All-Island

Animal Disease

Surveillance Report, 2020

Department of Agriculture, Food and
the Marine of Ireland,
Agri-Food and Bioscience Institute and,
Animal Health Ireland

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Introduction

Surveillance for animal disease continues in a changing Europe and a changing world, to monitor trends in disease prevalence and impact. Many factors such as climate change, political change, new trading patterns and the evolution of our food animal production systems ensure that animal disease is an ever-mobile shape-shifting target. While the recently implemented Animal Health Law mandates surveillance standards for EU member states, the OIE (World organisation for Animal Health) sets global standards and targets for every country on the globe and the sharing of intelligence on diseases, pathogens, and indeed even the specific strains of pathogens remain as key functions for animal surveillance systems globally. This report produced collaboratively between the Agri-Food & Biosciences Institute in Northern Ireland and the laboratory service of the Department of Agriculture & Food in Ireland continues to be a prime example of transboundary information sharing and collaboration.

This report represents a synthesis of literally thousands of post-mortem dissections, laboratory tests, histopathological examinations and painstaking note taking, report writing and data entry by dedicated teams of vets and scientists in both jurisdictions. The report is compiled by the same people, who aggregate and analyse the year's work and present a summary of the key findings, their meaning and implications. We thank and salute them for their diligent work, and hope you find something of interest and relevance for you, whether you are a specialist, or someone seeking an overview of animal disease patterns in food animals on this island.

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Preface

This All-Island Animal Disease Surveillance Report (AIADSR) is the fifteen Animal Disease Surveillance Report and the tenth report in collaboration with our colleagues from the Agri-Food and Bioscience Institute (AFBI), Northern Ireland, and Animal Health Ireland (AHI). As in the previous three years, most of the data has been almost entirely analysed and compiled with the programming languages R and LaTeX respectively. Both languages provide an excellent environment for data analysis, visualisation and typesetting, and we hope that this edition reflects the surveillance work carried out in the different institutions contributing to this report.

Although the AIADSR is intended for Private Veterinary Practitioners, it has always been conceived and constructed to provide valuable animal health surveillance information to other stakeholders. An effort has been made to present and visualise the data by including numerous tables, colourful charts and photos throughout its pages to transmit the information gathered from submissions to the Veterinary Laboratory Service (VLS) of the Department of Agriculture, Fooad and the Marine (DAFM) and AFBI of Northern Ireland. The data and contents in this report represent only a tiny fraction of a considerable amount of data produced by the work undertaken by both the VLS and AFBI, and also AHI.

This year we have adapted Dirk Eddelbuettel and Jonathan Gilligan tint R package based on the style of Edward Tufte. We hope you enjoy the clear layout design and focused use of the margins for complementary information. Also, on a minor note, at the end of each chapter, there is a small symbol representing "magical" staves taken from the Icelandic folklore and provided by A. Syropoulos in his LaTeX package. The disclaimer included in the package https://ctan.org/pkg/staves?lang=en also applies to this report too. You will find more information about these symbols at https://galdrasyning.is/galdrastafir/

Cosme Sánchez-Miguel (Editor)
Cork Regional Veterinary Laboratory, DAFM.

Acknowledgements

The 2020 All-Island Animal Disease Surveillance Report (AIADSR) has been produced by a group of talented and dedicated people from the Veterinary Laboratory Service of the Department of Agriculture, Food and the Marine of Ireland (DAFM), the Agri-Food and Bioscience Institute (AFBI) of Northern Ireland and Animal Health Ireland (AHI). Behind these veterinary officers, an extended group of colleagues, laboratory technicians, clerical staff, and laboratory attendants support and assist with our work as Research Officers, and they have made possible the material presented in this report.

I would like to thank all the individuals involved directly or indirectly in this 2020 AIADSR. Special gratitude to Alan Johnson (Limerick RVL), Aideen Kennedy (Kilkenny RVL) and Ian Hogan (Limerick RVL) for coordinating the different sections of the report and for patiently proofreading the text. Also I would like to thank Maria Guelbenzu (AHI), Lawrence Gavey (AHI) and Siobhan Corry (AFBI) and their colleagues for their collaboration in the 2020 All-Island Animal Disease Surveillance Report. In addition, the advice provided by Nathan Doyle (Data Analytics Unit) regarding some of the R code used in this report is very much appreciated.

Finally, I would like to thank Micheál Casey (Director of the Regional Veterinary Laboratories) and my colleagues Jim O'Donovan, Mercedes Gómez-Parada ,Ciara Hayes and Isabel Coen for their support and continuous encouragement throughout this project.

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Overview of Cattle Diseases

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The Covid-19 pandemic which entered our country in early 2020 had an effect on the farmers, veterinary practitioners and staff members working in the Regional Veterinary Laboratories (RVLs). With the public being advised to stay at home, avoiding non-essential travel, and workers being asked to work from home where possible, the number of 'voluntary' submissions of carcasses to the RVLs was affected.

It should be noted that the examining pathologist can only assign one cause of death to each animal submitted for *post mortem* examination. In some cases more than one system may be affected by disease e.g. a calf may have gross lesions of enteritis and pneumonia, or joint ill and enteritis. If the lesions are not considered to be linked, as they might be in the case of a systemic infection (sepsis), then the examining veterinarian assigns the cause of death to the condition considered to be the most significant leading to the death of the animal. It is not an exact science and examining pathologists differ to a small extent.

Neonatal Calves (birth to one month of age)

Of the 545 neonatal calves submitted for *post mortem* during 2020, the deaths of 141 (25.9 *per cent*) were attributed to gastrointestinal infections. As in previous years this was the most commonly diagnosed cause of death in this age group (Table 1 and Figure 2).

Table 1: Conditions most frequently diagnosed on *post mortem* examinations of bovine neonatal calves in 2020 (n=545).

Category	No. of Cases	Percentage
GIT Infections	141	**25.9**
Systemic Infections	115	**21.1**
Respiratory Infections	57	**10.5**
Other	36	**6.6**
GIT ulcer/perforation/foreign body	34	**6.2**
Navel Ill/Joint Ill	33	**6.1**
GIT torsion/obstruction	31	**5.7**
Hereditary and developmental abnormality	26	**4.8**
Diagnosis not reached	19	**3.5**
Nutritional/metabolic conditions	16	**2.9**
Hypogammaglobulinaemia	15	**2.8**

Table 1: Conditions most frequently diagnosed on *post mortem* examinations of bovine neonatal calves in 2020 (n=545). *(continued)*

Category	No. of Cases	Percentage
Peritonitis	14	**2.6**
Cardiac/circulatory conditions	8	**1.5**

Note:
The 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Figure 1: Intestinal intussusception in a calf. Photo: Alan Johnson.

The pathogens associated with these gastrointestinal infections are discussed in greater detail in chapter on neonatal enteritis. Hypogammaglobinaemia is commonly associated with gastrointestinal infections because of suboptimal levels of passive immunity (see chapter on Zinc Sulphate Turbidity test on page 38). It is vital to ensure that newborn calves receive adequate volumes of good quality colostrum in the first six hours after birth. Hypogammaglobulinaemia also makes the calf more vulnerable to systemic infections, respiratory infections and navel and joint ill.

Systemic infections were diagnosed in 21.1 *per cent* of the neonatal calves submitted to the RVLs. A systemic infection affects many organs and spreads via the bloodstream. An infection may become systemic following entry into the animal via any location, but most frequently via the gastrointestinal, respiratory system or navel.

Navel and joint ill were associated with the death of 6.1 *per cent* of the neonatal calves submitted. In some of those calves the *post mortem* findings included abscessation of the liver (photograph), the result of infection tracking up the umbilical blood vessels to the liver.

Respiratory infections were associated with 10.5 *per cent* of the neonatal calves examined, a rate similar to previous years (see chapter on bovine respiratory disease on page 18).

GIT torsion/obstruction, which accounted for 5.7 *per cent* of deaths were mostly associated with mesenteric volvulus.

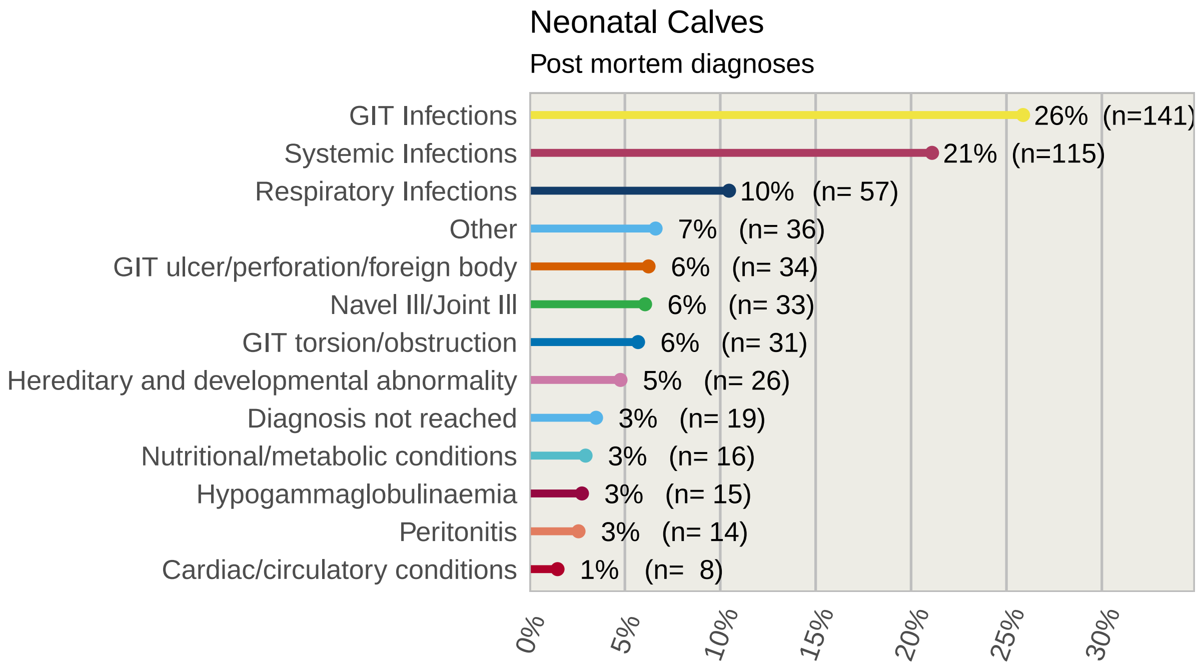

Figure 2: Conditions most frequently diagnosed on *post mortem* examinations of bovine neonatal calves in 2020 (n=545). Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Hereditary and developmental abnormalities were recorded in 4.8 *per cent* of the neonatal calves examined, mostly associated with intestinal atresia (Figure 3) and septal defects of the heart. A cause of death was not established in 3.5 *per cent* of neonatal calves examined.

Figure 3: Intestinal atresia in a neonatal calf. Photo: Alan Johnson.

Calves (one to five months of age)

551 calves in the one to five-month-old age group were examined during 2020, down from 610 in 2019.

Respiratory disease continued to be the most significant cause of mortality among one to five-month-old calves examined in the Regional Veterinary Laboratories during 2020. It accounted for 184 (33.4 *per cent*) of the deaths in this age group (Table 2 and Figure 4). The primary respiratory pathogen deemed most likely to be associ-

Table 2: Conditions most frequently diagnosed on *post mortem* examinations of calves (1-5 months old) in 2020 (n=551).

Category	No. of Cases	Percentage
Respiratory Infections	184	**33.4**
GIT Infections	76	**13.8**
Systemic Infections	63	**11.4**
GIT torsion/obstruction	48	**8.7**
GIT ulcer/perforation/foreign body	29	**5.3**
Clostridial disease	24	**4.4**
Other	20	**3.6**
CNS	19	**3.5**
Diagnosis not reached	18	**3.3**
Nutritional/metabolic conditions	15	**2.7**
Urinary Tract conditions	12	**2.2**
Cardiac/circulatory conditions	10	**1.8**
Poisoning	10	**1.8**
Liver disease	8	**1.4**
Navel Ill/Joint Ill	8	**1.4**
Peritonitis	7	**1.3**

Note:
The 'Other' grouping is a combination of multiple minor categories that have less than five cases.

ated with the animal's death was *Dictyocaulus viviparus* (in 32 cases), *Pasteurella multocida* (27 cases), *Mannheimia haemolytica* (26 cases), *Mycoplasma bovis* (24 cases) and Respiratory Syncytial Virus (RSV) (16 cases), A breakdown of the detected agents is presented in more detail in the chapter on bovine respiratory disease on page 18.

Gastro-intestinal tract (GIT) infections (76 cases, 13.8 *per cent*) and systemic infections (63 cases, 11.4 *per cent*) were the second and third most frequently diagnosed causes of death. Coccidial species (10 cases) and gastrointestinal parasites (10 cases), mostly *Ostertagia ostertagii*, were the most commonly identified causes of GIT infections.

Intestinal accidents describe cases of gastrointestinal torsion, volvulus, intussusception and strangulation. They are a relatively common cause of death in young calves, most being associated with mesenteric intussusception (Figure 1). They accounted for 8.7 *per cent* of deaths in this age category in 2020. A typical history accompanying the calf to the PM room is that of a sudden, unexpected death, with the calf drinking as normal at the previous feed. Severe vascular compromise and intestinal ischaemia can occur in many cases, with anaerobic bacteria multiplying rapidly and producing toxins which can lead to shock and circulatory failure within hours.

Clostridial disease accounted for 24 (4.4 *per cent*) of the deaths in this age group, 20 of which were associated with *Clostridium chauvoei* infection (blackleg).

