International Journal of Agriculture and Biosciences 2023 12(4): 216-221.
https://doi.org/10.47278/journal.ijab/2023.067

Review Article eISSN: 2306-3599; pISSN: 2305-6622

Bovine Environmental Mastitis and Their Control: An Overview

Roland Meçaj[1], Gerald Muça[2*], Xhelil Koleci[2], Majlind Sulçe[2], Luigj Turmalaj[2], Pëllumb Zalla[2], Anita Koni[2] and Myqerem Tafaj[3]

[1]National Veterinary and Plant Protection Authority. Street Jordan Misja, building 141/1, Tirana 1001, Albania.
[2]Faculty of Veterinary Medicine, Agricultural University of Tirana, Street Paisi Vodica, Kodër Kamëz, SH1, Tirana 1029, Albania.
[3]Faculty of Agriculture and Environmental, Agricultural University of Tirana, Street Paisi Vodica, Kodër Kamëz, SH1, Tirana 1029, Albania.
*Corresponding author: gmuca@ubt.edu.al

ABSTRACT

One of the most prevalent diseases affecting the dairy sector is mastitis in cows. Bovine mastitis is an infection or trauma-induced mammary gland inflammation that causes abnormally low milk output. Contagious and environmental mastitis are more prevalent compared to other gland inflammations. Today, the bacteriological aetiology of mastitis has changed from contagious to environmental pathogens. The dairy cattle environment serves as the main reservoir for environmental infections, while infected mammary glands serve as the main source for contagious infections. The process of milking is connected to the exposure of healthy mammary quarters to infectious microorganisms. On the other hand, uninfected quarters can be exposed to environmental mastitis at any point during the cow's lifespan. Because they do not directly affect the reservoir of environmental infections, the methods for limiting contagious mastitis are ineffective in managing environmental mastitis. Environmental mastitis, as opposed to contagious mastitis, is more frequently linked to clinical mastitis cases than subclinical infection. Environmental mastitis episodes are thought to cost an average of $107 per lactating cow. It is crucial to understand and manage environmental mastitis. This manuscript reviews recent study findings and makes suggestions related to environmental mastitis prevention strategies.

Keywords: Environmental Mastitis, Contagious Mastitis, Mastitis prevention, *Staphylococcus aureus, Escherichia coli*

Article History
Article # 23-379
Received: 26-Jul-2023
Revised: 17-Aug-2023
Accepted: 28-Aug-2023

INTRODUCTION

Bovine mastitis has not vanished despite years of diligent research, and it has not even significantly decreased. By definition, mastitis is an inflammatory udder response (mast—breast; it is-inflammation) that is mostly brought on by bacterial infection. *Streptococcus agalactiae* and *Staphylococcus aureus*, which dwell on the skin of the teat or inside the udder and are passed while milking, from one cow to another, are the major bacteria that cause contagious mastitis. Organisms like *Streptococcus uberis*, *Escherichia coli* and *Klebsiella* are the causes of environmental mastitis. Commonly, they do not live on the surface or inside the udder but pass into the teat canal when the cow gets in contact with an infested environment (Hogan & Smith, 2012). The relationship between a certain bacterial pathogen and contagious or environmental mastitis is currently not the same. Recent research has shown that bacteria that have been linked to contagious mastitis, like *Staphylococcus aureus*, can also induce environmental mastitis (Klaas & Zadoks, 2018). In several nations during the past few years, the percentage of environmental pathogens acting as mastitis-causing agents has increased (Pyorala, 2002).

Mastitis can be divided into a variety of categories. The following groups are produced by categorizing according to the infection level (Hospido & Sonesson, 2005): Subclinical mastitis, which is characterized by a change in milk somatic cell count but without clinical signs or milk abnormalities; acute clinical mastitis, which is distinguished by acute clinical signs of an inflammatory process; and chronic mastitis, which is mostly a long-lasting inflammation without clinical signs and may continue for years (Hospido & Sonesson, 2005). Despite the huge advances and prevention measures implemented at the herd level throughout several decades, mastitis is commonly regarded as the condition that causes the dairy sector the greatest financial losses, ranging from €61 to €97 for each affected cow (Hogeveen & Lam, 2011). Each case of mastitis affects a number of courses within the dairy farm that contribute to the environmental sustainability of milk production in addition to causing two

Cite this Article as: Meçaj R, Muça G, Koleci X, Sulçe M, Turmalaj L, Zalla P, Koni A and Tafaj M, 2023. Bovine environmental mastitis and their control: an overview. International Journal of Agriculture and Biosciences 2023 12(4) 216-221. https://doi.org/10.47248/journal.ijab/2023.067

A Publication of Unique Scientific Publishers

distinct milk losses (a decrease in production capacity due to milk of inferior quality and milk that is never produced) (Hospido & Sonesson, 2005; Hogeveen & Lam, 2011).

