D. E. (2009). Parturition and the care of parturient animals, including the newborn. In: Noakes, D. E., Parkinson, T. J., &England, G. C. W. (Eds.). Saunders Elsevier, Edinburgh, United Kingdom, pp. 154-205.

Tenhagen, B. A., Helmbold, A., & Heuwieser, W. (2007). Effect of various degrees of dystocia in dairy cattle on calf viability, milk production, fertility and culling. J. Vet. Med. A Physiol. Pathol. Clin. Med. 54:98-102.

Thatcher, W. W., Wilcox, C. J., Collier, R. J., Eley, D. S., & Head, H. H. (1980). Bovine conceptus – Maternal interactions during the pre- and postpartum periods. J. Dairy Sci. 63:1530- 1540.

Titler, M., Maquivar, M. G., Bas, S., Rajala-Schultz, P. J., Gordon, E., McCullough, K., Federico, P., & Schuenemann, G. M. (2015). Prediction of parturition in Holstein dairy cattle using electronic data loggers. J. Dairy Sci. 98:5304-5312.

Von Keyserlingk, M. A. G., & Weary, D. M. (2007). Maternal behavior in cattle. Hormones and Behavior 52:106-113.

Wehrend, A., Hofmann, E., Failing, K., & Bostedt, H. (2006). Behaviour during the first stage of labour in cattle: influence of parity and dystocia. Appl. Anim. Behav. Sci. 100:164-170.

Chapter 2

EVALUATION OF A COMMERCIAL INTRAVAGINAL THERMOMETER TO PREDICT CALVING IN A HUNGARIAN HOLSTEIN-FRIESIAN DAIRY FARM

Ali Ismael Choukeir[1], Levente Kovács[2], Luca Fruzsina Kézér[3], Dávid Buják[1,3,†], Zoltán Szelényi[1,3], Mohamed Kamel Abdelmegeid[1], András Gáspárdy[4], Ottó Szenci[1,3]

[1]University of Veterinary Medicine, Department and Clinic for Production Animals, Üllő – Dóra major, Hungary
[2]National Agricultural Research and Innovation Center, Research Institute for Animal Breeding, Nutrition and Meat Science, Herceghalom, Hungary
[3]MTA-SZIE Large Animal Clinical Research Group, Üllő – Dóra major, Hungary
[4]University of Veterinary Medicine, Department of Animal Breeding and Nutrition, Budapest, Hungary

***Reproduction in Domestic Animals 2020.00.1-6, https://doi.org/10.1111/rda.13803*.**

Evaluation of a commercial intravaginal thermometer to predict calving in a Hungarian Holstein-Friesian dairy farm

Abstract

In this study, the utility of a commercial intravaginal thermometer was evaluated as an automated method for the prediction of calving in a total of 257 healthy pregnant Holstein-Friesian female cattle. The accuracy and the sensitivity of predicting calving within 48 hr before calving were also evaluated. The intravaginal temperature changes from 72 hr before and up to calving was significantly ($p \leq 0.001$) affected by parity, season (summer vs. autumn), the time of day (8 a.m. or 8 p.m.) and the 6-hr time intervals (38.19°C: first interval 0 to 6 hr before calving vs. 38.78°C: twelfth interval 66 to 72 hr before calving), while the gender ($p = 0.943$), and the weight of the calf ($p = 0.610$), twinning ($p = 0.300$), gestation length ($p = 0.186$), foetal presentation ($p = 0.123$), dystocia ($p = 0.197$) and retention of foetal membranes ($p = 0.253$) did not affect it significantly. 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%. It can be concluded that the investigated thermometer is not able to predict calving within 48 hr accurately; however, imminent calving can be accurately alerted.

Keywords: dairy cattle, intravaginal thermometer, prediction of calving

Introduction

Prediction of the exact time of calving would be highly important especially in small farms where there are no assistants working in day and night shifts. It has been known for a long time that precalving decrease in body temperature can be used for prediction of calving (Graf & Petersen, 1953; Porterfield & Olson, 1957; Ewbank, 1963). Since then several reports have confirmed the precalving decrease in vaginal temperature by using sensors inserted into the vagina after attaching to a modified controlled internal drug release device without progesterone at least 6 days before the expected time of calving retrospectively as temperature data could be downloaded only after calving (Burfeind et al., 2016; Miwa et al., 2019). By this way, the optimal cut-off points of decrease in vaginal temperature (≥0.3°C) one day before calving could be determined (Burfeind et al., 2011; Streyl et al., 2011; Ouellet et al., 2016). Due to significant diurnal variations (by up to 0.5°C) in rectal and vaginal temperatures (lowest in the morning and highest in late afternoon) at least two temperature measurements are needed on a daily basis making temperature measurement impractical for calving prediction without converted them into automated signals (Aoki et al., 2005; Burfeind et al., 2011).

Digital data loggers have recently made the continuous recording possible and via Global System for Mobile (GSM) technology the actual vaginal temperature data can be received on mobile phones. Vaginal thermometers inform the user via SMS on its activation, the day-to-day changes in temperature, of the imminence of calving in the last 48 hr before calving, and of the expulsion of the device (the onset of the second stage of labour).

There are paucity of information (Chanvallon et al., 2012; Ricci et al., 2018) regarding the actual performance of those marketed devices used under field conditions, therefore, the aim of the present study was to evaluate the utility of an intravaginal thermometer as an automated method for prediction of calving in a

Holstein-Friesian Hungarian dairy farm. The accuracy of predicting calving within 48 hr by sending a SMS was also evaluated.

Materials and Methods

The work was conducted in full compliance with the guidelines of the Animal Experimentation Committee (22.1/1606/003/2009, Budapest, Hungary).

Housing, feeding and milking technology

Our study was conducted as part of a larger research project on metabolic, behavioral and physiological aspects of bovine parturition at the Prograg Agrárcentrum Ltd. in Ráckeresztúr, Lászlópuszta, Hungary, which has a herd of 900 Holstein-Friesian cattle. From 28 days before the expected time of calving, preparturient heifers and cows were housed in a precalving group pen (measuring 45 × 25 m), which included 50 to 60 animals and was bedded with deep straw. If calving assistance was needed, there was an individual maternity pen (measuring 4 × 5 m) where the straw was changed after each assistance. Before calving, cows were fed a prepartum total mixed ration (TMR) *ad libitum* containing a dietary forage-to-concentrate ratio of 78:22 on a dry matter (DM) basis. After calving, cows were fed a postpartum TMR *ad libitum* with a 60:40 forage-to-concentrate ratio on a dry-matter basis as described previously (Kovács et al., 2016a). Water was available *ad libitum*.

Experimental groups and calving management

Five days before the expected date of calving (the mean duration of gestation for nulliparous and pluriparous cows calculated for a year basis (n= 927) before starting the experiment was 275.9 (SD: 5.8) days, 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 described previously (Choukeir et al., 2020). 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. Location device was used to detect the expelled thermometers in the deep straw. After finding it, a soft brush was used to clean the thermometer and appendages which were disinfected and stored until the next usage in the blue trunk as recommended in the manual. The mean ± SD body condition scores using the 5-point scoring system (Hady et al., 1994) following calving were 3.1 ± 0.2 for heifers and 3.3 ± 0.2 for pluriparous cows, respectively. 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., 2016b).

