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Democratic and Popular Republic of Algeria
Ministère de l'Enseignement Superieur et de la Recherche Scientifique
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المدرســة الوطنيــة العليــا للبيطــرة

Order N° **: 011**

Domain: Natural and Life Sciences
Study: Veterinary sciences

Final study dissertation

For the attainment **of the Veterinary Doctor diploma**

TOPIC

Predictive methods to detect the onset of calving in dairy cows: a literature review

Presented by:
Miss: Dina Aridje MESSAI
Miss: Yousra KARI

Publicly supported on 03/07/2024, before the jury:

Mr LAMARA ALI	Pr (ENSV)	President
Mrs AOUANE Nedjma	MCB (ENSV)	Supervisor
Mr SOUAMES Samir	Pr (ENSV)	Examiner

Academic year 2023-2024

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DEDICATION

To my parents, for their enduring moral support, heartfelt prayers, and comforting presence that have been a constant source of inspiration.

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Dina.

DEDICATION

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Abbreviation's list

1. **HPA :** Hypothalamus-Pituitary-Adrenal.
2. **P4 :** Progesterone.
3. **E2 :** Oestradiol .
4. **PGF2α :** Prostaglandin F2 alpha.
5. **PGE2 :** Prostaglandin E2.
6. **CL :** Corpus Luteum.
7. **CRH :** Corticotropin-Releasing Hormone.
8. **ACTH :** Adrenocorticotropic Hormone.
9. **DMI :** Dry Matter Intake.
10. **CRL :** Crown-Rump Length.
11. **E1S :** Estrone Sulfate.
12. **E2β :** Estradiol 17-beta.
13. **AI :** Artificial Insemination.
14. **Mm :** millimeters

Abstract

Calving is a crucial event in the lifecycle of dairy cows, with significant implications for animal welfare and farm productivity. This literature review explores the types of calving, including eutocic anddystosic calving, and the various signs indicating the onset of calving. Traditional manual methods for detecting calving are examined for their effectiveness. The study then focuses on how technological advancements have enhanced calving detection through the use of specialized devices. These devices provide more accurate and reliable predictions, allowing fortimely interventions. The transition from traditional to technological methods in calving management represents a significant improvement in dairy farming practices, contributing to better outcomes for both cows and farmers.

Key words: Calving Prediction, Dairy Cattle, Calving Signs, Technological Advances, Calving Detection Devices, Farm Management.

Résumé

Le vêlage est un événement crucial dans le cycle de vie des vaches laitières, avec des implications significatives pour le bien-être des animaux et la productivité des fermes. Cette étude bibliographique explore les types de vêlage, y compris le vêlage eutocique et dystocique, et les divers signes indiquant le début du vêlage. Les méthodes manuelles traditionnelles pour détecter le vêlage sont examinées pour leur efficacité. L'étude se concentre ensuite sur la manière dont les avancées technologiques ont amélioré la détection du vêlage grâce à l'utilisation de dispositifsspécialisés. Ces dispositifs fournissent des prédictions plus précises et fiables, permettant des interventions en temps opportun. La transition des méthodes traditionnelles aux méthodes technologiques dans la gestion du vêlage représente une amélioration significative des pratiques de l'élevage laitier, contribuant à de meilleurs résultats pour les vaches et les éleveurs.

Mots-Clés : Prédiction du Vêlage, Vaches Laitières, Signes de Vêlage, Méthodes de Détection Traditionnelles, Avancées Technologiques, Dispositifs de Détection du Vêlage, Gestion de la Ferme.

ملخص

تعتبر الولادة حدثًا حاسمًا في دورة حياة الأبقار الحلوب، مع تداعيات كبيرة على رفاهية الحيوانات وإنتاجية المزارع. تتناول هذه الدراسة أنواع الولادة، بما في ذلك الولادة الطبيعية والعسيرة، والعلامات المختلفة التي تشير إلى بداية الولادة. يتم فحص الطرق اليدوية التقليدية للكشف عن الولادة من حيث فعاليتها. يركز الاستعراض بعد ذلك على كيفية تحسين التقدم التكنولوجي للكشف عن الولادة من خلال استخدام الأجهزة المتخصصة. توفر هذه الأجهزة تنبؤات أكثر دقة وموثوقية، مما يسمح بالتدخلات في الوقت المناسب. يمثل الانتقال من الأساليب التقليدية إلى الأساليب التكنولوجية في إدارة الولادة تحسينًا كبيرًا في ممارسات تربية الألبان، مما يسهم في تحقيق نتائج أفضل لكل من الأبقار والمزارعين

الكلمات المفتاحية: التنبؤ بالولادة، الأبقار الحلوب، علامات الولادة، طرق الكشف التقليدية، التقدم التكنولوجي، أجهزة الكشف عن الولادة، إدارة المزارع

.

Introduction

Calving is crucial for both animal welfare and farm economics, marking the beginning of lactation which is vital for milk production and profitability in the dairy industry **(Mee, 2008).** However, managing calving effectively remains a significant challenge. Early detection of calving signs traditionally relies on manual observation methods, which, despite being valuable, have notable limitations. These methods can be time-consuming and prone to errors, leading to delayed interventions and increased risks of complications **(Miedema *et al.*, 2011).**

The question then arises: how can we improve these limitations and save time for veterinarians, breeders, dams, and calves? The literature reveals various existing technologies designed to detect calving onset globally. These technologies range from traditional manual observation to advanced systems utilizing sensors and artificial intelligence **(Rutten *et al.*, 2013)**. Each method offers unique advantages and limitations, influencing their adoption and effectiveness in different farming contexts **(Ouellet, 2015).**

Despite these advancements, there is still a lack of a reliable, non-invasive, and easy-to-use method for predicting calving onset that can be seamlessly integrated into daily farm management practices. This highlights the main problem: the need for a more effective and efficient calving detection method.

Understanding these technologies is essential for developing innovative solutions that improve calving management practices **(Dizier et Maillard, 2015).** In this literature review, we explore the current landscape of calving detection technologies worldwide. By evaluating existing systems and methodologies, we aim to identify gaps and opportunities for enhancing calving prediction accuracy and timeliness.

Chapter I: General data on eutocia and dystocia calving's

1. Normal calving (Eutocia):

The calving period is the shortest phase of the peri-partum, yet poor management of calving can prove fatal for the calf, the mother, her productivity, and her future reproductive capability. It is therefore a critical period that must be mastered ***(Borowski, 2006)***.

1.1. Definition of normal calving:

Eutocia, originating from the Greek words Eu (meaning normal) + tokos (parturition) + ia, refers to a spontaneous calving following a normal gestation period, indicating the dam's capacity to naturally expel the foetus(es*)* ***(*Simões et Stilwell, 2021*),*** This process is a painful and stressful event for dairy cows, similar to other mammals **(Mainau et Manteca, 2011)**.

In dairy cattle, gestation typically spans from 277 to 287 days, varying based on factors such as breed, parity, occurrence of twinning, and the sex of the calf ***(*Matamala *et al.*, 2021*).*** For instance, in Holstein heifers and cows, the average gestation length was 278 and 279 days, respectively, with estimated standard deviations ranging from about 5 to 6 days **(Norman *et al.*, 2009)**, While gestation duration may vary slightly among different breeds of dairy cows, the processes leading to calving remain consistent for all cows, irrespective of their breed **(Mee, 2008).**

1.1.1 Hormonal induction of calving:

As gestation nears its end, various functional and morphological changes become crucial to prepare for and facilitate calving, ultimately leading to the birth of a live calf and the initiation of a healthy and successful lactation period. These changes are orchestrated by hormones influencing myometrial contractility, cervical dilation, lactogenesis, and specific maternal behaviours that support the newborn's survival outside the uterus **(Simões et Stilwell, 2021).**

Parturition is an endocrine event that depends on the activation of the foetal hypothalamus-pituitary-adrenal (HPA) axis, as demonstrated by the classical experiments conducted by **Liggins and colleagues** in the early **1970**s ***(*e.g., Liggins *et al.*, 1973*)*** in sheep. It is assumed that similar mechanisms operate in cattle ***(*Ball et Peters, 2004*).***