Bacterial Pathogen Related Environmental Mastitis

Mastitis often originates from a bacterial intra-mammary infection, with *staphylococci*, *streptococci*, and coliforms being the most frequent culprits. Environmental mastitis is a disease condition with numerous putative causative agents and numerous host and environmental contributory variables. Environmental bacteria are thought to originate from the cow's surroundings and are most likely to contaminate the teats between milkings, especially under unfavorable housing conditions (Vanderhaeghen et al., 2015). Previous studies have employed a binary classification based on the epidemiology of the principal pathogens as contagious or environmental mastitis (Hogan & Smith, 2012).

Gram-negative bacteria are the main cause of environmental mastitis. Coliform bacteria (*Escherichia coli, Klebsiella*, and *Enterobacter*), *streptococci*, and *enterococci* are more prevalent among them. *Escherichia coli* lives normally in the mammalian digestive system (Hogan & Smith, 2012). Mastitis caused by *Escherichia coli* is often temporary, and the severity of the infection is greatly influenced by host characteristics, such as lactation stage, etc. Longitudinal investigations have shown that *Escherichia coli* infections can be chronic, frequently with repeated bouts of clinical mastitis followed by times of subclinical infection, despite the fact that the majority of *Escherichia coli* infections are transient (Döpfer et al., 1999; Klaas & Zadoks, 2018).

The majority of clinical coliforms cases are characterized by milk clots, flakes and little to mild edema of the afflicted gland. Early lactation, up to 100 days after the commencement of subclinical coliform infections, can result in clinical mastitis (Klaas & Zadoks, 2018). Both *Enterobacter* spp. and *Klebsiella* spp. are common in soil, cereals, water, and animal intestinal tracts. *Enterobacter* spp. infections can last for up to 100 days and are chronic. Their infection during lactation is more prevalent in the early stages of lactation and begins to decline as lactation progresses (Smith & Hogan, 1993). At the same time, the dry season was when Enterobacter infections were more common (Bradley & Green, 2000). *Kelbsiella* species used to cause mild to moderate mastitis (Klaas & Zadoks, 2018). Acute clinical mastitis and *Klebsiella pneumonie* infections were linked (Hisaeda et al., 2011). It was discovered that dairy cows' *Klebsiella* spp. contamination came from sawdust. Due to antibiotic resistance, most treatments for *Klebsiella* spp. are ineffective, and on-farm mortality may be significant (Klaas & Zadoks, 2018).

Streptococcus dysgalcatiae, Streptococcus uberis and *Enterococcus* spp. are among the bacteria categorized as environmental streptococci. These pathogens may also be found in feed ingredients like silages and forages, and infection of the reproductive system may lead to environmental and teat end contamination (Petersson-Wolfe et al., 2008). *Streptococcus dysgalactiae,* a member of the streptococcal bacterium family, can occasionally act as an environmental pathogen and other times as a contagious pathogen (Smith & Hogan 1993; Wente & Krömker, 2020). Environmental streptococcal pathogens are more common in dairy herds than coliform infections. Streptococcal infections are linked to clinical mastitis in about 40–50% of cases. (Smith & Hogan, 1993).

Nowadays, attitudes toward a particular bacteria that might cause contagious or environmental mastitis have shifted. Recent investigations have shown that bacteria like *Staphylococcus aureus* and *Streptococcus agalactiae*, which were once thought to be particular pathogens of contagious mastitis, also behave as environmental pathogens. (Klaas & Zadoks, 2018). *Staphylococcus aureus* is one of the very few infections that uses insects (Hydrotaea irritans) as a transmission vector, and it has been observed to induce severe clinical mastitis (Chirico et al., 1997). Mild to moderate clinical mastitis is linked to *Streptococcus agalactiae* (Cortinhas et al., 2016).

Summer Mastitis

Farmers and veterinarians are both aware of the clinical condition known as summer mastitis in cattle, which primarily affects non-lactating cattle over the summer period. An acute infection due to *Trueperella* (*Arcanobacterium, Actinomyces*) *pyogenes*, either by itself or as a coinfection with other pathogens (Yassin et al., 2011). This is a complex and sporadic disease, and its incidence varies from 2.5% to 10% (Shearer & Harmon, 1993). Infected quarters become very hard, swollen, and painful. Despite appropriate therapy, most animals develop complete loss of function in the affected quarter or entire gland (Shearer & Harmon, 1993). Animals with severe summer mastitis symptoms are often culled since the affected quarter has not recovered (Ishiyama et al., 2017). Bacteriological findings show that from infected animals have been isolated *Trueperella pyogenes, Streptococcus dysgalactiae*, *Peptococcus indolicus*, *Fusobacterium necrophorum, Bacteroides melaninogenicus* and other organisms. It appears that regional differences related to the prevalence of various pathogens partially account for the variability in bacteriologic results (Chirico et al., 1997; Madsen et al., 1992).

