Epidemiology of Equine Abortion in Varying Locales

Abby Klawes

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Introduction

Equine abortion, defined as fetal loss before 10 months of gestation [1], occurs for a multitude of reasons, but the economic and emotional impact never wavers. Although a variety of causes have been identified, consistent primary diseases/disorders are described, including bacterial placentitis, viral placentitis, umbilical torsions, and twinning[1–5]. The etiology of equine abortion and broodmare management varies between countries, and therefore the correlation between management practices and causative agents of abortion requires further inspection. Here, we review the etiology of fetal loss in the horse and provide inferences into management practices around the world.

Infectious Causes of Abortion:

Ascending Placentitis

Inflammation of the placenta is one of the leading causes of abortion in mares [2,6]. Deemed placentitis, it can arise in multiple pathophysiologies. Ascending placentitis is infection of the placenta caused by bacteria that migrates through the cervical canal, after the mucous plug has been compromised, to the cervical pole [7,8]. Bacteria spreads along the cervical pole of the placenta, resulting in necrotizing inflammation of the chorioallantois and increases pro-inflammatory cytokine levels [6,7]. Pro-inflammatory signaling can result in uterine contractions, leading to early expulsion of the fetus [9]. Thickening of the placenta is commonly seen as a result of placentitis and can negatively impact the fetus' nutrient, waste and oxygen exchange [7]. *Streptococcus equi zooepidemicus* and *Escherichia coli* are the most noted bacteria associated with ascending placentitis, but *Pseudomonas aeruginosa, S. equisimils, Staphylococci*, and others have been seen [2,10,11].

Common clinical symptoms associated with placentitis are premature mammary gland development, thickening of chorioallantois noted on ultrasound, and vaginal/vulvar discharge [9]. Separation of the chorion and endometrium may also be noted during transrectal ultrasonography to determine the combined thickness of the uterus and placenta (CTUP) [12]. Elevated progestagen levels may be observed, as elevated progestagen levels are associated with mammary development and lactation during a normal prepartum period [13,14]. Diagnostic measures used to evaluate placentitis include use of a speculum to visualize the the mucous plug and cervix [7]. Careful handling of the speculum is essential, as cervical stimulation can induce early parturition. Trans-rectal ultrasounds are utilized to obtain CTUP measurements, as well as separation of the chorion from the endometrium [12]. A CTUP >15mm in horses and >12mm in ponies after day 310 of gestation is often associated with placental inflammation [8]. Serial measurements of circulating hormone levels can offer insight into fetal stress, including plasma pregnane concentrations. Increasing levels prior to 48 hours of parturition may indicate fetal stress or increased fetal maturation. Therefore, if progestagen levels suddenly drop, a spontaneous abortion will likely follow [15]. After foaling, uterine cultures can assist in providing information relating to treatment selection for ascending placentitis; and uterine lavage is used to ensure retained organisms are removed from the mare [16].

A multi-modal approach utilizing anti-inflammatories, antimicrobials, tocolytics, and anti-cytokine therapeutics are commonly prescribed for treatment of ascending placentitis [17], but limited research on efficacy and pharmacokinetics for this purpose have been performed. Thereby, the individual efficacy should be questioned. The most common combination of medications administered for the treatment of bacterial placentitis are trimethoprim-sulfamethoxazole (TMS), flunixin meglumine (FM), and pentoxifylline[17]. A study done by Bailey *et al.* examined treatment efficacy of long-term pentoxifylline, altrenogest (ATL), and TMS for improved pregnancy outcome in mares affected by placentitis and found that treated mares carried longer pregnancies and had a higher rate of live foal delivery than untreated mares [17]. Another study done by Curcio *et al.* examined a basic placentitis treatment of TMS and FM with estradiol cypionate (ECP) and ATL [18]. Findings included success with supplementation of ECP with TMS + FM, as evidenced by no premature parturition or pregnancy loss and normal gestation length. Educated and case-dependent decisions should be made when choosing a treatment plan for a mare with ascending placentitis.

Chlamydia-Induced Placentitis

Chlamydia, an avian pathogen most commonly noted in Australia, can result in abortion as well as neonatal pneumonia [19,20]. In addition to the risk posed to horses by *Chlamydia*, the strain *C. psittaci* can also be transmitted to humans who are exposed to aborted fetuses and fetal fluids [21]. The prevalence of *C. psittaci* varies year to year (6.5-27.1%), but can cause lesions on the fetal lungs, amnion, allantois, and placenta [22]. Many cases submitted to the veterinary diagnostic laboratory presented with similar patterns of lymphohistiocytic placentitis, such as lesions and development of long-term infection . *Chlamydia* can cause mild placentitis symptoms or present with no signs until abortion [21]. A farm in Australia investigated four mares who aborted their fetuses due to *Chlamydia,* without signs of impending fetal loss including no cervical discharge or premature mammary gland development [19]. Some mares were treated with tetracycline after two mares on the farm aborted, but no difference was found in foal survival. Chlamydia is not routinely tested for in equine abortion submissions, but due to the lack of specific knowledge about the disease, it is recommended that there be more specific testing for the pathogen [23]. *C. psittaci* diagnostics are highly accurate and should be utilized whenever possible [19].