Ten cases of poisoning were recorded, seven of which were associ-

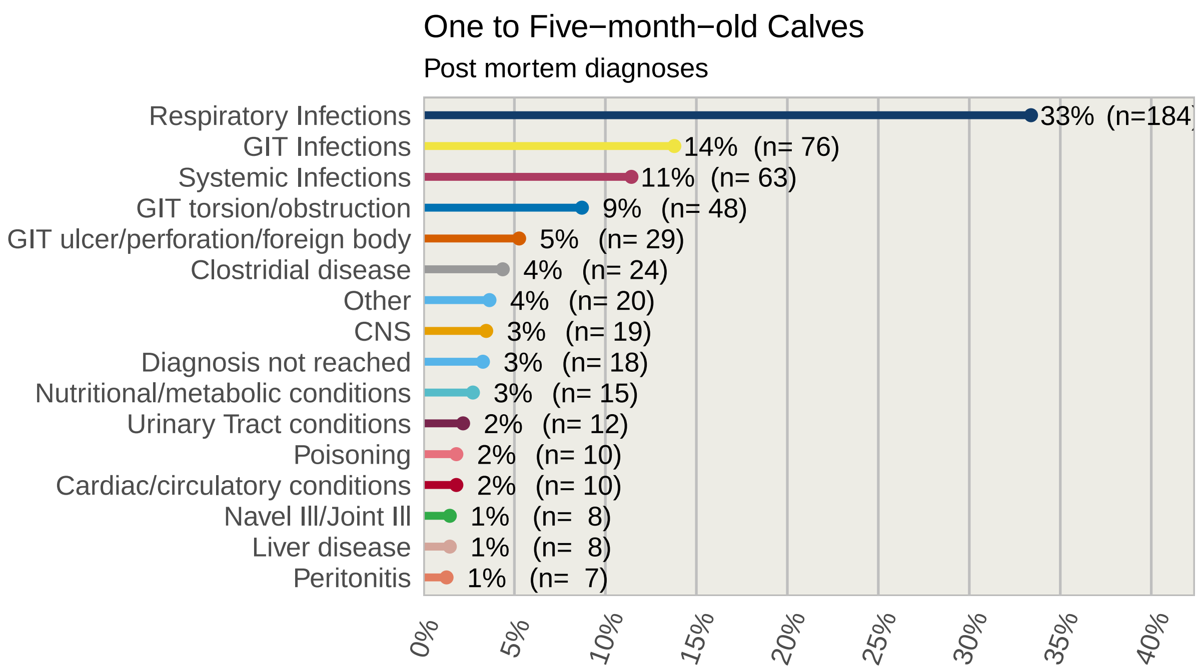

Figure 4: Conditions most frequently diagnosed on *post mortem* examinations of calves (1–5 months old) in 2020 (n=551). Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

ated with lead, two with copper and one with yew tree ingestion.

Weanlings (six months to one year of age)

377 bovine weanlings were submitted for *post mortem* in 2020, similar to 2019 with 367 carcasses. As with the one to five month old age category, respiratory disease was the most commonly diagnosed cause of mortality (39.8 *per cent*) in this age group (Table 3 and Figure 5). This was up from 30.6 *per cent* in 2019. The primary respiratory pathogen deemed most likely to be associated with the animal's death was *Dictyocaulus viviparous* (in 40 cases), followed by *Mannheimia haemolytica* (25 cases), *Histophilus somni* (17 cases), *Pasteurella multocida* (16 cases), RSV (15 cases) and *Mycoplasma bovis* (8 cases).

Gastro-intestinal tract (GIT) infections (68 cases, 18 *per cent*) and systemic infections (45 cases, 11.9 *per cent*) were the second and third most frequently diagnosed causes of death. Gastrointestinal parasites were the most commonly identified cause of GIT infections (21 out of 68 cases), as would be expected in spring calves following turn out to grass.

Clostridial disease accounted for 24 (6.4 *per cent*) of the deaths in this age group, 19 of which were associated with *Clostridium chauvoei* infection (blackleg), see the chapter on Clostridial diseases on page 54. In many of these cases there was no clostridial disease vaccination programme in place on the farms affected. Five of the nine cases associated with central nervous system (CNS) conditions were associated with cerebrocortical necrosis (CCN).

Table 3: Conditions most frequently diagnosed on *post mortem* examinations of weanlings (6–12 months old) in 2020 (n=377).

Category	No. of Cases	Percentage
Respiratory Infections	150	**39.8**
GIT Infections	68	**18.0**
Systemic Infections	45	**11.9**
Other	28	**7.4**
Clostridial disease	24	**6.4**
Diagnosis not reached	17	**4.5**
GIT torsion/obstruction	10	**2.6**
Nutritional/metabolic conditions	10	**2.6**
Cardiac/circulatory conditions	9	**2.4**
CNS	9	**2.4**
Poisoning	7	**1.9**

Note:
The 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Seven cases of poisoning were recorded, 1.9 *per cent* of the total number of weanlings submitted for *post mortem*. Of these, two were associated with ragwort, two with laurel, one with bracken fern, one with copper and one with lead. The two laurel poisoning cases were from the one farm, submitted to Kilkenny RVL on separate days (Kennedy et al., 2021). The animals were in one group that had access to foliage of a laurel hedge (Figure 6) through a fence and in grass clippings.

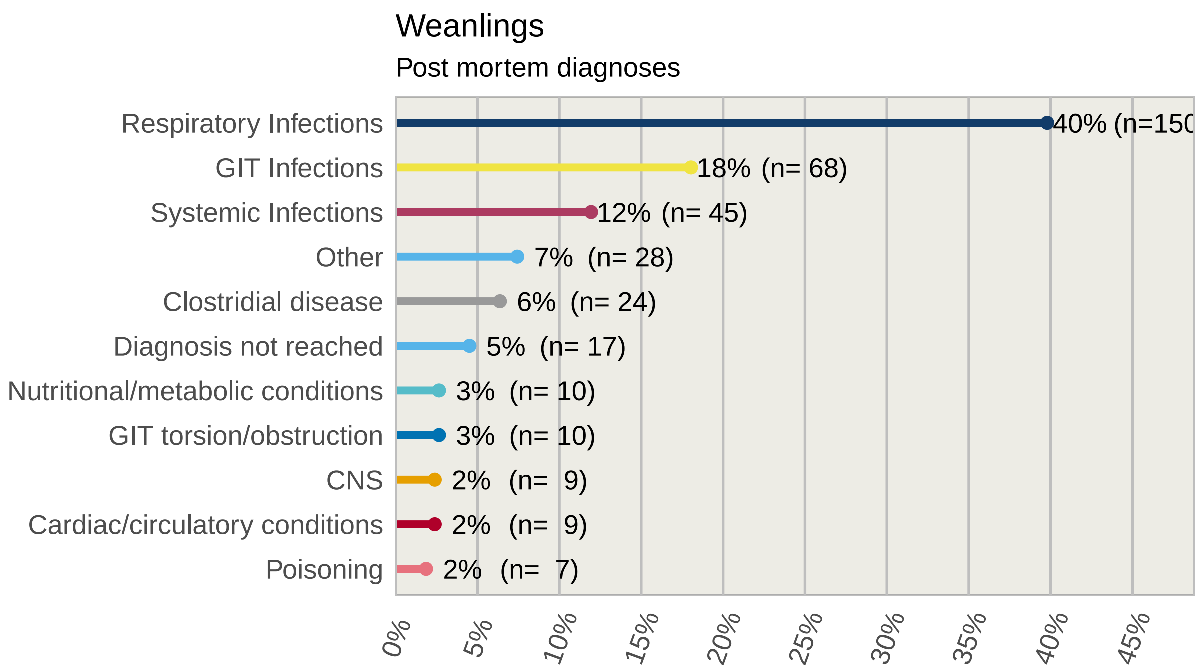

Figure 5: Conditions most frequently diagnosed on *post mortem* examinations of weanlings (6–12 months old) in 2020 (n=377).

36 animals, from a group of 51, died over a 12-day period. The

rumen of both animals submitted for *post mortem* contained laurel leaf remnants. Laurel (*Prunus laurocerasus*), a common garden hedge plant, is cyanogenic. Cyanide, the lethal agent of cyanogenic plants, prevents haemoglobin in erythrocytes from releasing oxygen to the tissues, with animals ultimately dying of anoxia.

Blood samples from seven cohort animals were collected and shipped to Toxlab, Paris, France for cyanide analysis by LC-Fluorimetry. One of the results was elevated and that animal subsequently died.

Figure 6: Laurel hedge on a farm where cyanide toxicity was diagnosed. Photo: Aideen Kennedy.

Adult Cattle (over 12 months of age)

Respiratory infection was the most common cause of death reported in the category, with 78 cases (17.5 *per cent* of the total, and similar to 2019) (Table 4) and Figure 9). *Mannheimia haemolytica* was attributed as the infectious agent involved in 22 of the cases, eight of which involved cows (Figure 7). Many of these cases involved freshly calved cows, with gross lesions of acute pleuropneumonia.

Figure 7: Pleuropneumonia in a cow associated with Mannheimia haemolytica infection. Photo: Alan Johnson.

Outbreaks of this type of pneumonia have been recorded in dairy cows in Ireland, the U.K. and the Netherlands (Biesheuvel et al., 2021). In many cases multiple cases present on the same farm. Parasitic bronchitis was diagnosed in 13 cases, all but two being in cattle between one and two years of age, with two cases in older cows. Other infectious agents identified as significant in respiratory infections of adult cattle examined in 2020 included Bovine Herpes Virus type 1 (6 cases), *Pasteurella multocida* (6 cases), *Mycoplasma bovis* (4 cases), *Salmonella Dublin* (2 cases), *Histophilus somnus* (2 cases) and Respiratory Syncytial Virus (1 case).

Gastrointestinal infections, diagnosed as the cause of death in 31 (7.0 *per cent*) adult cattle included coccidiosis, gastrointestinal parasitism, clostridial disease and, *Salmonella spp.* infections.

A cause of death was not established in 9 *per cent* of the adult cattle submitted for *post mortem*. In many of these cases the cause of death was thought to have been associated with a metabolic con-

Table 4: Conditions most frequently diagnosed on *post mortem* examinations of adult cattle (over 12 months old) in 2020 (n=445).

Category	No. of Cases	Percentage
Respiratory Infections	78	**17.5**
Diagnosis not reached	40	**9.0**
Nutritional/metabolic conditions	38	**8.5**
GIT Infections	31	**7.0**
Systemic Infections	27	**6.1**
Peritonitis	26	**5.8**
Cardiac/circulatory conditions	25	**5.6**
Other	24	**5.4**
Poisoning	18	**4.0**
CNS	17	**3.8**
GIT ulcer/perforation/foreign body	17	**3.8**
Liver disease	16	**3.6**
Reproductive Tract Conditions	14	**3.1**
Clostridial disease	13	**2.9**
GIT torsion/obstruction	12	**2.7**
Integument/Musculoskeletal	12	**2.7**
Mastitis	10	**2.2**
Trauma	8	**1.8**
Babesiosis	7	**1.6**
Abscessation	6	**1.4**
Johne's Disease	6	**1.4**

Note:
The 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Figure 8: Coccidiosis in a yearling bullock. Photo: Alan Johnson.

dition, but with no corroborating evidence to confirm. Hypomagnesaemia in particular, a common cause of death in beef and dairy cows, can be very difficult to diagnose in cows at *post mortem*. Frequently it is recommended to blood sample and test a number of cohort cows to establish if there is magnesium deficiency in the group.

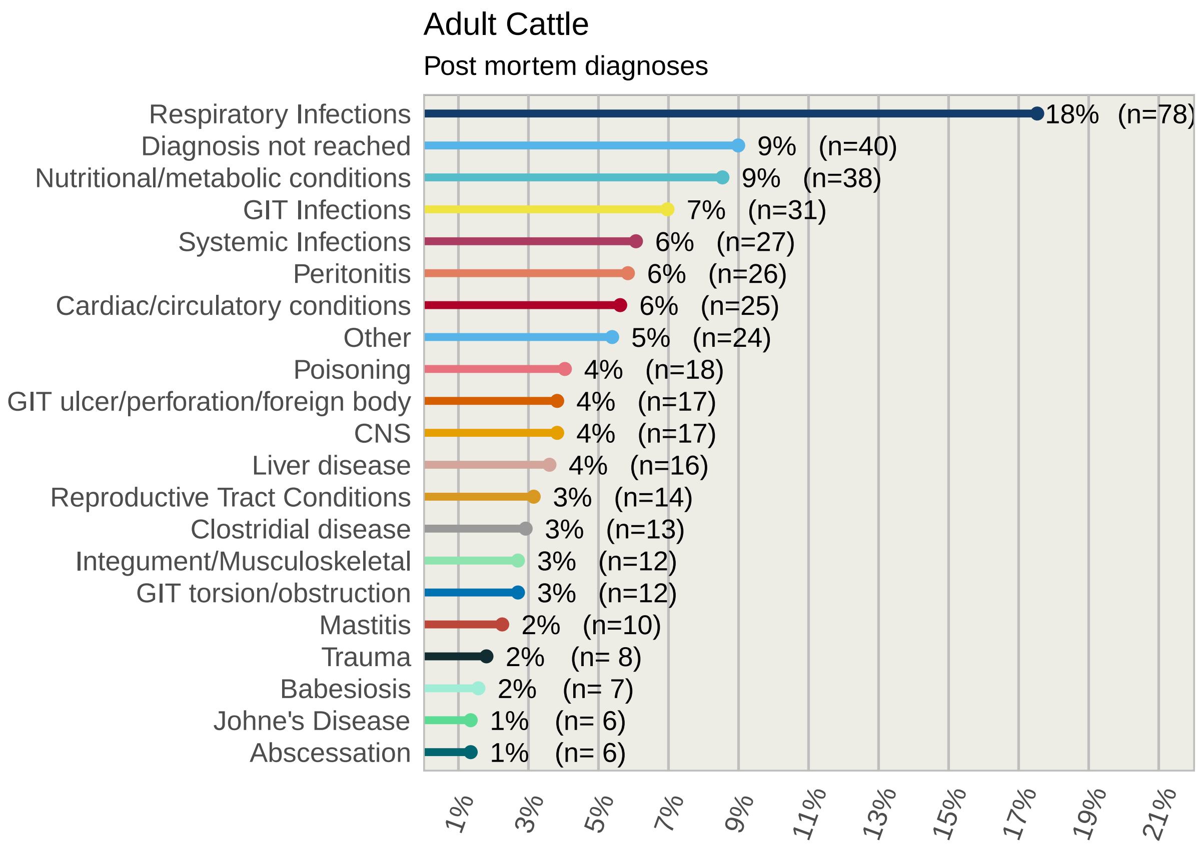

Figure 9: Diagnoses of adult cattle. Conditions most frequently diagnosed on *post mortem* examinations of adult cattle (over 12 months old) in 2020 (n=445). Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Cardiac and circulatory system conditions were identified in 25 (5.6 *per cent*) cases in 2020. This category includes endocarditis, pericarditis, caudal vena cava thrombosis, haemorrhage and haemolytic disorders. Central nervous system associated deaths, of which there were 17 (3.8 *per cent*) recorded, included CCN (10 cases) and encephalitis associated with listeriosis (3 cases).