Higher rates of summer mastitis are associated with wet summer weather conditions that simulate flies activities, such as *Hydrotaea irritans*, which are demonstrated to transmit the disease (Ishiyama et al., 2017). Studies found *Hydrotea irritans* to be the most consistent visitor to cattle teats in Europe, which can harbor vital summer mastitis pathogens up to 4 days after exposure (Chirico et al., 1997). The bacterial species *Trueperella pyogenes*, *Peptococcus indolicus*, *Streptococcus dysgalactiae*, and *Bacteroides melaninogenicus* have been isolated from field-caught flies (Madsen et al., 1992).

Prevention of Environmental Mastitis

Keeping environmental mastitis within a herd at a manageable level requires limiting the exposure of the cows to the infections. But among the common causative factors of infectious diseases in dairy cows are the same bacteria that cause environmental mastitis. Environmental mastitis pathogens often induce intra-mammary infections by bridging the teat canal and proliferating inside the udder.

Both streptococci and *Escherichia coli* cannot survive on teat skin for long periods of time. If there are numerous examples of these germs on the skin, it certainly implies a contaminated environment. (Hogan & Smith, 2012). There are a number of risk factors for environmental mastitis, but according to the author's knowledge and experience, the three that are most crucial are 1) stall bending, 2) maternity care and dry cow and 3) milking hygiene.

1) *Stall bedding*. Cows rest around 12 to 14 hours per day, while their teats are in direct contact with the bedding material and surrounding substances where they repose. Bacterial populations of the bedding are correlated to the number of bacteria on teat ends and the proportion of clinical mastitis. A reduction in bacterial bedding contamination normally results in a decline in environmental mastitis. Hygiene and proper management

of lots, stall and pastures are crucial (Hogan & Smith, 2012). As recommendation, bedding should be composed by inorganic materials that are low in moisture level and contain low quantity of nutritive elements that can be used by bacteria. The bedding material mostly recommended for preventing environmental mastitis is washed sand. In contrast to organic materials (sawdust, straw and recycled manure solids), washed sand contains 100-fold less mastitis bacteria per unit of bedding. For bedding composed of sand, it is reasonable to aim for more than 95% dry matter. On the other hand, organic matter in the sand used for bedding needs to be under 5% (Kristula et al., 2005; Hogan & Smith, 2012). There was not seen differences in bacterial contamination between clean and recycled sand (van Gastelen et al., 2011). Used bedding composed by sand and sawdust or other wood materials in comparison with used recycled manure solids was seen to have lower level of bacterial *(Streptococcus spp. Klebsiella spp.* and all gram-negatives*)* contamination (Robles et al., 2020). In another study, was seen that recycled sand can be as a source of *Mycoplasma* spp. including *M. bovis. Mycoplasma* spp. survives in used sand for around 8 months, and 0.5% sodium hypochlorite or 2% chlorhexidine were most effective in eradicating them (Justice-Allen et al., 2010). Also, relationships were seen between used and unused bedding materials and udder health in United States dairy herds (Patel et al., 2019). This association was not seen in dairy cows during late lactation or approximating dry period (Rowe et al., 2019). Using one organic material instead of another has little advantage. In comparisons between these different types of bedding, straw typically has the highest streptococcal counts and sawdust typically has the highest coliform counts. Before using organic materials as bedding, bacterial levels can be effectively reduced by composting them. The mastitis pathogen populations frequently increase 10,000-fold within hours of use as bedding, despite the fact that many organic bedding materials have relatively few mastitis bacteria before use. (Hogan & Smith, 2012). Affordable waste products from the forestry and timber industries or grain harvests have historically been utilized as bedding. However, recycled manure solids are now often used as bedding on many dairy farms as a result of two trends. First, with more people using sawdust, wood shavings, and straw as fuel for house heating, etc., these materials are less readily available. Second, the use of solids for bedding is required by the profitability of methane digesters, which are used on some dairy farms (Hogan & Smith, 2012). Unused recycled manure solids were seen to have greater bacterial contamination compared to unused straw bedding (Beauchemin et al., 2022). At the same time, bedding composed of manure solids has a higher incidence of udder health problems compared to other bedding types (Patel et al., 2019). Despite the mentioned studies, in a recent study (Leach et at., 2015; Fréchette et al., 2022), there was no association between bedding composed of recycled manure solids and subclinical mastitis when compared to cows housed on straw bedding. Lowering the moisture content of manure solids is essential to reducing the bacterial counts; a reasonable target for manure solids is 35% dry matter (Hogan & Smith, 2012). Regarding experiments conducted in different housing systems, in free stalls for primiparous dairy cows, there was no difference in mastitis incidence between different bedding types (Rowbotham & Ruegg, 2016). Animals housed in compost-bedded packs had poorer udder health than did herds housed in cubicles (Emanuelson et al., 2022). In the free-stall housing system, despite the increase in dry matter, bacterial counts of mastitis pathogens (gram-negative bacterial, coliform, *Klebsiella* species, or *Streptococcus* species) in composted recycled manure solids were comparable with those in fresh recycled manure (Cole & Hogan, 2016). Removing dirty bedding from the back third of stalls will drastically lower bacterial counts, regardless of the bedding type being used. When animals are placed in milking stalls, the stalls should be scraped at least twice daily. The stalls, holding spaces, and lots are better off being free from stationary water and mud. Free-stall barn overcrowding increases the amount of manure contaminating the lanes and alleys. During the rainy seasons, when cows are exposed to dirt-manure lots and milking parlors, outbreaks of coliform mastitis are frequent (Hogan & Smith, 2012).