Nocardioform Placentitis

Nocardioform placentitis (NP) is placental inflammation in which bacteria is confined to the chorionic surface of the ventral placenta, with no bacteria or infection noted in the fetus [24]. Nocardioform placentitis has been described around the world. This disease is believed to be associated with a variety of gram-positive branching bacteria, including *Amycolatopsis* ssp., *Crossiela equi*, and *Streptomyces*, which are commonly found in soil, and noted during dry periods. NP pathogenesis is poorly understood, leaving room for research, 45% of NP cases, the common Actinomycete bacteria were not found [25]. It has been found that focal mucoid placentitis affects pattern recognition receptors, causing upregulation of transcription factors leading to placental separation, placental inflammation, and placental insufficiency; all affecting fetal growth or pregnancy outcome [26]. Canisso *et al.* attempted to induce nocardioform placentitis in mares using *Crossiela equi* to gain a better understanding of the disease [27]. Multiple study groups were used, and mares were inoculated with *C. equi* through intrauterine, intravenous, intranasopharyngeal, and inoculation methods while others were used as controls on the same farm as infected mares, and 200 mares had swabs collected before and after mating in an attempt to detect nocardioform-related microorganisms. Although a few mares aborted throughout the study duration, none of them presented with evidence of NP. This was the first attempt at developing an experimental model for NP, and results show that more research needs to be put into the disease as no significant information was shown and the pathogenesis of NP is still undetermined.

While infection does not reach the fetus, placental separation due to lesions leads to insufficiency that may cause growth retardation in foals that do carry to term [28]. Late-term abortions, premature foals, neonatal deaths, and weak foals at term are common consequences of NP [26]. Often, large NP lesions results in premature mammary gland development, and vulvar discharge is sometimes observed. Attempts at visualizing a NP lesion can be made with transabdominal and transrectal ultrasounds but do not have a high success rate due to the focal location of the lesions [25]. With weekly blood assessments, increased progestins, decreases in estradiol-17β and an increase in Alpha-Fetoprotein [26], information about NP in a mare can be provided. While these markers provide insight, there is a need for a NP diagnostic biomarker test [25]. There is no standardized treatment for NP, as pathophysiology of the disease is unclear, but treatment usually includes broad spectrum antibiotics, anti-inflammatories, and therapeutics to improve uterine/placental blood flow [25].

Viral Placentitis

Equine Herpesvirus (EHV) is a double stranded DNA virus that is associated with late-term abortion, neonatal death, equine herpesvirus myeloencephalopathy (EHM), and "abortion storms," affecting whole farms [2,4,29]. EHV-1 is the most commonly noted strain, and is found worldwide [3,4,29–32]. Transmission of EHV-1 occurs via direct contact with infected bodily secretions or inhalation of infected aerosols [4]. EHV-1 migrates to the endothelial cells of the uterus and leads to vasculitis and avascular necrotic edema in the endometrium which can cause detachment of the chorioallantois, leading to abortion and/or neonatal death. Clinical symptoms of EHV-1-associated abortion may include fever and respiratory symptoms, but abortion often occurs with no prior clinical symptoms. Diagnosis of EHV-1 includes PCR testing, immunohistochemical staining, or restriction fragment length polymorphism of viral DNA, but these typically occur following abortion [2,30]. Aborted fetuses can present with fluid in the thoracic and/or abdominal cavity, subcutaneous edema, lesions throughout the body, and more [2,11,31]. EHV management such as proper vaccination, small groups of mares, reduction of stress, and separating pregnant mares from all other horses can help mitigate the risk of abortion storms [11,32]. The recommended vaccination strategy includes administering pregnant mares on a vaccine schedule at five, seven, and nine months to help prevent EHV induced abortions [33]. The EHV vaccine does not provide full protection against the disease, and does not provide full protection against the disease, proving a need for better preventative therapies [4].

Leptospirosis

Leptospirosis is an infectious agent caused by the spiral bacterium *Leptospira* [34]*.* There are many varieties of Leptospires, which are serologically classified into different groups by similarity of lipopolysaccharides called serovars [35]. While strains adapt to specific animal species as hosts, they can further adapt to infect other species therefore causing incidental infections. Striped skunks, opossums, racoons, rodents, and grey and red foxes are all wildlife that are hosts for serovars and can spread infections to horses through contaminated urine or reproductive fluids and contaminated water or soil [36]. Equines affected with leptospirosis variants can present with a variety of clinical symptoms including disease of the eyes, kidneys, pulmonary, and reproductive tracts [34,35].

Leptospirosis can present in the reproductive system in horses as acute or chronic disease [35]. The most common serovar associated with acute leptospirosis-caused equine abortion is Pomona type *kennewicki*[24,34,36]. Epidemiologically, acute onset leptospirosis occurs when horses access contaminated sources, which are believed to penetrate through skin abrasions or mucosal membranes[37]. Bacteria adheres to host cells, enters the bloodstream, and is transmitted to organs where lesions develop and damage endothelial cells [34]. The body responds with antibodies that rid all but the eyes, kidneys, and reproductive tract of bacteria. Infection of pregnant mares can lead to inflammation of the placenta, fetal infection or death, and abortion [34,35,37]. It is common for no clinical signs to be presented prior to abortion or foal delivery, but serovar titers may be high if tested [24]. If a foal does not die *in utero*, they may be born weak with neonatal jaundice. Results of necropsies following acute onset abortions show

Leptospira lesions in the kidney, liver, placenta, and umbilical cord [34]. Mares who abort have the potential to shed serovars through their urine for approximately 2-3 months. Although Leptospirosis has negative outcomes for some mares and foals, a considerable number of infected mares produce healthy foals. While there has been a small amount of leptospirosis epidemics recorded, occurrence varies based on geographical location.

Diagnostics for leptospirosis-caused abortion includes PCR testing of the aborted tissue or fluids or fluorescent antibody testing of the fetal kidney, fetal liver, placenta, or umbilical cord [24,34]. Mares found with, or suspected to have, leptospirosis are often treated with antibiotics, although there is no scientific data on efficacy or treatment rates, so there is potential for increased antimicrobial resistance. If a horse is acutely infected with or aborting from *Leptospira*, they should be isolated for several weeks with PCR testing of urine to determine shedding rate, if any. According to the American Association of Equine Practitioners, pregnant mares should be vaccinated against *Leptospira* annually to aid in prevention of the disease [38].