Bovine Respiratory Disease

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This chapter reviews bovine respiratory disease (BRD) diagnosed at *post-mortem* examination in Ireland during 2020.

A multifactorial aetiology underlies many cases of BRD due to the potential for complex interactions between pathogens, the environment, and the host.

The respiratory tract of the ox has several host defence mechanisms including warming and moistening of inspired air in the nasal cavity, the resident microflora, the mucociliary escalator, secreted antimicrobial peptides and proteins and innate and adaptive immune responses (Ackermann et al., 2010; Caswell, 2014).

To cause BRD, pathogens must evade or manipulate these host defences, or take advantage when the host's defences are already compromised. Stressors that can negatively impact the defence mechanisms of the host and increase susceptibility to infection include transportation, overcrowding, weaning, mixing groups of animals and inadequate ventilation. Respiratory tract infections are frequently caused by multiple agents e.g. primary infection with a viral pathogen that compromises the defences of the respiratory tract can facilitate colonisation of the lower respiratory tract (bronchi and lungs) by bacteria.

Caveat: BRD cases are often caused by infection with more than one agent. However, there are limitations to the ability to establish the agents involved by *post-mortem* examination. Confounding factors include longer duration of disease, antimicrobial treatment and the laboratory techniques employed in individual cases. As examples, viral pathogens that initiated BRD may no longer be detectable in the respiratory tracts of animals that have died or were euthanised following a chronic clinical course; antibiotic treatment *ante mortem* may confound attempts to isolate bacteria from lesion tissue; PCR techniques are exquisitely sensitive and can detect viruses as well as non-viable bacteria that could not be isolated by culturing, but the small sample volumes required makes representative sampling of extensive or multiple lung lesions difficult.

Aetiology	Neonatal (0-1 month old)	Calves (1-5 months old)	Weanling (6-12 months old)	Adult Cattle (over 12 months old)	Total
Bacterial	37 (72.5)	**107 (58.5)**	76 (51.0)	45 (60.8)	265 (58.0)
Parasitic	0 (0.0)	**32 (17.5)**	40 (26.8)	13 (17.6)	85 (18.6)
Viral	7 (13.7)	**22 (12.0)**	23 (15.4)	6 (8.1)	58 (12.7)
No agent identified	7 (13.7)	**21 (11.5)**	9 (6.0)	8 (10.8)	45 (9.8)
Other	0 (0.0)	**1 (0.5)**	0 (0.0)	2 (2.7)	3 (0.7)
Fungal	0 (0.0)	**0 (0.0)**	1 (0.7)	0 (0.0)	1 (0.2)

Table 5: Number of cases and percentage (%) by age of the general pathogenic groups detected in the BRD cases diagnosed on *post mortem* examination (n=457).

In cases where two or more aetiological agents may have been identified, the final diagnosis represents what the pathologist would have considered to be the primary cause of disease. However, in many reports of cases diagnosed as bacterial pneumonia, the pathologist also acknowledged the possibility that an undetected primary viral infection could have preceded the development of the bacterial infection.

In 2020, 457 carcases were diagnosed as BRD based on *post-mortem* examination and subsequent laboratory test results. The number of cases categorised by age group and aetiological agent are present in Table ?.1.

Organism	No. of cases	Percentage
Dictyocaulus spp	85	**18.6**
Mannheimia haemolytica	81	**17.7**
Pasteurella multocida	56	**12.3**
No agent identified	45	**9.8**
Mycoplasma bovis	44	**9.6**
RSV	37	**8.1**
Histophilus somni	36	**7.9**
Other minor organisms	28	**6.1**
Trueperella pyogenes	16	**3.5**
Bibersteinia trehalosi	10	**2.2**
IBR virus	9	**2.0**
Coronavirus	6	**1.3**
Salmonella dublin	2	**0.4**
BHV4	1	**0.2**
Fungal	1	**0.2**

Table 6: Number of cases and relative frequency of the top ten pathogenic agents detected in BRD cases diagnosed on *post-mortem* examination (n=457).

Definitions:

- Pneumonia = Pneumonitis: Inflammation of the lungs.
- Pleurisy = pleuritis: inflammation of the pleura (the membrane lining the outside of the lungs and the thoracic cavity.

Parasitic Bovine Respiratory Disease

Parasitic bronchitis in cattle is caused by the nematode worm, *Dicytocaulus viviparus*. This disease typically affects cattle in their first grazing season. Significant infections can cause clinical disease, which can be fatal, but many animals acquire immunity over the course of their first grazing season. In adult cattle a reinfection syndrome is recognised in dairy cattle, typically presenting as a cough and milk drop in dairy cows after turnout. During 2020 *D.viviparus* was the most commonly diagnosed cause of BRD (18.6 *per cent* of cases). 72 cases (85 *per cent*) of BRD due to *D.viviparus* occurred in cattle less than one year old and 13 cases (15 *per cent*) in older cattle, and 90% occurred between the months of July and October inclusive.

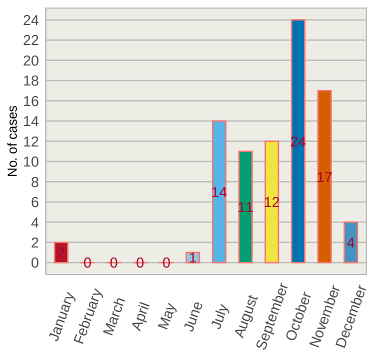


Figure 10: Number of diagnoses of parasitic bronchopneumonia by month during 2020 (n=85).

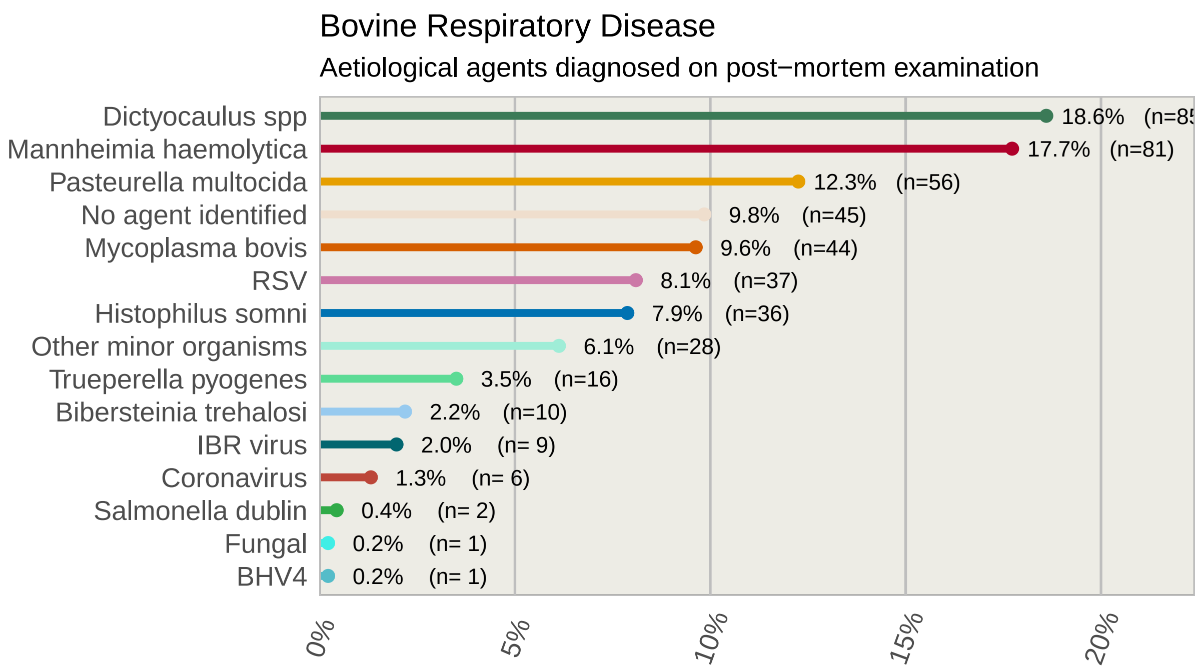


Figure 11: Relative frequency of the top ten pathogenic agents detected in BRD cases diagnosed on *post-mortem* examination, (n=457).

Table 7: Count and percentage by age goup of the general specific organisms detected in BRD on *post mortem* examination, (n=457).

Aetiology	Neonatal (0-1 month old)	Calves (1-5 months old)	Weanling (6-12 months old)	Adult Cattle (over 12 months old)	Total
BHV4	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)	1 (0.2)
Bibersteinia trehalosi	3 (5.9)	3 (1.6)	2 (1.3)	2 (2.7)	10 (2.2)
Coronavirus	2 (3.9)	3 (1.6)	1 (0.7)	0 (0.0)	6 (1.3)
Dictyocaulus spp	0 (0.0)	32 (17.5)	40 (26.8)	13 (17.6)	85 (18.6)
Fungal	0 (0.0)	0 (0.0)	1 (0.7)	0 (0.0)	1 (0.2)
Histophilus somni	5 (9.8)	12 (6.6)	17 (11.4)	2 (2.7)	36 (7.9)
IBR virus	0 (0.0)	1 (0.5)	4 (2.7)	4 (5.4)	9 (2.0)
Mannheimia haemolytica	7 (13.7)	26 (14.2)	26 (17.4)	22 (29.7)	81 (17.7)
Mycoplasma bovis	7 (13.7)	24 (13.1)	9 (6.0)	4 (5.4)	44 (9.6)
No agent identified	7 (13.7)	21 (11.5)	9 (6.0)	8 (10.8)	45 (9.8)
Other minor organisms	6 (11.8)	12 (6.6)	4 (2.7)	6 (8.1)	28 (6.1)
Pasteurella multocida	7 (13.7)	27 (14.8)	16 (10.7)	6 (8.1)	56 (12.3)
RSV	5 (9.8)	16 (8.7)	15 (10.1)	1 (1.4)	37 (8.1)
Salmonella dublin	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.7)	2 (0.4)
Trueperella pyogenes	2 (3.9)	6 (3.3)	5 (3.4)	3 (4.1)	16 (3.5)

Clinical signs of BRD can include:

- pyrexia
- depression
- serous-to-muco-purulent ocular and/or nasal discharge
- increased respiratory rate
- increased respiratory effort
- increased heart rate
- cough
- abnormal lung sounds (stethoscope)
- anorexia and/or loss of condition

Bacterial Bovine Respiratory Disease.

In line with previous years, bacterial agents were identified as the cause in 58 percent of BRD cases in 2020 (Table 5). Bacterial agents were the most frequently detected cause of pneumonia in all age groups.

During 2020 the most frequently detected bacterial pathogens associated with BRD were *Mannheimia haemolytica* and *Pasteurella multocida* (17.7 *per cent* and 12.3 *per cent* of BRD cases, respectively). Both organisms are commensals of the nasopharynx and an important cause of respiratory disease in cattle, sheep and goats.

Mycoplasma bovis pneumonia was diagnosed in 9.6 *per cent* of cases and was most commonly detected in animals less than six months old.

Histophilus somni was detected in 7.9 *per cent* of BRD cases and was more frequently detected in animals less than a year old than on older animals.

Trueperella pyogenes was isolated in approximately 3.5 *per cent* of cases of BRD, irrespective of age group. *Bibersteinia trehalosi* was implicated in 2.2 *per cent* of cases of BRD and in a minority of BRD cases from all age groups.

Salmonella enterica Dublin was isolated from 2.7 *per cent* of BRD cases aged 12 months or older. Overall *S. enterica* Dublin was only isolated from 0.4 *per cent* of all BRD cases.

Viral Bovine Respiratory Disease

Bovine respiratory syncytial virus was (RSV) was the diagnosed cause of 8.1 *per cent* of BRD cases. Most cases of RSV pneumonia occurred in younger cattle between 1 and 12 months of age and between December and February inclusive, indicating transmission is highest during the housing period (Figure 12).

Bovine herpesvirus 1, the viral cause of infectious bovine rhinotracheitis (IBR) was implicated in 2 *per cent* (n=9) of BRD cases in 2020, the majority of cases occurred in cattle more than six months of age.

Bovine parainfluenzavirus 3 (PI3) was not diagnosed as a cause of BRD in 2020. However serological testing for antibodies to PI3 and RSV viruses shows the vast majority of adult Irish cattle are seropositive for antibodies against both viruses.

The clinical significance of bovine herpesvirus 4 (BHV4) and bovine coronavirus are uncertain. BHV4 was deemed as significant in only one case of BRD during 2020 involving an adult bovine animal while Bovine Coronavirus was detected in 6 cases of BRD (1.3 *per cent*), all in animals less than 12 months old.

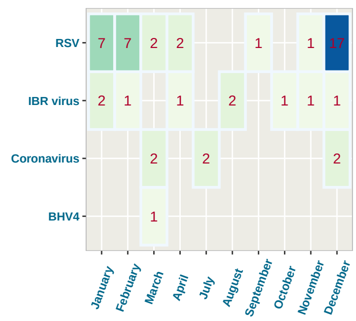
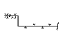


Figure 12: Viral respiratory infections in carcasses. Monthly number of viral pneumonia diagnoses by primary microorganism in 2020.



Bovine Abortion, Stillbirth and Perinatal Mortality

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Bovine abortion, stillbirth and perinatal mortality are common issues in cattle populations worldwide. Abortion is defined as death of a pre-term foetus that is not viable outside the uterus, often considered to be prior to 260 days' gestation. Stillbirth is defined as birth of a dead, full term calf that would otherwise have been viable. There is some overlap between the terms stillbirth and perinatal mortality, which encompasses death of a calf during parturition or up to 48 hours afterwards. These distinctions can be important factors when considering the aetiology of these conditions.

Many of the pathogens that cause abortion in cattle can also cause serious disease in humans. Some can even be shed during apparently normal parturition. Appropriate protective measures, including personal protective equipment and disinfection, should be put in place. This refers not only to aborted and stillborn cases, but when assisting any calving.

Consequences of all three syndromes include reduced number of calves produced per cow, reduced milk production in dairy systems and the associated economic effects. In the case of an abortion storm, losses may be so severe as to result in insufficient replacement heifers to maintain herd size and associated production levels on farm. Anecdotally, the experience of an abortion storm in their herd, and the associated consequences can have a negative impact on the mental health of the farmer, something which is likely to be underestimated.

