Impact of bovine viral diarrhoea on reproductive function: impact on fertility and early pregnancy losses, impact on mid term and late pregnancy losses: miscarriages and stillbirths, reproductive effect on bulls, general effect on reproduction

Reproductive efficiency on cattle farms, both milk and meat, is very important, so we now focus on the scientific evidence published regarding the reproductive impact of BVD virus infections.

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The impact of any infection on the reproductive function of animals can be mediated by different mechanisms and effects. Evidence of infertility (which can include early embryo losses or the inability to get pregnant), late embryo/early foetal losses (after a positive pregnancy diagnosis), miscarriages and, lastly, the birth of weak calves that die during birth or in the first 24 hours (stillbirths) is sought.

Impact on fertility and early pregnancy losses

Fray et al. (1998; 2001) showed the ability of the virus to replicate and affect the cells of the ovarian follicles in cows at any time during follicular development in animals experimentally infected with the virus. These animals also presented less estradiol release from days 6 to 11 of infection, with no change in their serum progesterone levels. Other authors (Sentongo et al., 1980) verified persistent oophoritis (inflammation of the ovary) for at least 60 days after the experimental infection of heifers. The preovulatory surge of luteinising hormone is also nearly completely abolished in experimental infections, together with necrosis of granulous cells (in the ovarian follicles) and of the ovocyte itself (McGowan et al., 2003). Therefore, the ability of BVD to directly affect ovarian tissue is clear. Indeed, if a PI cow becomes pregnant, the result is always a PI calf, probably due to viral replication in the ovarian and reproductive tissues (Meyling et al., 1990). Therefore, Fulton (2013) believes that it can be assumed that BVD is related to fertility problems and greater season repetition in animals that have or have had viraemia.

Most studies agree that BVD infection increases the risk and incidence of miscarriage.

However, an analysis of the different studies that have linked contact with BVD (whether or not the animals on the farm have antibodies) to reproductive efficiency, either individually (Houe et al., 1993a; Larsson et al., 1994; Rüfenacht et al., 2001) or in a herd (Fredriksen et al., 1998 Valle et al., 2001; Robert et al., 2004), shows contradictory results. Some investigators, such as Houe et al. (1993), detected a lower conception rate during viral circulation phases in the herd, thus confirming that BVDV infection temporarily reduced the conception rate. Likewise Larsson et al. (1994) found clearly negative effects with more AI (artificial insemination) and pregnancy, greater duration of pregnancy in multiparous cows pregnant with PI calves (287 vs 280 days of pregnancy, probably due to a delay in triggering the birth signal by full-term calves) and a higher placenta retention rate in cows with PI calves. These results are also confirmed by McGowan et al. (1993), with low conception rates and early embryo death.

The incidence of neonatal mortality in the first 24 hours or stillbirths is significantly higher in the presence of BVD in herds.
By contrast, other studies (Rüfenacht et al., 2001; Fredriksen et al., 1998) did not find the infection to have a negative effect in the first 30-45 days of pregnancy. Valle et al. (2001) found a negative effect on the reproductive efficiency of heifers with a delay in age at the first AI in heifers, with no effect on the cows' birth-to-birth interval.

In Bretagne (France), Robert et al. (2004), with a total of 150,854 AI, from 122,697 cows from 6,149 herds, showed that the risk of oestrus repetition did not increase in the first three weeks after AI with the BVD infection. However, there was a risk of late oestrus, showing that BVD increases the risk of late embryo/early foetal death (embryo death in the stages of pregnancy that comprise the end of embryo development and the first days of what is known as foetal development between days 30 and 45 of pregnancy) rather than reducing fertility itself. The results had previously been published from observational studies of BVD infections in commercial herds, and they confirm the existence of foetal losses (Barber et al., 1985; Roeder et al., 1986; Sprecher et al., 1991; Taylor et al., 1997). The contradiction with the above studies could be because Rüfenacht et al. (2001) and Fredriksen et al. (1998) did not include late embryo or early foetal losses, as they ceased to observe when the animals were diagnosed as pregnant (Roberts et al., 2004). On the other hand, Niskanen et al. (1995) found a relationship between greater placenta retention rates, greater use of oestrus synchronisation treatments and a longer birth-to-birth interval on farms with exposure to BVD (positive antibodies in bulk tank milk without previous vaccination) than in animals free from contact with the virus. More recently, Yavru et al. (2013), in Hungary, showed that the presence of virus (but not the presence of antibodies) was related to a lower conception rate at the first postpartum AI (27.8% vs 70.9%), which would indicate that viraemia at AI has a negative impact on fertility.

In dairy farms in New Zealand, Heuer et al. (2007) linked the presence of antibodies against BVD in bulk tank milk (which represents the degree of infection in the herd) to clearly elevated miscarriage rates, more days open and more AI/pregnancy. Specifically they found poorer reproductive rates on farms with more antibodies in bulk tank milk, farms that probably had an active BVD infection at the time, with PI animals present. Therefore, they found evidence that BVD interfered with fertilisation or early embryo death (which would imply longer days open and more AI/pregnancy). This study also described a loss of milk production directly related to the level of antibodies in bulk tank milk.

Aono et al. (2013) showed an improvement in reproductive efficiency in beef cow herds through vaccination against BVD and Herpesvirus type 1 and Leptospira vs non-vaccinated herds, or those vaccinated only against Leptospira, designing the study to detect late embryo/early foetal losses precisely in animals diagnosed as pregnant on day 30 post-insemination and before day 120.