Obstetrical assistance and dystocia scoring

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. (2016b). 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.

Statistical analysis

All statistical analyses were done with the Statistica Computer Software, version 13 (Tibco Software Inc., 2017). Analysis of raw data of temperature was performed by general linear models (GLM), and the following fixed effects were chosen: type of calving (single or twin calving), presentation of the calf (anterior or posterior), calving ease (dystocic or eutocic), gender of the calf , time of day (8 a.m. or 8 p.m.), season (summer with calving in June, July and August or fall with calving in September, October and November), parity (nulliparous or pluriparous cows), and RFM (absence or presence) diagnosed from 12 to 24 hr after calving. The last 72-hr temperature measurements were split into twelve 6-hr periods and used also as a fixed effect. Birth weight of the calf (with a mean value of 43.3 kg) and gestation length (with a mean value of 297.6 days) were considered as covariates.

The statistical significance of these effects was estimated by a backward elimination, taking into account what effects were eligible for removal. As a result, the P-value of each effect, as well as the least squares mean (LSM) and standard error of mean (SEM) were presented according to significant effects. To measure eventually differences the Tukey's post hoc test was used for temperatures.

The SMSs for the expected calving within 48 hr and for the expulsion were arranged as follows: correct positive diagnosis (occurrence of calving within 48 hr or after expulsion), incorrect positive diagnosis (calving did not occur within 48 hr) and incorrect negative diagnosis (calving was not predicted at all). From these values, sensitivity [100×a/(a+c)] and the positive predictive value of the SMS messages [100×a/(a+b)] were calculated as described previously by Szenci et al. (1998).

Results

None of the thermometers were lost during the trial. Intravaginal temperature was not affected by the gender (P = 0.943), the birth weight of the calf (P = 0.610), twinning (P = 0.300), gestation length (P= 0.186), foetal presentation (P = 0.123), calving ease (P = 0.197) and RFM (P= 0.253), while parity, time of day (8 a.m. vs. 8 p.m.), season (summer vs. autumn), (Table 1), and the 6-hr time intervals (38.2^{o}C: first interval between 0 and 6 hr before calving vs. 38.8^{o}C: twelfth interval between 66 and 72 hr before calving) significantly ($P \leq 0.001$) affected it (Table 2).

Table 1 Vaginal temperatures are significantly affected by the following variables

Effect	**Number of observations**	**Vaginal temperature (ºC)**	
		LSM†	**SEM‡**
Time of day		*P* < 0.001	
8 a.m. (morning)	651	38.28[a]	0.0180
8 p.m. (evening)	690	38.82[b]	0.0177
Season		*P* = 0.001	
Summer	558	38.59[b]	0.0199
Fall	783	38.51[a]	0.0160
Parity		*P* < 0.001	
nulliparous	324	38.48[a]	0.0238
pluriparous	1017	38.62[b]	0.0131

†LSM – least square mean

‡SEM – standard error of the mean

Table 2 Vaginal temperatures are significantly (*P*< 0.001) affected by the 6-hr time intervals

6-hr time intervals	Number of observations	Vaginal temperature (ºC) LSM†	SEM‡
12th (66 to 72 hr before calving)	93	38.78^{d}	0.0441
11th	103	38.68^{cd}	0.0417
10th	95	38.72^{cd}	0.0435
9th	113	38.74^{cd}	0.0399
8th	103	38.71^{cd}	0.0418
7th	118	38.59^{bcd}	0.0392
6th	110	38.57^{bcd}	0.0406
5th	121	38.61^{bcd}	0.0386
4th	112	38.45^{bc}	0.0402
3rd	122	38.37^{ab}	0.0384
2nd	119	38.21^{a}	0.0390
1st (0-6 hr before calving)	132	38.19^{a}	0.0370

†LSM – least square mean
‡SEM – standard error of the mean

a, b, c, d – different letters mean significant (*P* < 0.05) differences (Tukey's post-hoc test)

After SMS messages of possible calving within 48 hr 68.5% of the cows, while after SMS messages of expected calving within 48 hr 58.8% of the cows calved within 48 hr. It is important to mention that among the 50 correct positive diagnoses 15 cows were already correctly predicted by the first SMS messages. Although the expulsion SMS messages were sent in each case (Table 3), thermometers did not generate any SMS messages before the onset of the parturition process in 37 cases (17.2%). The mean (±SD) duration between SMS message of possible calving within 48 hr and calving was 139 ± 117 hr (min: 15 hr, max: 529 hr), while between expected calving within 48 hr and calving was 64 ± 83 hr (min: 2 hr, max: 428 hr), respectively. There were no two alarms during the first 12 hr period before calving.

Table 3 Accuracy of prediction of calving by an SMS message

Grouping and evaluation	SMS of possible calving within 48 hr (n = 215)	SMS of expecting calving within 48 hr (n = 215)	SMS of expulsion (n = 257)
Correct positive diagnosis †	16	111	257
False positive diagnosis ‡	60	67	-
False negative diagnosis §	139	37	-
Sensitivity ¶	21.1	62.4	100
Positive predictive value #	10.3	75.0	100

† Occurrence of calving within 48 hr (a),

‡ Calving did not occur within 48 hr (b)

§ Calving was not predicted at all (c)

¶ 100×a/(a+c)

100×a/(a+b)

Discussion

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 (data not given in Table 1).

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'Phone calving 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).

Acknowledgements

The authors would like to thank Ferenc Bodó, farm owner, Ágoston Bodó, farm manager for supporting the study, Dr. Gyula Gyulay for his valuable technical assistance and the farm staff of Prograg Agrárcentrum Ltd. at Ráckeresztúr, Lászlópuszta for taking care of the animals during the experimental period. Levente Kovács was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences, Budapest, Hungary [BO/00040/16/4].

Conflict of interest

None of the authors have any conflict of interest to declare.

Author contributions

Choukeir, A.I. performed the experiment 'on field', analysed data and wrote the manuscript. Kovács, L. collaborated on the study design, performed the experiment 'on field' and revised the manuscript. Kézér, L.F., Buják, D., Szelényi, Z. and Abdelmegeid, M.K. collaborated in the experiment 'on-field'. Gáspárdy, A. collaborated in analysing data. Szenci, O. collaborated in the study design and revised the manuscript.

Orcid

Levente KovácsID https://orcid.org/0000-0001-9149-404X

Zoltán Szelényi ID https://orcid.org/0000-0003-3763-857X

Ottó Szenci ID https://orcid.org/0000-0002-3248-173X

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Aoki, M., Kimura, K., & Suzuki, O. (2005). Predicting time of parturition from changing vaginal temperature measured by data-logging apparatus in beef cows with twin fetuses. Anim. Reprod. Sci. 86:1-12.

Burfeind, O., Suthar, V. S., Voigtsberger, R., Bonk, S., & Heuwieser, W. (2011). Validity of prepartum changes in vaginal and rectal temperature to predict calving in dairy cows. J. Dairy Sci. 94:5053-5061.

Chanvallon, A., Leblay, A., Girardot, J., Daviere, J. B., & Lamy, J. M. (2012). Surveillanceautomatise des velages chez la vache laitiere. Proceedings of the Rencontresautour des Recherches sur les Ruminants, Paris, France, p. 408.

