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An overview of infectious causes of abortion in Ireland in 2013

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TABLE OF CONTENTS:

1. Abstract:

Bovine abortions cause major financial loss to the farming industry of Ireland each year. The aim of this thesis is to evaluate the prevalence and trends of common infectious bovine abortifacients in Ireland in 2013. It will also examine in detail the aetiology of the identified abortifacients, the pathophysiology and in some cases the available preventative and curative measures which can be taken. This thesis has used quantitative data extracted from yearly reports compiled by the Department of Agriculture, Fisheries and the Marine and the Agri-Food Biosciences Institute of Ireland. The findings from this thesis demonstrate that while there were many common causes of abortion in cattle in Ireland in 2013 such as Salmonella dublin and Neospora caninum, the most common cause in 2013 was Trueperella pyogenes, detected in 208 out of the 3517 foetuses or foetal samples submitted.

2. Introduction:

Abortion in cattle causes significant losses every year, both to the individual farmer and in turn to the overall farming industry of Ireland. For this reason, it is important to achieve a prompt and accurate diagnosis of the causative agents of the abortion, in order to prevent the spread of abortion and as such, further economic loss. The loss due to a single abortion can be difficult to discern, but is roughly estimated to be approximately £630 or €700, (Cabell, 2007). In any herd there will be a number of unexplained sporadic abortions, but if the rate exceeds 3%, or if an abortion storm happens within a short time, it is recommended an investigation be done, to find the causing pathogen (Department of Agriculture, Fisheries and Food & Agri-Food Biosciences Institute, 2010). This should be done promptly so that informed measures can be taken to prevent the further spread and financial loss.

The term abortion means the premature expulsion of the foetus from the dam. It occurs because the foetus has died. It is called an early embryonic death when the mortality occurs up to the 42nd day of the pregnancy (McGavin *et al*, 2001). If it occurs before the second month, the foetus will usually be resorbed by the dam, and the cow will present as one not in calf, usually with no other clinical signs. If it occurs when the foetus is older than two months, the foetus and placental tissues will be shed by the cow. If it occurs near term and the calf is born fully formed but dead, this is called a stillbirth (Bagley, 1999).

Figure 1: A still born Calf. (Kenny, 2014)

The gravid uterus has a higher sensitivity to pathogens when compared to the inactive or immature uterus. Infection can reach the uterus or foetus in many ways: via the lymph system, hematogenously, transplacentally or can ascend from the vagina through the cervix. Ruminants have a cotyledonary type placenta. This means there is a large area to accommodate the accumulation of infectious agents and exudate which can help lead to the higher risk of abortions (McGavin & Zachary, 2007). There are many different pathophysiological processes which can occur and lead to foetal death, and so lead on to resorption, maceration, mummification, emphysema and autolysis of the foetus (Maxie, 2007).

Figure 2: An example of a mummified foetus. (Department of Agriculture, Fisheries and Food and Agri-Food Biosciences Institute, 2010)

Figure 3: An example of an autolysed foetus. Source: (Kenny, 2014)

Abortion diagnosis is difficult and a cause is achieved in only a small proportion of submitted foetuses (Department of Agriculture, Food and the Marine & Agri-food and Biosciences Institute, 2013). As much information as possible should be provided with the submissions. Useful facts would include an estimate of the rate of abortion in the herd, and the stage of pregnancy at which the abortion occured. If possible, it is also useful to inform the lab, if not sending the whole foetus, whether it was fresh or autolysed. Are the abortions happening in cows or heifers, what is the herd vaccinated against, do they retain the placentas (Anderson, 2007). The abortion protocol for the region should be followed. Most protocols involve sending the intact aborted foetus, serum samples from the cow, and the placenta. If the foetus is freshly aborted there will be clear amber fluid visible in the body cavities, and 1 - 2 days after the death, the body cavities and subcutis will have sero-sanguinous fluid collections. There will then be a dehydration of the tissues and a week after the foetal death there will be no abomasal content and the whole foetus will be dehydrated (Anderson, 2007). It is also important to send the foetus so as to determine the time of gestation the abortion occured in because this can be indicative of the causative pathogen, for example Neospora caninum usually causes abortion between the 5th - 7th month of gestation (Dubey *et al*,2006). The placenta is useful to sample as certain fungi and bacteria affect it and the resulting placentitis

is what causes the abortion (Anderson, 2007). When the whole foetus cannot be sent, certain samples can be sent instead. They include lung, liver, kidney, placenta, foetal thoracic fluid, foetal abomasal fluid and a selection of other tissues fixed in formalin. If more than one abortion has occurred, it is recommended to send samples from each incidence. The fluids should be sent in sterile tubes, the tissues in separate sterile containers. Useful formalin-fixed tissues for examination by histopathology include kidney, adrenal gland, thymus, lymph node, brain, lung, heart, liver, abomasum, small intestine, skeletal muscle, placenta, eyelid. (Barr *et al*, 1993).

In Ireland the regional veterinary laboratories have an important task to fulfil in the investigation into the causative agents of bovine abortions, not only due to the fact that it plays an important economic role in the farming industry but also due to the public health significance of some of the pathogens. For example, many Salmonella species can cause abortion in cattle, and some of these species can also infect humans. Other agents like Brucella abortus and Listeria monocytogenes also pose a major health risk to humans.