An abortion rate of 3–5 *per cent* may be considered 'normal'. Above this, or if a number of abortions occur within a herd over a short space of time, investigation is warranted. Laboratory-based diagnostics play a vital role in diagnosis and mitigation of abortion, stillbirth and perinatal mortality issues. However, they are only one part of the investigative process, which should also include thorough history taking, assessment of cow management and environment and peripartum management, as appropriate.

There were 1665 abortion, stillbirth or perinatal mortality cases submitted to the Veterinary Laboratory Service (VLS) in 2020. This figure includes whole carcasses, part carcasses (e.g. foetal stomach contents only), and placentas submitted without a carcass.

Although cases were submitted throughout the year, the vast majority of submissions were from January to March and October to

December. This reflects Ireland's predominantly seasonal beef and dairy systems (see Figure 13).

Diagnostic Rate

Of all bovine abortion, stillbirth and perinatal mortality cases submitted, 980 (59 *per cent*) were undiagnosed. This figure reflects the difficulty in achieving a diagnosis in cases of this type and is comparable to other international studies (Wolf-Jäckel et al., 2020).

Many cases of abortion, stillbirth and perinatal mortality are not associated with infection. Forty-seven cases were diagnosed with developmental abnormalities, although these may not have been the actual cause of death. These included intestinal atresia, cardiac defects, congenital hepatic fibrosis, chondrodysplasia and other cardiovascular, musculoskeletal and neurological abnormalities.

Many stillbirths may be related to the calving event, with the foetus having been alive prior to the commencement of parturition. Sixty-three cases were diagnosed with conditions likely related to parturition, including hypoxia, dystocia and umbilical haemorrhage.

Infectious Causes

Bacterial pathogens

Material from all suitable cases is subjected to routine culture methods.

Salmonella Dublin is a common cause of bovine abortion in Ireland. In 2020, *S. Dublin* was cultured from 101 or 6.1 *per cent* of submitted cases (Table 8). As in previous years, the proportion of cases with an *S. Dublin* diagnosis peaked in the second half of the year (see Figure 13), emphasising the importance of appropriate timing of vaccination against this disease. One other Salmonella serotype was isolated from a single case in 2020: *Salmonella Montevideo*.

Table 8: Number of *Salmonella* Dublin isolates in foetal material in 2020 (n=1665).

Total Submissions	No. of Cases	Percentage
1665	101	**6.1**

Other bacterial pathogens

T. pyogenes is a common cause of sporadic abortion, identified in 155 cases (9.5 *per cent*) in 2020 (see primary abortifacients table). It is a common finding in purulent infections of cattle, and is assumed to reach the foetus haematogenously from another focus of infection in the dam.

Bacillus licheniformis (5.1 *per cent*) and ***Listeria monocytogenes*** (2.7 *per cent*) abortions are often associated with feeding of poorly

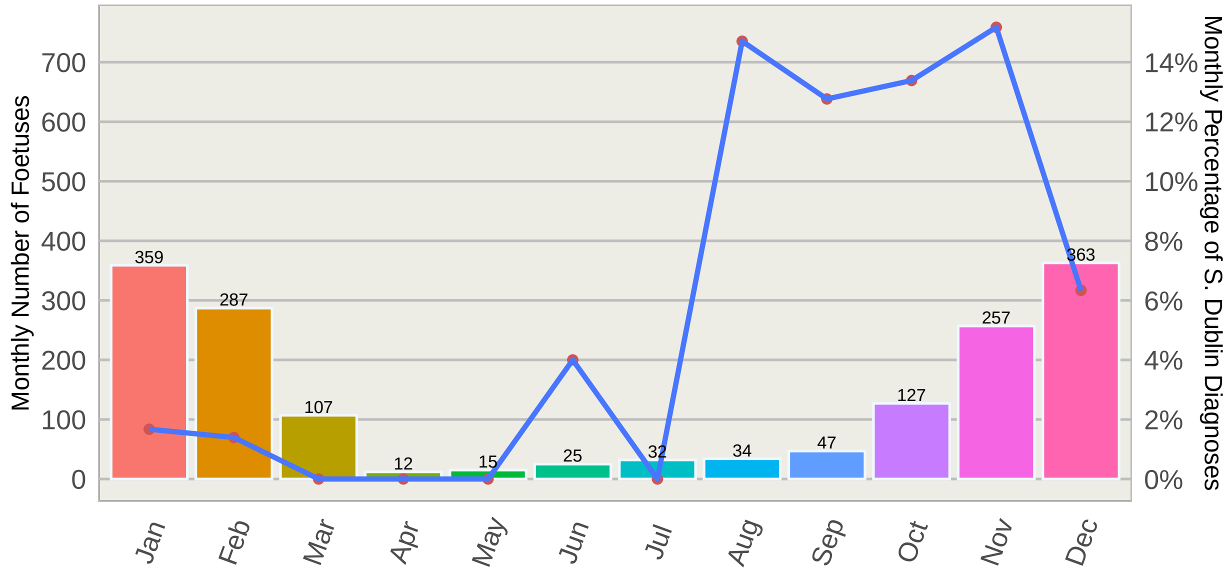

Figure 13: Annual distribution of foetal submissions (bars) and *Salmonella* Dublin isolates (line plot) from foetal bacterial cultures as a percentage of monthly bovine submission (n=1665).

preserved silage (Table 9).

Other bacteria isolated from cases in 2020 are listed in the table of bacterial pathogens (Table 11). The significance of some of these isolates can be difficult to determine. Some, particularly coliforms, may be the result of contamination of the sample. Others may be secondary pathogens which have had the opportunity to cross the placenta due to compromise for another reason.

Fungal pathogens

Aspergillus spp were isolated from 17 cases (1 *per cent*). This is also often associated with feeding of contaminated foodstuffs. Other fungi and yeasts were found in 15 cases (0.9 *per cent*) (see Table 11).

Table 9: Frequency of detection of other primary abortion pathogens in foetal culture during 2020 (n=1665).

Organism	No. of cases	Percentage
Trueperella pyogenes	155	**9.5**
Bacillus licheniformis	83	**5.1**
Listeria moncytogenes	44	**2.7**
Aspergillus spp	17	**1.0**

Viral pathogens

Foetal tissue is tested for viral pathogens associated with bovine abortion, stillbirth and perinatal mortality in specific circumstances. These viruses include bovine herpesvirus-1 (BHV-1), bovine herpesvirus-4 (BHV-4), bovine viral diarrhoea (BVD) and Schmallenberg virus (SBV). Of the 130 cases tested for BHV-1, two positive and two inconclusive results were returned (Figure 10).

Table 10: Frequency of detection of viruses in foetal material during 2020.

Virus	Inconclusive	No virus detected	Positive	Percentage
BHV-1	2	**126**	2	1.5
BHV-4	0	**61**	1	1.6
SBV	0	**69**	0	0.0

Foetal infection with BHV-1 can be the result of acute infection or recrudescence of a latent infection. Vaccination offers the best means of disease control. BHV-4 was detected in one out of 62 tested cases. The role of BHV-4 in reproductive disorders of cattle is currently unclear, and there are no vaccines available against the virus. None of 162 and 69 cases tested positive for BVD and SBV, respectively.

Table 11: Combined frequency of detection of selected secondary abortion agents on routine foetal culture.

Organism	No of Cases	Percentage
No Significant Growth	1093	**67.3**
Coliforms	261	**16.1**
Streptococcus spp	63	**3.9**
Other minor organisms	25	**1.5**
Yeasts and Fungi	15	**0.9**
Bacillus spp	12	**0.7**
Staph. spp	11	**0.7**
Pseudomonas spp	7	**0.4**
Pasteurella multocida	4	**0.2**
Histophilus somnus	3	**0.2**
Listeria spp	2	**0.1**
Mannheimia haemolytica	2	**0.1**
Yersinia pseudotuberculosis	1	**0.1**

Protozoal pathogens

Neospora caninum is the primary protozoal pathogen associated with bovine abortion, stillbirth and perinatal mortality. It is one of the most common causes of both sporadic abortions and abortion storms in cattle. The life cycle is indirect, with canids and bovines the definitive and intermediate hosts, respectively. Cattle can be infected through ingestion of oocysts in feed or water contaminated with dog faeces. However, vertical transmission is thought to be more common, with infection passing from dam to calf in utero.

Currently, *N. caninum* is diagnosed within the Veterinary Laboratory Service by histopathology of the foetal tissues or antibody ELISA of foetal blood or fluids. Both methods have inherent limitations. Histopathology on its own can only detect lesions consistent with protozoal infection (Figure 14). It cannot be used to conclusively diagnose *N. caninum*. Detection of these lesions is also dependent

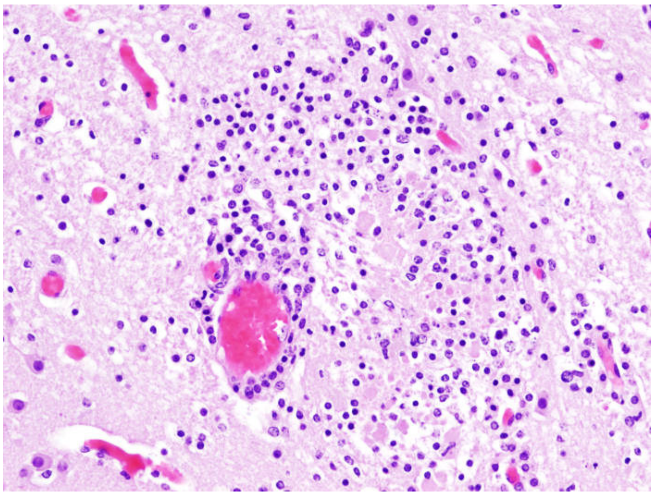

Figure 14: Focal central necrosis with scattering of mononuclear cells at the periphery (encephalomyelitis) associated with *Neospora caninum* in the brain of a bovine foetus. Photo: Cosme Sánchez.

on the specific sections of foetal tissue examined. Antibody ELISA results can be affected by degree of autolysis of the sample and age of the foetus. In 2020, *N. caninum* was diagnosed in 91 cases. This figure may be falsely reduced, as samples are not submitted for histopathology or *N. caninum* antibody ELISA in all cases. PCR for Neospora is occasionally carried out in some foetuses.

There is no effective treatment or vaccine for *N. caninum* currently available. Control is dependent on identification of infected cows through serology, applying culling or selective breeding policies, and limiting access of dogs to cattle areas and material associated with calving (e.g. placenta).

Johne's Disease

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Mycobacterium avium subspecies *paratuberculosis* (MAP), is the causative agent of Johne's disease (JD), a chronic granulomatous enteritis of ruminants. JD is a slowly progressive disease. Clinical signs include weight loss despite a normal appetite, diarrhoea, submandibular oedema, emaciation, lethargy, and eventual death as currently there is no effective treatment for JD.

Johne's Disease Diagnostics

As treatment of MAP is generally regarded as ineffective, diagnostic testing is often used to direct subsequent management decisions (e.g. calf in separate area, cull, etc). As MAP is a slow growing bacterium, infection can remain latent for many years making diagnosis difficult. Diagnostic tests currently in use involve either identification of MAP itself (culture), identification of MAP genetic elements (PCR), or detection of the immune response MAP infection elicits (ELISA).

Faecal culture is generally taken as the reference test for MAP. An advantage of culture is that detection of MAP in faecal samples confirms presence of viable MAP in the animal.

Due to absent or intermittent shedding of bacteria early in the disease process, sensitivity of culture can be low. Specificity, however, is almost 100 *per cent*. Due to the fastidious nature of MAP, culture takes a number of weeks. Polymerase Chain Reaction (PCR) is another faecal based test used to detect DNA of MAP, it offers a rapid method of detecting MAP status. Enzyme-Linked Immunosorbent Assay (ELISA) examines the host's immune response to MAP and is extensively used for routine diagnosis. ELISA is favoured as a screening test due to its relatively low cost, compared to faecal culture or PCR. ELISAs also provide faster results when compared to culture methods. It is important to note that a positive ELISA reaction is NOT confirmation of JD. The specificity of MAP ELISA tests can be influenced by tuberculin testing and by exposure to non-MAP environmental mycobacteria (giving rise to false positive results). The sensitivity of MAP ELISA tests is influenced by stage of infection, high in animals with clinical disease but lower in the infected animals that are shedding few MAP organisms (where false negative results may arise).

Table 12: Summary of MAP positive faecal cultures by breed and gender in 2020, (n=24).

Breed	Female	Male	Total
FR	8 (38.1)	1 (33.3)	9 (37.5)
LM	7 (33.3)	1 (33.3)	8 (33.3)
CH	2 (9.5)	1 (33.3)	3 (12.5)
AA	2 (9.5)	0 (0.0)	2 (8.3)
BB	1 (4.8)	0 (0.0)	1 (4.2)
NR	1 (4.8)	0 (0.0)	1 (4.2)

Post mortem examination

Figure 15: Thickened and corrugated intestine from a cow with MAP confirmed on faecal culture. Photo: Aideen Kennedy.

On post mortem, gross and microscopic lesions associated with JD are primarily confined to the intestine and mesenteric and ileo-caecal lymph nodes. Gross lesions are characterised by thickening and corrugation of intestinal mucosa (Figure 15), most prominent in the ileum and ileo-caecal valve. Histological lesions associated with JD can vary widely; villi are frequently fused and the mucosa is invariably thickened, infiltration of macrophages –including giant cells– is commonly identified in the submucosa and acid fast bacilli are commonly present (Figure 16). JD cannot be diagnosed solely on postmortem, diagnosis needs to be confirmed by faecal culture and/or histology (intestine/lymph nodes).

Table 13: Number of JD positive animals detected in the herd of birth by faecal culture.