Choukeir, A. I., Kovács, L., Szelényi, Z., Kézér, L. F., Albert, E., Abdelmegeid, M. K., Baukje, A., Aubin-Wodala, M., Buják, D., Nagy, K., & Szenci, O. (2020). Effect of monitoring the onset of calving by a calving alarm thermometer on the prevalence of dystocia, stillbirth, retained fetal membranes and clinical metritis in a Hungarian dairy farm. Theriogenology 145:144-148.

Ewbank, R. (1963). Predicting the time of parturition in the normal cow: a study of theprecalving drop in body temperature in relation to the external signs ofimminent calving. Vet. Rec. 75:367-371.

Graf, G. C., & Petersen, W. E. (1953). Changes in respiration and heart rates, body temperatures plasma lactic acid levels and plasma creatinine levels caused by stress in daily cattle. J. Dairy Sci.36:1036-1048.

Hady, P. J., Domecq, J. J., & Kaneene, J. B. (1994). Frequency and precision of body condition scoring in dairy cattle. J. Dairy Sci.77:1543-1547.

Kovács, L., Kézér, F. L., Ruff, F., & Szenci, O. (2016a). Timing of obstetrical assistance affects peripartal cardiac autonomic function and early maternal behavior of dairy cows. Physiology and Behavior 165:202–210.

Kovács, L., Kézér, F. L., & Szenci, O. (2016b). Effect of calving process on the outcomes of delivery and postpartum health of dairy cows with unassisted and assisted calvings. J. Dairy Sci.99: 7568–7573.

Lammoglia, M. A., Bellows, R. A., Short, R. E., Bellows, S. E., Bighorn, E. G., Stevenson, J. S., & Randel, R. D. (1997). Body temperature and endocrine interactions before and after calving in beef cows. J. Anim. Sci. 75:2526-2534.

Mee, J. F. (2013). Explaining unexplained bovine stillbirth: How to deal with 'farm blindness'. Vet. J. 197:120-121.

Miwa, M., Matsuyama, S., Nakamura, S., Noda, K., & Sakatani, M. (2019). Prepartum change in ventral tail base surface temperature in beef cattle: comparison with vaginal temperature and behavior indices, and effect of ambient temperature. J. Reprod. Dev. 65:515-525.

Ouellet, V., Vasseur, E., Heuwieser, W., Burfeind, O., Maldague, X., & Charbonneau, É. (2016). Evaluation of calving indicators measured by automated monitoring devices to predict the onset of calving in Holstein dairy cows.J. Dairy Sci. 99:1539-1548.

Palombi, C., Paolucci, M., Stradaioli, G., Corubolo, M., Pascolo, P. B., & Monaci, M. (2013). Evaluation of remote monitoring of parturition in dairy cattle as new tool for calving management. BMC Vet. Res. 9:191, doi: 10.1186/1746-6148-9-191.

Porterfield, I. D., & Olson, N. O. (1957). Vaginal temperature of dairy cows before and after calving. J. Am. Vet. Med. Ass. 131:381-383.

Ricci, A., Racioppi, V., Iotti, B., Bertero, A., Reed, K. F., Pascottini, O. B., &Vincenti, L. (2018). Assessment of the temperature cut-off point by a commercial intravaginal device to predict parturition in Piedmontese beef cows. Theriogenology113:27-33.

Sakatani, M., Sugano, T., Higo, A., Naotsuka, K., Hojo, T., Gessei, S., Uehara, H., & Takenouchi, N. (2018): Vaginal temperature measurement by a wireless sensor for predicting the onset of calving in Japanese Black cows. Theriogenology 111:19-24.

Streyl, D., Sauter-Louis, C., Braunert, A., Lange, D., Weber, F., & Zerbe, H. (2011). Establishment of a standard operating procedure for predicting the time of calving in cattle. J.Vet. Sci.12:177-185.

Szenci, O., Beckers, J. F., Humblot, P., Sulon, J., Sasser, G., Taverne, M. A. M., Varga, J., Baltusen, R., & Schekk, Gy. (1998). Comparison of ultrasonography, bovine pregnancy specific protein B, and bovine pregnancy associated glycoprotein 1 test for pregnancy detection in dairy cows. Theriogenology 50:77-88.

Chapter 3

EFFECT OF MONITORING THE ONSET OF CALVING BY A CALVING ALARM THERMOMETER ON THE PREVALENCE OF DYSTOCIA, STILLBIRTH, RETAINED FETAL MEMBRANES AND CLINICAL METRITIS IN A HUNGARIAN DAIRY FARM

Ali Ismael Choukeir[1], Levente Kovács[2], Zoltán Szelényi[1,2], Luca Fruzsina Kézér[2], Ervin Albert[1,2], Mohamed Kamel Abdelmegeid[1], Andela Baukje[1], Mária Aubin-Wodala[2], Dávid Buják[1,2], Krisztina Nagy[2], Ottó Szenci[1,2]

[1]*University of Veterinary Medicine Budapest, Department and Clinic for Production Animals, H-2225 Üllő – Dóra major, Hungary*
[2]*MTA-SZIE Large Animal Clinical Research Group, H-2225 Üllő – Dóra major, Hungary*

Theriogenology 2020.145.144-148.

Effect of monitoring the onset of calving by a calving alarm thermometer on the prevalence of dystocia, stillbirth, retained fetal membranes and clinical metritis in a Hungarian dairy farm

Abstract

The objective of the present study was to assess the effectiveness of an intravaginal thermometer in the field prediction of the second stage of labor and to determine its impact on the health of dams and newborn calves. Holstein cows (n = 241) were randomly selected about 5 (mean ± SD: 4.7 ± 2.0) days before the expected date of calving and the thermometer was inserted into the vagina. Another 113 cattle served as controls. There was no false alarm during the experiment. 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. The prevalence of stillbirth was 7 times higher in cows with dystocia compared to cows with eutocia. 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. The results indicate that 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.

Keywords: Dairy cow, Vaginal thermometer, Stillbirth, Retained fetal membranes, Clinical metritis

Introduction

Dystocia has been defined as a difficult birth resulting in prolonged calving or severe assisted extraction of a calf at birth (Mee, 2004). The prevalence of dystocia ranged from 28.6% (Meyer et al., 2001) to 51.2% (Lombard et al., 2007) in nulliparous and from 10.7% (Meyer et al., 2001) to 29.4% (Lombard et al., 2007) in multiparous dams in the United States, respectively. Dystocia has negative effects on the dam and the newborn calf by increasing the stillbirth rate (Lombard et al., 2007; Tenhagen et al., 2007). Furthermore, it increases the prevalence of retained fetal membranes (RFM), injuries of the birth canal (Kovács et al., 2016), culling rate (Bell and Roberts, 2007), risk of maternal mortality (Dematawewa and Berger, 1997) and postnatal calf morbidity and mortality (Lombard et al., 2007). Therefore, the prevention of dystocia is of crucial importance in dairy farm management.