2) *Maternity and Dry Cow Lots*. Earlier during lactation, clinical mastitis related to dry period infections was more likely to occur than clinical mastitis not associated with dry period infections (Green et al., 2002). Before calving, using organic bedding materials in the stables was linked to subclinical mastitis (Krömker et al., 2012). The rate of new intra-mammary infections caused by environmental mastitis pathogens is bigger during the dry period than during lactation (Smith & Hogan, 1993). Priority should be given to the management and cleanliness of the maternity and dry cow housing. Dry cow areas should be clear of extra manure and well-drained. Areas for loose housing and box stalls should be cleaned often. Manure packs should be avoided since they frequently have high levels of germs for both cows and calves (Hogan & Smith, 2012).

3) *Milking Hygiene*. Early postpartum cow udder infections and manifestations of clinical mastitis are correlated with parameters linked to cow and farm management (Leelahapongsathon et al., 2016). The sanitation of the environment in which the animals are housed is fundamental for udder health and the eradication of mastitis. A healthy udder is influenced by a proper milking technique that satisfies the dairy cows sanitary requirements. To prevent environmental mastitis, achieving the lowest contamination of the body, especially the udder, should be a high priority in the management of dairy cows (Zigo et al., 2021). The foundation for controlling contagious mastitis is good sanitation during milking; however, this has less of an impact on environmental mastitis. The incidence of new intramammary infections brought on by streptococci or environmental coliform bacteria cannot be significantly affected by the application of antiseptic teat dips after milking. Long after milking, the killing power of teat dips has waned, even though the majority of antiseptic solutions can eradicate coliforms on teat skin. According to field tests, predipping in herds with low contagious mastitis reduces the occurrence of clinical mastitis by 50%. The newest recommendations call for forestriping the first streams of milk and eliminating teat dirt (Hogan & Smith, 2012). Predipping teats with antiseptic and drying them prior to milking was related to reduced numbers of *Streptococcus* and *Enterococcus* spp. in milk (Bradley et al., 2018). Some latex barrier teat dips may reduce the occurrence of coliform mastitis, but their effectiveness in preventing other infections is limited; nevertheless, barrier teat dips with germicides are more efficient than traditional germicidal dips at preventing environmental mastitis (Hogan & Smith, 2012). Disinfecting clusters between milking different cows was associated with a reduction in thermophilic and psychotropic bacteria in milk. (Bradley et al., 2018). The most frequent errors in milking hygiene activities include: sprinkling water on the

udder while cows enter the parlor; emptying the teat cistern on the ground; weak stimulation and ineffective udder predipping; unwashed clusters of the milking machine; attachment of the milking cluster to a dirty udder; failure to disinfect the teats after each milking; ineffective dipping posterior milking (Zigo et al., 2021). It is crucial to adhere to a clearly defined workflow with conditions set for each of the following steps: (a) washing and drying of teats; (b) performing a sensory evaluation of the milk quality by forestripping the first streams from all of the quarters in a container; (c) application of prediping teats; (d) drying of teats; (e) proper attachment of the milking unit; (f) no milking on dry periods; (g) post-dip application (preparation after milking); (h) cleaning and routine technical maintenance of the milking unit; (i). After milking, feed the animals to keep them upright until the teats close (20–30 min.). The efficiency of milking and routine maintenance of the milking equipment are additional important aspects of milk production, and errors in mechanical milking raise the possibility of pathogen colonization of the teat duct (Zigo et al., 2021).

