PSM
Veterinary Research

Review Article 2021 | Volume 6 | Issue 3 | 74-88

Open Access

Article Information

Received: October 12, 2021

Accepted: November 21, 2021

Online first: November 27, 2021

Published: November 30, 2021

Keywords
Chronic metritis,
Risk factor,
Small ruminants.

Authors' Contribution
JK and NYN supervised and designed the project, cross-checked the draft of the manuscript, and finally approved it for submission. CLMD conducted the project, collected data, analyzed data, and wrote the first draft of the manuscript. LCF read and revised the draft of the manuscript. All the authors approved the final draft of the manuscript for submission.

How to cite
Doumtsop, C.L.M., Kouamo, J., Njintang, N.Y., Fru, L.C., 2021. Chronic Metritis in Small Ruminants: A Review. PSM Vet. Res., 6(3): 74-88.

***Correspondence**
Justin Kouamo
Email:
justinkouamo@yahoo.fr

Chronic Metritis in Small Ruminants: A Review

Claude Landry Makuetamang Doumtsop[1], Justin Kouamo[1*], Nicolas Yanou Njintang[2], Landry Che Fru[1]

[1]School of Veterinary Medicine and Sciences, The University of Ngaoundere, P.O. BOX 454, Ngaoundere, Cameroon.
[2]Faculty of Sciences, The University of Ngaoundere, P.O. BOX 454, Ngaoundere, Cameroon.

Abstract:
The peri-partum period is a very delicate period in the life of reproductive females. During postpartum uterine involution, the uterus undergoes major changes. Infection by opportunistic bacteria is normal, almost systematic, but the natural defences usually eliminate these. When there is an imbalance between the self-defence capacity of the uterus and the pathogenicity of the bacteria, the latter can determine various uterine infections including chronic metritis. As metritis is a multifactorial disease, it is better to identify all the factors that increase the risk of the disease than to treat it. This review brings together the literature on risk factors for chronic metritis in small ruminants to explain the causal relationship between each risk factor and the disease. The prevention of chronic metritis requires the inclusion of these risk factors in the breeding strategy. Monitoring of reproduction by the veterinarian is therefore essential. In summary, some factors are specific to one form of chronic metritis and others are common to all chronic metritis, but all make the disease more severe and more frequent.

INTRODUCTION

The peri-partum period is considered particularly important in reproductive life because of its consequences on reproductive efficiency (uterine involution, start of ovarian activity, fertility). Uterine integrity in particular is often impaired in females due to bacterial contamination which is almost systematic shortly after parturition. Indeed, bacteria can be isolated from more than 90% of ruminants in the first two weeks postpartum (Paisley *et al.,* 1986). Most animals clear these germs within five weeks of parturition, but in 10-17% of cases, the persistence of these bacteria results in a uterine infection, which is diagnosed on general examination of the animal (LeBlanc *et al.,* 2002).

In practice, a distinction is made between two forms of uterine infection: puerperal metritis and chronic metritis or endometritis (Leblanc *et al.,* 2006); the former occurring between zero and 21 days postpartum and associated with general symptoms, and the latter occurring beyond 21 days postpartum and mostly without associated general symptoms (Lohuis, 1998).

Chronic metritis or endometritis, as opposed to puerperal metritis, does not cause general symptoms (Leblanc *et al.,* 2002). It appears from the third week postpartum. Uterine and cervical involution may or may not be complete. The inflammatory state of the uterus is characterised by oedema, mucosal congestion and extensive leukocyte infiltration. Abnormal (mucopurulent or purulent) contents of the uterine cavity may be present or absent. On pathological section, areas of desquamation with degenerative damage to the glandular areas, infiltration of the superficial epithelium, dilatation or hypoplasia of the glands and periglandular fibrosis can be seen.

It may be secondary to puerperal metritis or the direct consequence of ascending contamination of the genital tract by environmental bacteria.

Clinical endometritis, in its classic form, is characterised by the presence of mucopurulent or purulent discharge into the vagina from twenty-one days postpartum. This is in the absence of any other clinical signs (Sheldon *et al.,* 2006).

Subclinical endometritis is the presence of an inflammatory state of the endometrium in the absence of abnormal secretions in the vagina. It occurs after complete histological involution of the uterus. It is characterized by minimal or no exudate in the uterine cavity. The inflammatory state of the endometrium is not macroscopically detectable. It requires further investigation (Sheldon *et al.,* 2006).

Pyometra is the accumulation of pus in the uterine cavity. This accumulation is most often associated with a functional corpus luteum and consequently with complete or partial closure of the cervix. It usually occurs after the first ovulation. The uterus becomes increasingly distended on one or both sides. The purulent discharge is more or less permanent depending on the degree of opening of the cervix. The animal presents with anoestrus. The epithelium and glands are fibrosed. In rarer cases, pyometra may be accompanied by repercussions on the general state (weight loss, peritonitis, etc.); (Sheldon *et al.,* 2006).

The incidence of endometritis is 5% to 10% in dairy sheep and 1.5% to 3.2% in goats (El-Rheem, 2020). Clinical and subclinical endometritis negatively affects the performance of the global dairy industry; economic losses are related to delayed recovery of ovarian activity, increased number of services per conception, decreased milk yield and costs of treating the disease (Cheong *et al.,* 2011).

Endometritis is considered a multifactorial disease, with many factors having a direct or indirect, determining or predisposing influence (Potter *et al.,* 2010). Interestingly, findings regarding risk factors for endometritis vary considerably (Adnane *et al.,* 2017).

We will attempt to review the literature in relation to etiological agents and risk factors for chronic metritis in small ruminants in order to explain the correlation between each risk factor and chronic metritis.

PREVALENCE OF ENDOMETRITIS

The reported incidence of endometritis in small ruminants is highly variable. This variation may be due to differences in the definition of the term "endometritis" and the time in the postpartum period when females were examined. In a number of papers, the term "metritis" is used to include cases of endometritis (Martinez and Thibier, 1984).

Table 1. Prevalence of endometritis in the genital tracts of small's ruminants observed during large and small-scale abattoir surveys.