It is important to correctly package and preserve the samples submitted, to ensure the proper handling and fast delivery of the samples. It has to follow the EU guidelines of the European Agreement for Transportation of Dangerous Goods Regulation 2007 which was brought in the 1st of January 2007 (Department of Agriculture, Food and the Marine, 2014). The method of packaging recommended by the Department of Agriculture, Food and the Marine is as follows: the sample should be put into a secure primary container that is leak proof. If it is a faecal sample it should be put into a screw top container to protect from opening by the gas forming and opening the lid. This primary container needs to be put into a second leak proof container, for example a leak proof bag. If this is the case then it must be placed into an outer rigid container, or else the secondary container should be rigid for protection of the sample. In between the primary and secondary containers there should be an absorbent material and it should have the capacity to soak up the total contents in the event of a spillage or leak. On the outer package should be printed, ‘BIOLOGICAL SUBSTANCES, CATEGORY B’ and a hazard symbol containing the following: UN3373

Figure 4: The hazard symbol which should be displayed on the outer packaging of samples (Department of Agriculture Food and Marine, 2014).

Also on it should be written the details of the consignor and the recipient, with contact names and numbers. If these rules are followed then the whole package can be sent by normal courier or normal post. All the samples sent to the labs have to be packaged according to the classification of different pathogens in specific risk categories, which are classified by the World Health Organisation. There should also be a submission form along with every sample. It should contain the information relevant to the case and the tests required by the vet in charge of the case (Department of Agriculture, Food and the Marine & Agri-food and Biosciences Institute, 2012). If it is a blood sample from the dam to rule out brucellosis, it needs to be sent to a specific brucellosis lab in county Cork in the south of Ireland. The foetus is sent to one of the Regional Veterinary Laboratories. In the Regional Vet Labs they use different methods to determine and realise the cause of the abortions. Foetal fluids are examined routinely. The abomasal contents are important for this. Foetal thoracic fluid, pleural fluid and blood from the heart are used for serology. The foetal tissues may also be examined microbiologically and histopathologically. The Bovine Viral Diarrhea virus detection process employs the techniques of Polymerase Chain Reaction, Enzyme Linked Immunosorbent Assay or Immunofluorescent antibody test. Neospora Caninum detection involves histopathological investigations of the myocardium or brain, Immunofluorescent antibody test and immunohistochemistry or solid phase immunoassay. Leptospira interrogans serovar hardjo detection involves examining thoracic fluid of the foetus by solid phase immunoassay. Polymerase Chain Reaction, Enzyme Linked Immunosorbent Assay, Immunofluorescent antibody test or Monoclonal Antibody Testing can detect the leptospira specific antibodies also. There may be macroscopically visible gross lesions on the foetus or placenta, for example there are characteristic lesions seen in the case of Aspergillus induced

abortion. In the case of Trueperella Pyogenes, placentitis may be found. A blood sample from the dam and her herdmates is useful, for example if Infectious Bovine Rhinotracheitis is suspected. The vaccination history of the dam should be included in the info given to the lab (Department of Agriculture, Food and the Marine & Agri-food and Biosciences Institute, 2012).

Abortion can be caused by a range of bacteria, viruses and fungi. Bacteria are usually the biggest cause of abortion, as table 1 shows. A lot of the abortions are caused by organisms which are present in the cows environment already, and not causing any harm. It is only when these bacteria enter the bloodstream and cross the placenta that a problem arises. Here they can cause placentitis, leading to foetal hypoxia and thus foetal death, or can enter the immunologically immature foetus and cause disease in it leading to its death. Fungal abortion is not majorly common in Ireland, there were 28 abortions attributed to Aspergillus species in 2013. (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2013). There will usually be characteristic lesions seen, for example in the case of Aspergillus spp. (Department of Agriculture, Fisheries and Food & Agri-Food Biosciences Institute, 2010).

3. Materials and methods:

The All Island Animal Health and Welfare Strategy was put into action in 2010 in Ireland, due to the realisation of the necessity for a high level animal health and welfare program, which would develop close co-operation and joint efforts on tackling disease on both sides of the border. The aim of the project is to develop a system of free movement of animals around the whole island of Ireland (Department of Agriculture, Fisheries and Food and Agri-Food Biosciences Institute, 2010). There have only been four reports compiled thus far, one for 2010, 2011, 2012 and 2013. They are called the All Island Animal Disease Surveillance Reports, and they are assembled by the veterinary diagnostic laboratories which are run by the Department of Agriculture, Food and the Marine laboratory services in the south of Ireland, and the Agrifood and Biosciences Institute in Northern Ireland. In the south there are seven laboratories which are organised by the Department of Agriculture, Food and the Marine. These are in Athlone, Cork, Dublin, Kilkenny, Limerick, Sligo and the Central Veterinary Research laboratories in Backweston in Kildare. In the north of Ireland there are two – one in Stormont, Belfast and one in Omagh, Tyrone.

These reports attempt to quantify diseases present on the island, monitor their trends in the Irish livestock population, and make available to the public the current diseases to be concerned about. If a farmer has any unexplained deaths or illness on their farm, they can be referred by their vet to use the services of the state supported veterinary laboratories of the Department of Agriculture, Food and the Marine and the Agri-Food Biosciences Institute. The labs accept carcasses of dead animals, foetuses, and samples like blood faeces and urine from live animals. They perform a wide range of diagnostic tests. The results of these tests are sent back to the farmer, who is advised on a course of action by their vet. The results are also kept and analysed by the Department of Agriculture, Food and the Marine and the Agri-Food Biosciences Institute, allowing them to compile these reports. By jointly reporting the data collected by the veterinary labs, the disease load of the island can be monitored and progress can be made on efforts to reduce restrictions on movement of livestock through the border. It is also important to maintain vigilance of disease status.

Even though Ireland is surrounded by sea which is a natural defence mechanism against many diseases, both sides of the border trade on a European and international level, so it is important to maintain vigilance in monitoring the disease status of herds, as many diseases

could be brought in via imported cattle or indeed be exported and cause damage to Irelands cattle trading status on an international level.