Nutrition

Deviations in nutrition during the drying period and near the time of calving that cause ketosis and fat mobilization syndrome significantly weaken the protective ability of cows against mastitis. The state of ketosis, as one of the most common metabolic disorders in cows with high production in the first phase and the peak of lactation, increases almost twice the predisposition of cows to suffer from mastitis (O'Rourke, 2009). As a consequence of the increased concentration of ketone bodies reduces the number of leukocytes in the blood, greatly limits the capacity of phagocytes and leukocytes in the mammary gland, and also reduces the production of cytokines. Deficiencies of vitamin E and/or selenium, especially during the drying period, decrease polymorphonuclear activity, while vitamin E and selenium supplementation before calving, but not after mastitis infection has occurred, leads to rapid polymorphonuclear growth and destruction of bacteria (Weiss et al., 1997). Studies of recent years (Khan et al., 2022; Wang et al., 2021) have also established the anti-inflammatory action of Selenium through the regulation of inflammatory mediators. Supplementation of vitamin E and Selenium in the rations of mastitis-affected cows treated with antibiotic therapy can improve cellular defense through a reduction of somatic cells compared to homologous groups of cows treated with antibiotic therapy alone (Mukherjee, 2008). There are data that even deficiencies in vitamin A and Ca can have negative impacts on mastitis in cows (Ganda et al., 2016). Supplementing cow rations with vitamin mixtures containing vitamins A, D3, and E helps to cure subclinical mastitis by increasing the expression of the responsible protective genes. Even the addition of fatty acids in combination with vitamin D3 in the diet can regulate the adhesion of gene expression as well as the internalization of bacteria in "non-maturated" phagocytic cells, which may lead to the development of anti-virulent factors for the control of mastitis caused by *S. aureus* in cows (Frutis-Murillo et al., 2019).

Vaccination

Most vaccines are based on reaching high levels of specific antibodies in the blood that pass into milk. The first drawback of vaccination against mastitis is that active transport, which is independent of antibody concentration, is used to transfer antibodies from blood to milk. (Zigo et al., 2021). Another disadvantage is the neutrophils low performance because they consume a high amount of oxygen, which in milk is 100 times lower than in blood. Additionally, macrophages need glucose for phagocytosis, which is also present in low concentrations in milk, and a large part of macrophage cells also swallow harmless fat globules, which reduce their number (Ulfman et al., 2018; Zigo et al., 2021).

The principal benefit of vaccination, in addition to reduced severity of clinical disease, is reduced loss of milk production following clinical infection in vaccinated cows (Wilson et al., 2008). However, although vaccination of dairy cows during the dry period and early lactation reduces the severity of coliform mastitis, it does not protect against infection and does not always reduce the prevalence of clinical mastitis (Wilson et al., 2007).

There is commercial vaccine available to prevent mastitis caused by *E. coli*. This vaccine is a rough mutant *E. coli* strain that lacks the O antigen and consists only of core antigen. The core antigen accounts for the cross-protection afforded by this vaccine against a broad range of Gram-negative pathogens (Dosogne et al., 2002). A commercial vaccines against streptococci causing bovine mastitis are not available but research is ongoing into the development of vaccines for *S. uberis* (Denis et al., 2009).

Conclusions

Environmental bacteria like *E. coli, Klebsiella*, and *Streptococcus uberis* are a prevalent cause of bovine environmental mastitis, an infection of the udder in dairy cows. These microorganisms can enter the udder through damaged teat ends, tainted bedding, or careless milking techniques. For dairy farmers, environmental mastitis can result in lower milk output, poor milk quality, and higher treatment expenses. Infected cows may need to be culled early, which may cost the farmer money. Bovine environmental mastitis can be controlled and prevented by adhering to correct hygiene procedures while milking, keeping cows clean and dry, providing cozy and clean bedding, and making sure the teat ends are disinfected. Mastitis cases that are identified and treated quickly can lessen the risk of the pathogen spreading across the herd.

A thorough strategy is required for the effective management of bovine environmental mastitis, including good management techniques, regular udder health monitoring, post milking disinfection and when necessary, the right use of antimicrobials. A vaccine against a specific environmental mastitis pathogen, such as *E. Coli*, is in circulation, but its efficiency is limited. Proper nutrition, especially vitamin E and selenium supplementation, should be considered as a mastitis prevention measure as well.

Author's Contributions

Gerald Muça, Roland Meçaj, Majlind Sulçe, Xhelil Koleci, Luigj Turmalaj, and Myqerem Tafaj designed the paper content. Gerald Muça, Roland Meçaj, Majlind Sulçe, Xhelil Koleci, and Myqerem Tafaj performed the literature research. Gerald Muça, Pëllumb Zalla, Majlind Sulçe, Xhelil Koleci, Luigj Turmalaj, and Anita Koni analyzed the data. Gerald Muça, Roland Meçaj, Luigj Turmalaj, Majlind Sulçe, Xhelil Koleci, and Myqerem Tafaj wrote the paper. Gerald Muça and Roland Meçaj had full responsibility for the final content. All authors approve the final version of the paper, and each author has contributed sufficiently to the paper presented for publication.

Acknowledgements

This study was made possible as part of the project "Prevalence of subclinical mastitis in dairy cattle, their economic and public health impact: their control and prevention" 2022-2023, financed by Albanian National Agency for Scientific Research and Innovation (AKKSHI).