Homebred	Number of Animals
No	10
Yes	14

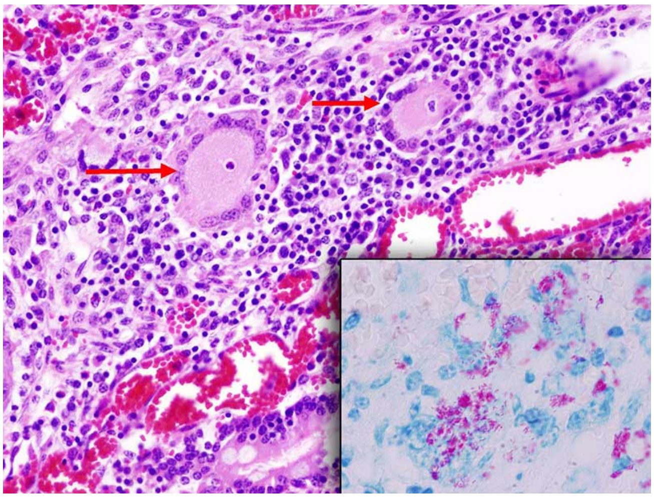

Figure 16: Microphotography of Langhan's-type giant cells (arrows) occasionally observed in tuberculoid granulomas in the lamina propia of the small intestine in animals with Johne's disease. Inset: Ziehl-Neelsen stained section showing acid-fast (*Mycobacterium avium ssp. paratuberculosis* bacilli). Photo: Cosme Sánchez-Miguel.

Minimum	Median	Maximum
0	1	6

Table 14: Statistics of the movements of cattle with JD excluding movements to factory or knackery.

Faecal Culture Positive results DAFM Laboratories

In total, 24 positive MAP faecal cultures, from 21 different herds, were recorded in 2020 (Table 12 and Figures 17 and 18). A mixture of dairy and beef breeds recorded positives. Over 80 *per cent* of positive animals were female (Table 12 and Figure 18). Like previous years Friesians were the most frequently reported breed (Table 12). It should be noted figures recorded DO NOT represent a national prevalence, they relate to faecal culture positive results identified in DAFM labs and do not include data from private laboratories. The large reduction in faecal culture positives from the previous year (58 culture positives from 48 different herds in 2019) likely does not reflect a decrease in the incidence but may reflect the increasing availability of faecal PCR in commercial laboratories. Indeed PCR testing is used as confirmatory testing as part of Animal Health Ireland's JD Control programme (see page 108 for further details).

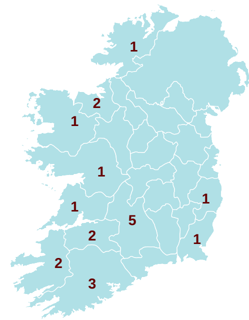

Figure 17: Number of herds by county with at least one animal diagnosed with JD by faecal mycobacterial culture in 2020.

JD transmission

In many herds, initial introduction of MAP usually occurs as result of acquiring an infected but clinically normal animal. In 2020, several animals that subsequently recorded MAP faecal culture positive results underwent multiple herd movements throughout their lifetime, potentially allowing spread of the disease. Six was the greatest number of herd movements recorded by a positive animal, excluding movements to factory or knackery (Table 14), an increase from a maximum of 3 movements in 2019.

Latency is a common feature of mycobacterial diseases; animals can remain subclinically infected without showing any clinical signs of the disease for many years. Clinical disease is reported to occur most frequently in cattle aged 2—5 years. In line with this, based on a number of assumptions, it is estimated that 50 *per cent* of animals that tested positive in 2021 were displaying symptoms of JD and culled by five years of age (Figure 19). At the time of analysis all male animals that had recorded a culture positive result were dead and only 14 *per cent* of female animals with a positive culture result remained alive (Figure 18).

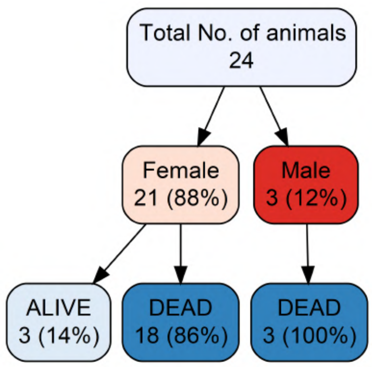

Figure 18: Status of animals diagnosed with Johnes disease in 2020 as per the 25th of May, 2020.

Control Programme

A voluntary national JD control programme is ongoing in Ireland under the guidance of Animal Health Ireland (see page for further

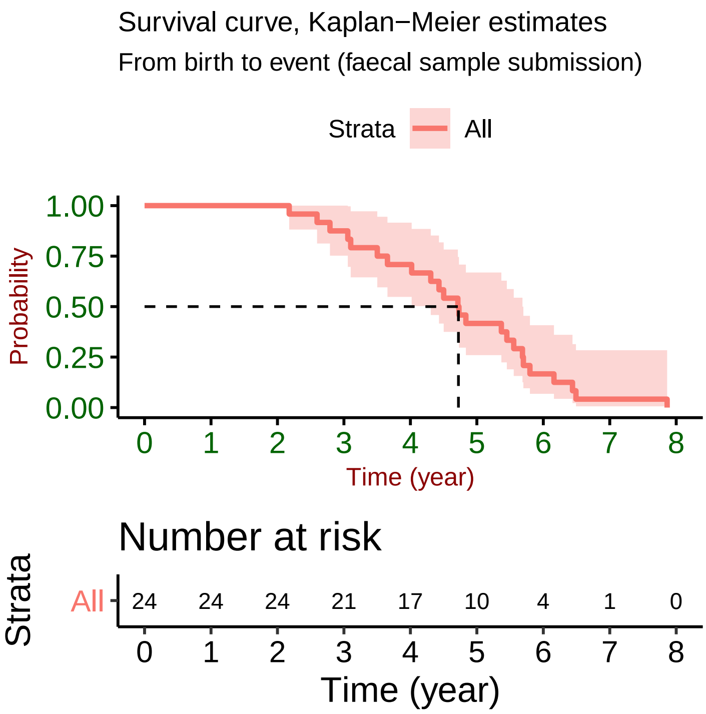

Figure 19: Survival curves measure how much time elapsed before a certain event occurred. In this case, the event is represented by submission of a faecal sample to an RVL. An assumption is made that faecal samples are submitted soon after the animal displays diarrheoa unresponsive to treatment. Fifty *per cent* of animals may have displayed symptoms consistent with the disease by five years of age. The graph on the bottom represents number of animals at risk of developing the symptoms overtime.

details see chapter on Animal Health Ireland Irish Johne's Control Programme on page 108).

Bovine Mastitis

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Mastitis, inflammation of the mammary gland, is one of the most common diseases of the cow and a problem for the dairy industry world wide. Mastitis causes a reduction in milk yield and milk quality and has therefore a severe economical impact in particular on the dairy industry. In order to support this important and growing agricultural sector of Irish agriculture DAFM supports CellCheck [1]. The programme aims to encourage the use of milk culture and antimicrobial sensitivity testing as part of farm mastitis control plans aimed at reducing somatic cell counts to encourage the appropriate use of antimicrobials. In order to support this programme DAFM, alongside a number of private and milk processor laboratories, offer milk culture and sensitivity testing.

[1] CellCheck is the national mastitis control programme coordinated by Animal health Ireland (AHI) in partnership with industry bodies representing farmers, processors and service.

Bacterial infections cause the vast majority of mastitis cases, both clinical and subclinical. Correct identification of the causative agents is needed to tailor adequate treatment. Sensitivity testing is needed in order to both treat the condition as accurately and efficiently as possible as well as to slow the development of antimicrobial resistance. Moreover, the identification of the agent enables the farmer and private veterinary practitioner (PVP) to identify the source of infection (environmental or contagious) to adjust control measures. Worldwide *Staphylococcus aureus*, coagulase-negative *Staphylococcus spp.*, *Escherichia coli*, *Streptococcus agalactiae*, and *Streptococcus uberis* are the most important mastitis pathogens (Krishnamoorthy et al., 2021).

The quality of milk samples taken for laboratory examination is extremely important. An aseptic technique for sample collection is a necessity. Contaminated samples lead to misdiagnosis, confusion and frustration.

Milk Culture in RVLs

DAFM requests for each submitted milk sample to be accompanied by a submission form detailing the herd number, animal number and date of sampling.

The milk culture results for 2020 are summarised in Table 15.

Figure 20: Example of growth on a contaminated milk sample. Photo: Rebecca Froehlich-Kelly.

All samples are initially tested for inhibitory substances, such as antibiotics, which can interfere with bacterial growth in the laboratory. At least four different types of agar plate are used to culture each milk sample (Figure 20). Suitable samples are then incubated 37^oC. If bacterial growth is seen on plates, further tests are carried out to identify the organisms growing. Antimicrobial sensitivity testing may then be carried out on the organism in accordance with guidelines issued by the Clinical and Laboratory Standards Institute (CLSI).

Table 15: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2020 (n=1627).

Result	No. of cases	Percentage
Contaminated	364	**22.4**
Staphylococcus aureus	304	**18.7**
No Significant Growth	263	**16.2**
Streptococcus uberis	230	**14.1**
E. coli	218	**13.4**
Other Isolates	148	**9.1**
Streptococcus dysgalactiae	57	**3.5**
Bacillus spp.	25	**1.5**
Trueperella pyogenes	18	**1.1**

While the number of contaminated samples has reduced from the previous year from 31.4 *per cent* to 22 *per cent*, Figure 21 highlights that a significant number of milk samples submitted are contaminated. Culture in these cases usually yields a mixed bacterial growth on agar and it is challenging to identify the exact causative organism. Contamination usually occurs during the sampling process when bacteria from other sources like udder skin, sampler's hands or even faeces can enter the sample container, or by not using a sterile sample container. The results emphasise the importance of collecting milk samples in a sterile manner. Other unsuitable samples are those collected from the bulk tank which are almost invariably contaminated with organisms originating from outside the udder.

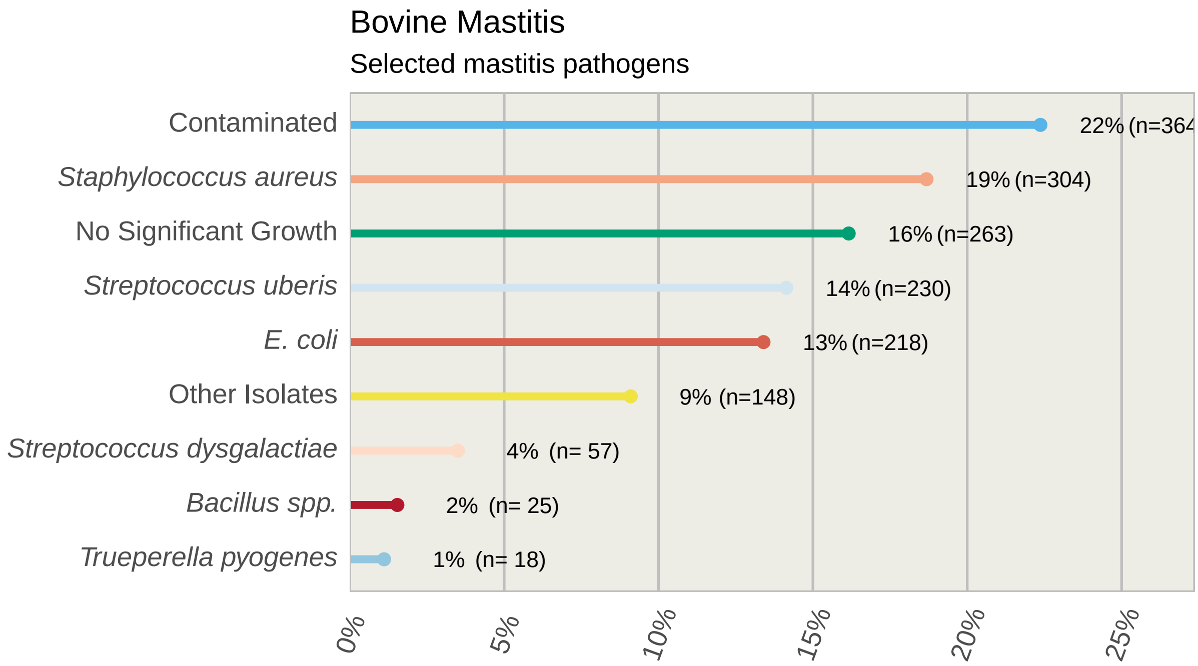

Figure 21: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2020 (n=1627).

Staphylococcus aureus

As in previous years *Staphylococcus aureus* was the most commonly cultured pathogen from mastitic milk samples.

Staphylococcus aureus is one of the main pathogens causing contagious mastitis. Contagious mastitis is spread from cow to cow by contact with contaminated cluster liners, wash cloths or milker's hands and can also be transmitted by flies. Typically, this pathogen causes subclinical mastitis leading to elevated somatic cell counts (SCC) rather than a change in milk or grossly visible udder lesions. As the infection is often persistent with rare flare-ups and once established very difficult to treat with antimicrobials, control is very difficult and poses severe impact on milking management and milking hygiene. Therefore, the culling of chronic carriers is most often the best option. However, identification of carrier animals can be challenging as SCC on their own are not sensitive enough to diagnose *Staph. Aureus* infections.

Streptococcus uberis

In contrast to *Staph aureus*, *Streptococcus uberis* is considered an environmental pathogen which is usually spread via faecal contamination of surfaces. However, it can also be spread from cow to cow at milking time. In contrast to the decline of isolation of *Staph. Aureus* the trend for the isolation rate of *Strep. uberis* is rising (Figure 22).