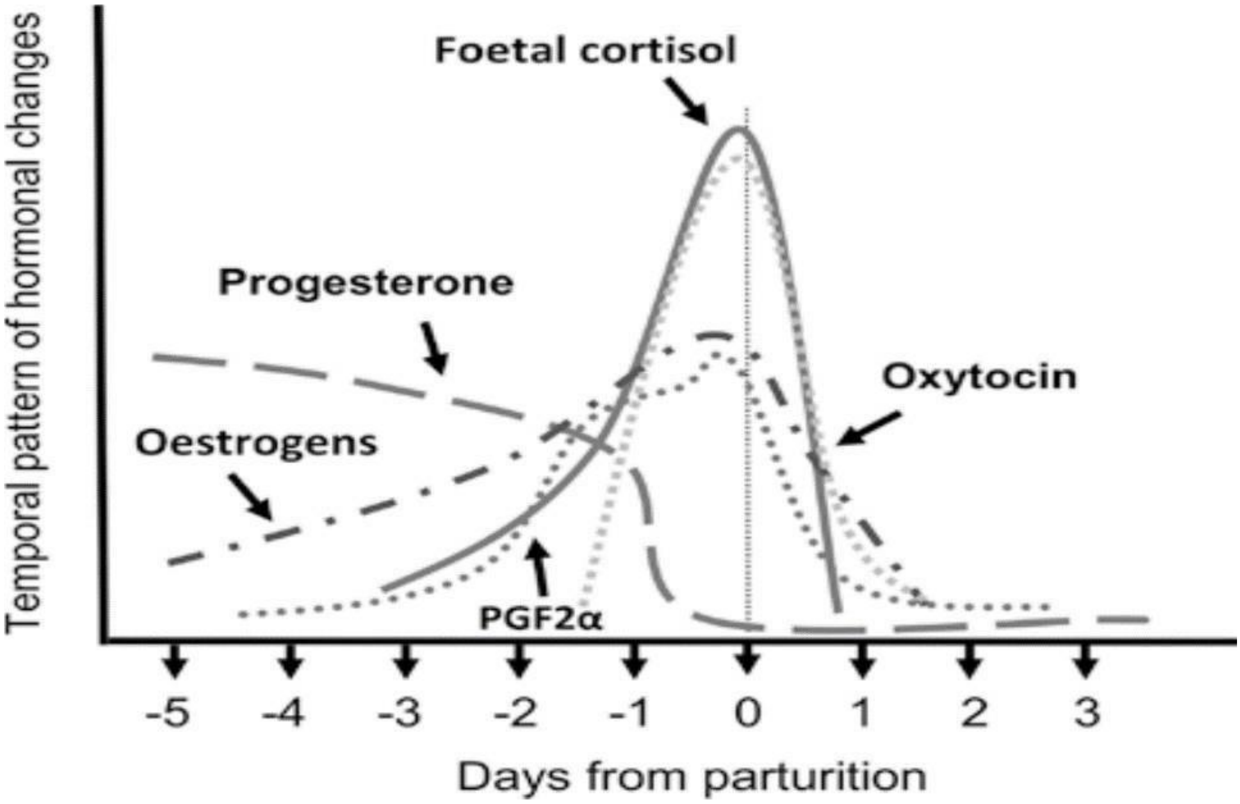

Figure 01: Relative hormonal changes during the peripartum **(Simões et Stilwell, 2021).**

The activation of the fetal HPA axis is fundamental for fetal cortisol release, which triggers the production of other hormones by the placenta, finally leading to an inversion in the progesterone (P4)/ oestradiol ratio **(Fig.1)**. It is thought that hormonal, biochemical, and physical stimuli act as stressors, thereby triggering these events **(Simões et Stilwell, 2021*).***

A. Maternal hormones :

a) Progesterone (p4) :

Progesterone is the key gestational hormone, primarily sourced from the corpus luteum **(Borowski, 2006)**. Between 150 and 200 days of gestation, the placenta becomes the primary source of progesterone production **(Arthur *et al.,* 1982).** Until the last month, when ovarian production becomes dominant ***(*Borowski, 2006*).*** Its effects include ***(*Simões et Stilwell, 2021*):***

- Indirect source of oestrogen precursors via C17,20 lyase enzyme.
- The decline in p4 levels allows for the increase in myometrial activity.

b) Oestradiol (E2) :

Estrogens are mainly produced by the placenta towards the end of gestation, and their plasma concentration increases ***(*Boroweski, 2006*)***. Its effects include **(Simões et Stilwell, 2021) :**

- Contributes to the formation of gap junctions in the myometrium, aiding ion and molecule passage.
- Stimulates the synthesis of PGF2α by the endometrium and increase the number of oxytocin receptors in the myometrium.
- Increasing myometrial contractions.
- Softening the cervix.
- Enhancing mucus secretion to dissolve the cervical seal.
- Increases vascular permeability in the mammary gland.

c) Prostaglandins:

Their primary source is found in the uterus. Their synthesis is believed to be under inhibitory control throughout the duration of gestation until the moment of parturition. Their action is very rapid and occurs towards the end of labor, with an increase in their concentration just before delivery **(Fairclough *et al.*, 1975).**

a. PGF2α **(Simões et Stilwell, 2021)** :

- Induces luteolysis of the corpus luteum (CL).
- Enhances myometrial activity and smooth muscle contraction while inhibiting the progesterone (P4) block.
- Disrupts feto-maternal contacts.
- Promotes the synthesis of relaxin.

b. PGE2 **(Simões et Stilwell, 2021)***:*

- Stimulates the final physiological modifications in the cervix, such as heightened water content and changes in the content or composition of proteoglycans, occurring shortly before or during parturition.

d) Relaxin :

is a protein hormone secreted at least in part by the ovary **(Ball et Peters, 2004).** It's involved in :

- Elevating collagenase activity and induces relaxation of the pubic symphysis, Sacrosciatic ligaments (facilitating pelvic expansion), and the cervix (resulting in cervical softening) **(Simões et Stilwell, 2021)**.

e) Oxytocin :

The secretion, triggered by stimuli from the pelvis **(Fuchs *et al.*, 1982)**, induces intense contractions of the myometrium smooth muscles, primarily through Ferguson's reflex, which is a neuroendocrine mechanism activated by stretching of the cervix and lower vagina during labour **(Vasicka *et al.*, 1978)**. This reflex stimulates the release of oxytocin from the posterior pituitary gland, promoting rhythmic contractions of the uterine smooth muscle (myometrium). These contractions facilitate labour progression and eventual delivery of the foetus, while also indirectly increasing pressure on the cervix due to the contents of the uterus **(Simões et Stilwell, 2021).**

B. Fœtal hormones :

At the level of the foetal HPA axis, corticotropin-releasing hormone (CRH) is released from the paraventricular nucleus of the hypothalamus, possibly in response to physiological stressors. This hormone triggers the production of pituitary adrenocorticotropic hormone (ACTH), which enhances the synthesis of foetal cortisol by the adrenal glands. Subsequently, cortisol is released into the circulation of both the foetus and the placenta as shown in **(Fig. 2).** Maternal cortisol levels also rise due to peripartum stress, transferring to the placenta. Foetal cortisol likely influences maternal changes in uterine contraction and aids in the onset of labour **(Simões et Stilwell, 2021).**