Authors (year)	Species	Incidence (%)
Kouamo et al. (2019)	Does and ewes	0.32
Kouamo and Asongafec (2020)	Does and ewes	3.2
Alosta et al. (1998)	Ewes	2.3
Dawood (2010)	Ewes	24.8
Sudhakar et al. (2010)	Ewes	0.49
Khodakaram and Davari (2013)	Ewes	2.93
Sharma et al. (2014)	Ewes	0.53
Beena et al. (2015)	Does	5.6
Borden et al. (2017)	Does	16.12

DETERMINING FACTORS

Etiology and pathogenesis

It is assumed that the uterus and its contents are sterile during normal gestation and prior to parturition, but that at or just after parturition the uterine lumen is contaminated with micro-organisms from the animal's environment, skin and faeces. The changes that occur during the normal puerperal period are: removal of bacterial contamination from the uterus, uterine involution, regeneration and repair of the endometrium, and return to normal ovarian cyclic activity in preparation for the next pregnancy. The presence and persistence of pathogenic organisms causing endometritis is thought to prevent the establishment of a pregnancy.

The fate of uterine infections depends on the self-defence capacity of the uterus on the one hand, and the virulence and number of bacteria on the other. There is a kind of equilibrium between the bacterial contamination and the animal's defence mechanisms (Sheldon, 2004). In most cases, the germs are gradually eliminated as the uterus involves and empties and through local defences such as mechanical mucus scavenging, antibodies and phagocytic cells.

Studies have classified the germs identified in the uterus during the postpartum period (Williams *et al.,* 2005). Thus, Arcanobacterium pyogenes (A.pyogenes), Prevotella spp., *Bacteroides spp., Porphyromonas spp., F. necrophorum, E. coli* can be qualified as pathogens. On the other hand, the following germs are recognised as potential pathogens or

simple opportunists: *Peptostreptococcus spp, Staphylococci spp, Streptococci spp, Lactobacillus spp, Bacillus spp, Proteus spp, Clostridium spp.* (Table 2).

Table 2. Classification of bacteria, isolated by aerobic and anaerobic culture, according to their pathogenicity, in the context of chronic metritis (Williams *et al.,* 2005)

MAJOR PATHOGENS	POTENTIALLY PATHOGENIC	OPPORTUNISTIC CONTAMINANTS
Arcanobacterium pyogenes *Bacteroides sp.* *Prevotella melaninogenicus* *Escherichia coli* *Fusobacterium necrophorum*	*Bacillus licheniformis* *Enterococcus faecalis* *Mannheimia haemolytica* *Pasteurella multocida* *Peptostreptococcus sp.* *Staphylococcus aureus* *Streptococcus* Non-hemolytic	*Clostridium perfringens* *Klebsiella pneumoniae subsp pneumoniae Proteus sp.* *Staphylococcus sp.,* coagulase negative *Streptococci* α-Hémolityque *Streptococcus acidominimus Aspergillus sp.*

Apart from these bacterial germs, which are the most commonly identified, other pathogens may be involved in the development of chronic metritis. This is the case, for example, with BHV-4 (Bovine Herpes Virus), which is recognised as having an immunosuppressive role (Frazier *et al.,* 2002), *Leptospira sp., Vibrio fetus, Trichomonas fetus* and *Brucella abortus, Haemophilus somnus, Mycoplasma sp.* and *Ureaplasma sp.* (Wittenbrink *et al.,* 1994).

The role of BHV-4 in uterine infections is still relatively unexplored. Donofrio observed, in vitro, that BHV-4 has a tropism for endometrial cells, causing a cytopathic effect (Donofrio *et al.,* 2007).

Synergy between pathogens of chronic endometritis

Endotoxins and liposaccharides released by coliforms in early postpartum conditions (post dystocia, retained placenta) could promote the subsequent establishment of *A. pyogenes* infection and gram-negative bacteria. Dohmen found that the presence of *E. coli* one day postpartum increased the prevalence of *Arcanobacterium pyogenes* and gram-negative anaerobes fourteen days after parturition (Dohmen *et al.,* 2000).

The virulence of a germ can also be externalised in association with other bacteria. Significant correlations have been demonstrated between *A. pyogenes* and *Prevotella spp* (bacteroides), and between *A. pyogenes* and *F. necrophorum*. In a study of 101 cows with chronic endometritis, *Prevotella spp* and *F. necrophorum* were found in 89% and 70% of samples positive for *A. pyogenes*, respectively, whereas they were only found in 54% and 45% of cows not infected with *A. pyogenes* (Dohmen *et al.* 1995).

The presence of *A. pyogenes* contributes to an increase in the severity and duration of endometritis, especially if it is concomitant with that of *Fusobacterium necrophorum* or *Bacteroides melanogenicus* (Dohmen *et al.,* 1995) and is present for more than one to two

weeks. The mechanism of this synergistic action has been the subject of several studies. It has been shown that *Bacteroides melanogenicus* releases a substance into the uterine environment that prevents phagocytosis and thereby inhibits the defence mechanisms of the uterus. Similarly, *Fusobacterium necrophorum* produces a leukotoxin that is toxic to phagocytes. However, these bacteria protect themselves and *A. pyogenes* from phagocytosis. Conversely, *A. pyogenes* produces a factor that stimulates the multiplication of *Fusobacterium pyogenes* (Roberts, 1986). However, these germs can only invade the uterine epithelium if it is damaged (Watellier, 2010). Some germs can also provide others with essential elements for their development such as vitamin K and growth factors (Watellier, 2010).

PREDISPOSING FACTORS

Endometritis varies depending on the method and day of diagnosis (Adnane *et al.,* 2017), determining the risk factors for endometritis will not be easy. In this part of the study, risk factors are classified into extrinsic and intrinsic factors.

Extrinsic factors

Season of the year

A retrospective longitudinal study of postpartum uterine infections was carried out in Denmark, where a significant correlation was found between clinical uterine infection during the first 30 days postpartum and the calving season (Bruun *et al.,* 2002). Although the retrospective study could not distinguish between clinical endometritis and metritis, the authors reported that calving between November and April significantly increased the incidence of clinical uterine infection during the first month postpartum (Bruun *et al.,* 2002). This relationship may be explained by the fact that during the rainy seasons, the general health of the animals decreases, making them more vulnerable to uterine infections (Parkinson 2009; Bruun *et al.,* 2002; Markusfeld 1984). Metritis is considered one of the most important risk factors for clinical and subclinical endometritis (Dubuc *et al.,* 2010), and the calving season has a significant indirect effect on the incidence of clinical and subclinical endometritis (Ghavi Hossein-Zadeh and Ardalan, 2011). In contrast, other authors found that clinical endometritis (Kim and Kang, 2003) and subclinical endometritis (Carneiro *et al.,* 2014) were not influenced by the calving season. These divergent results may be explained by the fact that the diagnostic criteria and climatic conditions were different between the studies, in particular, for example, the average environmental temperature, which was very different between the countries where the experimental work was conducted (Adnane *et al.,* 2017).