REFERENCES

Beauchemin, J., Fréchette, A., Thériault, W., Dufour, S., Fravalo, P., Thibodeau, A. (2022). Comparison of microbiota of recycled manure solids and straw bedding used in dairy farms in eastern Canada. J. Dairy Sci. 105, 389–408. http://doi.org/10.3168/jds.2021-20523

Bradley, A. J., Green, M. J. (2000). Study of the Incidence and Significance of Intramammary Enterobacterial Infections Acquired During the Dry Period. J. Dairy Sci. 83(9):1957-65. http://doi.org/10.3168/jds.S0022-0302(00)75072-7

Bradley, A. J., Leach, K. A., Green, M. J., Gibbons, J., Ohnstad, I. C., Black, D. H., Payne, B., Prout, V. E., Breen, J. E. (2018). The impact of dairy cows' bedding material and its microbial content on the quality and safety of milk – A cross sectional study of UK farms. Int. J. Food Microbiol. 269, 36–45. http://doi.org/10.1016/j.ijfoodmicro.2017.12.022

Chirico, J., Jonsson, P., Kjellberg, S., Thomas, G. (1997). Summer mastitis experimentally induced by Hydrotaea irritans exposed to bacteria. Med. Vet. Entomol. 11, 187–192. http://doi.org/10.1111/j.1365-2915.1997.tb00312.x

Cole, K. J., & Hogan, J. S. (2016). Short communication: Environmental mastitis pathogen counts in freestalls bedded with composted and fresh recycled manure solids. J. Dairy Sci. 99, 1501–1505. http://doi.org/10.3168/jds.2015-10238

Cortinhas, C. S., Tomazi, T., Zoni, M., Moro, S. F., Veiga dos Santos, E. M. (2016). Randomized clinical trial comparing ceftiofur hydrochloride with a positive control protocol for intramammary treatment of nonsevere clinical mastitis in dairy cows. J. Dairy Sci. 99, 5619–5628. http://doi.org/10.3168/jds.2016-10891

Denis, M., Wedlock, D., Lacy-Hulbert. S., Hillerton, J., Buddle, B. (2009). Vaccines against bovine mastitis in the New Zealand context: What is the best way forward? N. Z. Vet. J. 57, 132–140. http://doi.org/10.1080/00480169.2009.36892

Döpfer, D., Barkema, H. W., Lam, T. J., Schukken, G. M., Gaastra, W. (1999). Recurrent Clinical Mastitis Caused by Escherichia coli in Dairy Cows. J. Dairy Sci. 82, 80–85. http://doi.org/10.3168/jds.S0022-0302(99)75211-2

Dosogne, H., Vangroenweghe, F., Burvenich, C. (2002). Potential mechanism of action of J5 vaccinein protection against severe bovine coliform mastitis. Vet. Res. 33, 1–12. http://doi.org/10.1051/vetres:2001001

Emanuelson, U., Brügemann, K., Klopčič, M., Leso, L., Ouweltjes, W., Zentner, A., Blanco-Penedo, I. (2022). Animal Health in Compost-Bedded Pack and Cubicle Dairy Barns in Six European Countries. Animals 12, 396. http://doi.org/10.3390/ani12030396

Fréchette, A., Fecteau, G., Côté, C., Dufour, S. (2022). Association Between Recycled Manure Solids Bedding and Subclinical Mastitis Incidence: A Canadian Cohort Study. Front. Vet. Sci. 9, 859858. http://doi.org/10.3389/fvets.2022.859858

Frutis-Murillo, M., Sandoval-Carrillo, M. A., Alva-Murillo, N., Ochoa-Zarzosa, A., López-Meza, J. E. (2019). Immunomodulatory molecules regulate adhesin gene expression in Staphylococcus aureus: Effect on bacterial internalization into bovine mammary epithelial cells. Microb. Pathog. 131, 15–21. http://doi.org/10.1016/j.micpath.2019.03.030

Ganda, E. K., Bisinotto, R. S., Lima, S. F., Kronauer, K., Decter, D. H., Oikonomou, G., Schukken, Y. H., Bicalho, R. C. (2016). Longitudinal metagenomic profiling of bovine milk to assess the impact of intramammary treatment using a third-generation cephalosporin. Sci. Rep. 6, 37565. http://doi.org/10.1038/srep37565

Green, M. J., Green, L. E., Medley, G. F., Schukken, Y. H., Bradley, A. J. (2002). Influence of Dry Period Bacterial Intramammary Infection on Clinical Mastitis in Dairy Cows. J. Dairy Sci. 85, 2589–2599. http://doi.org/10.3168/jds.S0022-0302(02)74343-9

Hisaeda, K., Haruki, A., Takahisa, S., Masanobu, N., K., Hagiwara, R. K., Tatsufumi, T., Naoya, K., Hajime, N. (2011). Changes in Acute-Phase Proteins and Cytokines in Serum and Milk Whey from Dairy Cows with Naturally Occurring Peracute Mastitis Caused by Klebsiella Pneumoniae and the Relationship to Clinical Outcome. J. Vet. Med. Sci. 73 (11): 1399-1404. http://doi.org/10.1292/jvms.10-0403