Predicting the onset of calving makes it possible to determine if there is a need for human intervention, and thus it enables the rescue of newborn calves and dams (Gundelach et al., 2009; Vasseur et al., 2010). Several protocols have been recommended for predicting the exact time of calving by measuring hormonal changes and/or evaluating clinical signs (relaxation of the pelvic ligaments, decrease in body temperature), recording feeding and rumination behavior before calving as reviewed recently by Saint-Dizier and Chastant-Maillard (2015)or determining the electrolyte concentrations in the mammary gland secretion (Bleul et al., 2006). Although these methods may help predict the time of calving, the inaccuracy and practical limitations of some methods may limit their use in the practice. On-farm devices like inclinometers and accelerometers detecting tail raising and behavioral changes, abdominal belts monitoring uterine contractions, intravaginal thermometers detecting a drop in body temperature and/or the expulsion of the allantochorion, and devices fixed in the vagina or at the vulvar lips signaling calf expulsion via SMS are currently marketed for automated calving detection (Saint-Dizier and Chastant-Maillard, 2015).

There is a paucity of information regarding the performance of these devices on commercial dairy farms (Saint-Dizier and Chastant-Maillard, 2015); therefore, the aim of the present study was to test the effectiveness of an intravaginal thermometer in predicting calving in the field. We also aimed to determine its impact on the health of dams and the survival of newborn calves.

Material and Methods

Housing, feeding and milking technology

Our study was conducted as part of a larger research project on metabolic, behavioral and physiological aspects of bovine parturition at the Prograg Agrárcentrum Ltd. in Ráckeresztúr, Lászlópuszta, Hungary, which has a herd of 900 Holstein-Friesian cattle. From 28 d before the expected calving, preparturient heifers and cows were housed in a precalving group pen (measuring 45 × 25 m), which included 50 to 60 animals and was bedded with deep straw. If calving assistance was needed, there was an individual maternity pen (measuring 4 × 5 m) where the straw was changed after each assistance. Before calving, cows were fed a prepartum total mixed ration (TMR) *ad libitum* containing a dietary forage-to-concentrate ratio of 78:22 on a dry matter (DM) basis. After calving, cows were fed a postpartum TMR *ad libitum* with a 60:40 forage-to-concentrate ratio on a DM basis as described previously (Kovács et al., 2016). Water was available *ad libitum*. During the first 5 days in milk, cows were milked twice daily at 4:00 a.m. and 2:00 p.m. in a 4-stall herringbone milking parlor operated with DeLaval Control Valve bucket milking machines (DeLaval International AB, Tumba, Sweden).

Experimental groups and calving management

Five days before the expected date of calving (the mean duration of gestation for heifers and multiparous cows calculated for a year basis /n= 927/ before starting the experiment was 275.9 /SD: 5.8/ days), 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) (Figure 1.). Depending on the size of the cow two appendage kits were used for heifers (turquoise) and multiparous cows (white) (Figure 1).

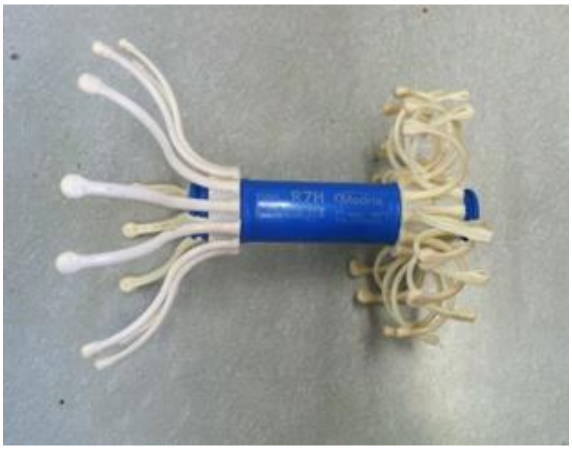

Figure 1. Intra-vaginal thermometer (11.5 cm x 2.2 cm) used for multiparous cows

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.

Newborn calves were removed from their dams within 30 min after birth. Following calf removal, the dams were kept in postpartum pens for 5 d before being introduced to the milking herd.

Obstetrical assistance and dystocia scoring

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).

Statistical analysis

All analyses were performed in R environment (R Core Team R, 2018). The significance level was set at $P < 0.05$.

Differences in duration of calving were analyzed by a general linear model, where parity, dystocia, body condition score, live body weight of the newborn calf, sex and presentation served as response variables.

Generalized linear models with binomial error distribution and logit link function were used to predict the risk factors influencing the occurrence of dystocia, stillbirth, RFM, and CM (as dichotomous variables). Explanatory variables to determine the risk factors for dystocia were group (control or experimental), parity, presentation, and body condition score. To determine the risk factors for stillbirth, dystocia was added as an explanatory variable to the above-mentioned variables. To identify risk factors for RFM we added dystocia and stillbirth, while for CM we added dystocia, stillbirth and RFM to the above-mentioned explanatory variables into the model.

The models were automatically built by using forward-backward simplification by ‘stepAIC’ (Akaike information criterion) function. The removal of the non-significant factors resulted in models with lower AIC in each case, interpreted as that the initial and final models have the same explanatory power. The exponentials of b-coefficients in the final models were interpreted as odds ratios (OR) of the outcome variables.

Results

All thermometers were expelled from the vagina and sent an SMS at the second stage of calving, and no false message occurred. No pathological clinical signs against the vaginal thermometer were recorded; however, signs of discomfort were shown by some heifers right after insertion. Calving was observed at 4.8 ± 2.3 days following the insertion of the device, ranging from 2 to 14 days. Average length (± SD) of gestation for heifers and multiparous cows was 278.1 ± 4.4 days in the monitored group and 278.2 ± 6.6 days in the control group ($P > 0.05$), or 280.0 ± 5.4 days in the monitored group and 276.5 ± 5.8 days in the control group ($P < 0.001$), respectively. Average length (± SD) of gestation in the monitored and the control group was 279.6 ± 5.3 and 277.1 ± 6.1 days ($P < 0.001$), respectively.

The odds for the presence of dystocia were 1.9 times higher (OR: 1.9, $P = 0.005$) in the control group compared to the experimental group, while parity and presentation of the calf did not influence the occurrence of dystocia (Table 1). Measured immediately after birth, the average weight of male calves (46.2 ± 7.1 kg) was higher ($P < 0.001$) compared to female calves (40.9 ± 6.7 kg), and thus the odds (OR: 1.9) for the presence of dystocia was higher ($P = 0.003$) if the calf was male (100/192 = 52.1%) compared to cows giving birth to female calves (58/162 = 35.8%).

Table 1. Grouping of monitored and control nulliparous and multiparous calvings according to the dystocia score.

Dystocia score	Experimental group		Control group		Experimental group	Control group
	Nulliparous cows (n = 57)	Multiparous cows (n = 184)	Nulliparous heifers (n = 37)	Multiparous cows (n = 76)	(n = 241)	(n = 113)
Score 1 (eutocia)	33	113	13	37	146	50
Score 2	22	64	21	36	86	57
Score 3	2	6	3	3	8	6
Score 4	0	1	0	0	1	0
Percentage of dystocia (Score > 1)	42.1%	38.5%	64.9%	51.3%	39.4%	55.8%

Score 1 = no assistance (eutocia), n= 196
Score 2 = delay in the assistance in the second stage of labor with assistance by one person without the use of mechanical traction; light dystocia
Score 3 = assistance with mechanical traction of the calf with a calf puller or more than one person; severe dystocia
Score 4 = Caesarean section

The odds of stillbirth were 19.8 times higher (OR: 19.8, $P< 0.001$) in the control group than in the experimental group (Table 2). Parity did not influence the occurrence of stillbirth significantly. The odds of stillbirth were 7.1 times higher (OR: 7.1, $P< 0.001$) in cases of dystocic births compared to calvings with eutocia (the prevalence of stillbirth was 7.6% and 1.0%, respectively). The odds of stillbirth were 28.8 times higher (OR: 28.8, *P*< 0.001) in posterior presentation compared to anterior presentation (the prevalence of stillbirth was 25.0% and 2.4%, respectively).