Nutrition

The amount and quality of protein in the diet plays a key role in the efficiency of the immune system (Badinand, 1975). Cellular immunity is also affected by the amount of protein in the diet; protein deficiency significantly reduces cellular phagocytosis (Bencharif and Tainturier, 2005). It should also be noted that excessive protein intake induces high serum ammonia, which reduces lymphocyte production and promotes the development of clinical endometritis (Sato *et al.,* 1995). Many vitamins are involved in immune system function, including vitamins B and C, which are involved in antibody synthesis, and vitamin C, which maintains the integrity of immune cell membranes and protects them from free radicals (Ducreux, 2003). Antioxidant deficiency contributes to prolonged and severe inflammation via activation of the NF-κB pathway and TNF production, the latter also influencing insulin resistance and exacerbating energy deficiency (LeBlanc, 2014). Vitamin A is important for epithelial tissue development and cell differentiation, which are very important in the early postpartum phase (Adnane *et al.,* 2017). Vitamin A also has immunological functions by enhancing the early inflammatory phase through increasing the number of macrophages at the site of injury, which improves the localisation and stimulation of the immune response in the event of uterine infection (MacKay and Miller, 2003). A variety of minerals are involved in the defence

mechanisms of the uterus (Mayer, 1978). Calcium acts as a complement activator and calcium deficiency delays uterine involution and prolongs uterine infection (Mayer, 1978). Calcium deficiency can be induced by excessive phosphorus consumption (Mayer, 1978). Magnesium is involved in opsonisation mechanisms (Badinand, 1975). Selenium is involved in neutrophil function and its deficiency affects the reproductive performance of the females and increases the risk of endometritis (Rutigliano *et al.,* 2008). Copper, zinc and iron are involved in lysosome production and their deficiency significantly reduces phagocytosis and promotes bacterial growth and the development of clinical and subclinical endometritis (Mayer, 1978; Badinand, 1975).

Intrinsic factors

Parity of the female

There are conflicting opinions regarding the relationship between the presence of endometritis and parity (Watellier, 2010). Some authors have found no significant association between clinical endometritis and parity, except for primiparous animals and animals with more than five parturitions (Chaffaux *et al.,* 1991). As primiparous are often prone to dystocia, endometrial lesions and clinical endometritis, such a relationship is not surprising (Potter *et al.,* 2010; Bruun *et al.,* 2002). It seems clear that the duration of endometritis is related to the severity of the initial uterine lesions (Adnane *et al.,* 2017). Older animals have reduced uterine elasticity and uterine involution is slower than in younger animals, which presumably increases the vulnerability of older females to persistent uterine infection and endometritis (Adnane *et al.,* 2017). However, this effect is counterbalanced by the fact that older female has experienced more episodes of bacterial contamination of the uterus, with the possibility of some immunological resistance to uterine infection (Adnane *et al.,* 2017). In the event of bacterial contamination, older female can effectively and rapidly clear bacteria from the uterus, whereas younger female may have had limited exposure, resulting in a delayed immune response and more severe and prolonged clinical and subclinical endometritis (Chaffaux *et al.,* 1991). Persistent uterine infection and clinical endometritis were less common in primiparous does than in multiparous does, as uterine involution was more rapid in the primiparous group (Chadio *et al.,* 2000). Similarly, Victor *et al.* (2019) found that age ($p = 0.03$) was a risk factor for endometritis in cows in Adamawa (Cameroon), and in this study the animals most at risk were older.

Dystocia

In females, dystocia is often associated with multiple postpartum complications, such as retained fetal membranes and delayed uterine involution, both of which undoubtedly favor the development of endometritis (Correa *et al.,* 1993; Markusfeld 1984). In a study of 27 Iraqi Goats, Al-Hamedawi (2011) confirmed that dystocia was a risk factor that significantly increased the overall incidence of pyometra in the first month after calving ($P < 0.001$). Giuliodori *et al.* (2013) confirmed the correlation between abnormal calving and clinical endometritis with an adjusted odds ratio (OR) of 2.2. Furthermore, dystocia indirectly increases the possibility of endometritis development by increasing the probability of metritis to ($P < 0.001$) (Ghavi Hossein-Zadeh and Ardalan, 2011). Abnormal calving and dystocia can induce endometrial trauma and assisted calving promotes the introduction of bacteria into the uterus and increases the potential for the development of clinical and subclinical endometritis (Bruun *et al.,* 2002). Calving assistance encountered in dystocia significantly increases the incidence of clinical and subclinical endometritis (Prunner *et al.,* 2014). Potter *et al*. (2010) also confirmed that calving assistance is a risk factor for clinical endometritis ($P > 0.05$). Interestingly, the birth of a male calf, which is often larger than a female, may increase the risk of dystocia and thus the risk of endometritis. These authors suggested that in the herd studied, the prevalence of endometritis could be reduced by 60% if all calves born were female. The high incidence in male calves is related to their size, which increases the risk of dystocia and the subsequent need for calving assistance. Ghavi Hossein-Zadeh and Ardalan

(2011) confirmed this correlation with an OR of 2.4.

Retention of fetal membranes

Retained placental tissue is the main significant risk factor for pyometra in Iraqi Goats (Al-Hamedawi, 2011). Other authors have confirmed this causality in the case of metritis and clinical endometritis with ORs of 27.7 and 40.3, respectively (Ghavi Hossein-Zadeh and Ardalan 2011; Potter *et al.,* 2010). The residual tissue encountered in retained placenta provides a favorable environment for bacterial growth in the uterus and necrotic tissue delays uterine involution and endometrial repair (Al-Hamedawi, 2011). In addition, residual tissue can lead to an open cervix and increased bacterial contamination of the endometrium (Potter *et al.,* 2010; Kim and Kang, 2003). A positive correlation between a retained placenta and subclinical endometritis appears to be due to impaired neutrophil function (Salasel, 2010). Indirectly, length of gestation induced calving, twins and stillbirth increase the prevalence of clinical and subclinical endometritis by promoting retention of fetal membranes. A study of 2017 calvings over 1 year concluded that primiparous cows with prolonged gestation (>270 days) had a higher risk of developing metritis and clinical endometritis than those with normal gestation length (Markusfeld, 1984). In addition, multiparous cows with short gestation were more vulnerable to the most important risk factor for clinical and subclinical endometritis, retained placenta, than those with long gestation (Potter *et al.,* 2010; Morton and Butler, 1995). Ghavi Hossein-Zadeh and Ardalan (2011) reported that cows with short gestation (<270 days) were four times more likely to have retained placenta (OR: 3.8) than cows with normal gestation length (270-280 days).

