ACTA VET. BRNO 2024, 93: 355–360; https://doi.org/10.2754/avb202493040355

Global perspective on bovine abortion - current prevalences, normal rates, diagnoses and aetiologies: a mini-review

John F. Mee

Animal and Bioscience Research Department, Moorepark Research Centre, Teagasc, Fermoy, Co. Cork, Ireland

Received January 18, 2024
Accepted December 12, 2024

Abstract

The case definition of bovine abortion varies with the purpose of use from legislative and research to field definitions; it generally encompasses days 42–260 of gestation. This variation can affect comparisons between prevalence rates. Animal-level prevalence estimates vary between 5 and 20% (mean ~10%) while herd-levels vary between 0 and 30% in published studies. Intervention thresholds ('normal herd-level abortion rate') also vary widely from 1 to 10% depending on the case definition and the underlying region-specific abortion rate. The infectious abortion diagnosis rate globally is ~45% with *Neospora caninum* being the most commonly detected abortifacient. Thus, the majority of abortions, in particular, sporadic (not outbreak) cases, have no diagnosed cause. However, current advances in the routine application of molecular diagnostics both for pathogens and for lethal alleles is steadily reducing this diagnosis-not-reached rate.

Cattle, gestation, pregnancy loss

While it is traditional to define bovine abortion as expulsion of a dead or non-independently viable live foetus and its adnexa between ~42 and ~260 days of gestation (Mee 2023) this is a purely academic case definition. In practice many different definitions of abortion are used which reflect legislative definitions, national regulations, institutional definitions and 'field definitions' as used by practicing veterinarians and their clients. For example, in some countries abortion is combined with perinatal mortality into a portmanteau 'abortion-perinatal mortality' (APM) (Van Loo 2023). Although this differentiation may appear to be semantic, it is critical when comparing abortion prevalence rates across countries or studies within countries and in establishing benchmarks for intervention.

Our perception of bovine abortion prevalence and aetiology usually comes from the scientific literature. But the latter is biased by gross under-reporting of all (especially first and second trimester) abortions (Bronner et al. 2014) when estimating prevalence. Reported causes of under-reporting include cost and resources involved in testing (50% of 1,157 Canadian dairy farmers surveyed), no interest in testing (29%), and not being aware of the importance of testing (21%) (Denis-Robichaud et al. 2019). Similarly, passive (rather than active) surveillance sampling of the minor proportion of reported abortions actually submitted for investigation (e.g. Hayes et al. 2023) potentially biases estimated causation rates. These limitations in our methodologies should be recognised when we review our current knowledge of bovine abortions and how we attempt to reduce such losses globally.

Despite these issues, it is clear that bovine abortion can exert a considerable financial cost estimated recently at US$ 1,415 per abortion for dairy and US$ 440 per abortion for beef farmers (Cantón et al. 2022). Though legally all abortions must be reported and investigated in many countries, most farmers 'accept' sporadic abortions and associated costs and so do not report them (Denis-Robichaud et al. 2019). The legal imperative to report all abortion cases stems from the public health concerns associated with zoonotic

Address for correspondence:
Prof. John F. Mee
Animal and Bioscience Research Department
Moorepark Research Centre
Teagasc, Fermoy, Co. Cork, Ireland

Phone: +353-25-42387
E-mail: john.mee@teagasc.ie

abortifacients, e.g. *Brucella abortus*. However, from personal experience, they become more interested in investigation and prevention of financial costs once prevalence increases. But the challenge is to define when has the abortion rate become 'too high'.

Prevalence of abortion

Before reviewing the prevalence of bovine abortion, it is instructive to background this by examining abortion rates in other farm animal species. In sheep an abortion (< 137 days) rate of 2–3% of ewes has recently been estimated (Crilly et al. 2021), in swine, an abortion (35–109 days) rate of up to 4% of sows is considered 'normal' (Maes et al. 2023), and in horses an abortion (70–300 days) rate of 4% has been recently recorded (Roach et al. 2021). Thus, abortion is reported to occur at a similarly low rate across our other common livestock species.