Early embryo death has been found in experimental studies (studying the effects of experimentally induced BVD infection in study animals; there were no observations of field infections on commercial farms) (Whitmore et al., 1981; Grahn et al., 1984; Bielanski and Dubuc, 1995; Van Roose et al. 1999), although other results show the opposite (Zurovac et al., 1994; Tsuboi and Imada, 1996; Stringfellow et al. 1997; Bielanski et al., 1998 Booth et al., 1998), and it has been argued that these differences are probably due to different strains of the BVD virus used in the experiments (Robert et al., 2004).
Impact on mid-term and late pregnancy loss: miscarriages and stillbirths

Most studies agree that BVD infection increases the risk and incidence of miscarriages (Fredriksen et al., 1998; Rüfenacht et al., 2001; Robert et al., 2004), and show that, in Switzerland for instance, 7% of foetal deaths could be attributed to BVD. There also appears to be overall consensus regarding the incidence of neonatal mortality and stillbirths, which is significantly elevated as a result of the presence of BVD in herds (Gates et al., 2013).

The effect of foetal BVD infection depends, once again, on the type of virus, the virulence of the strain and the moment during pregnancy when the pregnant animal is infected and presents viraemia (Grooms 2004). It actually depends on the foetus’s immune capacity to fight off the infection (Moening and Liess, 1995). During the first 18 days, while the embryo is not yet implanted there is no foetal infection as the virus does not cross the zona pellucida (Moening and Liess, 1995). From days 29 to 41, when there are cotyledons in the incipient placenta, viraemia in the pregnant mother gives rise to direct foetal death (Carlsson et al., 1989; McGowan et al., 1984) and therefore to lower pregnancy rates (Gahn et al. 1984).

The birth of a PI calf is most likely when there is an infection from day 30 to day 90 of pregnancy, as it does not react to the virus and accepts it as something proper (Brownlie et al., 1998; Swasdipan et al., 2002). If this does not happen, foetal resorption, foetal death and miscarriages can also be induced during these phases (Kellig and Topliff, 2013).

Infection in middle stages of pregnancy (days 80-150) causes miscellaneous congenital malformations that largely affect the nervous system but also other foetal organ systems. Said malformations include cerebellar hypoplasia, microencephaly, hydrocephaly, hydranencephaly, porencephaly, cerebral cyst formation, hypomyelination, congenital cataracts, microphthalmia, retinal degeneration, optic neuritis, thymic hypoplasia, hypotrichosis osteogenesis imperfecta, arthrogryposis, brachynathia, incomplete foetal pulmonary development and delayed intrauterine growth (Fulton, 2013 and Lanyon et al., 2013). Some of these malformations are compatible with live calves with certain symptoms. Cerebellar malformations, for instance, give rise to typically ataxic animals, with uncoordinated and abnormally uncontrolled movements.

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In these phases of pregnancy, the infection of the pregnant mother can also give rise to foetal death and miscarriage without malformations (Done et al., 1980). However, the symptoms can vary, depending considerably on the strain and type of virus. For instance, Blanchard et al. (2010) described an outbreak of BVD on a farm basically associated with late miscarriages with malformations and premature births.

Finally, a primary infection during the last third of pregnancy (days 150-180) can give rise to the birth of healthy seropositive calves (they have seroconverted and survived the intrauterine infection; Hansen et al., 2010), or miscarriages, premature or stillbirths (Matsuno et al., 2007).
Reproductive effect on bulls

It has been shown that acute infection in sexually active bulls gives rise to a reduction in seminal density and motility and an increase in the abnormal sperm rate (Paton et al., 1993). In vitro studies have confirmed that fertilisation rates are significantly reduced when semen is incubated with non-cytopathic strains of the BVD virus (Garousi and Mehrzad, 2011). Furthermore, the BVD virus can persist in the semen of an infected bull for an average of 2.75 years after the infection (Givens et al., 2009) and, lastly, it has also been found that PI bulls can present testicular hypoplasia as a result of the virus’s constant replication in the testicular tissues (Borel et al., 2007).

General effect on reproduction

As the economic impact on a farm depends on several factors, the same can be said of the specific effect of a BVD virus infection on a farm’s reproductive efficiency. In the first instance, it depends on the status of the herd’s initial infection (Heuer et al., 2007). In other words, how many animals present anti-BVD antibodies, whether the antibodies are natural post-infection or post-vaccination, and when the infection or vaccination occurred. An indirect idea of the immune status of a farm can be obtained from an antibody analysis of bulk tank milk, as it is directly related (Bitsch and Ronsholt, 1995). As immunity induced by natural infections is considered to be long-lasting, we might generally expect a smaller effect on farms that have had active infections and whose animals largely have antibodies (high intra-herd prevalence) or on vaccinated farms.

It will also depend on the number of animals infected in the herd from a PI animal or animals with transient infections, which in turn depends on the biosafety and biocontainment measures applied (to prevent or contain intra-herd germ transmission). If we assume that PI animals are usually young animals, intra-herd prevalence will depend on the contact of the different productive lots (adult cows) with offspring and different lots of differently aged heifers.

On the other hand the BVD virus, as well as having two recognised species and different subgenotypes in each one, presents a wide range of strains with different pathogenicity or virulence, so the clinical, and therefore economic, effect depends on their virulence. Therefore, the greater the pathogenicity, the greater the expectations of worse, more expensive and more persistent consequences.

Therefore, based on these premises, we can understand the numerous cases where BVD infection has caused a clear reduction in reproductive efficiency, whereas this negative impact on reproduction by the BVD virus cannot be determined in other herds, even when they have an active infection. There are also cases where we are not able to conclude that deficient reproductive efficiency found on a farm and not attributable to other causes is due to BVD.

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