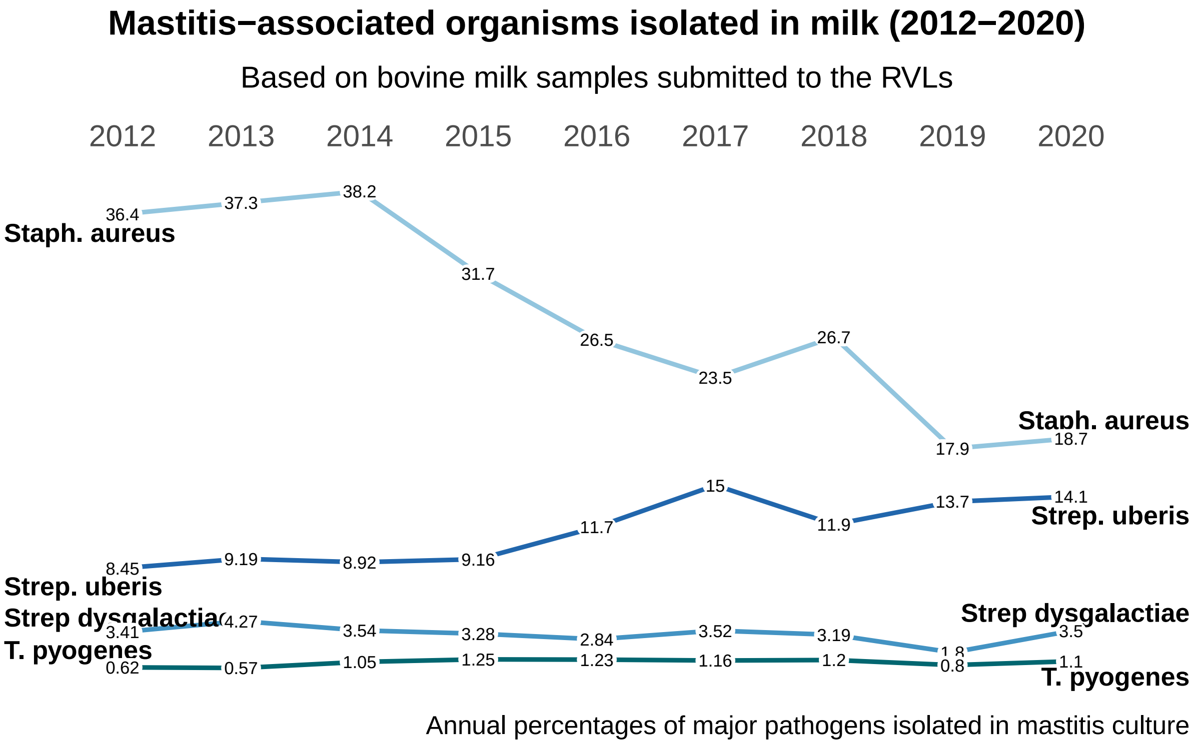

Figure 22: Mastitis-associated Organisms Isolated in Milk (2012-2020).

Trueperella pyogenes

Trueperella (formerly *Arcanobacterium*) *pyogenes* is commonly associated with cases of summer mastitis and presents typically with a suppurative foul-smelling secretion. Treatment is challenging and loss of the quarter for milk production is common. Insect vectors, in particular *Haematobia irritans*, are considered central to its spread.

Neonatal Enteritis

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Bovine Neonatal Enteritis (BNE) is the predominant cause of mortality in calves up to one month of age; it is due to one or more enteric pathogens (virus/bacteria/parasite), often in combination with predisposing factors. Failure of passive immunity transfer (colostral immunity) is considered the most important predisposing factor; others would include age, environmental pathogen load, adverse weather, etc.

Table 16: Number of tests and relative frequency of enteropathogenic agents identified in faecal samples of calves up to one month of age in 2020.

Organism	No. of Tests	Positive	Percentage
Rotavirus	1308	418	**32.0**
Cryptosporidia	1357	196	**14.4**
Campylobacter Jejuni	1180	134	**11.4**
Giardia	815	37	**4.5**
Coronavirus	1301	13	**1.0**
E.Coli K99	1019	9	**0.9**
Salmonella Dublin	1296	3	**0.2**

Rotavirus has consistently been the most frequent enteropathogen isolated in cases of bovine neonatal enteritis in Ireland (see Table 16 and Figure 23). In the first few days of life, calves with insufficient colostral antibodies to protect against disease, will develop diarrhoea resulting in dehydration and electrolyte loss that can lead to hypovolaemic shock and death. Peak incidence occurs in the first two weeks of life. Infective load is small. In the small intestine, the virus attaches to mature enterocytes, where it rapidly multiplies destroying these cells, causing villi atrophy and consequential malabsorption. Large numbers of virus are shed through faeces contaminating the environment, transmission is faecal-oral.

Rotaviral infections are localised, non-invasive infections (damage is limited to intestinal mucosa) with mild inflammatory response and an infection rate that increases as the calving season progresses, younger calves are exposed to virus shed by older calves and adults. It is treated with supportive therapy of oral/parenteral hydration and electrolyte replacement.

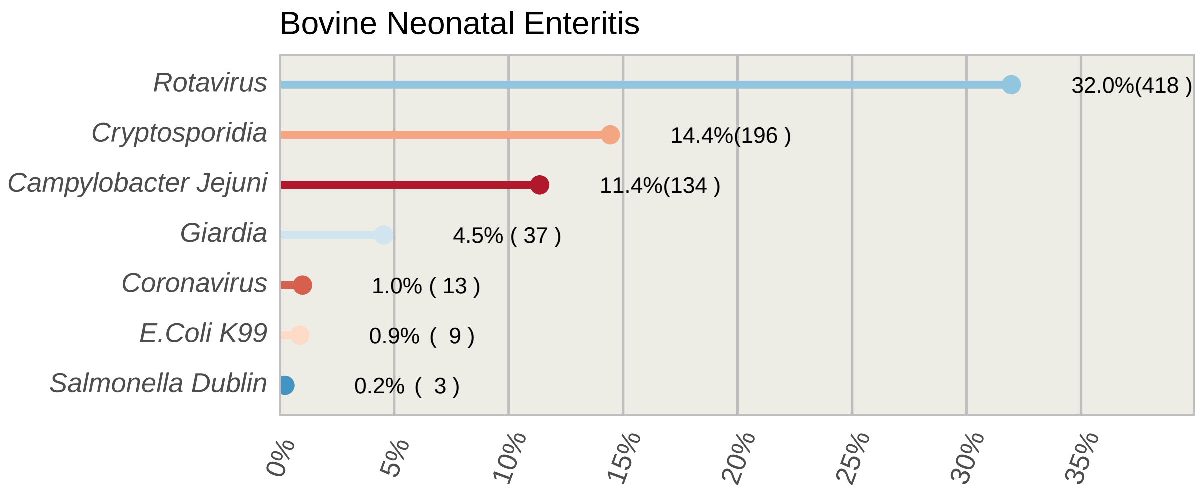

Figure 23: Relative frequency of enteropathogenic agents identified in calf faecal samples (neonatal enteritis package) tested in 2020. Percentage of positive results. Total samples examined varies with the agent, see 16

Cryptosporidiosis is caused by the protozoa *Cryptosporidium parvum*. It is also a non-invasive neonatal infection. Protozoa attach to epithelial brush border on villi (Figure 24) causing atrophy and malabsorption. It can be detected as early as 5 days of age, frequently there are concurrent infections. There is a rapid loss of condition. Treatment, as in rotaviral infections, is hydration and electrolyte replacement. Cryptosporidiae can be found in the normal intestine of older bovines; therefore, it is important to keep calves in environments with low pathogenic loads.

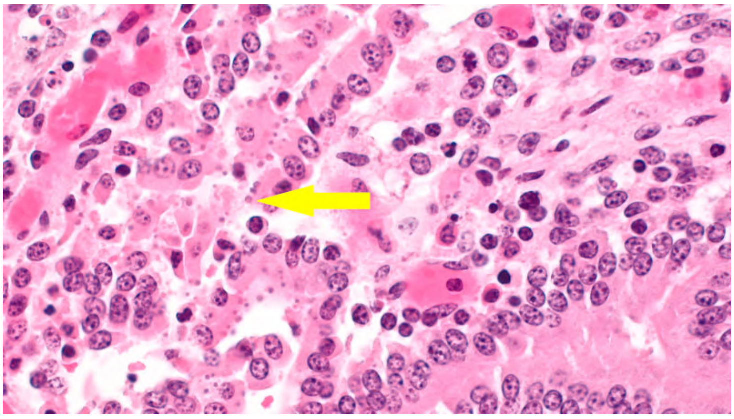

Figure 24: Cryptosporidiae attached to brush border of intestinal epithelium (arrow). Photo: Shane McGettrick

Coronaviral infections are similar to rotaviral. They are less commonly encountered, tend to be more severe, lesions can also be found in the colon and peak incidence is one to two weeks.

Bovine Neonatal enteritis caused by bacteria (*E.coli* K99, *Salmonella* Dublin) and Clostridial enteritis are invasive infections that can result in septicaemia and/or toxic shock (*E.coli* K99 and *S.* Dublin produce endotoxins, clostridia produce exotoxins). There is a significant inflammatory response, which can extend to deeper tissues and lead to septicaemia. Diarrhoea and dehydration may, in occasions, not be as severe and cases of peracute deaths may occur. Calves are weak and there may be signs of septicaemia (congested mucosae, swollen joints, pneumonia). Treatment will include replacement of fluid and electrolytes, and antimicrobials.

No. of Tests	Positive	Percentage
635	103	**16**

Table 17: The number of tests and relative frequency of coccidiosis in faecal samples of calves up to around one month of age in 2020.

E. coli K99 is an enterotoxigenic *Escherichia coli* (ETEC) that affects the small intestine of newborn calves in their first five days of life. *E. coli* K99 secretes enterotoxins that cause reduction of intestinal absorption (malabsorption) and increase secretion of fluids and electrolytes.

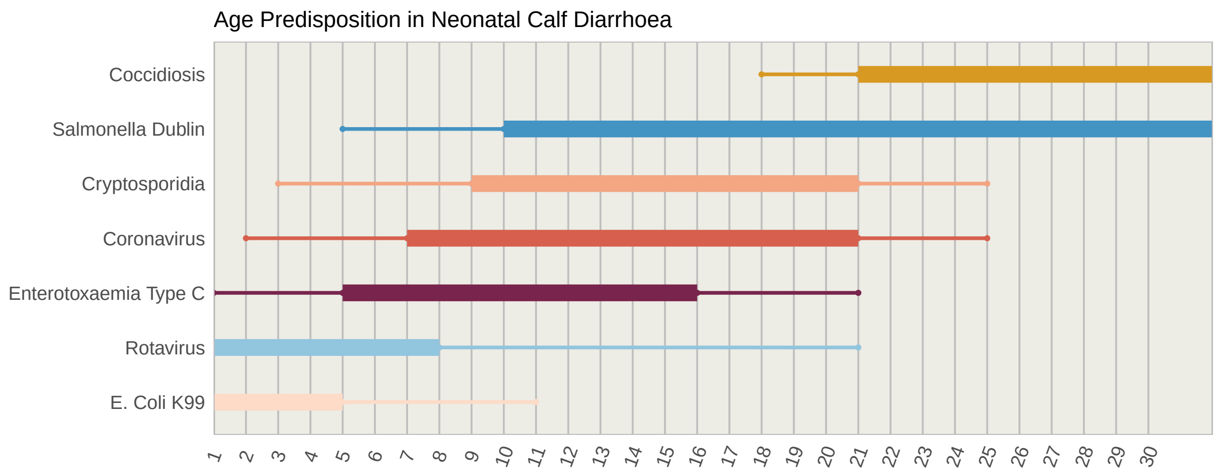

Figure 25: Agent and age predisposition in neonatal calf diarrhoea, the thick area represents the most likely period of disease

Salmonella enterica subspecies enterica serovar Dublin, *S.* Dublin, its incidence has been steadily declining through recent years (Table 16 and Figure 23), probably due to increased herd vaccination. Calves up to six month of age are most at risk.

Clostridial enteritis caused by *Clostridium perfringens* type C, is not a frequently diagnosed disease in calves in Ireland, it affects animals in the first two weeks of life. Peracute deaths with no clinical signs can occur.

Pathogenicity of *Campylobacter jejuni* and* *Giardia* in calves is uncertain. However, as they are common causes of enteritis in humans, their presence in calf faeces is monitored (Table 16 and Figure 23).

Zinc Sulphate Turbidity Test

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The Zinc Sulphate Turbidity Test (ZST) has been adopted in the Regional Veterinary Laboratories to estimate the successful transfer of Immunoglobulins (*Ig*) via colostrum from the dam to its calf. The test provides an indirect measurement of immunoglobulins, Zinc Sulphate precipitates from solution in direct proportion to the level of immunoglobulins present in a serum sample.

Newborn calves are born without an active immune system as the cows placenta does not allow immunoglobulins to pass across into the calf's circulation before birth, hence calves are born without protection to disease and acquire this through ingestion of colostrum.

Successful passive transfer is defined as occurring when serum Immunoglobulin G (*IgG*) concentration is greater than 10*mg/ml* as measured by the Radial Immunodiffusion (RID) this test is accepted as the gold standard , however, it is an expensive and difficult test to run. As a result, other tests like ZST, Serum Total Protein, serum globulin *Gamma Glutamyltransferase* (GGT)and enzyme-linked immunosorbent assay (ELISA) are used to establish the failure of passive transfer (FPT).

These other tests are not the gold standard for the measurement of *IgG*, therefore the sensitivity and specificity of detection of FPT vary between tests . Other limitations for the ZST are the effects of haemolysis and CO_2 on serum samples.

Table 18: Zinc Sulphate Turbidity Test Results in 2020 (n=1045).

Submission type	Status	No. of samples	Mean	Percentage
Diagnostic	Optimal	541	29.5	**67**
Diagnostic	Adequate	170	16.5	**21**
Diagnostic	Inadequate	97	7.6	**12**
Carcass	Optimal	59	28.0	**25**
Carcass	Adequate	60	15.5	**25**
Carcass	Inadequate	118	7.0	**50**

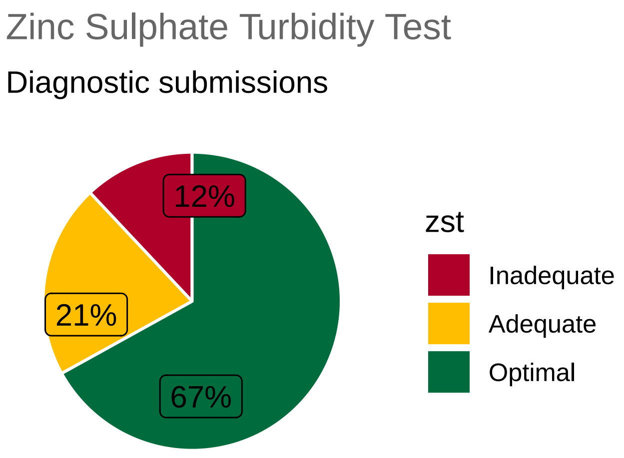

Figure 26: Results of ZST from submitted bovine blood samples in 2020 (n=808).

Twenty units are commonly used as a cut off to determine the adequacy of passive transfer for ZST; however, the test has low specificity and will likely over-estimate the prevalence of FPT. As a result, a range from 12.5 to 20, sub-optimal range, is included to compensate for this. Any results below 12.5 are inadequate and confirm FPT.