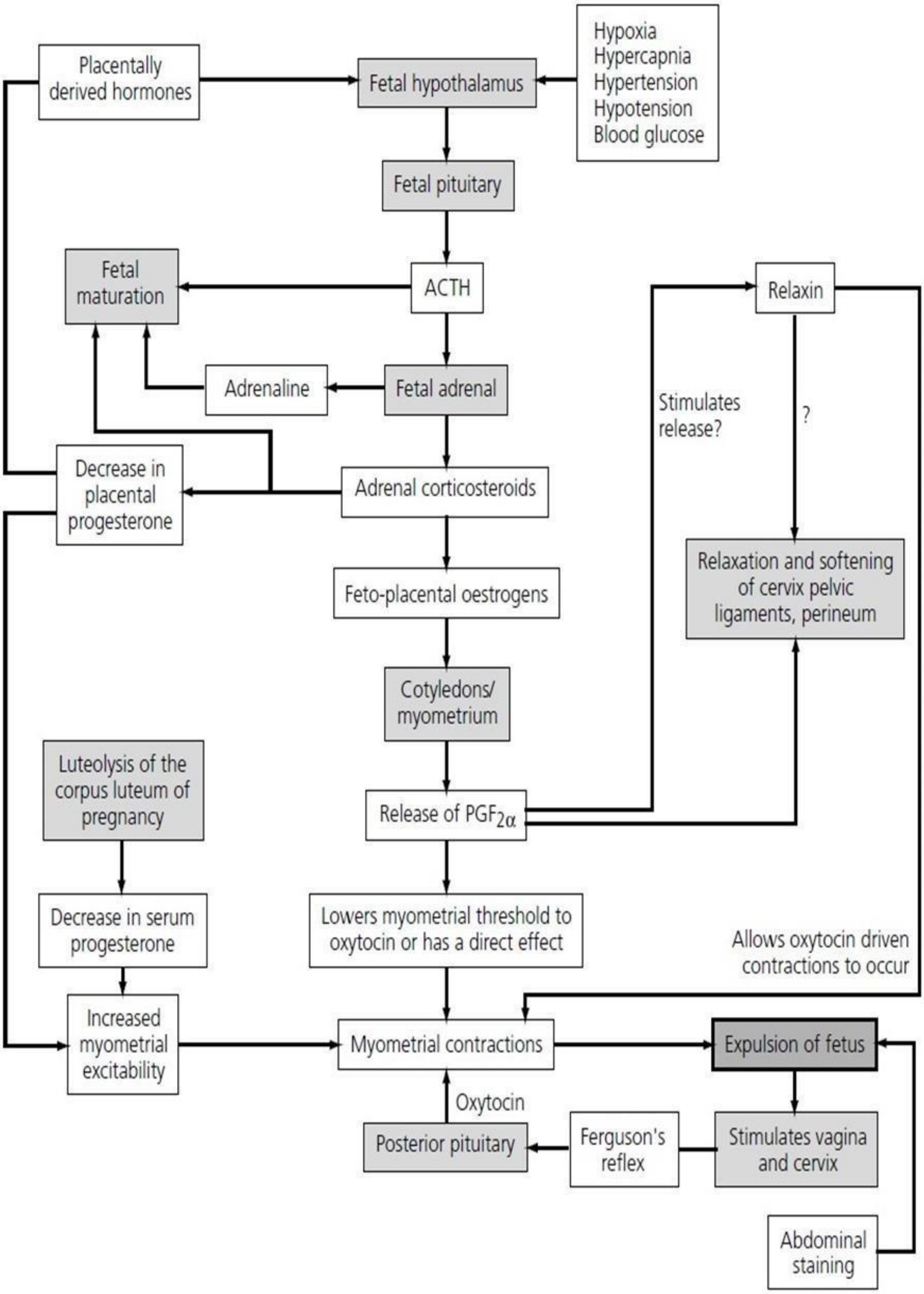

Figure 02: the endocrine changes that occur before and during parturition in the sow, ewe and cow, and their effects **(Arthur *et al.*, 1982).**

1.2. Stages of parturition:

The process of parturition is conventionally segmented into three phases, commonly known as the stages of parturition, which progress sequentially from one stage to the next ***(*****Wehrend *et al.*****, 2006; Miedema *et al.*****, 2011 Schuenemann *et al.*****, 2011*****)***. It culminates in the delivery of the calf and the expulsion of the placenta ***(*****Noakes, 2001; Schuenemann *et al.*****, 2011*****)***.

1.2.2 First stage (cervical dilatation phase):

Represents the time between the onset of more intense restlessness behaviour in the dam or the beginning of myometrial contractions, and the complete cervical dilation and/or the appearance of the chorioallantoic (allantoic) sac at the vulva **(Simões et Stilwell, 2021*)*.**

Main events on this stage:

- Initiation of myometrial contractions, their rate is usually 12–24 contractions per hour **(Gillette et Holm, 1963).**
- Increased restlessness behaviour.
- The cotyledonary attachments of the placenta start to loosen, and the cervix shortens and dilates, partly due to contractions, but also due to the breakdown of collagenous tissue ***(*****Fitzpatrick et Dobson, 1979*****)*.**
- The fetus rotates to its birthing position and transitions into the birth canal ***(*****Noakes, 2001*****)*.**
- Cervical dilation, including activation of the Fergusson reflex for mechanical enlargement ***(*****Simões et Stilwell, 2021*****)*.**
- Passage of the chorioallantoic sac (i.e., the first water bag) into the vagina, often followed by its rupture **(Simões et Stilwell, 2021).**

The diameter of a fully dilated cervix varies among individuals but can exceed 25 cm. Vaginal palpation allows for evaluation of cervical dilatation and comparison between cervical and pelvic diameter at both cranial and caudal ends of the cervix. However, maximum cervical and vulvar dilatation typically occurs during the passage of the foetus, which is the primary cause of pain during parturition **(Simões et Stilwell, 2021).**

Approximately 12 hours before the onset of the second stage, the duration, frequency, and amplitude of myometrial contractions increase and become more regular ***(*Mainau et Manteca, 2011).**

1.2.3. Second stage (foetal expulsion phase):

interval between the appearance of the chorioallantoic sac, or amniotic sac if the former ruptures within the birth canal, at the vulva and the complete expulsion of the foetus(es***)*** **(Simões et Stilwell, 2021*)*.**

- Onset of vigorous abdominal contractions, where 8–10 of these these are superimposed with the beginning of each myometrial contraction. During this stage, the frequency of myometrial contractions ranges from 24 to 48 per hour, resulting in nearly continuous contractions, as one contraction is swiftly succeeded by another ***(*Gillette et Holm, 1963; Zerobin et Spörri, 1972).**
- The amniotic sac typically appears either immediately before or after the onset of abdominal contractions. Calving progress is marked by the appearance of the calf's feet outside the vulva, followed by the nose and head in a front presentation or by the tail and pelvis of the calf in a posterior presentation. These indications of calving occur approximately every 15-20 minutes ***(Matamala et al.,*** **2021).**
- Complete delivery of the foetus or foetuses ***(*Schuenemann *et al.,* 2011*)*.**

The second stage is significantly longer for assisted cows and heifers, compared with unassisted animals ***(*Miedema *et al.,* 2011*)*.** And it lasts longer in heifers compared to cows, with an average duration of 54 minutes and 22 minutes, respectively ***(*Doornbos *et al.,* 1984*)*.**

1.2.4. Third stage (foetal membranes expulsion Phase):

The interval between from birth until the expulsion of the foetal membranes **(Noakes, 2001*)***, which normally should occur within the first 12-24 h after birth in both primiparous and multiparous cows **(Schuenemann *et al.,* 2011*)*.**

- Persistence of abdominal contractions Although a temporary pause has been recorded in the cow ***(*Gillette et Holm, 1963*).***
- Persistence of myometrial contractions; in general, they decrease in amplitude but become more frequent and less regular in duration ***(*Mainau et Manteca, 2011)**
- The weakening of the acellular adhesive protein layer, known as the "glue line," observed in cows between the cotyledonary and caruncular epithelium, likely plays a crucial role in ensuring placental separation ***(*Bjorkmann et Sollen, 1960)**.
- Loss of placental circulation occurs due to the rupture of the umbilical cord.
- Expulsion of the placenta.

1.3. Maternel behaviour:

In cattle, "maternal behaviour" refers to the range of behaviours exhibited by the dam before and after parturition, which facilitate offspring survival and performance **(Chenoweth *et al.*, 2014)**. Hormones such as oestradiol, progesterone, prolactin, and oxytocin play key roles in mediating the activation of maternal behaviour, alongside neural and neuroendocrine responses **(Bridges, 1984; Rosenblatt *et al.*, 1988)**. Additionally, sensory stimuli and experiential events throughout the female's lifetime influence the regulation of maternal behaviour **(Bridges, 2015)**.

Prior to parturition, cows often seek isolation by separating or hiding from other herd members to give birth in a calm environment ***(*Lidfors *et al.*, 1994*)***. Following the birth of the calf, cows devote significant time to licking the calf, a behaviour that stimulates the calf to stand, suckle, reduce heat loss, and establish the mother-offspring bond ***(*Keyserlingk et Weary, 2007*)***. Moreover, the act of licking has been observed to reduce the heart rate in the receiving cow, suggesting a role in alleviating discomfort **(Laister *et al.*, 2011)**. Studies indicate that older cows tend to initiate licking of their newborn calves sooner compared to first parity cows, indicating that maternal experience influences the motivation of cows to attend to their offspring and varies with parity number ***(*Le Niendre, 1989*;* Jensen, 2012*;* Campler *et al.*, 2015)**.