Given cattle are a herd species, we need to address bovine abortion prevalence at both animal- and herd-levels. In addition it must be recognised that loss rates are much higher in early than late pregnancy. Thus the most recent estimates of animal-level early abortion rates from meta-analyses are 9% (45–90 days) in dairy cows (Albaaj et al. 2023) and 6% (32–100 days) in beef cows (Reese et al. 2020). Estimates of animal-level full pregnancy abortion rates in dairy cows have recently been reviewed at between 5 and 20% (30–279 days), (Ealy and Seekford 2019) with an average of ~12% (42–260 days), (Wijma et al. 2022). Estimates of animal-level dairy mid-late term abortion rates are much lower varying between 1.2% (> 152 days and < 251 days), (Neupane et al. 2023) and 1.7% (120–259 days) (Mee, 1992). As expected, herd-level abortion rates vary widely, between 0 and 31%, in published studies (McDougal et al. 2005, Gadicke and Monti 2013). It is estimated that between 5 and 10% of herds experience high (> 5%) abortion rates though this may vary with underlying base-rates. With increasing use of precision livestock farming (PLF) technologies which can monitor activity, which is altered by abortion/calving (Lin et al. 2023, Horváth A et al. 2021), it is possible detection/recording rates of (early) potential abortions will increase in future as bovine digital phenotypes are more clearly defined.

There are very few published datasets showing secular temporal trends in abortion rates though more are published on temporal trends in infectious causes of abortion (Hecker et al. 2023; Mee 2023). A recent report from the US showed a significant decline in late-term abortion rates (> 152 days) in recent years attributed to indirect genetic selection (Neupane et al. 2023). With increased use of anti-abortifacient vaccines (e.g. *Leptospira* spp.) and establishment of abortifacient eradication programmes (e.g. BVDv) internationally, it might be expected that infection-associated abortion rates would decline (Mee et al. 2023a), though infection-associated diagnosis rates may increase due to improved diagnostics.

'Normal' herd-level abortion rates

Given the wide variation in abortion rates at the herd-level outlined above (0–31%), farmers (and their veterinarians) need a benchmark above which the abortion rate is 'abnormal' and intervention, with associated costs, is warranted. However, as all outbreaks ('abortion storms') start with a single case, it is recommended to submit all cases for investigation, especially apparently 'sporadic' index cases. This breakpoint for what is 'normal' and hence acceptable (threshold of acceptance) and not warranting investigation may be calculated statistically or by farmer and veterinarian opinion based on their experience of pregnancy loss rates in their herds. If the former approach is adopted, one may arbitrarily use the highest percentile of herds' abortion rate as 'abnormal', accepting that under-recording of actual abortion rates is common so many herds will have '0' abortions right skewing the distribution. For example, Thobokwe and Heuer (2004) found that 4% of their dairy herds had an abortion rate of > 5% whereas Clothier et al. (2020) found that 10% of dairy and 11% of beef farmers reported abortion rates of > 5%. However, in the absence of accurate data on herd-level abortion rates, the opinions of farmers and their vets are more commonly used to decide on the threshold of acceptance/intervention. This approach may yield very different thresholds in different regions/countries based on local experience of abortion rates. For example, in the UK and Ireland a recent study showed that the most commonly selected thresholds by vets (81%), dairy (55%) and beef (48%) farmers were 2–5, 2–5 and > 0%, respectively, for abortions defined as expulsion of a foetus between the size of a mouse and a small calf (Clothier et al. 2020). In contrast, an intervention level of 10% has been recommended for dairy herds in the US (Heersche 2023). Some of this large difference in herd-level abortion thresholds may be attributable to differences in underlying actual abortion rates and abortion recording rates and some to differences in the case definition of 'abortion' referred to above. Thus, where early abortions are included (e.g. following confirmed pregnancy at ~30-day ultrasonography examination), intervention thresholds are likely to be much higher than when abortion only includes 'observed abortion', usually > 120 days based on the gestational submission profile of foetuses submitted to veterinary diagnostic laboratories (Mee 2021; Van Loo 2023).