Induced calving directly and indirectly affects the incidence of endometritis by increasing the risk of metritis, metabolic disorders, retained placenta and stillbirth (Benedictus *et al.,* 2011; Morton and Butler, 1995). Calving induction with dexamethasone negatively affects chemotactic and phagocytosis activities and, as a result, cotyledon disengagement is reduced and placental retention is enhanced, increasing the risk of developing clinical and subclinical endometritis (Benedictus *et al.,* 2011). The birth of twins has often been considered a risk factor for uterine infection (Adnane *et al.,* 2017) as it may indirectly increase the prevalence of clinical and subclinical endometritis by promoting the development of other uterine diseases known as potential risk factors for endometritis. It appears that the incidence of retained placenta was higher in cows with twins than in those with a single calf (35.7% versus 7.7%, respectively) (Muller and Owens, 1974). Potter *et al.* (2010) confirmed this observation and stated that the birth of twins was strongly correlated with retention of fetal membranes. It is showed that cows with twins were six times more likely to develop metritis (OR: 6.5) and three times more likely to develop retained placenta (OR: 2.7) than cows with singletons (Ghavi Hossein-Zadeh and Ardalan, 2011). Calculating the odds ratio using univariate conditional logistic regression, Potter *et al.* (2010) found that twins were associated with clinical endometritis with an OR of 5 (P = 0.003). Twin birth, dystocia and associated trauma promote bacterial contamination of the uterus and increase the risk of developing retained placenta, metritis and clinical endometritis (Dubuc *et al.,* 2010; Sheldon and Dobson, 2004). However, Prunner *et al.* (2014) found that twins were not significantly associated with clinical endometritis, although the small number of twin births in their study (n = 18/400) may explain the failure to demonstrate any relationship. Markusfeld (1984) reported a relationship between stillbirth and subsequent uterine infection and proposed that stillborn cows are often exposed to retained placenta and metritis. The relative risk of stillbirth on the incidence of clinical endometritis was 3.1 (Potter *et al.* (2010). Indirectly, stillbirth increases the risk of clinical and subclinical endometritis by increasing the incidence of metritis with an OR of 6.3 (Ghavi Hossein-Zadeh and Ardalan, 2011). Placental immaturity associated with the reduced duration of pregnancy seen in stillbirths may also be part of the cause of retained placenta, metritis and endometritis (Laven and Peters, 1996).

Metritis

Until relatively recently, metritis and endometritis were not considered to be two distinct clinical conditions (Bruun *et al.,* 2002; Correa *et al.,* 1993). Currently, however, it would be inexcusable not to distinguish between these two uterine conditions (Sheldon *et al.,* 2009; Sheldon *et al.,* 2006). It is clear that almost all goat and sheep develop metritis without any systemic signs after calving. There is then a divergence: some females return to normal while others develop puerperal metritis with systemic signs (Sheldon *et al.,* 2006), and female that continue to have a contaminated uterus after the third week postpartum develop clinical or subclinical endometritis. Animal that developed metritis shortly after calving were more likely to develop clinical endometritis with an OR of 2.3 (Dubuc *et al.,* 2010). Cheong *et al.* (2011) confirmed this correlation and reported that metritis was a risk factor for subclinical endometritis with an OR of 1.9. It seems that there is a positive correlation between the degree of clinical signs of metritis and the risk of developing endometritis. Giuliodori *et al.* (2013) worked on 303 dairy cows and reported that cows with puerperal metritis were more likely to develop clinical endometritis than those with clinical metritis (OR: 2.2 vs. 1.4, respectively). As the relationship between metritis and endometritis appears to be strong, any risk factor that favors the development of metritis shortly after calving may indirectly increase the risk of developing endometritis. Ghavi Hossein-Zadeh and Ardalan (2011) found that dystocia (OR: 4.3), stillbirth (OR: 6.6), retained placenta (OR: 27.7), twins (OR: 6.6), primiparity (OR: 1.7), winter calving (OR: 2.4) and male calves (OR: 2.4) significantly affected the risk of developing metritis.

Hypocalcemia

Insufficient calcium mobilisation at the time of calving results in hypocalcaemia. As calcium is an important component of the uterine involution process, any deficiency delays this process and is considered a risk factor for retained fetal membranes (OR: 3.6), and can affect the incidence of metritis and endometritis (Ghavi Hossein-Zadeh and Ardalan, 2011) and the severity of endometritis (Whiteford and Sheldon, 2005). Metabolic disorders, including hypocalcaemia, can significantly affect the incidence of clinical endometritis (OR: 3.5, 95% CI: 1.1-10.8, P = 0.03) (Kim and Kang, 2003). Other authors have confirmed that hypocalcaemia reduces uterine contractions, causes dystocia, prolongs gestation and increases the risk of placental retention and endometritis (Roche, 2006; Guterbock, 2004). In addition, subclinical hypocalcaemia decreases rumen motility, leading to reduced feed intake, which increases the risk of ketosis, and since hypocalcaemia can affect rumen motility (Adnane *et al.,* 2017), it may indirectly increase the risk of developing displaced abomasum (1.41). However, the effects of a displaced abomasum on the incidence of endometritis are not yet well understood (Adnane *et al.,* 2017). Curtis *et al* (1985) and Markusfeld (1987) reported a significant correlation between displaced abomasum and clinical endometritis with ORs of 3.6 and 4.7, respectively, but in these two studies it was not possible to distinguish clinical endometritis from metritis. Kim and Kang (2003) examined the effect of metabolic disorders on the occurrence of clinical endometritis and concluded that metabolic disorders (displaced abomasum, hypocalcaemia, and ketosis) significantly increased the prevalence of clinical endometritis in dairy cows (P < 0.03). As these authors (Kim and Kang, 2003) included all three metabolic disorders in one variable, the interpretation of the correlation between displaced abomasum and clinical endometritis is difficult. Although metabolic problems can significantly affect the occurrence of retained fetal membranes and this is considered a risk factor affecting the incidence of endometritis, Cheong *et al.* (2011) found that this correlation was not always significant.