1.3.1. Fœtal presentation and position:

1.3.1.1 Presentation:

Presentation refers to the alignment of the foetal spinal axis with that of the mother. Presentation can take two forms: longitudinal or transverse. In the case of longitudinal presentation, the fetus can be oriented either cranially or caudally, while in transverse presentation, the orientation can be dorsal or ventral. The cranial longitudinal presentation is typically considered normal ***(*Norman et Youngquist, 2007*)*.**

1.3.1.2 Interior presentation:

In cattle, the typical presentation during birth is the anterior presentation, where the forefeet first, head resting on the limbs, and the eyes level with the knees **(fig 3)**. Any deviation from this position, such as the calf's head turned backward or one of its legs turned backward, is considered abnormal **(Selk et Sparks, 2008).**

Figure 03: Interior presentation **(Selk et Sparks, 2008).**

1.3.1.3. Posterior presentation:

In a posterior presentation, both of the calf's hind feet are visible, and the calf's spine is oriented upward, aligning with the cow's spine **(Fig 4)**. In this position, the soles or undersides of the hooves will be facing upward ***(*Selk et Sparks, 2008).**

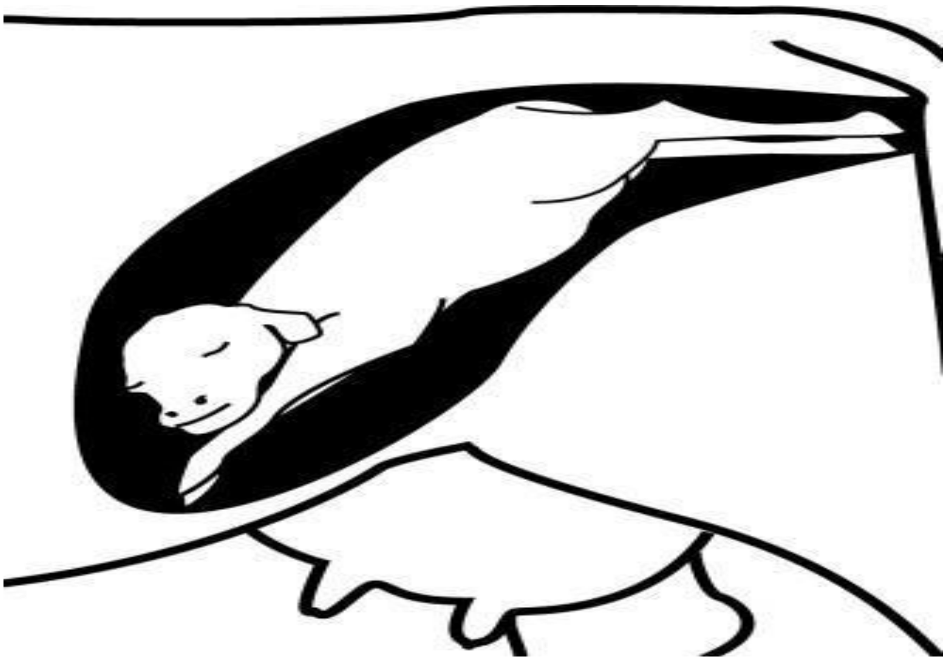

Figure 04: A posterior presentation **(Selk et Sparks, 2008)**.

1.3.2. Position :

Position refers to the alignment of the foetus's dorsum in relation to the quadrants of the maternal pelvis, which include the sacrum, right ilium, pubis, and left ilium. The dorsosacral position is typically considered the normal alignment **(Norman et Youngquist, 2007)**.

1.3.3.Posture :

Posture refers to the alignment of the foetal extremities, such as the head, neck, or limbs, in relation to its own body. These extremities can exhibit flexion, extension, or retention (often referring to the head). Retention can occur to the right, to the left, or above or below the foetus **(Norman et Youngquist, 2007).**

2. Difficult calving (Dystocia) :

2.1. Definition of dystocia:

Dystocia in cows refers to difficult or abnormal calving, often characterized by prolonged labour or complications during the birthing process **(Wehrend *et al.*, 2006).** It can result from various factors such as foetal malpresentation, inadequate uterine contractions, or maternal pelvic abnormalities **(Rajesh *et al.*, 2019*).*** Dystocia poses significant challenges to both cow and calf health and can impact productivity and welfare in dairy and beef production systems **(Rajesh *et al.*, 2019*).***

2.2. Signs of dystocia in cows:

Identifying the precise moment when eutocia transitions into dystocia can be challenging. Any noticeable or suspected deviation from the typical birthing process should be thoroughly examined. Specific indicators of dystocia include:

1. Prolonged, non-progressive first-stage labour.
2. Abnormal posture exhibited by the cow during the first stage of labour; in the case of uterine torsion, the cow may adopt a posture with a dipped back resembling a sawhorse.
3. Failure of the calf to be delivered within 2 hours after the appearance of the amnion at the vulva.
4. Clear instances of malpresentation, malposition, or maldisposition, such as the appearance of the foetal head without accompanying forelimbs, the tail without hind limbs, the head along with a single forelimb, or the presence of detached chorioallantois, foetal meconium, or blood-stained amniotic fluid at the vulva. Commonclinical signs of dystocia include the initiation of labour without the subsequent deliveryof the foetus and/or foetal membranes, followed by the receding of parturition signs. The cow may exhibit indications of mild discomfort, often adopting a rocking horse stance and displaying mild colic-like pain. These signs can be indicative of a dystocic situation that requires attention and intervention **(Jackson, 1995).** Additional clinical signs of dystocia may include partial anorexia, dullness, and depression in the affectedcow. Notably, one or both lips of the vulva may be drawn inward due to the torsion of the birth canal. When the cervix is fully dilated, it cannot be felt as a distinct structure but rather appears as a continuous extension of the vagina. However, in cases where the

cervix is incompletely dilated; it can still be palpated through a rectal examination. These physical findings help veterinarians assess and diagnose dystocia **(Purohit *et al.*, 2011).**

2.3. Behavioural changes associated with dystocia:

In their study, **Wehrend *et al* (2006)** observed a higher frequency of specific behaviours, such as rubbing against walls and scraping on the floor, among cows experiencing dystocia. This suggests that behavioral changes may occur in a subset of cows facing birthing challenges. **Proudfoot *et al* (2009)** similarly found distinct behavioral patterns in cows with dystocia, noting more frequent transitions from lying to standing and increased cumulative standing bouts in the 24 hours preceding calving. They identified a threshold of 34 standing bouts per 24 hours as indicative of cows likely to experience dystocia. Conversely, **Proudfoot *et al* (2009) and Barrier *et al* (2012)** reported that, in most cases, the presence of calving difficulties did not significantly alter the behaviour of cows during the 12 hours before calving. These findings underscore the variability in behavioral responses to calving challenges among dairy cows, highlighting the importance of further research to better understand and predict such responses.

Regarding lying behaviours closer to calving, **Barrier *et al* (2012)** observed no effect of calving difficulty on lying to standing transitions in the 6 hours preceding calving, while **Miedema *et al* (2011)** reported delayed increases in lying bouts in cows with dystocia compared to those with normal calving. Notably, tail-raising behaviours were more pronounced in cows with dystocia, occurring earlier and for longer periods before calving, as observed by **Miedema *et al* (2011), Barrier *et al* (2012)**.

Investigations into feeding, drinking, and rumination behaviours before parturition have been limited. **Proudfoot *et al* (2009)** found that, compared to eutocic cows, those experiencing dystocia spent less time feeding, had reduced dry matter intake (DMI), and consumed less water in the 24 hours before calving. They also identified individual DMI thresholds for predicting dystocia with reasonable accuracy.