The odds of RFM were 2.8 times higher (OR: 2.8, *P* = 0.002) in control than in experimental cows (Table 2). Parity and the presentation of the calf did not influence the occurrence of RFM significantly. The odds of RFM were 4.2 times higher (OR: 4.2, *P*< 0.001) in cows with dystocia (Score 1) compared to cows with eutocia (the prevalence of RFM was 26.0% and 7.1%, respectively). The odds of RFM were 5.3 times greater (OR: 5.3, *P* = 0.007) in the case of stillbirths compared to calvings resulting in a viable calf (the prevalence of RFM was 64.3% and 13.5%, respectively).

The odds of CM were 10.5 times higher (OR: 10.5, *P* = 0.030) in the control group compared to the experimental group **(**Table 2**).** Parity and presentation of the calf did not influence the occurrence of CM significantly. The odds of CM were 2.3 times higher (*P* = 0.020) in dystocic cows compared to cows with eutocia (the prevalence of CM was 29.1%, and 9.2%, respectively). The odds of CM were 21.7 times higher (OR: 21.7, *P*< 0.001) if RFM was present compared to calvings without RFM (the prevalence of CM was 72.8% and 8.0%, respectively).

Table 2. Prevalence of stillbirth, retained fetal membranes and clinical metritis in the control and monitored nulliparous and multiparous dairy cows.

Variable	Experimental group		Control group		Experimental Group (n=241)	Control group (n=113)
	Nulliparous cows (n=57)	Multiparous cows (n=184)	Nulliparous cows (n=37)	Multiparous cows (n=76)		
Prevalence of stillbirth n (%)	1 (1.7%)	1 (0.5%)	4 (10.8%)	8 (10.5%)	2 (0.8%)	12 (10.6%)
Retained fetal membranes n (%)	5 (8.8%)	18 (9.7%)	12 (32.4%)	20 (26.3%)	23 (9.5%)	32 (28.3%)
Clinical metritis n (%)	8 (14.0%)	20 (10.9%)	14 (37.8%)	22 (29.0%)	36 (11.6%)	28 (31.9%)

Discussion

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.

In summary, our results indicate the benefits of the Vel'Phone calving monitoring system in terms of well-being and health of the dam and newborn calf survival, evidenced by decreased dystocia and stillbirth rates and lower prevalence of RFM and CM in the experimental group compared to the control group. According to Schuenemann et al. (2015), the target prevalence (<2%) of stillbirth can be achieved in large dairy farms by using Vel'Phone through prediction of the onset of the second stage of calving, which supports appropriate and timely assistance at calving whenever it is needed.

Acknowledgements

The authors would like to thank Ferenc Bodó, farm owner, Ágoston Bodó, farm manager for supporting the study, Dr. Szabolcs Boldizsár for his valuable technical assistance and the farm staff of Prograg Agrárcentrum Ltd. at Ráckeresztúr, Lászlópuszta for taking care of the animals during the experimental period. Levente Kovács was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences, Budapest, Hungary [BO/00040/16/4], the OTKA Postdoctoral Scholarship of the National Research, Development and Innovation Office, Budapest, Hungary [NKFIH-6493-1/2016], the VEKOP-2.1.1-15-2016-00186 project, and the New National Excellence Program 'Bolyai plus' Project of the Ministry of Human Capacities [ÚNKP-19-4-I-SZIE-2].

References

Bell, M. J., & Roberts, D. J. (2007).The impact of uterine infection on dairy cow's performance. Theriogenology 68:1074–1079.

Bleul, U., Spirig, S., Hassig, M., & Kahn, W. (2006). Electrolytes in bovine prepartum mammary secretions and their usefulness for predicting parturition. J. Dairy Sci.89:3059–3065.

Buják, D., Szelényi, Z., Choukeir, A., Kovács, L., Kézér, F. L., Boldizsár, Sz., Molnár, L., & Szenci, O. (2018). A Holstein-Friesian dairy farm survey of postparturient factors influencing the days to first AI and days open in Hungary. Acta Vet. Hung.66:613–624.

Chanvallon, A., Leblay, A., Girardot, J., Daviere, J. B., & Lamy, J. M. (2012). Surveillanceautomatise des velages chez la vache laitiere. Proceedings of the Rencontresautour des Recherches sur les Ruminants, Paris, France, p. 408.

Dematawewa, C. M., & Berger, P. J. (1997). Effect of dystocia on yield, fertility, and cow losses and an economic evaluation of dystocia scores for Holsteins. J. Dairy Sci.80:754-761.

Gundelach, Y., Essmeyer, K., Teltscher, M. K., & Hoedemaker, M. (2009). Risk factors for perinatal mortality in dairy cattle: cow and foetal factors, calving process. Theriogenology71:901–909.

Hady, P. J., Domecq, J. J., & Kaneene, J. B. (1994). Frequency and precision of body condition scoring in dairy cattle. J. Dairy Sci.77:1543-1547.

Kovács, L., Kézér, F. L., Ruff, F., & Szenci, O. (2016a). Timing of obstetrical assistance affects peripartal cardiac autonomic function and early maternal behavior of dairy cows. Physiology and Behavior 165:202–210.

Kovács, L., Kézér, F. L., & Szenci, O. (2016b). Effect of calving process on the outcomes of delivery and postpartum health of dairy cows with unassisted and assisted calvings. J. Dairy Sci.99: 7568–7573.

Lange, K., Fischer-Tenhagen, C., & Heuwiese, W. (2017). Predicting stage 2 of calving in Holstein-Friesian heifers. J. Dairy Sci. 100:4847-4856.

Lombard, J. E., Garry, F. B., Tomlinson, S. M., & Garber, L. P. (2007). Impacts of dystocia on health and survival of dairy calves. J. Dairy Sci.90:1751–1760.

McGuirk, B. J., Forsyth, R., & Dobson, H. (2007). Economic cost of difficult calvings in the United Kingdom dairy herd. Vet. Rec.161:685-687.

Mee, J. F. (2004). Managing the dairy cow at calving time. Vet. Clin. Food Anim. 20:521–546.

Mee, J. F. (2009). Bovine perinatology: Current understanding and future developments. In: Dahnof, L. T. (Ed.) Animal reproduction: New research developments. Nova Science Publishers, Inc., Hauppauge, NY, USA. pp. 67-106.

Meyer, C. L., Berger, B. J., & Koehler, K. J. (2001). Phenotypic trends in incidence of stillbirth for Holsteins in the United States. J. Dairy Sci. 84:515–523.

Palombi, C., Paolucci, M., Stradaioli, G., Corubolo, M., Pascolo, P. B., & Monaci, M.(2013). Evaluation of remote monitoring of parturition in dairy cattle as new tool for calving management. BMC Vet. Res. 9:191, doi: 10.1186/1746-6148-9-191.

R Core Team R. (2018). A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; https://www.R-project.org/.