Ireland's dairy sector is set to expand massively due to the fact that restrictions on milk production are going to be lifted in 2015. In order to sustain the industry and ensure profitability of the expanding dairy industry, the early detection of existing disease patterns and emerging diseases is extremely important. In 2013 in the south of Ireland there was a 0.89% increase in the number of cattle in Ireland to 6.31 million and in the north of Ireland there was a 2.32% increase in the number of cattle up to 1.59 million (Department of Agriculture, Food and the Mariner & Agri-food and Biosciences institute, 2013). 2013 started off as a very wet year, and also ended with higher rainfall than normal. However there was a long period of good weather, allowing for a good harvest of good quality fodder.

4. Results:

In 2013, 3517 foetuses were sent to the Department of Agriculture, Food and the Marine and the Agri-Food Biosciences Institute laboratories. The most frequently detected bacteria was Trueperella pyogenes, found in 208 cases. Salmonella dublin also featured frequently with 165 cases. Many other abortifacients were detected in the submitted foetuses, some of lesser importance than others, but which can cause sporadic abortions nonetheless. In Britain for the same period, out of 630 foetuses surveyed, the most common abortifacient was found to be Neospora caninum, found in 100 cases.

Agent	**Number of cases**
Trueperella pyogenes	208
Bacillus licheniformes	205
Salmonella dublin	165
Leptospira hardjo	150
Neospora caninum	124
Listeria monocytogenes	61
Schmallenberg virus	53
Aspergillus	28
Fungal/Yeast	20
Staphylococcus species	18
Salmonella spp other than S. dublin	5
Campylobacter spp	3
Histophilus somnus	1

Table 1: The combined frequencies of some common abortifacients detected by the DAFM and AFBI in 2013 (Department of Agriculture, Food and the Marine and Agri-Food Biosciences Institute, 2013).

Agent:	Number of cases:
Trueperella pyogenes	58
Bacillus licheniformes	82
Salmonella dublin	79
Leptospira	2
Neospora caninum	100
Listeria spp.	38
Schmallenberg virus	44
Non-specific fungi	36
Salmonella spp other than S. dublin	6
Campylobacter species	22

Table 2: Some common causes of bovine abortion detected in the United Kingdom in the same time period as table 1.

5. Discussion:

From the results collected, it can be seen that there are many infectious agents responsible for causing abortions in cattle in Ireland. Bovine abortions are a common problem in cattle herds all over the world and are the cause of a large loss of income to the beef and dairy industry of Ireland each year. In order to tackle this, some countries have implemented eradication programs against some of the major pathogens. For example there was a Bovine Viral Diarrhea eradication program undertaken in Ireland in 2013, involving the testing of every single newborn bovine animal, and if an infected animal is found it is advised to the farmers to remove it. This is a nationwide scheme. There are also vaccination programs implemented on many farms against other abortion inducing agents. The most common include vaccinations against Infectious Bovine Rhinotracheitis, Bovine Viral Diarrhea, Salmonella and Leptospirosis. Farmers are also advised on how to implement good biosecurity measures to prevent the further spread.

5.1 Trueperella pyogenes:

Trueperella pyogenes (was formerly known as Arcanobacterium pyogenes) may be the causative agent of a sporadic abortion during any part of the pregnancy. It can often be found normally in the nasopharyngeal region of some healthy cows, and also can be isolated from abcesses. It should not be found in the foetal membranes or foetus itself, and if detected is usually important. If it enters the bloodstream of the cow, it can then enter the uterus and cause placentitis and endometritis. The placentitis will lead to foetal hypoxia and placentomal dysfunction (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2012). The foetus will most likely then be autolysed. The bacteria is easiest cultured from the abomasal contents of the foetus or the placenta. There is no effective bacterin available (Kahn, 2010). The contaminated placenta, pus and milk should be destroyed as they could be infectious to other cattle. Trueperella Pyogenes had quite a high incidence of detection in 2013, being identified in 208 of the aborted foetal samples for the year, making it the most common bacterial abortifacient detected in 2013, but showing a slight decrease from the previous two years.

YEAR	%
2013	5.9
2012	6.8
2011	6.9

Table 3: The percentage of the total foetuses submitted in which Trueperella pyogenes was detected in the last three years. Source: (Department of Agriculture, Food and the Marine & Agri-food and Biosciences Institute 2011, 2012 &2013)

5.2 Bacillus licheniformes:

Bacillus licheniformes is widespread in the environment. It is often found in the soil, and because of this can contaminate hay and silage, thus reaching the cattle. It can lead to sporadic abortions. It can cause a necrotising placentits with a superficial necrosis of the epithelium and subepithelial stroma (Agerholm *et al*, 1999). There may also be a thickening of the allantochorion observed (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2012) or there may be no lesions at all seen in the foetal tissues. 205 foetuses showed the presence of Bacillus licheniformes, making it the second most common bacterial agent causing abortion detected in foetal samples in 2013 (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2013).

5.3 Salmonella:

Salmonella enterica subspecies enterica serovar (Salmonella dublin) is a potential zoonose. It can cause large financial loss in the cattle industry due to death of calves and young cattle, reproductive disorders in adult cattle, and abortions. (Visser *et al*, 1997). Salmonella dublin is a contagious abortion inducing agent and can often lead to abortion storms in Irish herds if they have the infection present (Department of Agriculture, Food and the Marine and Agri-Food Biosciences Institute, 2012). Salmonella typhimurium can also cause abortion in cattle but is not too common in Ireland, with only 5 abortions proven to be caused by Salmonella species other than S. dublin in 2013 (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2013).