Overall, cows with dystocia can be distinguished from those with normal calving based on various behaviours such as standing/lying patterns, tail-raising behaviours, feeding time, DMI, and water intake, particularly when monitored starting 24 hours before calving. There are promising developments in using technology such as accelerometers and automated image analysis systems for dystocia prediction, but further research is needed to validate these methods and develop practical on-farm devices **(Saint-Dizier et Chastant Maillard, 2015).**

Table 01: Behavioural changes before the onset of calving, association with dystocia **(Saint-Dizier et Chastant Maillard, 2015)**

Behaviour	Evolution before normal calving	Association with dystocia	References
Lying time	↓ the actual day of calving[a] ↑ in the final 2 h period[b]	No difference	Huzzey et al., 2005 Maltz and Antler, 2007 Miedema et al., 2011a and b Barrier et al., 2012 Gatien et al., 2012 Jensen, 2012
Overactivity	↑ steps and restlessness on the actual day of calving[a] ↑ head turns and stamping in the final 2 h period[b]	↑ restlessness in the final 4 h period in dystocia without calf malpresentation vs. eutocia or no difference	Owens et al., 1985 Maltz and Antler, 2007 Miedema et al., 2011a and b Barrier et al., 2012 Gatien et al., 2012 Jensen, 2012
Number of lying/standing transitions	↑ the actual day of calving ↑ in the final 4–6 h period, peak in the last 2 h[b]	↑ in the final 24 h period before dystocia vs. eutocia Later ↑ in lying frequency or no difference in the final 6 h period	Huzzey et al., 2005 Proudfoot et al., 2009 Miedema et al., 2011a and b Barrier et al., 2012 Jensen, 2012
Isolation	↑ the actual day of calving[a]	Not determined	Lidfors et al., 1994
Tail raising	↑ in the final 2–4 h period[b]	Earlier ↑ in the final 6 h before dystocia vs. eutocia	Miedema et al., 2011a and b Barrier et al., 2012 Gatien et al., 2012 Jensen, 2012
Lateral lying position with head rested	↑ in the final 4 h period[b]	No difference	Barrier et al., 2012
Abdominal contractions	↑ in the final 4–8 h period and peak in the last 2 h[b]	Earlier ↑, longer contractions and higher frequency before dystocia vs. eutocia	Barrier et al., 2012 Gatien et al., 2012 Jensen, 2012
Feeding time	↓ in the actual day of calving or no variation[a] ↓ in the final 6 h or 2 h period[b]	↓ in the final 24 h period before dystocia vs. eutocia	Proudfoot et al., 2009 Miedema et al., 2011a Barrier et al., 2012 Jensen, 2012 Schirmann et al., 2013 Büchel and Sundrum, 2014
Drinking time	No variation[a] ↓ in the final 2 h period[b]	No difference	Proudfoot et al., 2009 Jensen, 2012
Dry matter intake	Tendency to ↓ on the actual day of calving[a] ↓ in the final 6 h period[b]	↓ in the final 24 h period before dystocia vs. eutocia	Proudfoot et al., 2009 Schirmann et al., 2013 Büchel and Sundrum, 2014
Water intake	No variation[a]	↓ in the final 24 h period before dystocia vs. eutocia	Proudfoot et al., 2009
Ruminating time	↓ the actual day of calving[a] ↓ in the final 4–6 h period[b]	Not determined	Pahl et al., 2013 Schirmann et al., 2013 Calamari et al., 2014 Büchel and Sundrum, 2014

[a] Compared with preceding days.
[b] Compared with preceding hours on the actual day of calving, i.e. within 24 h before calving.
↑ increase; ↓ decrease.

2.4. Prevention:

Preventing and managing dystocia in dairy cows is crucial for minimizing losses in herds and can be achieved through effective herd management practices. While dystocia cannot always be predicted, its occurrence can be reduced with careful management. Identifying specific physical traits, environmental factors, or management practices that contribute to dystocia prevalence can aid in its management. Diagnosing dystocia requires a comprehensive approach, including monitoring and recording various parameters such as the growth of replacement heifers from weaning to calving, pelvic area measurements of yearling heifers, birth weights of calves, calf birth dates, pasture quality and quantity, daily rainfall, and assessing trace element status through suitable samples. This information allows for both prospective and retrospective assessments **(Abdela et Ahmed, 2016).**

Jason et al (2013) propose three avenues for reducing the prevalence and impact of dystocia:

1. **Prebreeding Management:** This involves selecting sires based on their calving ease and dams based on adequate pelvic size, a practice not commonly undertaken in the dairy industry. Additionally, heifers should be bred according to recommended height and weight, and they should receive optimal nutrition during pregnancy.
2. **Calving Time:** Ensuring that calving areas are comfortable and stress-free is essential. Providing assistance when necessary, using appropriate techniques and procedures can help mitigate dystocia during this critical period.
3. **Neonatal Assistance:** This involves providing maternal and additional care as required to stimulate respiration, maintain body temperature (thermoregulation), and increase blood volume through colostrum administration.

3. Importance of calving detection:

The detection of calving helps reduce the impacts of dystocia on the cow, the calf, and the dairy operation ***(*Shah *et al.*, 2006*;* Streyl *et al.*, 2011*;* Palombi *et al.*, 2013*).*** It allows monitoring the progress of the parturition process and intervening when necessary and at the right time **(Miedema *et al*, 2011*)***. Forecasting the onset of calving enables the evaluation of whether human intervention is needed, thereby facilitating the timely rescue of both newborn calves and their mothers ***(*Vasseur *et al.*, 2010*).*** Moreover, it helps avoid unnecessary or premature interventions, which can have harmful effects on the health of the cow and the calf **(Mee, 2004).** Indeed, the gestation period for dairy cows typically lasts an average of 280 days with a standard deviation of 7.5 days **(Meyer *et al*., 2001).** Therefore, the insemination date alone does not accurately predict the timing of calving. Typically, calving prediction involves observing or measuring indicators related to the approach of this event in dairy cows. A calving indicator is a measurable change (external, behavioural, or internal) with a consistent response across cows and recognized to be associated with the approach of calving in dairy cows **(Miedema *et al*, 2011).**

Regarding this matter, according to **Szenci (2008)**, calving detection in cows is of utmost importance for several reasons:

1. **Reducing Stillbirth Rate**: Monitoring calving allows for timely assistance during the birthing process, which can help reduce the incidence of stillbirths. Early detection of calving signs can lead to prompt intervention, potentially saving both the cow and calf.
2. **Optimizing Reproductive Performance**: Effective calving detection is crucial for achieving optimal herd reproductive performance, including maintaining a desirable calving interval and improving overall reproductive efficiency.
3. **Enhancing Calf Viability**: Timely detection of calving allows for immediate attention to new born calves, ensuring their well-being and increasing their chances of survival.
4. **Improving Milk Production**: Proper calving management, facilitated by accurate calving detection, can positively impact milk production per lactation, contributing to the overall productivity of the dairy herd.
5. **Preventing Complications**: Early recognition of calving signs can help prevent complications during the birthing process, such as dystocia, which can have negative effects on both the cow and the calf.

6. **Cost-Effectiveness**: Efficient calving detection can lead to cost savings by reducing the need for extensive veterinary interventions and treatments associated with birthing complications.

In conclusion, calving detection plays a vital role in ensuring the health and productivity of dairy cows, as well as in reducing stillbirth rates and optimizing reproductive performance in dairy farming operations.

Chapter II: Tools for Assisting in Calving Surveillance

1. Tools for calving prediction:

Optimal management of the herd plays a crucial role in enhancing reproductive efficiency and increasing the overall profitability of the farm. However, globally, there tends to be insufficient attention given to monitoring and aiding in the calving process, despite its paramount importance for both the mother and the new born. Instances of prolonged or challenging calving, referred to as dystocia, and inadequate timing of assistance, whether too late or too early, can have adverse effects on the welfare of the mother, her reproductive capabilities, and milk production. Furthermore, these factors can negatively impact the survival, development, and future performance of the calf **(Crociati e*t al.*, 2022).**

1.1. Visuel observation :

Predicting calving precisely is not a simple task. Indeed, the gestation period of dairy cows' averages 280 days with a standard deviation of 7.5 days **(Meyer *et al.*, 2001).** Therefore, the date of insemination alone does not allow for the precise prediction of the calving moment. Generally, calving prediction is done by observing or measuring indicators related to the approach of this event in dairy cows. A calving indicator is a measurable change (external, behavioral, or internal) with a consistent response among cows and is recognized to be associated with the approach of calving in dairy cows **(Miedema *et al.*, 2011).**

1.1.1 Relaxation of the sacro-sciatic ligaments:

Several studies have demonstrated that pelvic ligaments, specifically the sacro-sciatic ligaments, become increasingly relaxed approaching calving in cows **(Shah *et al.*,2006; Streyl *et al.*,2011).** It softens under hormonal influence (oestrogens: E1S, Oestradiol 17beta and Relaxin) **(Shah *et al.*, 2006).** 24 hours before calving, the relaxation of the Sacro sciatic ligament increased by 4.5 mm (millimetres) in primiparous cattle and 3.7 mm in multiparous cattle compared to the mean relaxation observed 24 hours earlier (with mean values of 21.8±7.7 mm for primiparous cows and 32.5±9.7 mm for multiparous cows) **(Mee, 2013).**