Mastitis

Mastitis represents a source of bacterial contamination in the environment that can promote the development of endometritis. Often, the bacteria isolated in uterine infections are non-specific, often environmental bacteria that contaminate the uterus during parturition

(Madoz *et al.,* 2014). Indirectly, risk factors for mastitis are sometimes considered as risk factors for endometritis. These include retained placenta (OR: 9.4), milk fever (OR: 12.4), multiparity (OR: 2.8) and winter calving (OR: 1.7) (Ghavi Hossein-Zadeh and Ardalan, 2011). Subclinical mastitis can directly and significantly influence the prevalence of subclinical endometritis at 30 days postpartum and 60 days postpartum with ORs of 4.5 and 3.6, respectively (Bacha and Regassa, 2010). Even though the mastitis odds ratio for the prevalence of clinical endometritis is greater than 1, sometimes the relationships are not statistically significant (Potter *et al.,* 2010).

Negative energy balance

A negative energy balance (NEB) is often associated with severe and prolonged uterine inflammation and delayed uterine involution, which appear to be associated with a lack of bacterial destruction after ingestion by phagocytes (Ingvartsen and Moyes, 2013; LeBlanc *et al.,* 2011; Hammon *et al.,* 2006). NBE promotes the development of many metabolic disorders, including ketosis, which can increase the major risk factors for endometritis, namely placental retention and metritis, by a factor of 6.1-9.5 (Markusfeld, 1987). Subclinical ketosis has been considered an entry condition for many metabolic disorders such as clinical ketosis and displaced abomasum, and for infectious problems such as metritis and mastitis (Suthar *et al.,* 2013). In early lactation, female require a significant amount of glucose to produce lactose, and these requirements are maximal after the third week postpartum. During this period, animal have an insufficient appetite to consume the necessary energy. The lack of energy leads to lipid mobilisation and accumulation of ketones which can reach toxic concentrations and reduce immune function and increase the risk of endometritis (Dohmen *et al.,* 2000; Goff and Horst, 1997).

In vitro studies have shown that high concentrations of ketones in plasma significantly and negatively reduce the efficiency of the non-specific immune system of sheep, including phagocytosis and neutrophil chemotaxis (Sartorelli *et al.,* 1999). According to Kim and Kang (2003), metabolic disorders, including ketosis, significantly affect the prevalence of clinical endometritis.

Lipid mobilisation induces accumulation of non-esterified fatty acids (NEFA), which increases the potential for endometritis in 80% of cases and contributes directly to a strong inflammatory response by binding to Toll-like receptor 4 (TLR4) and triggering an inflammatory cascade through TNF(tumor necrosis factors)(LeBlanc, 2014). Furthermore, elevated NEFA levels in the postpartum period increase the risk of clinical endometritis with an adjusted OR of 1.0 ($P < 0.05$) (Giuliodori *et al.,* 2013). Elevated circulating plasma NEFA induces hepatic steatosis (fatty liver) and impairs polymorphonuclear function, including phagocytosis (Ingvartsen and Moyes, 2013). Decreased intake capacity, NEB and lipid mobilisation actively contribute to poor immune function from 2 weeks before calving to 3 weeks after calving (LeBlanc *et al.,* 2011).

High-yielding dairy cows are more exposed to the effects of NEB and are more likely to develop endometritis (Cheong *et al.,* 2011; Markusfeld, 1984). As the postpartum period is characterised by low feed intake capacity, NEB and lipid mobilisation, metabolic disorders and hepatic steatosis are common and reduce the efficiency of the immune system (LeBlanc *et al.,* 2011; Goff and Horst, 1997). In addition, the altered anatomical, histological and cytological properties of the reproductive tract expose animal to a wide range of bacteria when the immune system is 'off' and prolonged endometritis can therefore develop.

According to Chaffaux *et al.* (1991), high milk yield seems to reduce the prevalence of clinical endometritis, but Giuliodori *et al.* (2013) found that animal with clinical endometritis had significantly higher milk production than animal without endometritis (27.8 ± 0.9 versus 25.7 ± 0.4 kg/day, $P = 0.04$). For the subclinical form, reported that increasing milk yield increased the risk of subclinical endometritis in primiparous cows but decreased the risk in multiparous cows (Cheong *et al.,* 2011). We believe that the

prevalences of clinical and subclinical endometritis are not influenced by the milk yield of the cow, as endometritis and milk yield are the result of the interaction of many intrinsic and extrinsic factors such as age, breed, feed intake, general health and body condition score (BCS) (Adnane *et al.,* 2017).

Animal with very high or very low BCS may suffer from prolonged gestation, dystocia, retained fetal membranes, persistent uterine infection and endometritis (LeBlanc, 2014; Steffan, 1987). Kadivar *et al.* (2014) showed that cows with clinical endometritis had significantly lower BCS than normal cows at all weeks before and after calving ($P < 0.05$). In addition, the loss of 1 to 1.5 BCS points between 30 days before and 30 days after calving was often associated with a high prevalence of clinical endometritis (Adnane *et al.,* 2017). This effect may have been associated with hepatic steatosis following lipid mobilisation (Roche, 2006; Frazer, 2005). These observations were also confirmed for subclinical endometritis and it was found that cows with low BSC (≤2.5) at 30 days postpartum had significantly higher prevalences of subclinical endometritis with an OR of 4.5 (Carneiro *et al.,* 2014; Bacha and Regassa, 2010). Because NEB is inevitable around calving, to avoid a drop in BCS, many farmers increase the amount of concentrate fed, which increases the risk of acidosis (LeBlanc, 2014). The decrease in rumen pH favors the growth of pathogenic bacteria and the production of bacterial endotoxins such as LPS, which of course occurs at the same time as the immune system is negatively affected by the decreased feed intake (LeBlanc, 2014; Mani *et al.,* 2012).

Hormonal imbalances and resumption of cyclical activity after parturition

Clinical and subclinical endometritis is a common cause of late resumption of ovarian activity after parturition. It is important to note that the timing of the resumption of ovarian activity significantly affects the process of uterine involution and therefore the potential for endometritis to develop (Sheldon *et al.,* 2009; Sérieys, 1997; Thibier and Steffan 1985). Animal that resume ovarian activity early are less prone to endometritis at 30 days postpartum than animal that resume cyclicity later (Sérieys, 1997; Thibier and Steffan 1985). In the case of endometritis induced by gram-negative bacteria such as Escherichia coli, LPS inhibits the secretion of gonadotropin-releasing hormone (GnRH) and luteinising hormone (LH) without affecting the secretion of follicle stimulating hormone (FSH), but it also suppresses the sensitivity of the pituitary gland to GnRH (Sheldon *et al.,* 2009). As a result, follicular waves develop but the dominant follicle does not ovulate, or when ovulation occurs, the resulting corpus luteum persists due to inadequate uterine PGF2α synthesis. In the latter case, continued progesterone secretion delays phagocytic cell recruitment and the effectiveness of the immune system is then diminished (Sheldon *et al.,* 2009; Sérieys, 1997).