Hogan, J., Smith, K. L. (2012). Managing Environmental Mastitis. Vet. Clin. North Am. Food Anim. Pract. 28, 217–224. http://doi.org/10.1016/j.cvfa.2012.03.009

Hogeveen, H., Huijps, K., Lam, T. J. (2011). Economic aspects of mastitis: new developments. N Z Vet J. 59(1):16-23. http://doi.org/10.1080/00480169.2011.547165

Hospido, A., & Sonesson, U. (2005). The environmental impact of mastitis: a case study of dairy herds. Sci Total Environ. 343(1-3):71-82. http://doi.org/10.1016/j.scitotenv.2004.10.006

Ishiyama, D., Mizomoto, T., Ueda, C., Takagi, N., Shimizu, N., Matsuura, Y., Makuuchi, Y., Watanabe, A., Shinozuka, Y., Kawai, K. (2017). Factors affecting the incidence and outcome of *Trueperella pyogenes* mastitis in cows. J. Vet. Med. Sci. 79, 626–631. http://doi.org/10.1292/jvms.16-0401

Justice-Allen, A., Trujillo, J., Corbett, R., Harding, R., Goodell, G., Wilson, D. (2010). Survival and replication of Mycoplasma species in recycled bedding sand and association with mastitis on dairy farms in Utah. J. Dairy Sci. 93, 192–202. http://doi.org/10.3168/jds.2009-2474

Khan, M, Z., Ma, Y., Xiao, J., Chen, T., Ma, J., Liu, S., Wang, Y., Khan, A., Alugongo, G. M., Cao, Z. (2022). Role of Selenium and Vitamins E and B9 in the Alleviation of Bovine Mastitis during the Periparturient Period. Antioxidants 11, 657. http://doi.org/10.3390/antiox11040657

Klaas, I. C., & Zadoks, R. N. (2018). An update on environmental mastitis: Challenging perceptions. Transbound. Emerg. Dis. 65, 166–185. http://doi.org/10.1111/tbed.12704

Kristula, M. A., Rogers, W., Hogan, J. S., Sabo, M. (2005). Comparison of Bacteria Populations in Clean and Recycled Sand used for Bedding in Dairy Facilities. J. Dairy Sci. 88, 4317–4325. http://doi.org/10.3168/jds.S0022-0302(05)73118-0

Krömker, V., Pfannenschmidt, F., Helmke, K., Andersson, R., Grabowski, N. T. (2012). Risk factors for intramammary infections and subclinical mastitis in post-partum dairy heifers. J. Dairy Res. 79, 304–309. http://doi.org/10.1017/S0022029912000222

Leach, K. A., Archer, S. C., Breen, J. E., Green, M. J., Ohnstad, I. C., Tuer, S., Bradley, A. J. (2015). Recycling manure as cow bedding: Potential benefits and risks for UK dairy farms. Vet. J. 206, 123–130. http://doi.org/10.1016/j.tvjl.2015.08.013

Leelahapongsathon, K., Piroon, T., Chaisri, W., Suriyasathaporn, W. (2016). Factors in Dry Period