Figure 05: Examples of relaxation of the Sacro sciatic ligament before, the night and after the calving ***(Anonymous 1).***

1.1.2. Distention of the udder and colostrum leakage:

The udder increases in size and becomes firm due to internal pressure resulting from the development of glandular tissue and the accumulation of colostrum **(Simões et Stilwell, 2021)**. *Udder* distension in cows as shown in **(Fig.6)**, begins one to two weeks prior to calving, regardless of breed. Lower parity cows show earlier distension compared to higher parity ones. Approximately 70% of cows exhibit significant udder distension one to two days before calving, with an average onset of 36 hours before birth **(Berglund *et al*.,1987).** Colostrum leakage was observed in only 17% of the animals, on average 13 hours before calving **(Streyl *et al.*,2011).**

Figure 06: A pic taken night of due date of calving ***(Anonymous 01).***

1.1.3. Swelling of the vulva and discharge of mucus:

Vulvar oedema as shown in **(Fig 07)** serves as a clinical indicator of imminent calving, often correlating with birth occurring within 12 hours. This physiological swelling of the vulva is typically mild and manifests shortly before calving **(Cheong et Gilbert,2014).** In the days leading up to parturition, typically 1 to 3 days before, oestrogen hormones (E1S and E2) induce swelling of the vulva, resulting in an expansion along the dorsal to ventral commissure axis. This swelling enhances the vulva's elasticity, thereby reducing the likelihood of tissue tearing **(Simões et Stilwell, 2021)**.

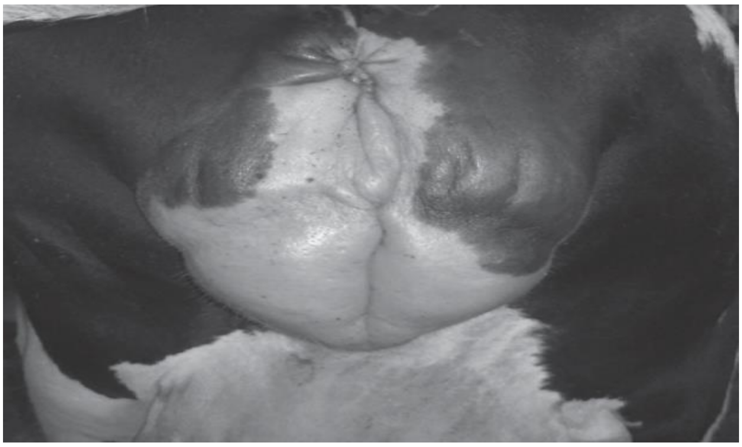

Figure 07: A cow exhibited significant vulvar oedema, noticeable one week before parturition. The oedema was initially observed 28 days before the due date and progressively increased in size until parturition **(Cheong et Gilbert, 2014).**

A mucus discharge was observed in only 38% of the animals. On average, this discharge is observed 64 hours before the onset of parturition **(Streyl *et al.*, 2011).** However, these two clinical signs vary greatly depending on the individual studied, as they can be observed at various times before calving. They are also only observable in a small proportion of cows. Therefore, they are not very promising for detecting calving in advance in dairy cows **(Ouellet, 2015).**

1.1.4. Isolation :

Indoor-housed dairy cows displayed a preference for a secluded calving site, particularly when housed alone in the pen and when calving during daylight hours. Among cows housed individually in shelters, the utilization of this area increased approximately 8 hours before calving. Similarly, for cows housed in pairs, separation from their pen partner also commenced around 8 hours before calving. These behavioral changes likely align with the onset of the first stage of labour. Given the chance, cows kept in individual maternity pens showed a preference for a secluded area when calving. They increasingly utilized this secluded spot in the hour leading up to calving and continued to favour it during the hour following calving **(Proudfoot *et al.*, 2014)**.

1.1.5. Transrectal Palpation :

Transrectal palpation, a traditional technique used for detecting calving in dairy cows, remains a cornerstone of reproductive management in many dairy operations. However, despite its historical significance and widespread use, challenges persist in its accuracy and reliability. Studies have shown that a notable proportion of cows within seasonal calving dairy herds may calve either prematurely or belatedly by more than 10 days in comparison to predicted dates derived from palpation-assisted foetal age estimation. This discrepancy raises pertinent questions regarding the factors influencing the efficacy of transrectal palpation. Factors such as the number of prior artificial inseminations and the age of the foetus at the time of diagnosis emerge as key determinants contributing to the observed variations. These findings underscore the inherent complexity of predicting calving dates solely through palpation techniques and highlight the need for further investigation into refining and enhancing the accuracy of this method. Additionally, precise pregnancy diagnosis scheduling within dairy farming management practices is essential. To address these challenges effectively, ongoing efforts are required to bolster training programs and improve the technical proficiency of practitioners involved in transrectal palpation. By doing so, we can strive towards optimizing the effectiveness of this traditional yet invaluable tool in the broader context of dairy herd management **(Matthews et Morton, 2012)**.

1.1.6. Ultrasound :

Ultrasound technology, renowned for its precision in modern dairy cow management, is instrumental in predicting calving dates with exceptional accuracy. Extensive research has investigated the efficacy of transrectal ultrasonography for this purpose. In the referenced study, it was found that over 90% of cows diagnosed pregnant through ultrasound calved within 10 days of the predicted date **(Brownlie *et al.*, 2016)**. Through transrectal ultrasonography, veterinarians' access comprehensive foetal development data, enabling precise measurements of parameters like crown-rump length (CRL) and cranial diameter for gestational age estimation **(Somnuk *et al.*, 2017)**. This data integration allows practitioners to calculate projected calving dates, typically based on an average gestation length of 282 days. However, the reliability of these predictions can be influenced by factors such as the age of the foetus at diagnosis, the timing of artificial insemination in relation to the mating period's conclusion, and the frequency of inseminations. Inaccuracies may occur, particularly with cows subjectedto multiple inseminations or those inseminated late in the mating period. Precise prediction of calving dates holds critical importance in dairy herd management, optimizing reproductive performance and overall productivity. Utilizing ultrasound technology facilitates informed decision-making regarding breeding strategies, nutrition, and veterinary interventions tailored to pregnant cows. In essence, ultrasound emerges as a pivotal tool, empowering stakeholders to implement targeted strategies that enhance the well-being of cows and offspring, thereby contributing to the sustainability and profitability of dairy operations. In comparison to manual palpation, ultrasound offers superior accuracy, providing visual and objective foetal measurements **(Brownlie *et al.*, 2016).**

1.1.7. Hormones :

Several tools measure hormones in cows' blood. The ELISA method quantifies progesterone or oestrogen in plasma. It's a qualitative method indicating the relative hormone concentration compared to a given threshold. For example, a low concentration of progesterone (< 2 ng/ml) may indicate calving within 24 hours, whereas a high concentration (> 2 ng/ml) may indicate no calving within 24 hours **(Matsas *et al.*,1992).**

Evaluated the concentrations of E1S and E2β during the gestation of Holstein cows to predict the onset of calving within 24 hours. Increased E1S levels in the last ten days before calving predicted less than 40% of calving's accurately, whereas an E2β concentration ≥ 1.25 ng/ml predicted the onset of calving within 24 hours with 76.5% accuracy **(Shah *et al.*,2006).**

The radioimmunoassay method is commonly used to measure hormones in the blood. This quantitative technique allows for the precise measurement of blood progesterone levels. A concentration of approximately 1.2 ng/ml measured by radioimmunoassay before calving is currently the most effective method for identifying cows likely to calve within the next twelve hours **(Streyl *et al.*, 2011).** However, this type of assay is time-consuming, expensive, and requires laboratory equipment **(Ouellet, 2015).**

1.1.8. Measurement of uterine and abdominal contractions:

Are measured using pressure sensors in the form of abdominal belts.

Abdominal contractions increase in the final 4 to 8-h period and peak in the last 2 h before normal calving and it increases Earlier with longer contractions and higher frequency when associated with dystocia **(Saint-Dizier et Chastant-Maillard, 2015)**.