Thibier and Steffan (1985) showed that cyclic females had a less than 30% chance of developing metritis compared to less than 50% for non-cyclic females ($P < 0.01$). Late resumption of ovarian activity is a risk factor for spontaneous recovery from uterine infection due to improved immune function (Parkinson, 2009) and oestrogen-induced phagocyte recruitment and function. In addition, oestrogen leads to a significant secretion of cervical mucus (Parkinson, 2009; Olso *et al.,* 1984), which is considered to be a physical barrier preventing bacteria from entering the uterus. Interestingly, despite these observations, Sheldon and Dobson (2004) did not demonstrate a clear effect of ovarian cyclicity on the incidence of endometritis, possibly due to the complications of NEB in the cow population studied (Galvao *et al.,* 2010; Hammon *et al.,* 2006).

CONCLUSION

It can thus be seen that endometritis, like many other pathologies, has a multifactorial etiology. It reflects a state of imbalance between, on the one hand, factors that defend the uterus and, on the other hand, factors of aggression, whether they are predisposing (risk factors) or determining (bacteria). The severity of the

consequences of endometritis will then depend on these predisposing and determining factors. The identification of risk factors has great potential as a source of information for the treatment and prevention of chronic metritis. Many of the risk factors and details of chronic metritis are still not known, and it is essential to collect the animal's history before further investigations are performed. The breeder should be asked about the animal's recent history. It is necessary to know: the date of parturition, the lactation number, the modalities and the consequences of the birth (assistance, twin birth, retention of fetal annexes), the date of the last heat and the existence of postpartum affections, such as metritis, NEB and hypocalcemia. Interestingly, but not surprisingly, this study found that there are interactions between the risk factors themselves; for example, certain nutritional imbalances and high or low feed conversion may all predispose to chronic metritis. From all of the above, it would be necessary, if not imperative, for the prevention and treatment of affected animals to identify the most important risk factors and tailor treatment specifically to each animal based on clinical examination of the identified risk factors. All this will allow a better management of chronic metritis and thus a reduction of the associated economic losses.

ACKNOWLEDGMENT

None

CONFLICT OF INTEREST

The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article

REFERENCES

Adnane, M., Kaidi, R., Hanzen. C., England, G.C.W., 2017. Risk factors of clinical and subclinical endometritis in cattle: a review. Turk J. Vet. Anim. Sci., 41: 1-11.

Al-Hamedawi, T.M., 2011. Post-Partum Pyometra in Iraqi Goats: Clinical & Therapeutical Study. The Iraqi J. Vet. Med., 35 (2): 36 – 39.

Bacha, B., Regassa, F.G., 2010. Subclinical endometritis in Zebu x Friesian crossbred dairy cows: its risk factors, association with subclinical mastitis and effect on reproductive performance. Trop. Anim. Health Prod., 42: 397-403.

Badinand, F., 1975. Les métrites chez la vache: influence des facteurs hormonaux et nutritionnels. Cah. Méd. Vet., 44: 205-221.

Beena, V., Pawaiya, R.V.S., Shivasharanappa, N., Gururaj, K., Gupta, V.K., Gangwar, N.K., Singh, D.D., Karikalan, M., Sharma, A.K., Kumar, H., Kumar, A., Singh, R., 2015. Occurrence of pathological conditions in the female genitalia of goats. Indian J. Vet. Pathol., 39(3): 197-201.

Bencharif, D., Tainturier, D., 2005. Les métrites chroniques chez les bovins. Point Vét., 36: 72-77.

Benedictus, L., Jorritsma, R., Knijn, H.M., Vos, P.L., Koets, A.P., 2011. Chemotactic activity of cotyledons for mononuclear leukocytes related to occurrence of retained placenta in dexamethasone induced parturition in cattle. Theriogenol., 76: 802-809.

Borden, M., Twiyizeyimna, S., Habarugira, G., Kandiwa, E., Chinyoka, S., Samkange, A., Bishi, A., 2017. Study of Incidence of Gross Urogenital Lesions and Abnormalities on Does Slaughtered at Nyagatare Slaughterhouse, Eastern Province, Rwanda. J. Vet. Med., 2017: 7 https://doi.org/10.1155/2017/7564019.

Bruun, J., Ersboll, A.K., Alban, L., 2002. Risk factors for metritis in Danish dairy cows. Prev. Vet. Med., 54: 179-190.

Carneiro, L.C., Ferreira, A.F., Padua, M., Saut, J.P., Ferraudo, A.S., Dos Santos, R.M., 2014. Incidence of subclinical endometritis and its effects on reproductive

performance of crossbred dairy cows. Trop. Anim. Health Prod., 46: 1435-1439.

Chadio, S.E., Zervas, G., Kiriakou, K., Goulas, C., Menegatos, J., 2000. Effects of recombinant bovine somatotropin administration to lactating goats. Small Rumin Res 35: 263-9

Chaffaux, S., Lakdissi, H., Thibier, M., 1991. Etude épidémiologique et clinique des endométrites post-puerpérales chez les vaches laitières. Rec. Méd. Vét., 167: 349-358.

Cheong, S.H., Nydam, D.V., Galvao, K.N., Crosier, B.M., Gilbert, R.O., 2011. Cow-level and herd-level risk factors for subclinical endometritis in lactating Holstein cows. J. Dairy Sci., 94: 762-770.

Correa, M.T., Erb, H., Scarlett, J., 1993. Path analysis for seven postpartum disorders of Holstein cows. J. Dairy Sci., 76: 1305-1312.

Curtis, C.R., Erb, H.N., Sniffen, C.J., Smith, R.D., Kronfeld, D.S., 1985. Path analysis of dry period nutrition, postpartum metabolic and reproductive disorders, and mastitis in Holstein cows. J. Dairy Sci., 68: 2347-2360.

Dawood, K.E., 2010. Pathological abnormalities of the reproductive tracts of ewes in Basra, Iraq. Vet. Rec. 166(7): 205-207.

Dohmen, M.J., Joop, K., Sturk, A., Bols, P.E., Lohuis, J.A., 2000. Relationship between intra-uterine bacterial contamination, endotoxin levels and the development of endometritis in postpartum cows with dystocia or retained placenta. Theriogenol., 54: 1019-1032.