Noninfectious Causes of Abortion

Umbilical Torsion

Umbilical torsion is one of the leading noninfectious causes of abortion in mares[1,2,5,39,40]. Torsion of the umbilical cord results in vascular compromise, ultimately leading to fetal death and abortion [39,41]. Diagnosis of umbilical torsion must be confirmed through disturbances in the cord such as hemorrhage, edema, umbilical vessel constriction and/or thrombosis or aneurisms which can lead to a compromised vascular network within the placenta[1,2]. Abortions are most commonly seen in gestational months 6-8, with fetal mobility being highest from months 4-7 of gestation[41–43]. Fetal mobility is normal during pregnancy, with reports of 78% of normal umbilical cords having 4.4 twists each[41]. It was found that umbilical torsion-caused abortion was highly linked to a longer umbilical cord (67.2cm vs 94.8cm) [39]. In other studies, it was found that umbilical cords >85cm was the only risk factor for umbilical torsion-associated abortion[42].

Twinning

Twinning is the undesirable development of two foals *in utero,* potentially originating from one or two ovulations[44]. Twin pregnancies frequently result in non-viable or severely compromised foals due to placental insufficiency to support two fetuses[45,46]. Additionally, parturition of twins can lead to dystocia, fetal membrane retention, death of one or both fetuses, or damage to the mare's reproductive tract; causing issues in subsequent foaling seasons[46,47]. If two embryos are found prior to day 16 of pregnancy, one may be pinched against the uterine wall to terminate it [48]. If two embryos are not noted by day 16 of gestation but are noted before day 40, a natural reduction will often occur due to lack of ability from the deprived embryonic vesicle to obtain adequate nutritional support from the endometrium. Manual reduction should be performed if multiple embryos are detected, and done so with manual crushing, although only 75% of twins can successfully be reduced while maintaining a viable embryo until day 30 [49]. There are further methods to reduce twin pregnancies, but they become increasingly less successful in only reducing one embryo as gestation age increases [48]. In many studies, it was shown that the rate of twinning has been severely reduced, as there is an advanced level of ultrasonographic technology readily available[1,10,43]. Considering the professional guidelines of ultrasounding a mare at day 15, day 25-30, day 40-60, and after day 170 [50], there should very few cases of twinning as a cause of equine fetal loss.

Idiopathic:

Idiopathic abortions are commonly described in epidemiology studies assessing the incidence of abortion around the world [1,5,51–53]. Idiopathic causes are seen when no final diagnosis is identified, and a large percentage of abortions are described as such[1,2,5,10,11,53]. In some reviews, causes such as congenital defects or fetal mummification were identified but still placed in the idiopathic category [1]. Speculations of unknown chemical teratogens in relation to congenital abnormalities have been suspected, but not further investigated [2]. A broad majority of epidemiology studies, as shown in Table 1, resulted in a dominant diagnosis of idiopathic/no diagnosis, including California [1], Italy [53], Canada [5], Hungary [52], and Denmark [54]. Further investigation into "idiopathic" causes may be neglecting new causes of abortion, potentially increasing the rate of preventable abortions. Equine chromosomal abnormalities have been investigated, with findings showing changes in chromosome number are among the most common non-infectious cause of fetal loss and foals born with congenital defects [55]. According to the University of Kentucky, even if an owner received an idiopathic or unknown result from a necropsy, there is still insight provided into maternal factors that may have played a role into abortions, such as genetic, anatomic, endocrinologic, metabolic, microbiologic origin, and immunologic [56]. While information into the abortogenic cause is beneficial for mare owners, studies should be done in more depth to explore these additional reasons, as there are most likely some patterns currently unseen.

PEER REVIEWED EPIDEMIOLOGY ON INCIDENCE RATES OF FETAL LOSS

Equine abortion occurs worldwide, though specific incidence rates vary by country [1,2,5,32,51–54]. Epidemiology has been performed on equine fetal loss in a variety of breeding locations, both within the United States and globally. Each breeding locale appears to have differed primary causes on late gestation loss, and gestational age concurring with issues was examined. All are summarized below.

North America:

Lexington, Kentucky

In a study performed in 1993 by Hong *et al.*, the fetus and/or placenta of 1,211 accessions were processed, and 83% of submissions received a diagnosis [2]. Leading causes of abortion in Kentucky were dystocia (19.5%), placentitis (19.4%), contracted foal syndrome, and other fetal abnormalities (8.5%). The highest incidence rates of aborted fetuses were noted at >300 days of gestation with 538/1211 (44.42%) specimens submitted at the time. Additionally, the most common month of abortion was March (15.4%) followed by April (14.9%). Unfortunately, epidemiology of fetal loss in Central Kentucky has not been investigated since.

California

A more recent epidemiological survey was performed in the United States Davis, California by Cantón *et al.*, where the accession records from 1990-2020 were investigated [1]. In total, 1,774 abortions were submitted, but results were only confirmed for 29.2% of submissions. Infectious abortions accounted for 18.7% of records, with single bacterial infections such as *Streptococcus* spp., *Leptospira* spp., and *Escherichia coli* making up 11.8% of abortions, and umbilical torsion making up 4.4% of abortion causes. Specific gestational ages were not provided in this study.

Canada

A 13-year retrospective study was performed in Canada by Ricard *et al.* using 901 equine abortion necropsy reports to inspect the incidence rates and most common causes of equine abortions [5]. Over half of reports were determined to have no final diagnosis. Umbilical torsion and Equine Herpesvirus both presented in 10.2% of reports, followed by bacterial placentitis at 7.0%. Overall, non-infectious fetoplacental results were most commonly seen. Out of the 901 submitted cases, 324 reports made up late term abortions, but there was no identified gestational length in 30.6% of cases [5]. The most commonly submitted specimens occurred at 9 months of gestation (24.5%), followed by 7 months (16.5%).