1.1.9. Measurement of temperature :

Various factors can influence body temperature and the circadian rhythm, including weather conditions **(Webster *et al.*, 2008)**, heat stress, the efficacy of cooling methods and milking frequency **(Kendall *et al.*, 2008)**. Additionally, the physiological status of the animal, such as oestrus, pregnancy, and lactation can affect the daily temperature pattern of dairy cows ***(*Piccione *et al.*, 2003*;* Kendall et Webster, 2009*;* Burfeind *et al.*, 2011).**

Previous research has demonstrated that the body temperature of bovines can decrease by up to 1°C before the onset of the calving process **(Lammoglia *et al.*, 1997)**. Evaluating various anatomical locations for temperature measurement (including the vagina, rectum, skin, and reticulo-rumen) has supported this hypothesis, suggesting that body temperature could serve as a predictor of calving **(Aoki *et al.*, 2005*;* Burfeind *et al.*, 2011*;* Cooper-Prado *et al.*, 2011)**, and more recently ventral tail base surface temperature served as a predictor of calving within 24 h (**Koyama *et al.*, 2018). Burfeind *et al* (2011)** observed the persistence of the diurnal rhythm in body temperature, although the range was lower, with vaginal and rectal temperatures showing a decrease of 0.2–0.4°C 24–48 hours before calving. **Kovács *et al* (2017)**reported that reticuloruminal temperature decreased by 0.23 ± 0.02°C in dystocic cows 32 hours before calving, whereas in eutocic cows, this decrease occurred only 20 hours before delivery

(0.48 ± 0.05°C). Temperature is measured using different temperature logger's whether in the vagina, tail base, ear and reticulo rumen **(Szenci, 2022).**

1.1.10. Tail raising:

A tail raise is counted when the tail is lifted from the base and held in an elevated position away from the body till it returned to its relaxed position **(Miedema *et al.*, 2011). Miedema et al (2011)** noted that the frequency of tail raising increases both in terms of frequency and duration, during the 12 h before calving compared with the control in both multiparous and primiparous cows. Those same authors noted that this behaviour begins earlier in cows requiring assistance compared to those calving unassisted. Tail raising is measured using accelerometers and inclinometers placed on the tail base **(Crociati *et al.*, 2022).**

1.1.11. Cow behaviour study :

A. Rumination and feeding behaviour:

Are measured using Microphones and Accelerometers, Electromyography or pressure presented as neck collars, nosebands and ear tags **(Crociati *et al.*, 2022).**

a. Rumination behaviour :

A decrease in rumination time serves as an indicator of stress **(Herskin *et al.*, 2004)**, anxiety **(Bristow et Holmes, 2007),** and is frequently linked to various diseases in dairy cows **(Hansen *et al.*, 2003).**

Soriani *et al* (2012) observed a gradual decrease in rumination time during the week leading up to parturition. Additionally, on the day of calving, rumination time decreased by 3 hours compared to the dry period, Meanwhile, **Calamari *et al* (2014)** observed that the reduction in rumination time on the day of calving averaged 70% of the value observed during the dry period. Changes in rumination time around calving may be influenced by parity, although there is limited literature on this aspect, **Soriani *et al* (2012)** demonstrated that primiparous Italian-Friesian dairy cows housed in a free stall barn exhibit reduced rumination time compared to multiparous cows in the days preceding calving and during the calving process itself; this contrast is especially prominent in the week following parturition.

b. Feeding behaviour :

Cows have been noted to reduce their Dry Matter Intake (DMI) by around 30% on the day of calving around 24 hours to 6 hours before *parturition* **(Huzzey *et al.*, 2007; Proudfoot *et al.*, 2009; Schirmann *et al.*, 2013),** this decrease is accompanied by a reduction in the time cows spend feeding **(Huzzey *et al.*, 2007; Proudfoot *et al.*, 2009; Miedema *et al.*, 2011; and**

Schirmann *et al.*, 2013). Cows also spend less time at the water trough, resulting in reduced drinking time before calving **(Huzzey *et al.*, 2005; Jensen, 2012).**

This reduction can be attributed to a shift in the motivational priorities of the cow, as proposed by **Proudfoot *et al* (2009),** or to pain and discomfort associated with the onset of parturition, as suggested by **Huzzey *et al* (2007)** or due to the fact that the uterus, as well as the growing foetus, take up more and more space inside the animal **(Ouellet, 2015).**

c. Lying behaviour and activity :

Are measured using accelerometers listed in hindleg, collars, nosebands and ear tags (**Crociati *et al.*, 2022).**

d. The number of lying-down episodes:

A lying-down episode is defined as a period spent lying down preceded and followed by a period spent standing, walking, or pacing **(Miedema *et al.*, 2011; et Jensen, 2012).**

Miedema *et al* (2011) observed a significant increase in the number of lying-down episodes 24 hours before calving with 16.4 ± 4.8 episodes observed in the control cows and 24.2 ± 6.8 episodes in the pre-calving cows.

e. Lying time :

Lying time refers to the total duration spent in a reclined position within a defined timeframe, typically measured in hours or minutes **(Ouellet, 2015).** During the last 24 hours before parturition, there is a significant decrease in lying time **(Huzzey *et al.*, 2005; Miedema *et al*., 2011; Jensen, 2012)**. **Miedema *et al* (2011)** observed a decrease in lying time during the last 24 hours before calving (12.6 ± 1.8 hours) compared to the control period (13.6 ± 1.8 hours). Similarly**, Huzzey *et al* (2005)** and **Jensen (2012)** also reported a reduction of approximately two hours in lying time on the day of calving compared to measurements from preceding days as shown in table 02. This difference is likely attributed to the housing conditions of the animals. The animals in the studies by **Miedema *et al* (2011)** and **Jensen (2012)** were housed in pens with large straw-covered stalls, whereas the animals in the study by **Huzzey *et al* (2005)** were housed in free-stall barns with sand-bedded cubicles. It has been demonstrated by **Norring *et al* (2008)** that housing conditions influence the lying time of cows.

f) **Stamping behaviour:**

is assessed by quantifying the number of steps taken by the animals. A step is recorded when a cow lifts its hind hoof completely off the ground, irrespective of any accompanying body movement or propulsion **(Felton *et al.*, 2013)**, they also observed that both primiparous and multiparous gradually increase their stamping behaviour starting from one week before calving, reaching a peak on the day before calving.

Table 02: Behavioural changes observed before the onset of calving as reported for housed indoor or pasture dairy cows **(Matamala *et al.*, 2021).**

Behaviour	Behavioural measurement	Type of housing system	Result	Reference
Feeding	Dry matter intake	Indoor	↓ 24 h before calving	Huzzey *et al* 2007, Proudfoot *et al* 2009
			↓ 8 h before calving	Schirmann *et al* 2013
			↓ 6 h before calving	Büchel and Sundrum 2014
		Pasture	Not determined	
	Feeding time	Indoor	↓ 24 h before calving	Huzzey *et al* 2007, Proudfoot *et al* 2009
			↓ 8 h before calving	Schirmann *et al* 2013
		Pasture	Not determined	
Rumination	Rumination time	Indoor	↓ 24 h before calving	Soriani *et al* 2012, Calamari *et al* 2014
			↓ 8 h before calving	Borchers *et al* 2017
			↓ 6 h before calving	Büchel and Sundrum 2014, Ouellet *et al* 2016
			↓ 4 h before calving	Schirmann *et al* 2013, Pahl *et al* 2014
		Pasture	↓ 24 h before calving	Clark *et al* 2015
Lying	Lying time	Indoor	↓ 24 h before calving	Miedema *et al* 2011, Jensen 2012, Titler *et al* 2015, Ouellet *et al* 2016, Black and Krawczel, 2016
		Pasture	↓ 24 h before calving	Black and Krawczel, 2016, Rice *et al* 2017, Sepúlveda-Varas *et al* 2018, Hendriks *et al* 2019
	Transitions standing/ lying (lying bouts)	Indoor	↑ 4 h before calving	Jensen 2012
			↑ 6 h before calving	Miedema *et al* 2011, Ouellet *et al* 2016
			↑ 12 h before calving	Titler *et al* 2015
			↑ 24 h before calving	Black and Krawczel 2016
		Pasture	↑ 24 h before calving	Black and Krawczel 2016, Sepúlveda-Varas *et al* 2018, Hendriks *et al* 2019
			No difference	Rice *et al* 2017
Activity	Number of steps	Indoor	↑ 8 h before calving	Borches *et al* 2017,
			↑ 12 h before calving	Titler *et al* 2015
			↑ 24 h before calving	Black and Krawczel, 2016
		Pasture	↑ 24 h before calving	Black and Krawczel, 2016, Hendriks *et al* 2019
			No difference	Rice *et al* 2017
	Walking time	Indoor	↑ 24 h before calving	Miedema *et al* 2011
		Pasture	Not determined	
	Index activity	Indoor	↑ 6 h before calving	Jensen 2012
		Pasture	Not determined	
	Neck activity	Indoor	↓ 18 h before calving	Borches *et al* 2017
		Pasture	No difference	Clark *et al* 2015

↑ increase; ↓ decrease.