Diagnosis of abortion

The diagnosis rate of bovine abortions (in most studies this is effectively the infection-associated abortion rate) has increased over time from approximately 40% in 2000 to ~50% in 2022 with an overall diagnostic rate of 46% over this period (Hecker et al. 2023). However, these point estimates obscure the most important modifiable factor affecting diagnosis rates – number of conceptuses submitted for thorough examination; the more foetuses submitted/herd the higher the diagnosis rate (Van Loo 2023). Unfortunately for most herds only in a minority of actual abortions is the foetus (and much less commonly, the placenta) submitted.

This has implications for prioritisation of testing resources. The first conceptus submitted/herd-year should be prioritised for regulatory or zoonotic testing (e.g. for *Brucella abortus*) and any additional tests that can be conveniently carried out on the same sample (e.g. abomasal contents, placenta), for example routine bacterial/fungal cultures. However, given the low diagnosis rate in sporadic abortions, escalated testing (e.g. wider pathogen profile, routine histopathology and molecular PCR, next-generation sequencing testing) might economically be reserved for multiple/outbreak/abortion 'storm' events where an infectious aetiology is much more likely to be diagnosed. However, such sample triage depends on an accurate case history differentiating 'first submitted' from 'first observed/occurred'.

One-off maternal post-abortion blood sampling is routinely used as a proxy for conceptual sampling when the latter is unavailable or to accompany the conceptus. In the former case it can be quite useful in predicting foetal infection status. For example, a single maternal serum sample from an unvaccinated cow can predict foetal *Salmonella* Dublin status with an accuracy of 85% (Sánchez-Miguel et al. 2018). Similarly, a *Neospora caninum*-seropositive dam serum sample warrants foetal cerebral histopathology/herd-level serology testing. Given that transporting the conceptus to a veterinary laboratory may be impractical, dam case-cohort sero-diagnosis may provide useful strong circumstantial evidence of an infectious abortifacient (e.g. *Coxiella burnetti*) in the herd (Barigye et al. 2021).

Traditional methods of abortifacient detection such as culture are being supplemented with PCR testing (now available as rapid in-house small pack units, e.g. POCKIT Central

Nucleic Acid Analyser manufactured by GeneReach) internationally for recognised abortifacients. However, recent studies on the microbiome of the pregnant uterus and of the conceptus indicate that in future next or whole genome sequencing will need to be applied to routine diagnostic samples from abortion cases (Maes et al. 2023) with the attendant challenges in interpreting site-specific microbiome profiles. Early studies using the metagenomics approach have yielded promising results in identifying pathogens undetectable with routine culture (Delooz et al. 2015).

In addition to these conventional approaches to abortion diagnosis, alternative methodologies have recently been proposed. For example, testing for biomarkers of inflammation in foetal serum (acute phase proteins, APPs) may differentiate infected from non-infected aborted or stillborn foetuses (Jawor et al. 2017; Aras and Yavuz 2022). Application of metabolomics to maternal post-abortion blood samples has also been proposed as an adjunct diagnostic tool which may differentiate between infectious and non-infectious abortions using APP profiles (Gädicke et al. 2021).

Aetiology of abortion

From submitted cases (which are a biased sample of actual abortion cases) globally between 40 and 50% can be attributed to infectious abortifacients (Hecker et al. 2023; Mee 2023). The other submitted cases with a diagnosis-not-reached (DNR) may be infectious in origin but not have tested 'positive' or are non-infectious in origin, hence this is potentially a false dichotomy. Additionally, in some countries little data exists on the causes of abortion (e.g. Barigye et al. 2021) hence it is not possible to establish the ratio of infectious to non-infectious aetiologies.