A big difficulty in the control of Salmonella dublin in cattle herds is the fact that it can cause long term carriers which will shed the bacteria and cause the spread to other animals. They carry it in the lymph nodes and internal organs and can intermittently or continuosly shed through faeces and/or milk (Nielsen *et al*,2004). It has been suggested that the process of drying off cows may be a predisposing factor causing the reactivation of a latent Salmonella Dublin infection which is in the herd (Crilly, 2004). Cows aborting due to a Salmonella species can sometimes show signs of septicemia or enteritis. The infection is thought to originate from the intestines. An episode of bacteremia may lead to localization of the pathogen in the placentome, which will destroy the foetal villi, leading to abortion without the invasion of the foetus by the bacteria (Anderson, 2007). The abortions usually occur

around the seventh and eighth month and the placenta will often be retained. The foetus can be mummified and have a distinct odour, or may be emphysematous. There may be pale indistinct foci in the liver of the foetus. 5.8% of abortion submissions in Ireland in 2013 tested positive for Salmonella dublin, an increase of 1.8% from the year before (In 2012, 4.0% of foetal submissions tested positive for Salmonella dublin). In 2013 there was a peak in October and November. This could be due to factors causing stress, for example housing and drying off in carrier animals (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2013). Vaccination is an option, but once Salmonella Dublin has entered into the herd, vaccination alone will not stop the spread of infection and good animal husbandry and hygiene is of major importance if control is to be achieved.

Figure 5: A foetus submitted for post-mortem which tested positive for Salmonella dublin (Department of Agriculture, Fisheries and Food & Agri-Food Biosciences Institute, 2010)

5.4 Leptospirosis:

Leptospirosis in cattle is a zoonose and so farmers and others in contact with cattle should be aware of the risks and take the necessary safety measures. Cattle are the maintenance hosts of Leptospira hardjo serovars, and although some other serovars of Leptospira are involved in bovine abortion, they are maintained in other species (Anderson, 2007). Infection of cattle occurs via mucous membranes, damaged skin or by sexual contact (Department of Agriculture, Food and the Marine and Agri-Food Biosciences Institute, 2012). Leptospira

interrogans serovar hardjo is the most common one found in Ireland (Department of Agriculture, Food and the Marine, 2009). Infection with Leptospira hardjo is associated with infertility, weak calves and abortion which is usually sporadic in nature. It is a bacterial infection spread by infected urine or contaminated water. Abortion occurs as a result of a chronic leptospiral infection, and is more common during the last trimester but can happen from the 4th month on. Abortion occurs usually one to three months after infection with the L. hardjo serovars, or one to six weeks after infection with the L. pomona serovars (Anderson, 2007). The aborting dam is usually not ill (Bagley, 1999). The foetus is usually autolysed (Anderson, 2007). Leptospiral abortion is diagnosed by detecting the Leptospira interrogans serovar hardjo specific antibodies in foetal thoracic fluid by using a solid phase immunoassay method or tissues from carcasses may also be analysed using the fluorescent antibody test (Department of Agriculture, Fisheries and Food, 2009). It is also useful to do serology on the dam but caution needs to be taken to distinguish between vaccination, previous exposure and current infection. The herd should ideally be vaccinated in the spring before the main season of transmission of Leptospira hardjo. It should not be administered within two weeks of breeding because it may reduce conception rates, however this could be down to handling stress as well. L. hardjo infected cows may need antibiotic treatment to prevent them from spreading the infection and to clear the infection from themselves (Bagley, 1999).

Year	**DAFM**	**AFBI**
2013	7.4%	5.3%
2012	1.9%	7.2%
2011	1.6%	4.5%
2010	5.2%	5.9%

Table 4: the percentage of bovine abortions submitted to the Department of Agriculture, Food and the Marine due to Leptospira hardjo in the last four years (Department of Agriculture, Food and the Marine & Agri-food and Biosciences Institute 2013, 2012, 2011, and Department of Agriculture, Fisheries and Food & Agri-Food Biosciences Institute, 2010)

5.5 Neosporosis:

Neosporosis is mainly a disease of the pregnant cow that results in either vertical transmission of the parasite to the foetus or abortion. It can also cause low milk yields and infertility. Neospora caninum is an infectious protozoan parasite belonging to the family Sarcocystidae, found worldwide. It is also a major cause of disease in dogs (Reichel *et al*, 2007) . Dogs are the definitive hosts and excrete oocysts which become infectious in a few days. Then cattle , the intermediate hosts, can accidentally ingest them. They can then cause infection in cattle and either have no clinical signs, or can cause an abortion, normally around the 5-7th month of gestation (Dubey *et al*.,2006). The infected foetus and placenta, when shed, can then be a source of infection when eaten by dogs, representing the horizontal form of transmission. Heifer calves born to infected cows that show no clinical signs have a high probability of being positive, and during their own pregnancy the Neospora caninum can be activated, cross the placenta, infect the foetus and so continue the infection in the herd. The abortion or foetal damage may be caused in many ways. There can be direct tissue damage to the foetus or placenta by the multiplication of the parasites. Another way in which the abortion is caused is by the activation of the maternal immune system that causes the production of Nitric oxide, Prostaglandins and pro-inflammatory cytokines in the placenta. The damage caused to the placenta will cause a lack of oxygen and nutrition to the foetus, that can lead to the abortion. Retention of the placenta is not common. Autolysis of the foetus can occur in a lot of cases, or it may be mummified. Serology of the dam and foetus available for detection of Neospora include Immunofluorescence Antibody Testing, Monoclonal Antibody Testing and Enzyme Linked Immunosorbent Assay. Polymerase Chain Reaction techniques for Neospora detection are reported to have a higher sensitivity than the immunohistochemistry in identifying cases of foetal infection (Schares *et al*,1998). Histological examination and immunohistochemistry are also tests that can be used for the identification of Neospora caninum. (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2011). To control Neosporosis the farmer can test and cull or vaccinate to prevent the further spread. However, the only commercially available vaccine Neoguard (r) did not produce a high efficacy and has been taken off the market (Monney, Hemphill 2014). In 2013 in Ireland, Neospora accounted for 124 of the 3517 foetuses submitted. (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2013).