1.1.12. Video surveillance:

Cangar *et al* (2008) devised an algorithm for real-time automated monitoring of locomotion and posture in periparturient cows using online image analysis via video cameras. The algorithm achieved a correct classification rate of 85–87% compared to evaluations conducted by operators. This approach was further investigated by **Nabenishi *et al* (2021)** on a commercial beef cattle farm, demonstrating that camera image analysis could serve as a non-invasive method for assessing behavioural changes to predict the timing of calving.

2. Existing Devices Worldwide:

The figure below illustrates different options for sensor placement on the cattle's body, along with the primary devices offered by the industry **(Crociati *et al.*,2022).**

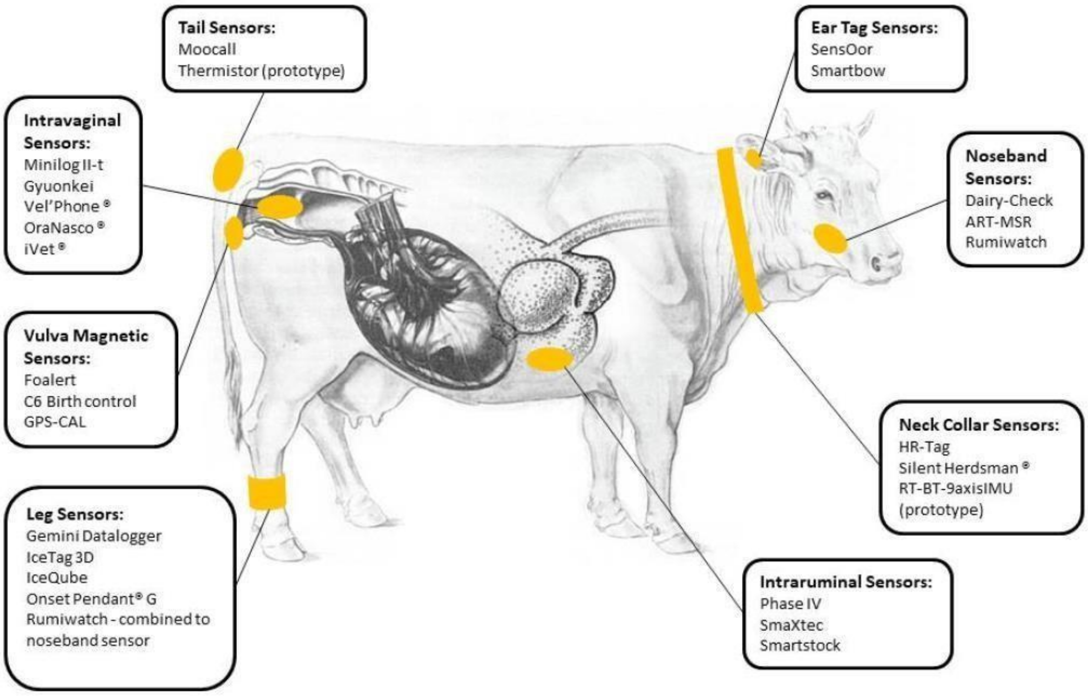

Figure 08: Utilization of existing devices for predicting calving in cattle ***(Crociati et al.,2022).***

2.1. Methods for Calving Detection: Traditional Approaches and Emerging Technologies:

The table below outlines various methods for calving detection. Traditional approaches such as evaluating external preparatory signs and transrectal palpation are still widely used in large dairy farms today. Additionally, it highlights several new possibilities, including measuring body temperature, detecting behavioural signs, and identifying the expulsion of devices inserted into the vagina.

Table 03: The various main calving detectors.

Tools	Device	Advantages	Inconvenient	Cost	References
Visual observation	**Eyes**	-No other expenses are needed. -Ease of implementation. -No risk of technical failure. -Absence of stress for the cow.	-Consuming a lot of time. -Imprecise and only allow the study of a limited number of cows. -Potential for Missed Signs. -Failure to intervene on time. -No data collection.	/	**(Schirmann, 2009)** **(Ouellet, 2015)**
Transrectal palpation	Veterinarian	- no need for sophisticated materials.	- Prediction of parturition in the 10 days. - subjective to each veterinarian. - accuracy varies (cow age / number of AI prior to pregnancy diagnosis).	Depends	**(Matthews et Morton, 2012).**

			- Knowledge of the cow's insemination history is essential. - difficult to realise on commercial farms.		
Ultrasound	Ultrasound	- objective measurements of the fetus.	- Prediction of parturition in the 10 days. - Knowledge of the cow's insemination history is essential. - accuracy varies (regions / cows age) - difficult to realise on commercial farms.	Depends	**(Brownlie *et al*, 2016)**
Hormones	- Laboratory	- prediction of parturition in the next 12 h	- Animal handling (blood sampling) - Time-consuming - Costly	Depends	**(Streyl *et al.*, 2011)** **(Shah *et al.*, 2006)** **(Ouellet, 2015)**

Temperature (vaginal)	**Vel phone** 	-Continuous monitoring. -Good sensitivity (98%) and specificity (100%) in the last hours before calving. -Ease of setup.	-Low sensitivity of early alerts, especially in primiparous cows. -Invasive. -Frequent loss of thermometer upon ejection (high additional cost).	**3500 €**	**(Chastant et Saint-Dizie, 2014)**
Tail raising	**Moocall** 		-Increased stress for primiparous cows. -Multiparous cows have lower tolerance for the device. -Issue of device loss or detachment. -False alarms.	**340€**	**(Górriz-Martín *et al.*,2022*)***
Cow behaviour	RumiWatch noseband-sensor and a hind limb accelerometer	- Prediction of parturition in the next 3 h. - The pedometers and noseband-	- high number of false positive alarms.	Not found	**(zehner *et al.*, 2019)** **(crociati *et al.*, 2022)**

	for rumination and activity measurements.	sensors were well tolerated.			
Video surveillance	Video cameras	-Non-invasive monitoring. -Remote monitoring. -Continuous monitoring. -Data collection.	-Privacy concerns. -High cost and infrastructure requirements for system setup. -Limitations in camera field of view. -Challenges in interpreting video data for calving sign detection.	**3500 to 5000€**	**(Hyodo *et al.*,2021)**

Conclusion

Our bibliographic study on calving detection has highlighted both significant advancements and existing challenges within this field. The strengths of our work lie in the comprehensive analysis of current technologies, providing an overview of the available methods for predicting the onset of calving. This includes a detailed understanding of sensors and machine learning algorithms, which show significant potential for improving the accuracy and speed of predictions.

However, our study also reveals certain weaknesses, particularly the limitations of current methods in terms of cost and technical complexity. In Algeria, the absence of these advanced devices is particularly notable, which limits the capabilities of farmers to adopt these innovative technologies. Economic constraints and a lack of technical training are additional barriers to the implementation of these systems.

Despite these challenges, significant opportunities emerge from our analysis. The rapid evolution of technology and the trend toward decreasing costs offer the possibility of making these innovations more accessible. Furthermore, in response to the identified needs, we have considered developing an Algerian device, Moonitor, which could provide a local solution adapted to the economic and technical constraints of Algerian farmers. This device would improve the accuracy and reliability of calving predictions, thereby transforming herd management and enhancing animal welfare.

However, certain threats must be taken into account. Increased reliance on technology involves risks such as system failures or data inaccuracies, which could compromise the effectiveness of detection methods. Additionally, farmers' reluctance to adopt new technologies and their attachment to traditional methods could slow the implementation of these innovations.

In conclusion, our bibliographic study highlights the promising potential of new technologies for calving detection, while also emphasizing the need to overcome economic and technical obstacles to encourage broader adoption. By continuing to explore and evaluate existing methods, we can identify opportunities to improve calving management, thereby ensuring animal welfare and farm profitability. The creation of an Algerian device, such as Moonitor, represents a promising step towards an effective and accessible local solution.

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