In either case, the majority of bovine abortions appear to be caused by non-infectious factors. Given this fact, it is perhaps misguided that the main focus of abortion diagnosis is on infectious, not non-infectious causes. Misguided but not surprising as determining non-infectious causes of abortion is much more challenging. While it may be possible to categorise the proximate cause of pregnancy loss as, for example, a lethal congenital defect (Mee et al. 2023b), this does not elucidate the ultimate cause. With the increasing detection of recessive lethal alleles in cases of bovine embryonic and early foetal mortality, it is likely that genetic causes contribute substantially to the aetiology of DNR-associated non-infectious abortion. The best example of mutation-associated bovine abortion is the sire Pawnee Farm Animal Chief which has been linked to over half a million abortions worldwide (Adams et al. 2016). The role of toxins, in particular, mycotoxins in bovine abortion is often proposed, and there are supportive (e.g. Kallela and Ettala 1984) and non-supportive case studies (e.g. Carlos et al. 2017) but lack of routine testing hampers elucidation of their prevalence and relevance. As modern dairy cows are pushed metabolically to achieve higher milk production, it is possible that dietary limitations and progesterone imbalances will lead to non-infectious abortions and conversely, cows on low input systems may also suffer from dietary deficiencies leading to abortion. In certain parts of the world heat stress is a physical cause of bovine abortion, particularly in Holstein cows (El-Tarabany and El-Tarabany 2015). Additionally, assisted reproductive technologies are associated with higher early abortion rates (Crowe et al. 2024). Recently, a hypothesis of environmentally-induced excess plant nitrate accumulation resulting in the formation of abiotic nanoparticles in the placenta leading to abortion outbreaks has been proposed in mares and ruminants (Swerczek and Dorton 2019).

While internationally, *Neospora caninum* is the most commonly detected pathogen in cases of bovine abortion (Mee 2023) in individual countries other pathogens may be of greater import, e.g. *Brucella abortus* in tropical and subtropical regions. The aetiology of abortion is determined by the presence/prevalence of abortifacients in the animals' environment and the control measures adopted to prevent abortion. Thus, where certain abortifacients are being eradicated, e.g. BVDv, the infectious profile may change with more abortions caused by sporadic infections (Mee and Kenneally 2021). Most studies on the aetiology of abortion report common bacterial and fungal causes (results readily available from routine culture/PCR) and common viral causes (increasingly from PCR testing). However, there are many other less commonly tested for pathogens capable of causing abortion but which are not routinely diagnosed as such due to limited laboratory resources, difficulties in detection or lack of prioritisation of these pathogens with unclear prevalence and relevance, e.g. *Mycoplasma* (Byrne et al. 1999) and *Ureaplasma* spp., (Delooz et al. 2023), *Anaplasma phagocytophilum* (Van Loo et al. 2023) and *Chlamydia* and *Chlamydia*-like organisms (Wheelhouse et al. 2015). These 'hard-to-reach' pathogens may contribute, in part, to the DNR gap in our knowledge of the aetiology of bovine abortion.

Conclusion

The disparate case definitions for bovine abortion require standardisation. Bovine abortion rates are relatively higher than those of other farm animal species. 'Normal' abortion rates need to be determined for each geographic region, not extrapolated. Abortion diagnosis rates are increasing and more widespread application of molecular diagnostics will accelerate this trend.

References

Adams HA, Sonstegard TS, VanRaden PM, Null DJ, Van Tassell CP, Larkin DM, Lewin HA 2016: Identification of a nonsense mutation in APAF1 that is likely causal for a decrease in reproductive efficiency in Holstein dairy cattle. J Dairy Sci **99**: 6693-6701

Albaaj A, Durocher J, LeBlanc SJ, Dufour S 2023: Meta-analysis of the incidence of pregnancy losses in dairy cows at different stages to 90 days of gestation. JDS Commun **4**: 144-148

Aras Z, Yavuz O 2022: Evaluation of fetal heart serum amyloid a concentrations in infectious cattle abortion cases. Heliyon **8**: 11

Barigye R, Hassan N, Alfaki I, Barongo M, Mohamed M, Mohteshamuddin K 2021: Seroprevalence of *Coxiella burnetii* in a dairy cattle herd from the Al Ain region, United Arab Emirates. Trop Anim Health Prod **53**:1-6

Bronner A, Hénaux V, Fortané N, Hendrikx P, Calavas D 2014: Why do farmers and veterinarians not report all bovine abortions, as requested by the clinical brucellosis surveillance system in France? BMC Vet Res **10**:1-12

Byrne J, Brennan P, McCormack R, Ball HJ 1999: Isolation of *Mycoplasma bovis* from the abomasal contents of an aborted bovine fetus. Vet Rec **144**: 211-212