Figure 6: Foetus aborted due to neospora infection (Institut für parasitologie, 2000).

5.6 Listeriosis:

Listeria species are found widely throughout the environment. The most common species causing abortion in Ireland is Listeria monocytogenes, detected in 61 of the foetal samples tested in 2012. Listeria can be ingested with poorly preserved silage, which is not fermented properly and is not acidic enough to kill the bacteria. It can be ingested via soil on the grass roots, and also the placenta and discharges from the infected cow are infectious. It usually has a sporadic appearance, but in certain conditions, for example a herd all eating the same batch of contaminated silage at the same time, an abortion storm can occur. In adult cattle it can occassionally cause encephalitis but this is not too commonly seen in association with abortion (Anderson, 2007). Usually the abortion occurs in the third trimester and the foetus can often be quite autolysed. In some cases, pinpoint white to yellow foci can be present on the liver of the foetus. There may also be small pale foci in the placental cotyledons (Anderson, 2007). The highest incidence of Listeria abortions are in the winter months when cattle are housed and fed silage, and if listeria is suspected as the cause it is useful to send a sample of the silage for examination in order to remove the possible source of infection.

Figure 7: an example of incorrectly preserved silage which could pose a serious risk to bovine health. (The Dairy Site, 2012)

5.7 Schmallenberg:

Schmallenberg virus is an Orthobunyavirus from the Bunyaviridae family. It affects ruminants, and was first identified near a town called Schmallenberg in Germany. It can lead to the birth of malformed calves, abortion or stillbirth, depending on the stage of pregnancy when infection occurs. Typical deformities include torticollis, arthrogryposis and brachygnathia. It has been shown to localize in the nerves of the foetus leading to the aforementioned deformities. The damage to the spinal cord and brain is thought to stop the foetus moving around in the uterus, which will mean the necessary stimulation for developing muscles is not provided, leading to immobility of the joints and twists in the spinal column (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2012).

It is known to be transmitted by a family of biting midges, Culicoides. Species of Culicoides that are present in Ireland have been shown to contain Schmallenberg virus. (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2011). The virus reached south-east England in January 2012, so the Department of Agriculture, Food and the Marine began a surveillance program in January 2012, and all deformed, stillborn and aborted bovine and ovine foetuses have been tested for Schmallenberg virus (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2012). The first

case was found by PCR testing, in a herd in cork in October 2012 (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2012). In November 2012, 532 herds were tested in a seroprevalence survey. Only three out of the 26 counties did not have any positive animals for Schmallenberg virus, showing the rapid spread of the virus. In northern Ireland, 38 animals were tested in 2012 for Schmallenberg virus by PCR. One case was positive. 203 were also serologically tested and 3 were seropositive (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2011). In 2013 there were 53 aborted foetuses submitted to the regional veterinary labs, which tested positive for Schmallenberg virus (Department of Agriculture, Food and the Marine & Agri-food and Biosciences institute, 2013). Adult cattle, once over the initial infection, are highly likely to develop a strong immunity. A vaccine was developed in 2013 but has been discontinued due to low demand, because of a far lower rate of spread than was expected.

Figure 8**:** Calf aborted due to Schmallenberg virus. Source: (MSD Animal Health, 2014)

5.8 Aspergillus species:

Mycotic abortions, mainly aspergillosis or rarely candidiasis or zygomycoses, are usually sporadic, and occur with low incidences within a herd. These fungi which are responsible are ubiquitous saprophytic organisms found within the environment. They occur more often in the winter when cattle are housed and fed preserved forage or grain, on which the fungi can grow, similar to the situation in which listeriosis can occur. If there is an injury to the digestive or respiratory tract of the cow, the infection might possibly enter the bloodstream in this way, and localise in the uterus. Certain characteristic lesions can be seen, for example in aspergillosis infection the placenta will be thickened, there may be necrosis of the cotyledons

and on the foetal skin there might be small circular lesions which can resemble ringworm lesions.(Department of Agriculture, Food and the Marine & Agri-Food Biosciences Institute, 2012). They usually occur sporadically in the last two months of the gestation (Djonne, 2007). In Ireland in 2012, 28 of the foetal submissions were proven Aspergillus positive in 2013. There were also 20 additional abortions caused by other fungal/yeast species in 2013 (Department of Agriculture, Food and the Marine & Agri-Food Biosciences Institute, 2013). It is identified in the lab by showing that there are fungal hyphae in the contents of the stomach of the foetus, on the skin or in the placenta. Preventative measures to be taken include proper preservation of grains, hay and silage to prevent conditions ideal to fungal growth.