Dohmen, M.J., Loohuis, J., Huszenicsa, G., Nagy, P., Gacs, M., 1995. The relationship between bacteriological and clinical findings in cows with subacute/chronic endometritis. Theriogenology, 43, 1379-1388.

Donofrio, G., Herath, S., Sartori, C., Cavirani, S., Flammini, C.F., Sheldon, I.M., 2007. Bovine herpesvirus 4 is tropic for bovine endometrial cells and modulates endocrine function. Reproduction, 134, 183-197.

Dubuc, J., Duffield, T.F., Leslie, K.E., Walton, J.S., LeBlanc, S.J., 2010. Risk factors for postpartum uterine diseases in dairy cows. J. Dairy. Sci., 93: 5764-5771.

Ducreux, P., 2003. Le sélénium chez les bovins : rôles biologiques et manifestations de carences. DVM, Ecole vétérinaire de Lyon, France, 2003.

El-Rheem, S.M.A., 2020. Case study: SAT, A New Treatment for Clinical Goat Endometritis. J Vet Sci Ani Husb 8(1): 106

Frazer, G.S., 2005. A rational basis for therapy in the sick postpartum cow. Vet. Clin. North Am Food Anim. Pract., 21: 523-568.

Frazier, K.S., Baldwin, C.A., Pence, M., West, J., Bernard, J., Liggett, A., Miller, D., Hines, M.E., 2002. Seroprevalence and comparison of isolates of endometriotropic bovine herpesvirus-4. J Vet Diagn Invest, 14, 457-462.

Galvao, K.N., Flaminio, M.J., Brittin, S.B., Sper, R., Fraga, M., Caixeta, L., Ricci, A., Guard, C.L., Butler, W.R., Gilbert, R.O., 2010. Association between uterine disease and indicators of neutrophil and systemic energy status in lactating Holstein cows. J. Dairy Sci., 93: 2926-2937.

Ghavi Hossein-Zadeh, N., Ardalan, M., 2011. Cow-specific risk factors for retained placenta, metritis and clinical mastitis in Holstein cows. Vet. Res. Commun, 35: 345-354.

Gilbert, R.O., Shin, S.T., Guard, C.L., Erb, H.N., Frajblat, M., 2005. Prevalence of endometritis and its effects on reproductive performance of dairy cows. Theriogenology, 64: 1879-1888.

Giuliodori, M.J., Magnasco, R.P., Becu-Villalobos, D., LacauMengido, I.M., Risco, C.A., De la Sota, R.L., 2013. Clinical endometritis in an Argentinean herd of dairy cows: risk factors and reproductive efficiency. J. Dairy Sci., 96: 210-218.

Goff, J.P., Horst, R.L., 1997. Physiological changes at parturition and their relationship to metabolic disorders. J. Dairy Sci., 80: 1260-1268.

Guterbock, W.M., 2004. Diagnosis and treatment programs for fresh cows. Vet. Clin. North Am Food Anim. Pract., 20: 605-626.

Hammon, D.S., Evjen, I.M., Dhiman, T.R., Goff, J.P., Walters, J.L., 2006. Neutrophil function and energy status in Holstein cows with uterine health disorders. Vet. Immunol. Immunopathol., 113: 21-29.

Ingvartsen, K.L., Moyes, K., 2013. Nutrition, immune function and health of dairy cattle. Animal, 7: 112-122.

Kadivar, A., Ahmadi, M.R., Vatankhah, M., 2014. Associations of prepartum body condition score with occurrence of clinical endometritis and resumption of postpartum ovarian activity in dairy cattle. Trop. Anim. Health Prod., 46: 121-126.

Khodakaram-Tafti, A., Davari, A., 2013. Congenital and acquired abnormalities of reproductive tract of non-pregnant ewes slaughtered in Fars province, Iran. Iranian J. Vet. Res. 14(2): 140-144.

Kim, I.H., Kang, H.G., 2003. Risk factors for postpartum endometritis and the effect of endometritis on reproductive performance in dairy cows in Korea. J. Reprod. Develop., 49: 485-491.

Kouamo, J., Asongafec, T.B., 2020. Prevalence and Associated Risk Factors of Genital Abnormalities of Does and Ewes in the West Region of Cameroon. PSM Vet. Res., 5(3): 81-96.

Kouamo, J., Obama, S.F.F., Sassa, M.S., 2019. Prevalence and Risk Factors of Genital Diseases of Goats and Ewes in the far North Region of Cameroon. PSM Vet. Res., 4(3): 62-73.

Laven, R.A., Peters, A.R., 1996. Bovine retained placenta: aetiology, pathogenesis and economic loss. Vet. Rec., 139: 465-471.

LeBlanc, S.J., 2008. Postpartum uterine disease and dairy herd reproductive performance: a review. Vet. J., 176: 102-114.

LeBlanc, S.J., 2014. Reproductive tract inflammatory disease in postpartum dairy cows. Animal, 8: 54-63.

LeBlanc, S.J., Duffield, T.F., Leslie, K.E., Bateman, K.G., Keefe, G.P., Walton, J.S., Johnson, W.H., 2002. Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows. J. Dairy Sci., 85: 2223-2236.

LeBlanc, S.J., Lissemore, K.D., Kelton, D.F., Duffield, T.F., 2006. Major advances in disease prevention in dairy cattle. J. Dairy Sci., 89: 1267-1279.

LeBlanc, S.J., Osawa, T., Dubuc, J., 2011. Reproductive tract defense and disease in postpartum dairy cows. Theriogenol., 76: 1610-1618.

Lohuis, J., 1998. Infections utérines post-partum chez la vache : bactériologie et fertilité. Le nouveau péripartum, SFB, Paris, 25-26 Novembre, 155-165.

MacKay, D., Miller, A.L., 2003. Nutritional support for wound healing. Altern. Med. Rev., 8: 359-377.

Madoz, L.V., Giuliodori, M.J., Migliorisi, A.L., Jaureguiberry, M., De la Sota, R.L., 2014. Endometrial cytology, biopsy, and bacteriology for the diagnosis of subclinical endometritis in grazing dairy cows. J. Dairy Sci., 97: 195-201.

Mani, V., Weber, T.E., Baumgard, L.H., Gabler, N.K., 2012. Growth and Development Symposium: Endotoxin, inflammation, and intestinal function in livestock. J. Anim. Sci., 90: 1452-1465.