United Kingdom

A survey was performed to examine equine abortion in the UK by Smith *et al.* from 1988 to 1997 [32]. This survey included 1252 diagnosed cases that were analyzed to conclude the following results. Umbilical torsion was most often seen, being found in 36.2% of cases. Dystocia/stillbirth was seen in 12.8% of cases, and ascending mixed placentitis was seen in 9.8% of cases. Of all studies reviewed, this one had the lowest observed idiopathic rate at only 7.8% and incidence of non-infectious causes was higher than infectious. Gestational ages in correlation to abortions were not studied.

France

A retrospective study was completed in France by Laugier *et al.* assessing 1,822 cases submitted for necropsy over 24 years [51]. Cause of abortion was determined in 74.9% of cases, with bacterial infections making up 38.1% of cases, fetal septicemia +/- placentitis making up 35.0% of cases, and umbilical cord disorders accounting for 16.5% of cases. 9 months was the most common gestation age associated with abortion, at 29.1% followed by 7 months at 21.4% - similar to Ricard's study from Canada.

Hungary

A smaller study was performed in Hungary by Szeredi *et al.*, assessing 96 aborted fetuses from a three-year period [52]. Cause of abortion was successfully identified in only 70% of cases. EHV-1 was the disease most commonly noted, causing 16% of abortions, followed by suspected *C. psittaci* at 10%, and EAV at 7%. *C. psittaci* is a suspected cause of abortion in this study due to lack of ability to determine the role of chlamydial infection in the abortion. Gestation age in relation to abortion was not reviewed in this study.

Italy

The study performed by Marenzoni *et al.* investigated causes of abortion in horses in central Italy and assessed 89 submissions [53]. No diagnosis was found for 38% of cases reviewed. It was observed that EHV-1 was presented in 15.7% of submitted cases, umbilical torsion in 6.7% of submitted cases, and a bacterial infection from *Klebsiella pneumoniae*, a pneumonia infection in the lungs, in 5.6% of submitted cases. Gestational ages in relation to abortion were not investigated.

Denmark

Agerholm et al. performed a diagnostic survey over 13 months investigating 50 cases of abortion in an attempt to identify causes of pregnancy loss in mares in Denmark [54]. Only 18% of cases resulted in no identification of cause. Umbilical torsion had the highest incidence rate at 50%, followed by bacterial infection at 12%, and EHV-1 and twinning both had incidence rates of 8%. Gestational age was only investigated in relation to EHV abortions or infections and was most commonly seen after day 255.

Locale	Kentucky	California	Italy	France	Canada	Hungary	Denmark	UK
Citation	Hong et al., 1993	Cantón et al., 2023	Marenzoni et al., 2012	Laugier et al., 2011	Ricard et al., 2022	Szeredi et al., 2008	Agerholm et al., 2021	Smith et al., 2003
Number of Animals	1211	1774	89	1822	901	96	50	1251
Cause of Abortion								
Bacterial Placentitis	19.4%	11.8%	1.9%	**38.1%**	7.0%	20%	12%	8.1%
Viral Placentitis	3.3%	4.8%	23.2%	14.2%	10.2%	23%	8%	6.5%
Leptospirosis	N/A	1%	1.9%	N/A	N/A	4%	N/A	N/A
Placental Insufficiency	N/A	N/A	0.9%	4.7%	5.7%	6%	2%	N/A
Umbilical Torsion	4.5%	4.4%	5.8%	16.3%	10.2%	2%	50%	**36.2%**
Twinning	6.1%	0.4%	N/A	1.5%	<4.1%	2%	8%	6.0%
Dystocia / Stillbirth	**19.5%**	0.7%	1.9%	N/A	N/A	1%	N/A	12.8%
No Diagnosis	16.9%	**70.8%**	**35.9%**	25.1%	**51.8%**	**30%**	**18%**	7.8%

Table 1: ***Common diagnosis of equine fetal loss across locales.*** Epidemiology studies from Kentucky (n=1,211) [2], California (n=1,774) [1], Italy (n=89) [53], France (n=1,822) [51], Canada (n=901) [5], Hungary (n=96) [52], Denmark (n=50) [54], and the United Kingdom (n=1,251) [32] were reviewed and analyzed for the most commonly seen causes of abortion. In 5/8 studies (62.5%), No diagnosis was most commonly noted. Bacterial placentitis was the overall leading cause of infectious abortions, while umbilical torsion was the leading cause of non-infectious abortions.

Survey

Therefore, we surveyed breeders to gain insight on mare care and management during gestation, and people involved in equine reproduction around the world were asked for their input. Responses were collected from 289 participants, with responses from Africa, Asia, Australia, Europe, New Zealand, North America, and South America. Of these, Australia, Europe, and North America, with 249 of the responses, were further pursued due to the power of analysis. There were 189 responses for North America (n=189), 41 responses for Europe (n=41), and 19 responses for Australia (n=19). The incidence of perceived causes of abortion, between days 150-330 of gestation, is shown in Figure 1.