Associated with Intramammary Infection and Subsequent Clinical Mastitis in Early Postpartum Cows. Asian-Australas. J. Anim. Sci. 29, 580–585. http://doi.org/10.5713/ajas.15.0383
Madsen, M., Aalbaek, B., Hansen, J. W. (1992). Comparative bacteriological studies on summer mastitis in grazing cattle and pyogenes mastitis in stabled cattle in Denmark. Vet. Microbiol. 32, 81–88. http://doi.org/10.1016/0378-1135(92)90009-I
Mukherjee, R. (2008). Selenium and vitamin E increases polymorphonuclear cell phagocytosis and antioxidant levels during acute mastitis in riverine buffaloes. Vet. Res. Commun. 32, 305–313. http://doi.org/10.1007/s11259-007-9031-9
O'Rourke, D. (2009). Nutrition and udder health in dairy cows: a review. Ir. Vet. J. 62, S15. http://doi.org/10.1186/2046-0481-62-S4-S15
Patel, K., Godden, S. M., Royster, E., Crooker, B. A., Timmerman, J., Fox, L. (2019). Relationships among bedding materials, bedding bacteria counts, udder hygiene, milk quality, and udder health in US dairy herds. J. Dairy Sci. 102, 10213–10234. http://doi.org/10.3168/jds.2019-16692
Petersson-Wolfe, C.S., Adams, S., Wolf, S. L., Hogan, J. S. (2008). Genomic Typing of Enterococci Isolated from Bovine Mammary Glands and Environmental Sources». J. Dairy Sci. 91 (2): 615-19. http://doi.org/10.3168/jds.2007-0253
Pyorala, S. (2002). New strategies to prevent mastitis. Reprod Domest Anim. 37, 211-6. http://doi.org/10.1046/j.1439-0531.2002. 00378.x
Robles, I., Kelton, D. F., Barkema, H. W., Keefe, G. P., Roy, J. P., von Keyserlingk, M. A. G., DeVries, T. J. (2020). Bacterial concentrations in bedding and their association with dairy cow hygiene and milk quality. Animal 14, 1052–1066. http://doi.org/10.1017/S1751731119002787
Rowbotham, R. F., & Ruegg, P. L. (2016). Associations of selected bedding types with incidence rates of subclinical and clinical mastitis in primiparous Holstein dairy cows. J. Dairy Sci. 99, 4707–4717. http://doi.org/10.3168/jds.2015-10675
Rowe, S. M., Godden, S. M., Royster, E., Timmerman, J., Crooker, B. A., Boyle, M. (2019). Cross-sectional study of the relationships among bedding materials, bedding bacteria counts, and intramammary infection in late-lactation dairy cows. J. Dairy Sci. 102, 11384–11400. http://doi.org/10.3168/jds.2019-17074
Shearer, J. K., & Harmon, R. J (1993). Mastitis in Heifers. Vet. Clin. North Am. Food Anim. Pract. 9, 583–595. http://doi.org/10.1016/S0749-0720(15)30631-9
Smith, K. L., & Hogan, J. S. (1993). Environmental Mastitis. Vet. Clin. North Am. Food Anim. Pract. 9, 489–498. http://doi.org/10.1016/S0749-0720(15)30616-2
Ulfman, L. H., Leusen, J. H. W., Savelkoul, H. F. J., Warner, J. O., Van Neerven, R. J. J. (2018). Effects of Bovine Immunoglobulins on Immune Function, Allergy, and Infection. Front. Nutr. 5, 52. http://doi.org/10.3389/fnut.2018.00052
Van Gastelen, S., Westerlaan, B., Houwers, D. J., van Eerdenburg, F. J. C. M. (2011). A study on cow comfort and risk for lameness and mastitis in relation to different types of bedding materials. J. Dairy Sci. 94, 4878–4888. http://doi.org/10.3168/jds.2010-4019
Vanderhaeghen, W., Piepers, S., Leroy, F., Van Coillie, E., Haesebrouck, F., De Vliegher, S. (2015). Identification, typing, ecology and epidemiology of coagulase negative staphylococci associated with ruminants. Vet. J. 203, 44–51. http://doi.org/10.1016/j.tvjl.2014.11.001
Wang, D., Jia, D., He, R., Lian, S., Wang, J., Wu, R. (2021). Association Between Serum Selenium Level and Subclinical Mastitis in Dairy Cattle. Biol. Trace Elem. Res. 199, 1389–1396. http://doi.org/10.1007/s12011-020-02261-1
Weiss, W. P., Hogan, J. S., Todhunter, D. A., Smith, K. L. (1997). Effect of Vitamin E Supplementation in Diets with a Low Concentration of Selenium on Mammary Gland Health of Dairy Cows. J. Dairy Sci. 80, 1728–1737. http://doi.org/10.3168/jds.S0022-0302(97)76105-8
Wente, N., & Krömker, V. (2020). Streptococcus dysgalactiae—Contagious or Environmental? Animals 10, 2185. http://doi.org/10.3390/ani10112185
Wilson, D. J., Grohn, Y. T., Bennett, G. J., González, R. N., Schukken, Y. H., Spatz, J. (2008). Milk Production Change Following Clinical Mastitis and Reproductive Performance Compared Among J5 Vaccinated and Control Dairy Cattle. J. Dairy Sci. 91, 3869–3879. http://doi.org/10.3168/jds.2008-1405
Wilson, D. J., Skirpstunas, R. T., Trujillo, J. D., Cavender, K. B., Bagley, C. V., Harding, R. L. (2007). Unusual history and initial clinical signs of Mycoplasma bovis mastitis and arthritis in first-lactation cows in a closed commercial dairy herd. J. Am. Vet. Med. Assoc. 230, 1519–1523. http://doi.org/10.2460/javma.230.10.1519
Yassin, A. F., Hupfer, H., Siering, C., Schumann, P. (2011). Comparative chemotaxonomic and phylogenetic studies on the genus Arcanobacterium Collins et al. 1982 emend. Lehnen et al. 2006: proposal for Trueperella gen. nov. and emended description of the genus Arcanobacterium. Int. J. Syst. Evol. Microbiol. 61, 1265–1274. http://doi.org/10.1099/ijs.0.020032-0
Zigo, F., Vasil, M., Ondrašovičová, S., Výrostková, J., Bujok, J., Pecka-Kielb, E. (2021). Maintaining Optimal Mammary Gland Health and Prevention of Mastitis. Front. Vet. Sci. 8, 607311. http://doi.org/10.3389/fvets.2021.607311