Analysis of Results

In 2020 (Table 18) there were 1045 blood samples submitted for ZST analysis (808 for diagnostic purposes, i.e. from live animals, and 237 from *post mortem* examinations); this compares with 807 in 2019 and 1207 in 2018.

Diagnostic results showed 67 *per cent* of samples were optimal, 21 *per cent* suboptimal, and 12 *per cent* had a failure of passive transfer (Figure 26) . This is a marginal improvement on the previous year of 65 *per cent* optimal, 18 *per cent* suboptimal and 16 *per cent* FPT. These results, which appear to have improved over the last number of years, would reflect the success of information campaigns to highlight the benefits of feeding colostrum to newborn calves. A distribution of the ZST test results of clinical submissions during 2020 is shown in Figure 27.

Post mortem (carcass) results showed 25 *per cent* optimal and 25 *per cent* suboptimal levels with a 50 *per cent* FPT; this compares with 31 *per cent* optimal, 23 *per cent* suboptimal and 47 *per cent* FPT in 2019.

Interpretation

Timing of blood sampling is critical to interpretation; it should not be done on the first day of life as peak circulating immunoglobulin is achieved 36 hours after ingestion of colostrum and then begins to decline. In colostrum deprived calves, endogenous *IgG* production has been detected after seven days of life, and it is difficult to distinguish between those with adequate immunity and FPT. As a result,

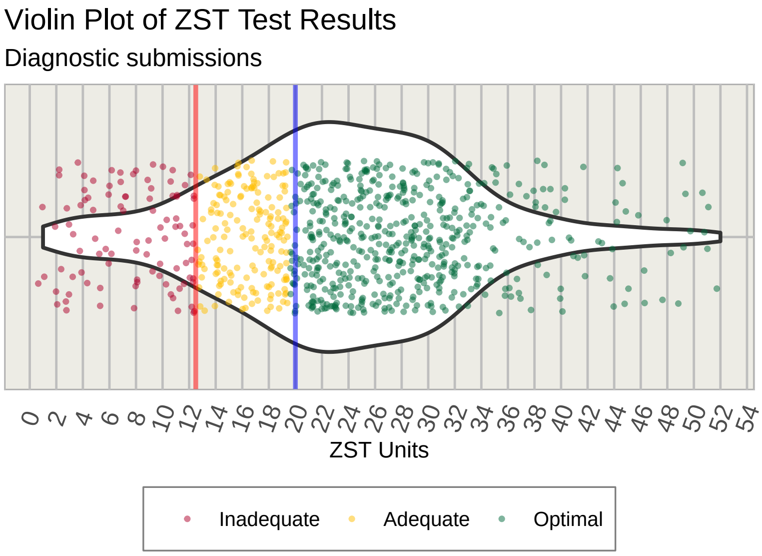

Figure 27: Distribution of ZST test results during 2020. Optimal colostral immunity is defined as greater than 20 units (blue line), adequated between 12.5 and 20 units and inadequated less than 12.5 units (red line). The width of the white area at each point of the x-axis is proportional to the number of samples returning a ZST result of that value. Outliers with values greater than 52 units were removed from the plot (n=808).

the ideal age to blood sample a calf for FPT is from 2–7 days, but the upper age limit can be extended to 10–14 days.

Figure 28: A useful on farm tool for measuring the concentration of immunoglobulins in colostrum is a Brix refractometer and so can aid in the overall picture of colostrum management in the herd.

Successful Passive Transfer

Successful Passive Transfer requires the following,

1. **Quality of colostrum.** Good quality colostrum in dairy cows is defined by an *IgG* concentration greater than 50*g/L*, direct measurement is expensive, and there are a couple of alternative indirect methods:

   - Brix Refractometer (Figure 28): this correlates well with *IgG* concentration in colostrum, and 22 *per cent* approximates to 50*g/L*.
   - Colostrometer: this is poorly sensitive, temperature variable and is not recommended.

   One of the most important factors affecting quality in dairy herds is the timing of colostrum collection, i.e. from when cow calved to time of collection of colostrum as *IgG* content drops immediately postpartum. Remember, the timing of collection is more important than specific animal factors such as dairy breed, yield and parity.

The timing of collection is more important than specific animal factors such as dairy breed, yield and parity.

Pooling of colostrums has a dilution effect and also increases the transmission of diseases and is to be discouraged. Published studies comparing dairy and beef cow first milking colostrum *IgG* concentrations show higher levels in beef colostrums, e.g. 113 *mg/ml* versus 43*mg/ml* (Guy et al., 1994). However, the variance in mean colostral *IgG* concentration across studies for beef and dairy cows is substantial.

2. **Quantity of colostrum.** The quantity of colostrum to be given is dictated by the quality, assuming an *IgG* concentration of 50*g/L*.

This equates to a recommended feed of at least 3L colostrums for dairy calves (150*g* recommended in the first feed).

3. **Efficient absorption.** Timing of the first feed is critical and is optimal in the first four hours of life and declines rapidly from 12 hours with closure at 24 hours.

It is essential to remember that calves fed colostrum with high coliform counts have decreased efficiency of absorption due to direct interference with Ig binding sites. Farms experiencing problems with FPT should consider monitoring bacterial contamination of colostrum at the point of feeding to the calves. A threshold >100,000 *cfu/ml* for Total Bacterial Count (TBC) and greater thab 10,000 *cfu/ml* for Total Coliform Count (TCC) could potentially interfere with absorption of immunoglobulins and lead to FPT.

Consider the long-term benefits of the non-immunoglobulin components of colostrums. Increased colostrum intake results in improved gut maturation and absorption, increased average daily gain, reduced age at first calving and increased milk and fat production in the first lactation compared with those with failure of passive transfer.

Conclusion

Individual ZST results from sick or healthy calves are only a snapshot and may not be reflective of herd status. Calves with a concurrent disease will have reduced immunoglobulins as it binds with antigen and therefore may be difficult to determine whether inadequate immunity or excessive challenge is the more significant factor in causing disease. Conversely, dehydration could artificially elevate ZST levels in sick calves suffering from scour. So care is needed in interpreting these individual results.

It is more important to look at groups of calves than individuals, which will give a more accurate picture of what is going on in the herd. Due to the nature of the sensitivity and specificity of the test, it is recommended to blood test 10–12 calves from 2–7 days of age (can extend to 10–14 days) (Hogan et al., 2015).

A review of colostrum management is recommended if 10–15 *per cent* are showing FPT.

It is also important to remember that the prevalence of FPT may vary according to the test used (McAloon et al., 2016) therefore compare like with like.

ZST results in this report may not truly reflect the overall national herd status as they are taken from clinically sick calves or animals from targeted herds with current health problems. Regardless, calves with lower passive immunity are at greater risk of an adverse health event or poor growth.

Bovine Parasites

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Parasitic disease is a common and significant cause of animal disease in bovines in Ireland. The Regional Veterinary laboratories (RVLs) test for the presence of parasites in faecal samples submitted by private veterinary practitioners (PVPs), and in intestinal contents harvested from animal carcasses at necropsy. Parasitic disease may also be diagnosed at necropsy by the detection of gross and histopathological lesions; other tests may support the diagnosis of parasitic disease in live animals.

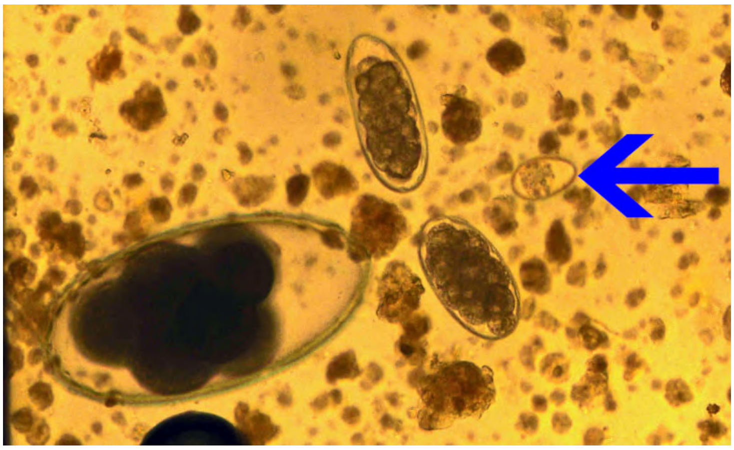

Figure 29: Eggs and oocysts visible during McMaster faecal egg counting. A *Nematodirus* egg (left) two strongyle eggs (centre) and a coccidial oocyst (arrow) are visible. Photo: Brendan Crowe.

Parasitic disease in cattle in Ireland is most commonly caused by nematodes (parasitic gastro-enteritis due to *trichostrongylidae* and parasitic bronchitis due to *Dictyocaulus viviparus*), coccidia (various species of *Eimeria*) and trematodes (the liver fluke *Fasciola hepatica* and the rumen fluke *Calicophoron daubneyi*).

Trichostrongylidae

Ostertagiasis type 1 occurs at grass and is due to build up of infectious *L3* on grazing fields during the late summer or autumn. Ostertagiasis type 2 is more commonly seen in housed cattle in late winter and early spring and is caused by the mass synchronous emergence of hypobiotic larvae from the abomasal mucosa. Milder weather will cause these larvae to emerge together, leading to the sudden onset of disease. Control of this condition must take place around the time of housing. It is seldom seen in recent years, and no diagnosis of Ostertagiasis type 2 was recorded by the RVLs in 2020.

Table 19: Number of bovine faecal samples tested for Trichostrongylidae eggs in 2020 and results by percentage (n=3972).

Result	No. of samples	Percentage
Negative	2930	**73.8**
Low (100-200 epg)	537	**13.5**
Medium (200-700 epg)	328	**8.3**
High (>700 epg)	177	**4.5**

Samples for faeces and intestinal contents are examined for eggs of the *Trichostrongylidae* by the McMasters test, which returns a faecal egg count in *eggs per gram* (EPG). Submissions were received throughout the year, with a peak in the autumn months (September to October) with a smaller peak during the summer (June–July). In previous years the pattern was similar with a shorter autumn peak in November prior to housing, as the treatment of animals at housing is being planned. In 2020 the number of submissions during August/September did not drop as in previous years.

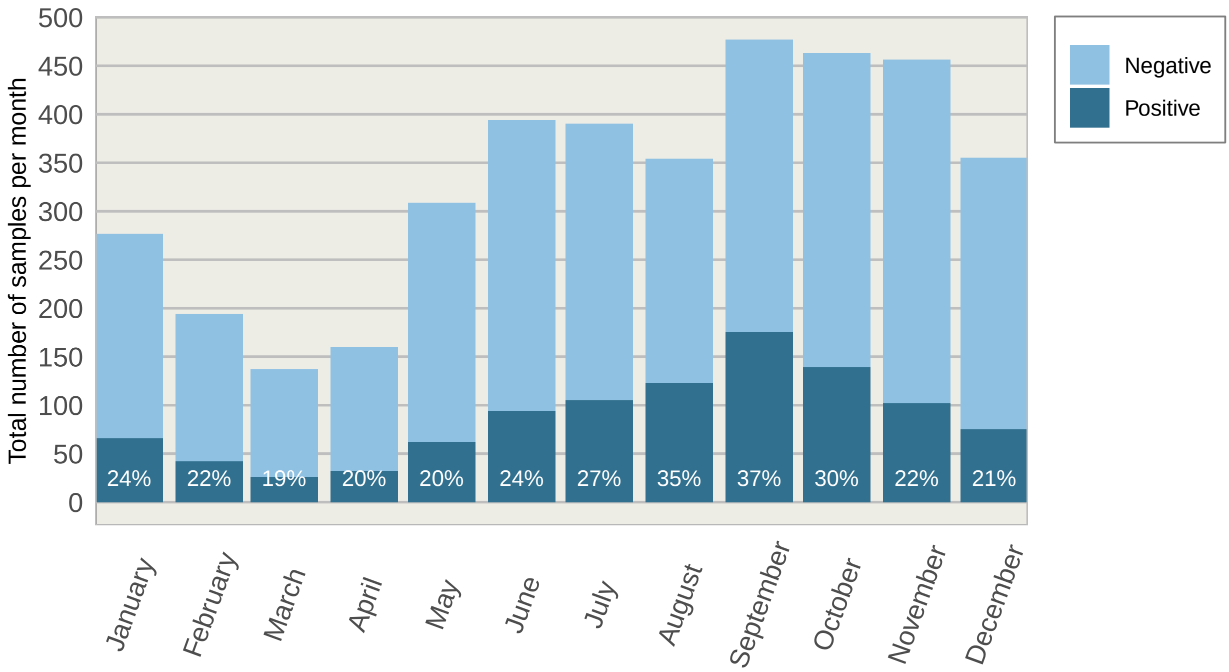

Figure 30: Stacked count of bovine faecal samples (all ages) tested per month for *Trichostrongylidae* during 2020. The percentage in each bar represents positive samples (n=3972).

August to September returned the most positive results to faecal sampling both as an absolute number and as a percentage of tests submitted, suggesting that the higher-than-normal submissions for nematode egg counts during these months may have been in response to an increased observation of clinical signs in these herds.

The *Trichostrongylidae* superfamily includes genera such as *Ostertagia*, *Cooperia*, *Teladorsagia*, *Trichostrongylus*, *Haemonchus* and *Nematodirus*. The most prevalent nematodes affecting cattle in Ireland are *Ostertagia ostertagi* and *Cooperia oncophora* (Murphy et al., 2006). These nematodes infect the abomasum and small intestine, respectively. This may result in diarrhoea, weight loss, and poor performance. *O. ostertagi* can cause two distinct syndromes in weanlings.

Control of disease due to nematodes mainly relied on anthelmintic prophylaxis, and in the past, several dosing programs and prolonged-action anthelmintics (such as delayed-release boluses) have been employed to prevent infection. However, the rising evidence of anthelmintic resistance development has led to a drive to develop grazing systems that minimise the risk of parasitic disease, along with strategic anthelmintic use when absolutely necessary. These seek to reduce the exposure of the more vulnerable, younger animals to heavy worm challenges and avoid building up anthelmintic resistant worm populations on pasture.

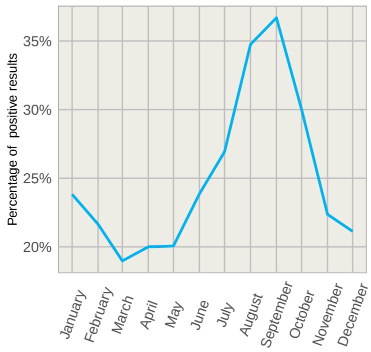

Figure 31: Percentage of positive bovine faecal samples for *Trichostrongylidae* eggs in 2020 (n=3972).