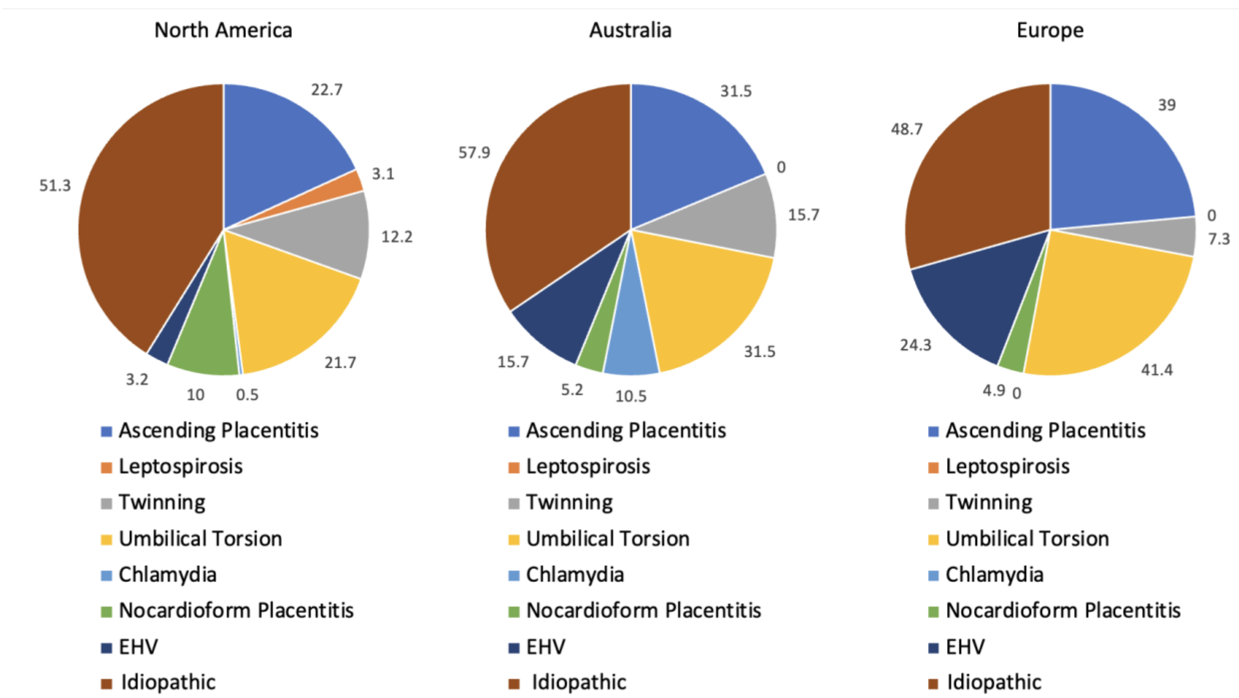

Figure 1: ***Perceived causes of equine abortion in North America, Australia, and Europe***. Participants of equine breeding industries in various locales were surveyed, including North America (n=189), Australia (n=10), and Europe (n=41). The predominant diagnosis associated with fetal loss was lack of diagnosis in all locales. Following that, the dominant causes of abortion included ascending placentitis, umbilical torsions, twinning, and equine herpes virus, and this was

noted regardless of locale. Less noted were leptospirosis, chlamydia, and nocardioform placentitis.

As shown in Figure 1, it was reported that ascending placentitis is most noted in Europe, accounting for 39% of abortions, with lesser perceived incidence noted in Australia and North America, at 31.5% and 22.7%, respectively. Nocardioform placentitis was perceived to account for 10% of abortions in North America, 5.2% in Australia, and only 4.9% in Europe. Not surprisingly, *Chlamydia* was mainly described in Australia, where it accounted for 10.5% of abortions, with just 0.5% in North America, and 0% in Europe. Finally, it was perceived that *Leptospirosis* was only noted in North America, accounting for 3.1% of abortions. Umbilical torsion was perceived to account for 26.9% of abortions in the survey and was seen around the world, similar to results of previously published studies discussed above.

Although there have been significant advancements in ultrasonographic technology, twinning was noted as a cause for abortion in many responders to the survey, as shown in Figure 2. In North America, this was described as the cause of 12.1% of abortions, followed by 10.5% in Australia, and 7.3% in Europe. This represents the need for stronger working relationships between veterinarians and clients, as this cause of abortion is preventable.

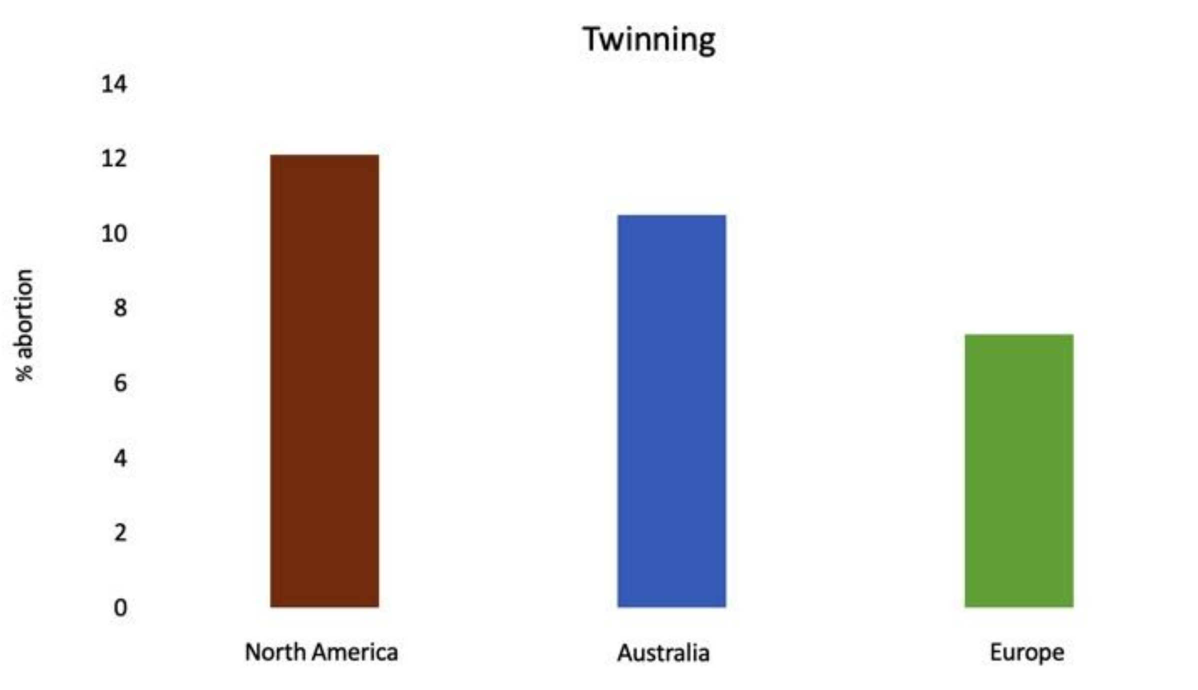

Figure 2: Perceived rate of twinning in North America, Australia, and Europe. Survey respondents (n=249) across all breeding locales (North America n-189; Australia n=19; and Europe n=41) noted a portion of their equine populations to experience late term pregnancy