Saint-Dizier, M., & Chastant-Maillard, S. (2015). Methods and on-farm devices to predict calving time in cattle. Vet. J. 205:349–356.

Schuenemann, G. M., Nieto, I., Bas, S., Galvão, K. N., & Workman, J. (2011). Assessment of calving progress and reference times for obstetric intervention during dystocia in Holstein dairy cows. J. Dairy Sci. 94:5494–5501.

Schuenemann, G. M., Bas, S., & Workman, J. D. (2015). Management practices for successful calving. WCDS Advances in Dairy Technologies27:301-316.

Sheldon, I. M., Cronin, J., Goetze, L., Donofrio, G., & Schuberth, H-J. (2009). Defining postpartum uterine disease and the mechanisms of infection and immunity in the female reproductive tract in cattle. Biol. Reprod. 81:1025–1032.

Szenci, O. (2003). Role of acid-base disturbances in perinatal mortality of calves: review. Veterinary Bulletin73:7R-14R.

Tenhagen, B. A., Helmbold, A., & Heuwieser W. (2007). Effect of various degrees of dystocia in dairy cattle on calf viability, milk production, fertility and culling. J. Vet. Med. A Physiol. Pathol. Clin. Med. 54:98–102.

Vannieuwenborg, F., Verbrugge, S., & Colle, D. (2017). Designing and evaluating a smart cow monitoring system from a techno-economic perspective. Internet of Things Business Models, Users, and Networks. Doi: 10.1109/CTTE.2017.8260982.

Vasseur, E,, Borderas, F., Cue, R. I., Lefebvre, D., Pellerin, D., Rushen, J., Wade, K. M., & de Passillé, A. M. (2010). A survey of dairy calf management practices in Canada that affect animal welfare. J. Dairy Sci. 93:1307–1315.

Chapter 4

GENERAL DISCUSSION

Ali Ismael Choukeir

University of Veterinary Medicine Budapest, Department of Obstetrics and Food Animal Medicine Clinic,2225 Üllő – Dóra major, Hungary

General Discussion

Monitoring of preparturient heifers and cows is essential to decrease mortality in newborn calves and to maintain health and production of dams. Depending on the severity of dystocia the total cost of loss may change between 150 and 600 EUR per cow (McGuirk et al., 2007).These economic effects are mainly related to animal health and welfare, which is very difficult to calculate. The surviving calves after dystocia are of enhanced susceptibility to stillbirth rate and postnatal mortality. The dams often suffer from direct trauma by injuries that occur during calving, such as rupture of the mucous membranes of the soft birth canal, which can result in phlegmone of the genital tract. These animals are also predisposed to RFM that have known effects, such as clinical or puerperal metritis and subsequent clinical endometritis. For both cows and heifers, the direct consequences of dystocia include an increased mortality rate and indirectly include decreased productivity and reduced fertility (including sterility), which often ends in an increased premature culling rate (Lombard et al., 2007).

Therefore, monitoring of peripaturient animals was the focus of several previous studies. Predicting the onset of calving and the early detection of the second stage of labour help to decide whether human intervention is needed during calving or not, and thus it enables the rescue of newborn calves and dams. Although all investigated methods may help to predict the time of calving, the inaccuracy and practical limitation of some of those may limit their use in the practice.

Detecting the onset of the second stage of calving

It has shown that the second stage of calving can be detected accurately by using intravaginal sensors in dairy farms where according to Chanvallon et al. (2012) the sensitivity of the thermometer to detect calf expulsion was 100% for both heifers and cows. This finding is consistent with our results 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).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 labour and on the progress and outcomes of calving in a large study population.As a result of detecting the onset of calving in our study, in harmony with the findings of previous studies (Palombi et al., 2013), animals received 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 labour 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 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 foetal hooves outside the vulva, therefore cows in the calving pen must be observed at least every hour 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 and 2 hourly observations, 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 behavioural changes, mainly bloody vaginal discharge and/or the appearance of amniotic sac and foetal hooves 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 increasing stillbirth rates (Saint-Dizier and Chastant-Maillard, 2015; Schuenemann et al., 2015). This may be one of the reasons why the prevalence of stillbirth was higher in our control group compared to animals with calving alarm thermometers (10.8% in heifer calving and 10.5% in cow calving). Somewhat higher stillbirth rates were reported for unmonitored heifers (16.7%) and cows (10%) in the calving barn also by Palombi et al. (2013).

Expectation the calving date

Several remote devices are available for dairy farmers to record decreases in body or vaginal temperatures for the prediction 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 (0.4°C). 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) suggested to use the intravaginal temperature 38.2°C as a cut-off value to predict calving within 24 hr because it can be more accurate (sensitivity: 86% vs. 66%) than a 0.21°C 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. The prediction of the date of parturition enables the farmer to be prepared for any assistant needs and give the dam a better environment for giving birth in the aim of minimizing the calving stress.

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 vaginal temperature 60 hr within 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).

References

Burfeind, O., Suthar, V. S., Voigtsberger, R., Bonk, S., & Heuwieser, W. (2011). Validity ofprepartum changes in vaginal and rectal temperature to predict calving in dairy cows. J. Dairy Sci.94:5053-5061.

Chanvallon, A., Leblay, A., Girardot, J., Daviere, J. B., & Lamy, J. M. (2012).Surveillanceautomatise des velages chez la vache laitiere. Proceedings of the Rencontresautour des Recherches sur les Ruminants, Paris, France, p. 408.

Lammoglia, M. A., Bellows, R. A., Short, R. E., Bellows, S. E., Bighorn, E. G., Stevenson, J. S., & Randel, R. D. (1997). Body temperature and endocrine interactions before and after calving in beef cows. J. Anim. Sci. 75:2526-2534.

Lange, K., Fischer-Tenhagen, C., & Heuwiese, W. (2017). Predicting stage 2 of calving in Holstein Friesian heifers. J. Dairy Sci. 100:4847-4856.

Lombard, J. E., Garry, F. B., Tomlinson, S. M., & Garber, L. P. (2007). Impacts of dystocia on health and survival of dairy calves. J. Dairy Sci.90:1751–1760.

McGuirk, B. J., Forsyth, R., & Dobson, H. (2007). Economic cost of difficult calvings in the United Kingdom dairy herd. Vet. Rec.161:685-687.

Ouellet, V., Vasseur, E., Heuwieser, W., Burfeind, O., Maldague, X., & Charbonneau, É. (2016). Evaluation of calving indicators measured by automated monitoring devices to predict the onset of calving in Holstein dairy cows. J. Dairy Sci. 99:1539-1548.

Palombi, C., Paolucci, M., Stradaioli, G., Corubolo, M., Pascolo, P. B., & Monaci, M.(2013). Evaluation of remote monitoring of parturition in dairy cattle as new tool for calving management. BMC Vet. Res. 9:191, doi: 10.1186/1746-6148-9-191.

Ricci, A., Racioppi, V., Iotti, B., Bertero, A., Reed, K. F., Pascottini, O. B., & Vincenti, L. (2018). Assessment of the temperature cut-off point by a commercial intravaginal device to predict parturition in Piedmontese beef cows. Theriogenology113:27-33.

Saint-Dizier, M., & Chastant-Maillard, S. (2015). Methods and on-farm devices to predict calving time in cattle. Vet. J. 205:349–356.