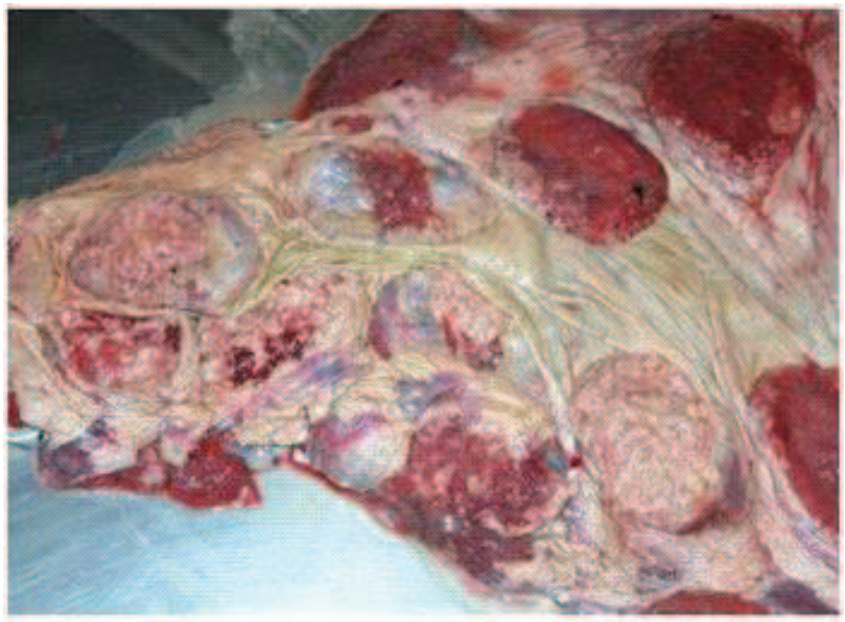

Figure 9: Mycotic Placentitis (Dr Mark Swendorwski, 2008)

5.9 Staphylococcus species:

Staphylococcus Bacteria are normal inhabitants found on the mucous membranes for example the genital tract and on the skin (Henton 1994). There are coagulase positive species including S. aureus and S. intermedius and coagulase negative species (Corbellini *et al*, 2006). Staphylococcal bacteria can be commonly found in cases of bovine mastitis and also occasionally in the uterus (Henton, 1994). If found in the uterus they can reach the foetus and lead to a sporadic abortion (Kirkbride, 1990). The infection can enter the uterus via the conjunctiva, orally, per vaginum (Miller, 1997). The infection can either ascend from the

uterus, or by the placenta haematogenously. It can reach the foetus via the umbilical vein, or the amniotic fluid (Corbellini *et al*, 2006). In 2013 in Ireland, there were 18 cases of bovine abortion attributed to Staphylococcal species, showing that while it is not currently a major abortifacient, it should still be considered important (Department of Agriculture, Food and the Marine & Agri-Food Biosciences Institute, 2013).

5.10 Campylobacter

There are a few species of Campylobacter that can be linked to abortion in cattle. The main ones are Campylobacter fetus subspecies venerealis, Campylobacter fetus serovar fetus and Campylobacter jejuni. Campylobacter fetus subspecies venerealis is an actual venereal disease. It is an obligate parasite of the reproductive tract of bovine animals, and is transmitted sexually. The rate of transmission from infected bulls to susceptible cows may reach 100% (Yaegar and Holler, 1997). C. jejuni and C. fetus subspecies fetus originate from the intestinal tract, and reach the uterus haematogenously, causing sporadic abortions (Walker, 1999). The abortions usually occur between the fourth to seventh month of the gestation. A placentitis with some necrosis can occur with brownish yellow discolouration of the cotyledons (Anderson, 2007). Microscopic examination of the foetus may show a suppurative pneumonia or hepatitis (Yaegar and Holler, 1997). Silver staining of the inflamed tissues of the foetus will show curved silver stained bacteria (Anderson, 2007). Young bulls are generally immune, and a chronic infection will occur in older bulls, usually above five years old. The infected bulls can be treated with an ointment applied topically. The ointment should contain 10 grams of neomycin and 4 grams of erythromycin, in 200 grams of carbowax. It should be applied to a clean penis and prepuce, at 24 hour intervals three times (Yaegar and Holler, 1997). All susceptible animals can be vaccinated. It should be done two times, two to four weeks apart, thirty days before the breeding season starts, and then once annually (Yaegar and Holler, 1997). In 2013, only three foetuses tested positive, showing that while the disease is present in Ireland, it is not a major issue at the moment (Department of Agriculture, Food and the Marine & Agri-Food Biosciences Institute, 2013).

5.11 Histophilus somnus:

Histophilus somnus is associated mainly with thrombotic meningoencephalomyelitis in cattle. It can also cause respiratory disease, otitis, myocarditis, mastitis, conjunctivits and

reproductive problems (Harris *et al*, 1989). It can cause sporadic abortions, at any stage of gestation. It is a common inhabitant of the vagina of the cow and can cause vaginitis and endometritis. The abortion is thought to be due to haematogenous spread, after a vaginal or respiratory infection. It is not thought to be due to infection ascending through the cervix (Yaeger *et al*, 1997). There may be a necrotising or necrosuppurative placentitis and placental oedema (Yaeger *et al*, 1997). Only one foetus tested positive for Histophilus somnus in 2013 in Ireland, showing that it is not an important problem in Ireland at the minute (Department of Agriculture, Food and the Marine & Agri-Food Biosciences Institute, 2013).