Cantón GJ, Moreno F, Fiorentino MA, Hecker Y, Spetter M, Fiorani F, Monterubbianes MG, García JA, Altamiranda EG, Cirone KM, Louge Uriarte EL 2022: Spatial–temporal trends and economic losses associated with bovine abortifacients in central Argentina. Trop Anim Health Prod **54**: 242

Carlos CV, Vital-Gutierrez J, Medina-Esparza L, Ortega-Mora L, Valdivia-Flores A, Quezada-Tristan T, Orihuela-Trujillo A 2017: *Neospora caninum* infection during the first gestation of Holstein heifers that consume food contaminated naturally with zearalenone under field conditions. Iran J Parasitol **12**: 563-571

Clothier G, Wapenaar W, Kenny E, Windham E 2020: Farmers' and veterinary surgeons' knowledge, perceptions and attitudes towards cattle abortion investigations in the UK. Vet Rec **187:** 447

Crilly JP, Carson A, Gascoigne E, Griffith B., Griffiths L, Henry, Hamer K, Hovers K, Lovatt F, Richey M 2021: Sheep abortion–a roundtable discussion. Livestock **26** (Sup5): S1-S15

Crowe A, Sánchez A, Moore S. McDonald M, Randi F, Santos A, Minela T, Branen J, Pursley R, Lonergan P, Butler S 2024: Time to conceptus attachment and subsequent pregnancy loss in seasonal-calving pasture-based lactating dairy cows following timed artificial insemination with conventional or X-sorted semen or timed embryo transfer with frozen–thawed *in vitro*-produced embryos. Repro Fertil Dev **36**: 149-273

Delooz L, Evrard J, Grégoire F, Houtain J 2023: Bovine abortion associated with *Ureaplasma diversum*. Proc European Buiatrics Forum, Berlin, Germany

Delooz L, Houtain J, Grégoire F, Evrard J, Daube G, Czaplicki G, Taminiau B 2015: New horizons in the etiological diagnosis of bovine abortions, the contribution of 16S rDNA sequencing. Proc European Buiatrics Forum, Rome, Italy

Denis-Robichaud J, Kelton D, Bauman C, Barkema H, Keefe G, Dubuc J 2019: Biosecurity and herd health management practices on Canadian dairy farms. J Dairy Sci **102**: 9536-9547

Ealy AD, Seekford ZK 2019: Symposium review: Predicting pregnancy loss in dairy cattle. J Dairy Sci **102**: 11798-11804

El-Tarabany M, El-Tarabany A 2015: Impact of maternal heat stress at insemination on the subsequent reproductive performance of Holstein, Brown Swiss, and their crosses. Theriogenology **84**: 1523-1529

Gädicke P, Letelier R, Chihuailaf R, Ruiz A, Junod T 2021: Variation in the multivariate relationships between serum amyloid, haptoglobin and biochemical profiles of aborted and non-aborted cows. SOJ Dairy Vet Sci **1**:1–6

Gädicke P, Monti G 2013: Factors related to the level of occurrence of bovine abortion in Chilean dairy herds. Prev Vet Med **110**: 183-189

Hayes C, Mee JF, McAloon C, Markey B, Casey M, Innes E, Sanchez C 2023: Prevalence of bacterial and fungal abortifacient pathogens in bovine foetuses and placentae – a national study. Anim SciPro Proceedings of the 11th International Ruminant Reproduction Symposium (IRRS 2023), Galway, Ireland, 28th May-1st June 2023, 539 p.

Hecker YP, González-Ortega S, Cano S, Ortega-Mora LM, Horcajo P 2023: Bovine infectious abortion: a systematic review and meta-analysis. Front Vet Sci **10**: 1249410

Heersche G 2023: Benchmarks for Evaluating the Reproductive Performance of the Dairy Herd. Cooperative Extension Service Bulletin, University of Kentucky, College of Agriculture. (https://afs.ca.uky.edu/files/benchmarks_for_evaluating_the_reproductive_performance_of_the_dairy_herd.pdf)

Horváth A, Lénárt L Csepreghy A, Madar M, Pálffy M, Szenci O 2021: A field study using different technologies to detect calving at a large-scale Hungarian dairy farm. Reprod Dom Anim **56**: 673-679