Sakatani, M., Sugano, T., Higo, A., Naotsuka, K., Hojo, T., Gessei, S., Uehara, H., & Takenouchi, N. (2018): Vaginal temperature measurement by a wireless sensor for predicting the onset of calving in Japanese Black cows. Theriogenology 111:19-24.

Schuenemann, G. M., Nieto, I., Bas, S., Galvão, K. N., & Workman, J. (2011). Assessment of calving progress and reference times for obstetric intervention during dystocia in Holstein dairy cows. J.Dairy Sci. 94:5494–5501.

Schuenemann, G. M., Bas, S., & Workman, J. D. (2015). Management practices for successful calving. WCDS Advances in Dairy Technologies27:301-316.

Chapter 5

SUMMARY

Ali Ismael Choukeir

University of Veterinary Medicine Budapest, Department of Obstetrics and Food Animal Medicine Clinic,2225 Üllő – Dóra major, Hungary

Summary

In Chapter 1 a short introduction is given on different protocols to predict the exact time of calving by measuring hormonal changes, or/and evaluating clinical signs (relaxation of pelvic ligaments, decrease in body temperature), recording feeding and rumination behaviour before calving, and determining the electrolyte concentrations in mammary gland secretion. Although these methods may help predict the exact time of calving, inaccuracy and practical limitations of some methods may limit their use in the field. On farm devices like inclinometers and accelerometers detecting tail raising and behavioural changes, abdominal belts monitoring uterine contractions, intravaginal thermometers detecting a drop in body temperature and/or the expulsion of the allantochorion, and devices fixed in the vagina or at the vulvar lips signalling calf expulsion via SMS are currently marketed for automated calving detection.

Due to the fact that there are paucity of information regarding the actual performance of marketed intravaginal thermometers, like Vel'Phone (Medria, France) used under field conditions, therefore, the aims of our study on the one hand was to evaluate the utility of an intravaginal thermometer as an automated method for prediction of calving in a Holstein-Friesian Hungarian dairy farm. We also, tested the effectiveness of an intravaginal thermometer in predicting calving in the field and to determine its impact on the health of dams and the survival of newborn calves.

In Chapter 2, the utility of a commercial intravaginal thermometer was evaluated as an automated method for the prediction of calving in a total of 257 healthy pregnant Holstein-Friesian female cattle. The accuracy and the sensitivity of predicting calving within 48 hr before calving were also evaluated. 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 (38.19°C: first interval 0 to 6 hr before calving vs. 38.78°C: twelfth interval 66 to 72 hr before calving), while the gender (*P* = 0.943), and the weight of the calf (*P*

= 0.610), twinning (*P* = 0.300), gestation length (*P* = 0.186), foetal presentation (*P*= 0.123), dystocia (*P* = 0.197) and retention of foetal membranes (*P* = 0.253) did not affect it significantly. 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%. It can be concluded that the investigated thermometer is not able to predict calving within 48 hr accurately; however, imminent calving can be accurately alerted.

In Chapter 3 the effectiveness of an intravaginal thermometer in the field prediction of the second stage of labor was assessed and its impact on the health of dams and newborn calves were determined. Holstein cows (n = 241) were randomly selected about 5 (mean $\pm$ SD: 4.7 ± 2.0) days before the expected date of calving and the thermometer was inserted into the vagina. Another 113 cattle served as controls. There was no false alarm during the experiment. 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. The prevalence of stillbirth was 7 times higher in cows with dystocia compared to cows with eutocia. 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. The results indicate that 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.

Finally in Chapter 4 the combined results of the studies in this thesis are discussed.

Novel scientific results

1. The intravaginal temperature changes from 72 hr before and up to calving was significantly ($P \leq .001$) 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. 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. 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. 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. 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.

ACKNOWLEDGEMENT

The completion of this thesis would have been impossible without the support of many individuals, to who I would like to express my most sincere gratitude. During this PhD, and my stay in Hungary, I have been very fortunate to be under the supervision of Prof. Szenci who was not just a supervisor for me but a guiding ideal and a great support, without his presence this work would never be completed.
Thank you Prof. Szenci for your support in the last years, I thank you for the possibility that you gave me to discuss all conflicts in a good and productive atmosphere. I appreciate the time you have spent teaching me and answering my questions with your heartiness and welcoming smile that simplify all difficulties and gave the push always forward.

Dear Dr. Kovács, I thank you a lot for helping me with the examinations and data collection as well as your suggestions. Finishing this dissertation was only possible with your support.

Dear Dr. Szelényi, I thank you for you for your initial support in this idea and for all possibilities I got by your help.

By the memmory of Dr. Buják, it was a great honour to work with him, his enthusiasm was always encouraging me, when we discussed the problems and new ideas of the work. I thank you a lot.

I would like to express my gratitude toward my family for the encouragement which helped me in completion of this dissertation. My beloved and supportive wife, Barbara who was always by myside when I needed her most, and my lovable children, Viktor and Izabella who served as my inspiration to pursue this undertaking.

My thanks and appreciations also go to my colleagues and people who have willingly

helped me out with their abilities.

Publications in peer-reviewed journals

1. Choukeir AI, Kovács L, Szelényi Z, Kézér LF, Albert E, Abdelmegeid MK, Baukje A, Aubin-Wodala M, Buják D, Nagy K, Szenci O. Effect of monitoring the onset of calving by a calving alarm thermometer on the prevalence of dystocia, stillbirth, retained fetal membranes and clinical metritis in a Hungarian dairy farm. Theriogenology, 2020.145.144-148.
2. Choukeir AI, Kovács L, Kézér LF, Buják D, Szelényi Z, Gáspárdy A, Szenci O. Evaluation of a commercial intravaginal device to predict calving in a Hungarian Holstein-Friesian dairy farm. Reprod Domest Anim 2020.55.1535-1540.
3. Szenci O, Lénárt L, Choukeir A, Szelényi Z, Buják D, Albert E, Kézér FL, Zouting Y, Kovács L. Ellések ellenőrzésének fontossága a halvaszületések csökkentése érdekében tejelő szarvasmarha állományokban: Irodalmi összefoglaló. Magyar Állatorvosok Lapja 2019.141.11-23.
4. Andela BG, Van Eerdenburg FJCM, Choukeir A, Buják D, Szelényi Z, BoldizsárSz, Kézér FL, Molnár L, Kovács L, Szenci O. Relationships among some serum enzymes, negative energy balance parameters, parity and postparturient clinical (endo)metritis in Holstein Friesian cows – Short communication. Acta Veterinaria Hungarica 2019.67.241-245.
5. Buják D, Szelényi Z, Choukeir A, Kovács L, Kézér FL, Boldizsár Sz, Molnár L, Szenci O. A Holstein-Friesian dairy farm survey of postparturient factors influencing the days to first AI and days open in Hungary. Acta Veterinaria Hungarica 2018.66.613-624.
6. Kovács L, Tőzsér J, Kézér F L, Ruff F, Aubin-Wodala M, Albert E, Choukeir A, Szelényi Z, Szenci O. Heart rate and heart rate variability in multiparous dairy cows with unassisted calvings in the periparturient period. Physiology & Behavior 2015.139.281-289.