5.12 Bovine Viral Diarrhea (BVD):

Bovine viral diarrhea is a contagious viral disease of cattle. It is a Pestivirus from the family Flaviviridae. Bovine Viral Diarrhea is considered by both veterinarians and farmers as one of the most important infectious diseases affecting cattle in Ireland (More *et al*, 2010). In a dairy herd infected by Bovine Viral Diarrhea will lead to a reduced milk yield, reduced reproductive performance, developmental impairments, increased vulnerability to other diseases, early culling and increased mortality of younger stock (Barrett *et al*, 2011). In an Irish study, the cost of an outbreak of Bovine Viral Diarrhea in a research dairy herd was calculated as 88 euro per cow (Byrne N, 2010). Bovine Viral Diarrhea is a disease that can affect the bovine animal at any life stage, from the early embryonic life to the adult cow. The effect on reproduction depends on the stage of gestation the cow is infected in. If she is infected up until the 120^{th} day of gestation, there may be embryonic death or early foetal mortality, manifesting as failure to concieve or infertility. Another possibility is if the infection occurs before the $4^{th}/5^{th}$ month, around the time that the immune system develops, there may be immune tolerance, leading to the birth of a persistently infected animal. The consequences of infection after day 120 of gestation are abortion, stillbirth and malformation. The PI (persistently infected) animal is the main source of the infection in the herd because they constantly excrete the virus. If the PI is a heifer and survives to adulthood, when impregnated she will give birth to another PI, continuing the infection in the herd. These PI calves, while appearing normal at birth, often become ill-thrifty and die before reaching slaughter weight. Ireland now has a national eradication scheme for Bovine Viral Diarrhea, as it is estimated to cost the farming industry in Ireland 102million euro per year according to Animal Health Ireland. In 2012 the eradication program was not compulsory but lots of

farmers partook on a voluntary basis. Since January 2013 it is now a compulsory program. All calves born from the 1st January 2013 have to be tested and cannot be sold on without a negative Bovine Viral Diarrhea result. The test is done when ear tagging the calves after birth. The official ear tags are specially adapted to collect a tissue punch while being inserted into the ear. The samples taken are then sent to official labs to be tested. If a PI is confirmed, it is strongly advised to remove it from the herd, but as of yet it is not illegal to keep it on your own farm. The program is aiming to have 3 years of tissue tagging, followed by three years of monitoring. Vaccination is extremely important in control of this disease. After 8 months of age, each animal should be vaccinated twice with an interval of four weeks and the second vaccination should be given not later than four weeks before the start of the gestation, with revaccination every year four weeks before the start of the next gestation. The foetus should be expected to be protected as long as the primary immunisation has been finalised four weeks before the start of gestation. In the year 2012, 8% of foetuses submitted to the Department of Agriculture, Fisheries and the Marine for sampling tested positive for Bovine Viral Diarrhea. This is higher than previous years (see table 5), but this may be due to increased submissions and vigilance by farmers as awareness of the virus is being raised by the eradication program. No data is available on Bovine Viral Diarrhea positive foetuses for 2013 yet. In 2013, 8126 dams of proven PI's were also tested with a Bovine Viral Diarrhea - antigen based Enzyme Linked Immunosorbent Assay test. 487 or 6% of these dams tested Bovine Viral Diarrhea virus positive (Department of Agriculture, Food and the Marine & Agri-Food Biosciences Institute, 2013).

2012	8%
2011	4.9%
2010	6.5%
2009	5.5%
2008	5.7%
2007	5.6%

Table 5: The percentage of BVD infected foetuses submitted to the DAFM over the past 6 years (Department of Agriculture, Fisheries and Food, 2009, Department of Agriculture, Fisheries and Food & Agri-Food Biosciences Institute, 2010, Department of Agriculture, Food and the Marine & Agri-Food Biosciences Institute, 2012).

Figure 10: Bovine Viral Diarrhea virus may cause Foetal death or abortion (National Animal Disease Information Service, 2014)

Figure 11: An example of the ear tags supplied by the Department of Agriculture to take an ear tissue sample while ear tagging as part of the National BVD Eradication program (Irish Farmers Journal, 2014)

5.13 Infectious Bovine Rhinotracheitis (IBR):

Bovine Herpesvirus type-1 (BHV-1) is a member of the alphaherpesvirinae family. It can cause genital and respiratory tract infections including Infectious Bovine Rhinotracheitis (IBR), Infectious Pustular Vulvovaginitis (IPV), and Infectious Balanoposthitis (IBP)

(Ackermann *et al*, 2006). Infectious Bovine Rhinotracheitis can cause abortion, usually secondary to respiratory and generalised systemic infections. It is a highly contagious disease and usually introduced into farms by the sale of previously infected animals, those that have a latent infection. The virus is easily spread by the aerogenic route or contact. It can also be spread by semen from infected bulls, so it is important to prove that bulls used for AI are free from the virus. Abortion most usually occurs in the second half of the pregnancy. Along with abortion, other signs include high temperature, reduced appetite, discharges from the nose and eyes. The abortion will occur due to viremia penetrataing the uterus and placenta. Autolysis of the foetus is a common feature of this infection. There are two types of vaccine available against Infectious Bovine Rhinotracheitis. There are marker vaccines which distinguish vaccinated and naturally infected animals. These are based on a test for gE antibodies. Using the conventional vaccine means that there is no possibility to identify if a vaccinated animal has also been infected with the virus. The samples to be submitted for diagnosis are the foetus, for flourescent antibody test and also the placenta. Blood should also be taken from the dams, usually from 10 or more herdmates. A four times increase in the antibody titre may implicate Infectious Bovine Rhinotracheitis. (Bagley, 1999). An investigation into the seroprevalence of Infectious Bovine Rhinotracheitis in Ireland was done and proven to be 74.9% (Cowley *et al*, 2011). In 2012, 0.5% of the foetuses submitted to the Department of Agriculture, Food and the Marine and also 0.5% of the foetuses submitted to the Agri-Food and Biosciences Institute, tested by Polymerase Chain Reaction showed a positive Bovine Herpes Virus-1 result. This is a very low result considering how high the Infectious Bovine Rhinotracheitis seroprevalence is in the national herd (Department of Agriculture, Food and the Marine & Agri-Food and Biosciences Institute 2012).