loss due to twinning. This included 12% of respondents from North America, 10.5% from Australia, and 7.3% from Europe, indicating that twinning is still a prominent issue in the equine breeding industry.

Identification of Fetal Loss

Obtaining a necropsy or field diagnostics to determine the cause of fetal loss is essential to preventing or managing disease spread. Many survey responses indicated that they used some form of diagnostic testing to identify the causation of their fetal loss. Ultrasonography was the most widely used diagnostic tool, with 78.9% of Australian responses indicating that they ultrasound their mares throughout pregnancy, 75.6% of European responses, and 73.5% of North American responses. Observation of clinical symptoms was utilized by some as well. Endocrine bloodwork was perceived to be used 6.3% of the time in North America, 7.3% in Europe, and 0% in Australia. Bloodwork titers were utilized 7.4% of the time in North America, 2.4% of the time in Europe, and 5.3% of the time in Australia. Necropsies were reported to be utilized by 81 respondents (32.5%) as an identification method. Although there are many methods utilized to identify causes of abortion, 51.3% of abortions in North America were idiopathic, 47.3% of Australian abortions were idiopathic, and 48.7% of abortions in Europe were idiopathic, as shown in Figure 3. This is similar to studies done in other countries, varying rates of idiopathic abortions, confirming the need for an increased depth level of necropsies, including reporting all information found and exploring chromosomal differences.

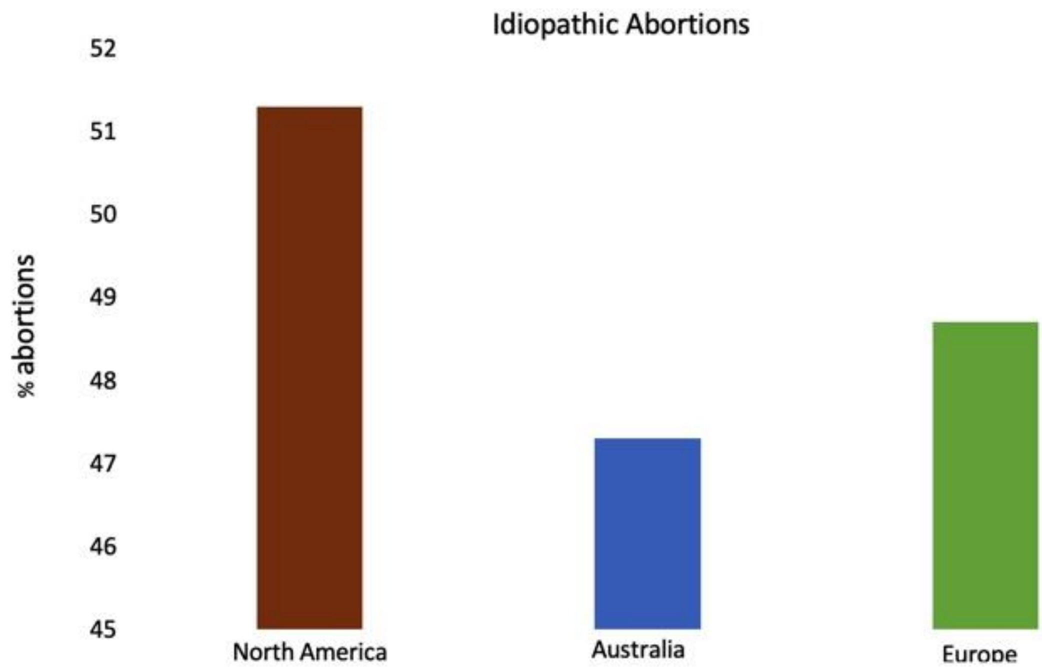

Figure 3: Perceived rate of idiopathic abortions in North America, Australia, and Europe. Survey responders (n=249) indicate that lack of diagnosis for causative agent/disease in equine abortion is the primary diagnosis in many locales. This included 51.3% of North American responders (n=189), 47.3% of responders for Australia (n=19), and 48.7% of responders for European breeders (n=41).

Vaccines

The use of vaccinations to prevent infectious disease in pregnant mares is risk-based and dependent on locale. Additionally, education on which vaccines can and cannot be given to pregnant mares is vital, as some vaccines have not been approved for use in this demographic. According to Zoetis Animal Health, , the Equine Arteritis Virus vaccine should not be given to mares in the last two months of pregnancy [57]. Yet, the survey indicates that 10 respondents administered pregnant mares the EVA vaccine in North America. Additionally, it was perceived that some mares who were vaccinated for EHV still had EHV-related abortions. In North America, 3.2% of the vaccinated mares had abortions, while 42.8% and 30.3% of vaccinated mares in Australia and Europe, respectively, had EHV related abortions. The high incidence rate of EHV-related abortions in mares who were vaccinated following the proper protocol is concerning and proves that additional research is needed to improve vaccine efficacy. This survey is a further identification that there is a need for an improvement in the efficacy of the EHV vaccine, which should be given in the fifth, seventh, and ninth month of pregnancy [33].