Jawor P, Stefaniak T, Mee JF 2017: Immune and inflammatory biomarkers in cases of bovine perinatal mortality with and without infection in utero. J Dairy Sci **100**: 1408-1416

Kallela K, Ettala E 1984: The oestrogenic Fusarium toxin (zearalenone) in hay as a cause of early abortions in the cow. Nord Vet Med **36**: 305-309

Lin D, Kenéz Á, McArt JA, Li J 2023. Transformer neural network to predict and interpret pregnancy loss from activity data in Holstein dairy cows. Comput Electron Agric **205**: 107638

Maes D, Peltoniemi O, Malik M 2023: Abortion and fetal death in sows. Reprod Dom Anim **58**: 125-136

McDougall S, Rhodes F, Verkerk G 2005: Pregnancy loss in dairy cattle in the Waikato region of New Zealand. New Zeal Vet J **53**: 279-287

Mee JF, Hayes C, Stefaniak T, Jawor P 2023a: Bovine foetal mortality–risk factors, causes, immune responses and immuno-prophylaxis. Animal **17**: 100774

Mee JF, Murphy D, Curran M 2023b: Bovine congenital defects recorded by veterinary practitioners. Reprod Dom Anim **59**: e14501

Mee JF 2023: Invited review: Bovine abortion—Incidence, risk factors and causes. Reprod Dom Anim **58** (Suppl 2): 23-33

Mee JF 2021: Bovine abortion. In: Bovine Prenatal, Perinatal and Neonatal Medicine. Hungarian Association for Buiatrics, Budapest, pp 58-66

Mee JF 1992: Epidemiology of abortion in Irish dairy cattle on six research farms. Irish J Agr Food Res **31**: 13-21

Mee JF, Kenneally J 2021: Risk factors and causes of abortion in Irish dairy herds. Moorepark Open Day Book, Teagasc, pp 198-199

Neupane M, Hutchison JL, Cole JB, Van Tassell CP, VanRaden PM 2023: Genomic evaluation of late-term abortion in cows recorded through Dairy Herd Improvement test plans. JDS Commun **4**: 354-357

Reese ST, Franco GA, Poole RK, Hood R, Montero LF, Oliveira Filho RV, Cook RF, Pohler KG 2020: Pregnancy loss in beef cattle: A meta-analysis. Anim Repro Sci **212**: 106251

Roach JM, Foote AK, Smith KC, Verheyen KL, de Mestre AM 2021: Incidence and causes of pregnancy loss after Day 70 of gestation in Thoroughbreds. Eq Vet J **53**: 996-1003

Sánchez-Miguel C, Crilly J, Grant J, Mee JF 2018: Sensitivity, specificity and predictive probability values of serum agglutination test titres for the diagnosis of *Salmonella* Dublin culture-positive bovine abortion and stillbirth. Transbound Emerg Dis **65**: 676-686

Swerczek T, Dorton A 2019: Effects of nitrate and pathogenic nanoparticles on reproductive losses, congenital hypothyroidism and musculoskeletal abnormalities in mares and other livestock: new hypotheses. Anim Vet Sci **7**: 1-11

Thobokwe G, Heuer C 2004: Incidence of abortion and association with putative causes in dairy herds in New Zealand. New Zeal Vet J **52**: 90-94

Van Loo H 2023: Epidemiology of bovine infectious abortion and perinatal mortality in Flanders, PhD Dissertation, University of Gent, Belgium, 284 p.

Van Loo H, Pascottini OB, Hooyberghs J, De Bleecker K, Ribbens S, Opsomer G, Pardon B 2023: Detection of *Anaplasma phagocytophilum* in fetal and placental tissue of bovine abortions and perinatal mortalities. Vet Rec **193**: 1-4

Wheelhouse N, Mearns R, Willoughby K, Wright E, Turnbull D, Longbottom D 2015: Evidence of members of the *Chlamydiales* in bovine abortions in England and Wales. Vet Rec **176**: 465-465

Wijma R, Weigel DJ, Vukasinovic N, Gonzalez-Peña D, McGovern SP, Fessenden BC, McNeel AK, Di Croce FA 2022: Genomic prediction for abortion in lactating Holstein dairy cows. Animals **12**: 2079