International and national scientific meetings (presentations)

1. Choukeir IA, Szelényi Z, Kovács L, Kézér FL, Albert E, Aubin-Wodala M, Buják D, Gáspárdy A, Szenci O. Monitoring vaginal temperature of Holstein -Friesian cows from 72 hours before calving using a vaginal thermometer. In: Szenci O, Brydl E. (szerk.) A Magyar Buiatrikus Társaság 29. Nemzetközi Kongresszusa: Proceedings, Hévíz, Magyarország, 2019.178-179.
2. Szenci O, Choukeir A, Kézér F, Buják D, Szelényi Z, Kovács L. Recent research on prediction of time of calving in dairy cows. Reproduction in Domestic Animals 2019.54.60-60.
3. Szenci O, Lénárt L, Choukeir A, Szelényi Z, Albert E, Kézér FL, Kovács L. Ellések ellenőrzésének fontossága halvaszületések csökkentése érdekében tejelő szarvasmarha állományokban: Importance of monitoring calving to decrease stillbirth rate in dairy farms. In: Szenci O, Brydl E. (szerk.) A Magyar Buiatrikus Társaság XXVII. Nemzetközi Kongresszusa = 27th International Congress of the Hungarian Association for Buiatrics: Proceedings Budapest, Magyarország, 2017.59-70.

4. Szenci O, Choukeir A, Kovács L, Kézér LF, Albert E, Buják D, Gáspárdy A, Szelényi Z. Importance of monitoring the onset of calving by a calving alarm thermometer to decrease stillbirth rate in a Holstein-Friesian dairy farm. In: Mudron P, Tóthová Cs. (szerk.) XVII Middle European Buiatrics Congress: Proceedings Book, Košice, Szlovákia: Univerzita veterinárskeho lekárstva a farmácie v Košiciach (University of Veterinary Medicine and Pharmacy in Košice), 2017.43.
5. Buják D, Szelényi Z, Choukeir A, Kovács L, Kézér L, Boldizsár Sz. Szenci O. Periparturient factors influencing the length of the service period and the result of the first artificial insemination postpartum. XVI Middle European Buiatrics Congress, Hradec Králové, Csehország. 2016.62.
6. Buják D, Szelényi Z, Choukeir A, Kovács L, Kézér L, Boldizsár Sz. Molnár L, Szenci O. Az ellést követő elsőtermékenyítésig eltelt napok számát és a szerviz periódus hosszát befolyásoló tényezők Holstein-fríz szarvasmarháknál. Magyar Állatorvosok Lapja 2016.138(Suppl. I).367-367.
7. Choukeir A, Szelényi Z, Kovács L, Albert E, Abdelmegeid K, Baukje A, Aubin-Wodala M, Buják D, Kézér LF, Szenci O. Monitoring the onset of calving by a calving alarm thermometer and its effects on the newborn calves. Magyar Állatorvosok Lapja 2016.138(Suppl. I).343-344.
8. Szenci O, Choukeir A, Kovács L, Kézér LF, Albert E, Buják D, Gáspárdy A, Szelényi Z. Importance of monitoring the onset of calving by a calving alarm thermometer to decrease stillbirth rate in a Holstein-Friesian dairy farm. In: XXI CONGRESO ANEMBE DE MEDICINA BOVINA, Santiago de Compostela, Spanyolország, 2016, Paper: 272.
9. Buják D, Szelényi Z, Choukeir A, Kovács L, Kézér L, Boldizsár Sz, Lénárt L, Szenci O. Egyes biokémiai paraméterek összefüggése az involúció során jelentkező szövődményekkel, szaporodásbiológiai és termelési mutatókkal egy nagyüzemi Holstein-fríz tehenészetben. Magyar Állatorvosok Lapja 2015.137(Suppl. I).348.
10. Choukeir A, Foley N, Buják D, Kovács L, Kézér L, Lénárt L, Szelényi Z, Szenci O. Control of mineral metabolism in a Hungarian Holstein-Friesian dairy farm in the periparturient period. Magyar Állatorvosok Lapja 2015.137(Suppl. I).340.
11. Aubin-Wodala M, Kovács L, Albert E, Choukeir A, Szelényi Z, Bajcsy Cs, Szenci O. Comparison of postpartum metabolic profiles, milk yield and cyclic ovarian activity in dairy cows with and without complications during and after calving. XIV Middle European Buiatrics Congress, Varsó, Lengyelország, 2014.101-102.
12. Bajcsy ÁCs, Choukeir A, Aubin-Wodala M, HuszeniczánéKulcsár M, Tibold J, Mádl I, Szenci, Ottó. Characteristics of puerperal uterine contractility and hormonal status in subclinical hypocalcemic cows. In: David S Beggs (szerk.) Proceedings of the XXVIII World Buiatrics Congress: Oral communication and poster abstracts, Cairns, Ausztrália, 2014.110.
13. Boldizsár Sz, Szelényi Z, Buják D, Choukeir A, Kovács L, Kézér L, Szenci O. Az újszülött borjak sav-bázis egyensúlyának hatása a felneveléskori megbetegedésekre. In: Szenci O, Brydl E. (szerk.) A Magyar Buiatrikus Társaság 24. Nemzetközi Kongresszusa, Budapest, Magyarország, 2014.116-121.
14. Buják D, Szelényi Z, Choukeir A, Kovács L, Kézér L, Boldizsár Sz, Szenci O. Az involúció lefolyásának ellenőrzése egy nagyüzemi Holstein-fríz tehenészetben. In: Szenci O, Brydl E.

(szerk.) A Magyar BuiatrikusTársaság 24. NemzetköziKongresszusa, Budapest, Magyarország, 2014.236-242.

15. Choukeir A, Szelényi Z, Bajcsy ÁCs, Kovács L, Albert E, Aubin-Wodala, M, Kézér FL, Szenci O. Az ellés monitorizálása ellés előrejelző thermométer segítségével és annak hatása a születendő borjakra. In: Szenci O, Brydl E. (szerk.) A Magyar Buiatrikus Társaság 24. Nemzetközi Kongresszusa, Budapest, Magyarország, 2014.106-107.
16. Choukeir A, Szelényi Z, Bajcsy ÁCs, Kovács L, Albert E, Aubin-Wodala M, Boldizsár Sz, Szenci O. Monitoring the onset of calving with a calving alarm thermometer. XIV Middle European Buiatrics Congress, Varsó, Lengyelország, 2014.111-112.
17. Choukeir A, Szelényi Z, Bajcsy ÁCs, Kovács L, Albert E, Aubin-Wodala M, Boldizsár Sz, Szenci O. Monitoring the onset of calving by a calving alarm thermometer. In: Szenci O, Brydl E, Jurkovich V. (szerk.) A Magyar BuiatrikusTársaság 23. Nemzetközi Kongresszusa = 23rd International Congress of the Hungarian Association for Buiatrics: Proceedings, Siófok, Magyarország, 2013.111.
18. Kovács L, Jurkovich V, Szelényi Z, Kézér L, Tőzsér J, Abdelmegeid M, Choukeir A, Szenci O. A szívritmus és a paraszimpatikus tónus változása az ellés körüli időszakban tejelő teheneknél. In: Szenci O, Brydl E, Jurkovich V. (szerk.) A Magyar BuiatrikusTársaság 23. Nemzetközi Kongresszusa = 23rd International Congress of the Hungarian Association for Buiatrics: Proceedings, Siófok, Magyarország, 2013.91-92.