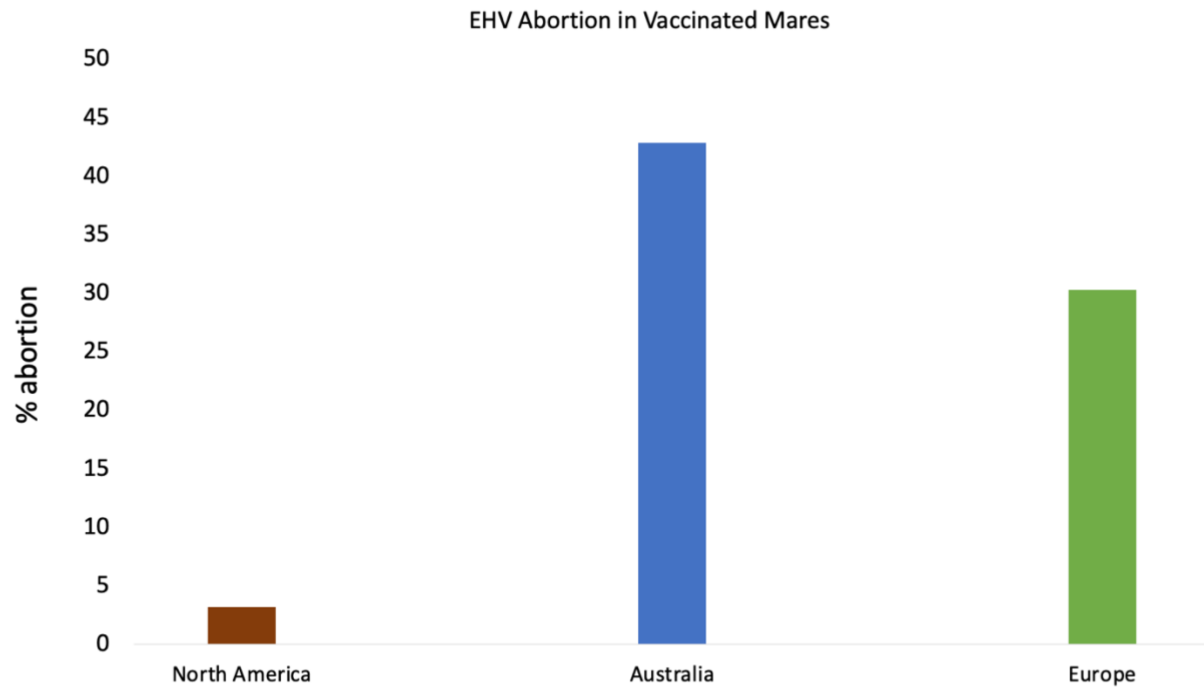

Figure 4: ***Perceived rate of EHV-caused abortions in mare vaccinated for EHV.*** North America (n=189) survey respondents indicated that 3.2% of mares vaccinated against EHV presented with EHV-caused abortions, while Australian respondents (n=19) indicated 42.9% and European respondents (n=41) indicated 30.3% of EHV related abortions in mares vaccinated against EHV.

Preventative Measures

Antibiotics and synthetic progesterone are both commodities used in equine reproduction. Antibiotics are most often used after breeding a mare who shows signs of endometritis [58] while synthetic progesterone, most commonly known as altrenogest (Regumate), is often used for the maintenance of pregnancy. While both have a time and place, the overuse of synthetic progestins in late gestation has been found to alter the lymphocyte to neutrophil ratios in neonates[59]. Additionally, synthetic progestins have been found to alter the immune system within the reproductive tract in mares. Therefore, the use of synthetic progestins during pregnancy should be critically assessed before administration. Additionally, antibiotic resistance is a growing global issue in all domesticated species in addition to humans. Both synthetic progestins and prophylactic antibiotics were assessed in the present survey, where Australia was found to have the highest use of preventative antibiotics. Additionally, North America indicated the highest use of progestins at 24%, but Australia was close behind at 21%. Europe has the lowest use of both prophylactic antibiotics and progestins, and this may be due to the higher regulations overseeing therapeutics in veterinary medicine, in addition to ease of obtainment.

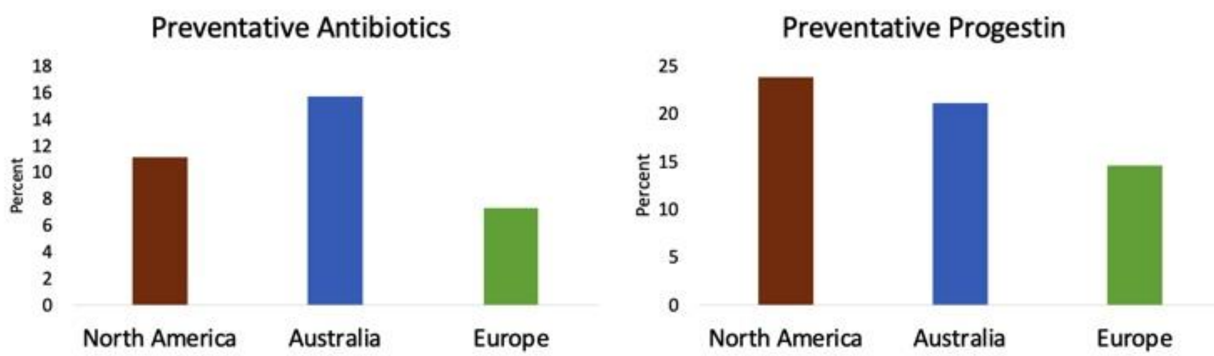

Figure 5: ***Perceived rate of preventative antibiotics and preventative progestins used in North America, Australia, and Europe.*** Survey respondents (n=249) indicated use of preventative antibiotics in all locales. It was perceived that 11.1% of North American respondents (n=189), 7.3% of European respondents (n=41) and 15.8% of Australian respondents (n=19) utilize preventative antibiotics. Additionally, survey responders (n=249) indicate the use of preventative progestins in many locales. This included 24% of North American responders (n=189), 21% of responders for Australia (n=10), and 15% of responders for European breeders (n=41).