Markusfeld, O., 1984. Factors responsible for post parturient metritis in dairy cattle. Vet. Rec., 114: 539-542.

Markusfeld, O., 1987. Periparturient traits in seven high dairy herds. Incidence rates, association with parity, and

interrelationships among traits. J. Dairy Sci., 70: 158-166.

Mayer, E., 1978. Relations entre alimentation et infécondité. Bull GTV, 78: 132.

Morton, J.M., Butler, K.L., 1995. The effects of induced parturition on the incidence of clinical disease and mortality in dairy cows from commercial herds in south-western Victoria. Aust. Vet. J., 72: 1-4.

Muller, L.D., Owens, M.J., 1974. Factors associated with the incidence of retained placentas. J. Dairy Sci., 57: 725-728.

Olson, J.D., Ball, L., Mortimer, R.G., Farin, P.W., Adney, W.S., Huffman, E.M., 1984. Aspects of bacteriology and endocrinology of cows with pyometra and retained fetal membranes. Am. J. Vet. Res., 45: 2251-2255.

Paisley, L.G., Mickelson, W.D., Anderson, P.B., 1986. Mechanisms and therapy for retained fetal membranes and uterine infections of cows: a review. Theriogenol., 25: 352- 381.

Parkinson, T., 2009. Infertility and subfertility in the cow: structural and functional abnormalities, management deficiencies and non-specific infections. In: Noakes DE, Parkinson T, England GCW, editors. Veterinary Reproduction and Obstetrics. Amsterdam, the Netherlands: Elsevier. 393-475.

Potter, T.J., Guitian, J., Fishwick, J., Gordon, P.J., Sheldon, I.M., 2010. Risk factors for clinical endometritis in postpartum dairy cattle. Theriogenol., 74: 127-134.

Prunner, I., Wagener, K., Pothmann, H., Ehling-Schulz, M., Drillich, M., 2014. Risk factors for uterine diseases on small- and mediumsized dairy farms determined by clinical, bacteriological, and cytological examinations. Theriogenol., 82: 857-865.

Roberts, S.J., 1986. Veterinary obstetrics and genital diseases. Theriogenelogy, Troisième edition, Ann Arbor, edwards Brothers, Michigan.

Roche, J.F., 2006. The effect of nutritional management of the dairy cow on reproductive efficiency. Anim. Reprod. Sci., 96: 282-296.

Rutigliano, H.M., Lima, F.S., Cerri, R.L.A., Greco, L.F., Vilela, J.M., Magalhães, V., Silvestre, F.T., Thatcher, W.W., Santos, J.E.P., 2008. Effects of method of presynchronization and source of selenium on uterine health and reproduction in dairy cows. J. Dairy Sci., 91: 3323-3336.

Salasel, B., Mokhtari, A., Taktaz, T., 2010. Prevalence, risk factors for and impact of subclinical endometritis in repeat breeder dairy cows. Theriogenol., 74: 1271-1278.

Sartorelli, P., Paltrinieri, S., Agnes, F., 1999. Non-specific immunity and ketone bodies. I: In vitro studies on chemotaxis and phagocytosis in ovine neutrophils. Zentralbl Vet. A, 46: 613-619.

Sato, S., Suzuki, T., Okada, K., 1995. Suppression of lymphocyte blastogenesis in cows with puerperal metritis and mastitis. J. Vet. Med. Sci., 57: 373-375.

Sérieys, 1997. Le tarissement de la vache laitière. Paris, France: France agricole; 1997.

Sharma, A., Kumar, P., Singh, M., Vasishta, N.K., 2014. Reproductive health status of north western Himalayan Gaddi sheep: An abattoir study. Open Vet. J., 4(2): 103-106

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., 8: 1025-1032.

Sheldon, I.M., Dobson, H., 2004. Postpartum uterine health in cattle. Anim. Reprod Sci., 82(83): 295-306.

Sheldon, I.M., Lewis, G., LeBlanc, S., Gilbert, R.O., 2006. Defining postpartum uterine disease in cattle. Theriogenol., 65: 1516-1530.

Sheldon, I.M., Price, S.B., Cronin, J., Gilbert, R.O., Gadsby, J.E., 2009. Mechanisms of

infertility associated with clinical and subclinical endometritis in high producing dairy cattle. Reprod. Domest. Anim., 44: 1-9.

Steffan, J., 1987. Métrites en élevage bovin laitier. Quelques facteurs influencant leur fréquence et leurs conséquences sur la fertilité. Rec. Méd. Vét., 166: 183-188.

Sudhakar, T., Roy, K.S., Raju, K., Anjaneyulu, Y., 2010. Reproductive disorders in Deccani ewes: An abattoir study. Indian J. Anim. Reprod. 31(1): 58-60.

Suthar, V.S., Canelas-Raposo, J., Deniz, A., Heuwieser, W., 2013. Prevalence of subclinical ketosis and relationships with postpartum diseases in European dairy cows. J. Dairy Sci., 96: 2925-2938.

Thibier, M., Steffan, J., 1985. Les métrites dans la pathologie du postpartum chez la vache laitière. Epidémiologie et cyclicité in Mieux connaître, comprendre et maîtriser la fécondité bovine. Journée de la société française de baraterie 1985: 157-183.

Victor, N., Justin, K., Djanan, G.W.N., Zoli, A.P., 2019. Prevalence, Etiology and Risk Factors of Endometritis in Zebus Cattle Slaughtered at the Municipal Abattoir of Ngaoundere, Adamawa Region, Cameroon. J. Vet. Sci., Med. Diagn. 8:3.

Watellier, P., 2010. Etude bibliographique des métrites chroniques chez la vache. DVM, Ecole Nationale Vétérinaire de Lyon, Lyon, France, 2010.

Whiteford, L.C., Sheldon, I.M., 2005. Association between clinical hypocalcaemia and postpartum endometritis. Vet. Rec., 157: 202-203.

Williams, E.J., Fischer, D.P., Pfeiffer, D.U., England, G.C., Noakes, D.E., Dobson, H., Sheldon, I.M., 2005. Clinical evaluation of postpartum vaginal mucus reflects uterine bacterial infection and the immune response in cattle. Theriogenol., 63: 102-117.

Wittenbrink, M.M., Kirpal, G., Thiele, D., Fischer, D., Krauss, H., Bisping, W., 1994. Detection of Chlamydia psittaci in vaginal discharge of cows: a necessary enlargement of bacteriologic diagnosis for the etiologic clarification of fertility disorders in the female cow. Zentralbl Veterinarmed B., 41, 492-503.