5.14 Brucellosis:

Brucellosis is a disease caused by the bacteria Brucella abortus (Bagley, 1999). It is a notifiable disease (OIE 2012). While Brucellosis is no longer present in the republic of Ireland, and there were no cases of Brucellosis abortion in northern Ireland since February 2012, it is important to consider it and be vigilant in screening processes for it. It can pose animal and human health risks and due to this eradication programs have been established all over the world. The presence of Brucellosis in a herd can lead to production losses due to abortions, reduced milk yield, longer calving intervals, birth of infected calves, increased rates of culling because of metritis, which occurs because of the retention of the placenta (Stringer *et al,* 2008). The animal acquires the infection per orally. It goes to the lymph nodes, where it can be dormant or cause septicemia and then settles in the predilection sites of the pregnant uterus, the placenta and the udder. Due to this, placentitis develops resulting in an abortion. A feature of abortion due to brucellosis is retention of the foetal membranes, and the fact that the abortion takes place in between the 6^{th} to 8^{th} months of gestation. There may also be a greyish white coloured vaginal discharge a day or two before the abortion and also vulvovaginitis may be seen. Samples used for the diagnosis are the foetus and placental tissues to be cultured, and blood serum from the dam is also used. Ireland is officially free of brucellosis, but tests are done as part of the routine examinations on all the aborted foetuses submitted to the Regional Veterinary Laboratories. Selective cultures for Brucella abortus are done on abomasal contents from the foetus. This is very important, as there is an ongoing reduction in serological screening due to the success of the eradication program. In 2004, 2359 samples were tested, 6 of which were positive. In 2005, 2472 samples were tested, 3 of which were positive. 2006 was the first year since the Veterinary Laboratory Service was set up, that Brucella abortus was not cultured in any of the nearly 2000 foetuses and or placentas tested by the Regional Veterinary Labs (Department of Agriculture, Fisheries and Food, 2006). 2008 was the third year in a row that Brucella species were not isolated from any of the samples submitted, showing the success of the vigilant eradication program. Due to this, in July 2009, the EU approved Irelands application for "Officially Brucellosis Free Status" (Department of Agriculture, Fisheries and Food, 2008). However, one case of Brucella abortus was identified in 2010 in Northern Ireland, and again in Febuary 2012 in Northern Ireland, which highlights the need to keep up the strict screening programs for the disease (Department of Agriculture, Food and the Marine and Agri-Food Biosciences Institute, 2011). As a result of the Official Brucellosis Free Status, the department of Agriculture has

gradually reduced the testing requirements. Herd owners are advised when they need to test their herd. An annual test is required on any female animal aged 24 months or more, and bulls aged 24 months or more. In the north these tests are done on any animal aged 12 months or older which is intended for breeding purposes. Any susceptible animal moving into a new farm must have had a negative brucellosis test within 60 days of entering the new herd, and any animal moving across the border must have had a negative brucellosis test in the last 60 days.

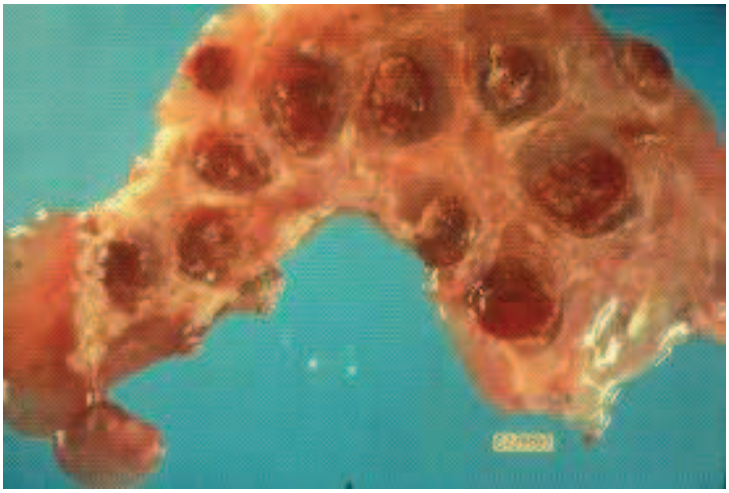

Figure 12: Bovine placenta showing numerous haemorrhagic cotyledons, as a result of infection by Brucella species (Vetnext, 2014).

6. Summary:

Using the data collected and provided by the Department of Agriculture, Food and the Marine and the Agri-Food and Biosciences Institute, the most important causative agents of bovine abortions in Ireland in 2013 were discussed and in some cases compared to data from 2012 and other previous years to show the trends in disease patterns, and also compared to data from the United Kingdom from the same time period. In 2013, 3517 foetuses were submitted to the Department of Agriculture, Food and the Marine & Agri-Food and Biosciences Institute laboratories. Trueperella pyogenes was the most commonly detected abortifacient in Ireland in 2013. Different tests were done depending on the clinical signs, history and gross lesions seen in the foetus and/or dam. For example for detection of Neospora caninum histological examinations or Enzyme Linked Immunosorbent Assay was used to detect. For Leptospira hardjo, Enzyme Linked Immunosorbent Assay or Fluorescent Antibody Testing was used. For Bovine Viral Diarrhea detection Polymerase Chain Reaction or Enzyme Linked Immunosorbent Assay was used. A wide range of pathogens can be detected from aborted foetuses, but they may also be cultured from healthy animal samples too. Therefore in some cases the presence of certain microorganisms in aborted foetuses alone may not always be enough to reach a definite diagnosis for the cause of the abortion. In these cases other information to support it as the cause of the abortion must be gathered. When the incidence of abortion goes above 3% on any farm, investigations should be undertaken. In this way mass outbreaks of abortion causing major economic losses can be avoided or at least reduced, and public health risks can be kept down.

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