Necropsies

Necropsies of the fetus and placenta are essential to obtaining information regarding pathological findings. As shown in Figure 6, only 28.6% North American respondents, 31.6% of Australian respondents, and 46.3% of European respondents indicated utilizing necropsy procedures after abortion. Necropsy availability may be more prominent in Europe than it is in the United States, which is shown in Figure 7. As shown, Montana, Idaho, Nevada, Utah, New Mexico, South Carolina, West Virginia, Delaware, Massachusetts, Vermont, Rhode Island, Vermont, New Hampshire, and Maine all do not have a veterinary diagnostic lab in state; most likely reducing the odds that an owner will bring an aborted fetus into a lab. Additionally, necropsy costs have a high variance rate, with Colorado State University costing $225 for fetal necropsy[60] while Texas A&M costs $96[61]. Cost may be a prohibitive factor in obtaining necropsies, as breeders are unlikely to send a fetus for necropsy if they have a healthy mare following abortion.

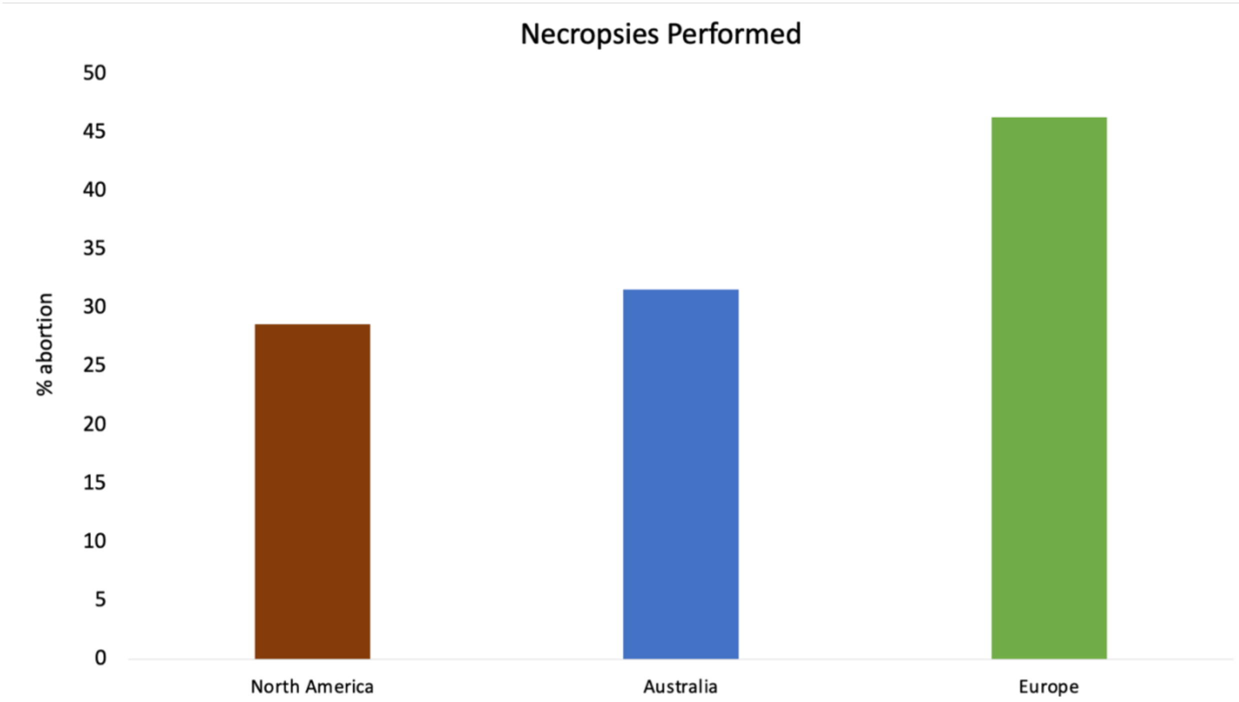

Figure 6: ***Perceived rate of performed necropsies following abortion.*** Survey respondents (n=249) from all locales indicated necropsies were performed following abortion. In North America (n=189) 28.6% respondents, 31.6% of Australian (n=19) respondents, and 46.3% of European respondents indicated a necropsy was performed post-abortion.

Figure 7: ***FDA map of Veterinary Laboratory Investigation and Response Network.*** Map of the United States showing states/locations of labs where necropsy services are provided. Adapted from the Food and Drug Administration (FDA).

Limitations

This survey identified horses by farms, leading to interpretations, as specific mare numbers were not counted. This means that all surveyed causes have potentially higher incidence rates than shown. Additionally, many more responses were received from North America (n=189) than from Australia (n=19). Finally, many perceived results were not specified to be validated by necropsy, and respondent education level was not assessed, potentially resulting in incorrect diagnoses of abortions.

Conclusion

The field of equine reproduction is a diverse, global industry that has potential to increase success and decrease economic loss resulting from equine fetal loss. While there are many potential causes of equine abortion, epidemiological science-backed practices can assist in leading to reduction of fetal loss. Proper diagnostics, treatments, and preventatives are methods owners and breeders can use to improve the likelihood of healthy, full-term pregnancies. More research should be performed on vaccination protocols, as well as improved diagnostics in relation to necropsy. Both of these can support breeders and horses by providing further information on the etiology of abortions. Further education on care and management of diseases such as bacterial placentitis, viral placentitis, umbilical torsion, twinning, and more will lead to higher success rates of equine pregnancies as well as reduce financial loss for owners and breeders.

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