Table 20: Number of bovine faecal samples tested for *Nematodirus* eggs in 2020 and results by percentage (n= (n=3972).

Result	No. of samples	Percentage
Negative	3913	**98.5**
Low (50-200 epg)	34	**0.9**
Moderate (200-700 epg)	20	**0.5**
High (>700 epg)	5	**0.1**

Nematodirus spp.

Nematodirus battus is an important pathogen of sheep in Ireland, but although it has been reported to cause disease in cattle, it is not thought to play a significant role in Ireland (McMahon et al., 2017). The rate of detection of this nematode in samples from cattle in 2020 was very low, in keeping with previous years.

Coccidia spp

While over a dozen species of coccidia can replicate in the intestines of cattle, only three species *Eimeria bovis*, *Eimeria zuerni* and *Eimeria alabamensis* are considered to be pathogenic. *Eimeria spp.* have a life cycle that involves several stages of replication within the epithelial cells of the intestinal mucosa, leading to rupture of cells as the next stage is released into the intestinal lumen. The clinical signs of disease include diarrhoea, dysentery, and tenesmus, and can occur from the age of about three weeks. Clinical disease in older cattle due to coccidiosis is less common than in calves. Coccidial oocysts may be

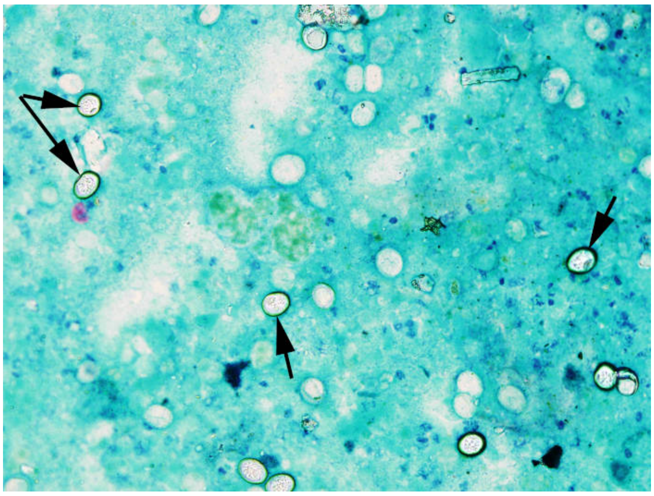

Figure 32: Photomicrograph highlighting coccidial oocysts (black arrows) in a slide of intestinal contents. Photo: Ian Hogan.

detected in faeces by means of the McMaster test or by the modified Ziehl-Neelsen staining method; results are semi-quantitative.

Table 21: Number of bovine faecal samples submitted in 2020 (all ages) for detection of coccidial oocysts and results by percentage, (n=4133).

Result	**No. of samples**	**Percentage**
Not Detected	3144	**76**
Light Infection	786	**19**
Moderate Infection	116	**3**
Heavy Infection	48	**1**
Severe Infection	39	**1**

The percentage of samples with moderate to severe levels of coccidial oocysts is relatively low. However, most of these samples are likely to be from clinical cases, where the production of oocyts may be low, especially in animals that have been affected for more than a few days. Sampling of animals less than two weeks of age will lead to false negatives as the pre-patent period for both *E. bovis* and *E. zeurnii* is 18 to 21 days and 15 to 17 days, respectively. Sampling of the most recently affected animals, or comrades which have not yet developed clinical disease, may be more effective at detecting the pathogens.

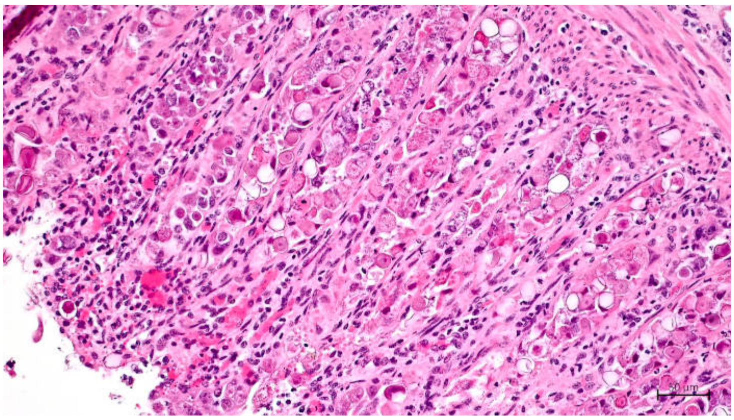

Figure 33: Photomicrograph of coccidial organisms widespread throughout the intestinal mucosa of a calf. Photo: Alan Johnson.

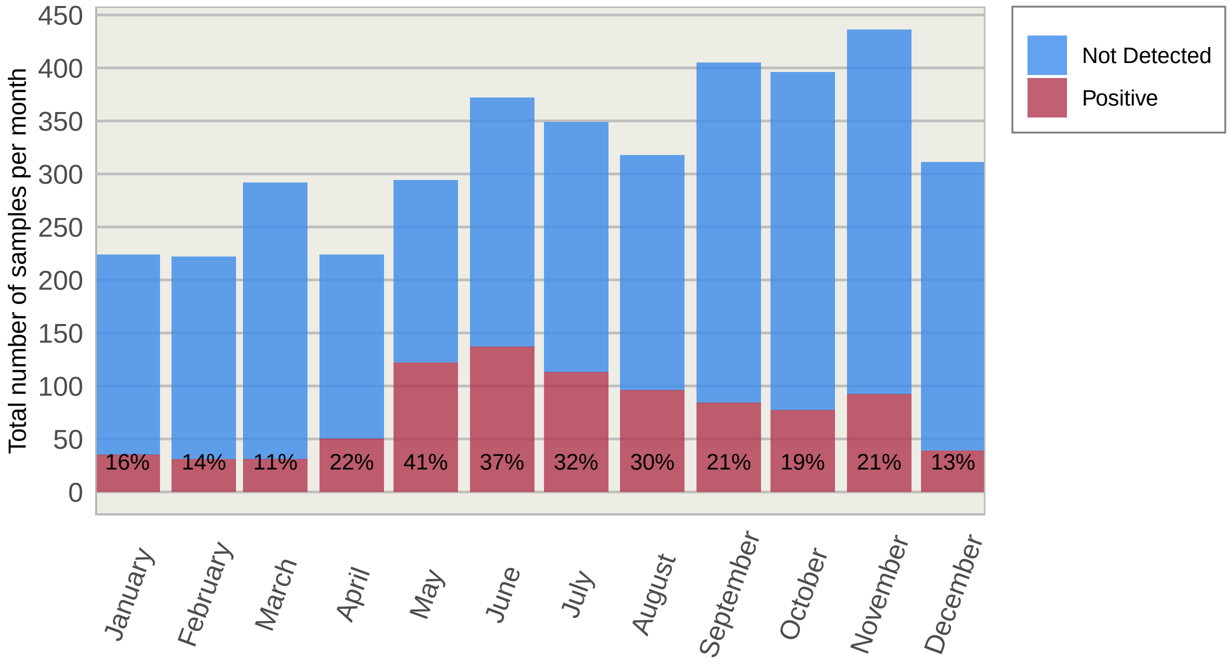

Figure 34: Stacked number of bovine faecal samples (all ages) tested for coccidial oocysts in 2020. The percentage in each bar represents the number of positives (n=4133).

The percentage of samples returning positive results for coccidial oocysts rises throughout the spring, reaching a peak in May before declining through the summer months. This reflects the infection pressure of increasing numbers of calves in spring-calving production systems, especially while the calves are housed.

Treatment of animals with anticoccidial remedies after the onset of clinical signs is usually unrewarding because diarrhoea develops at the end of the parasitic life cycle; however metaphylaxis with a coccidial treatment is warranted. Scouring calves should be isolated, given adequate rehydration and maintained on milk or milk replacer.

Coccidiostats are most effective when used prophylactically, which requires knowledge of the herd history of coccidiosis, or assessment of the risk factors to which animals in the vulnerable age groups are exposed to. Hygiene is vital in the control of this parasite in calves and necessitates dry bedding, elimination of water and faecal puddles in the calf shed, and avoidance of faecal contamination of feed and water troughs. The stocking rate should also be maintained at appropriate levels. Disinfectants should be used appropriately, and disinfectants effective against *Eimeria spp.* should be selected.

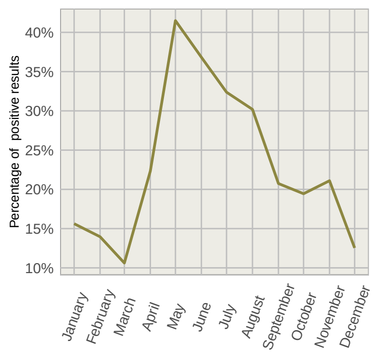

Figure 35: Percentage of bovine faecal samples testing positive for coccidial oocysts in 2020 (n=4133).

Rumen and Liver Fluke

Two species of trematodes are considered to be of significance in the cattle herd in Ireland, the liver fluke *Fasciola hepatica* and the rumen fluke *Calicophoron daubneyi*. Eggs from these trematodes are detected in faeces and intestinal contents by means of sedimentation tests. As infection with these parasites results in intermittent shedding of eggs, low numbers of eggs present in faeces do not always correspond with low numbers of fluke infecting the host. In recent years detection of liver fluke eggs in faecal samples has declined while detection of rumen fluke has remained steady. The two trematodes share a life cycle in Ireland with the same intermediate host, the mud snail *Galba truncatula*.

Result	No. of samples	Percentage
Liver fluke eggs not detected	3360	**99**
Positive liver fluke eggs	50	**1**

Table 22: Number of bovine faecal samples submitted in 2020 (all ages) for detection of liver fluke eggs and breakdown of positive and negative results (n=3410).

Liver Fluke

While liver fluke can cause acute infections in animals such as sheep, in cattle the chronic form of the disease is the more common. Juvenile liver fluke penetrate the intestinal wall and migrate through the liver to the bile ducts and on to the gall bladder. Depending on the nature of the challenge, infection can result in inappetance, weakness, pale mucous membranes, impaired productivity, weight loss and submandibular oedema (bottle jaw). In acute disease in sheep, sudden deaths may occur as a result of widespread liver damage and associated haemorrhage due to large numbers of migrating juvenile fluke.

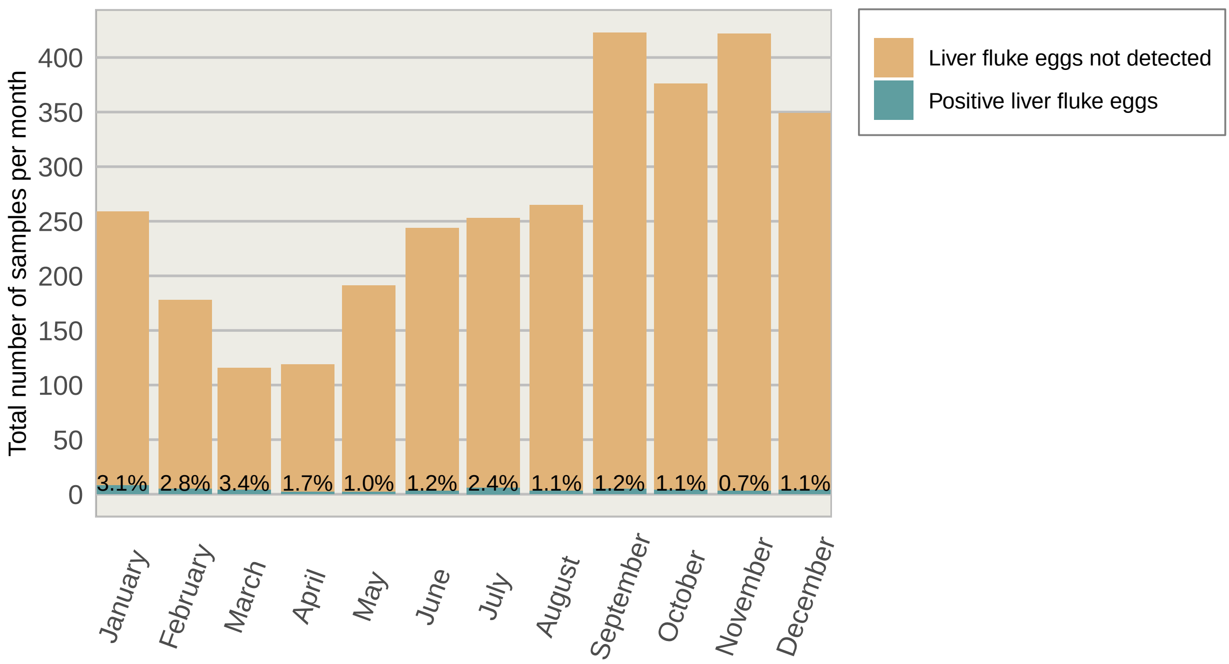

Figure 36: Stacked number of bovine faecal samples (all ages) tested for liver fluke in 2020. The percentage in each bar represents the number of positive samples per month (n=3410).

The proportion of faecal samples submitted for detection of liver fluke eggs returning a positive result has declined in recent years to just over 1 *per cent* of samples. In contrast, the detection of rumen fluke eggs in faecal samples has become commonplace. It has been hypothesised that competition for the common intermediate host has seen liver fluke numbers fall in the face of rumen fluke increase; it must be remembered; however that co-infection of the host by both species is possible (Naranjo-Lucena et al., 2018). Irish climate conditions and selective treatment for *F. hepatica* may favour *C. daubneyi* (O'Shaughnessy et al., 2018). In 2015, 4 *per cent* of samples submitted for examination contained liver fluke eggs, while in 2010 this figure was 18 *per cent*; the decline has been consistent over the years.

Paramphistomosis

Paramphistomes, or rumen fluke, infect cattle via ingestion and adhere to the duodenal wall, where considerable damage to the mucosa is caused, and this larval stage is considered significant pathogenically. Damage to the mucosa here, if large numbers are ingested, can result in severe diarrhoea and hypoproteinaemia, sometimes leading to recumbency and death (O'Shaughnessy et al., 2018, Toolan et al. (2015)).

As the flukes reach adulthood, they travel to the rumen and adhere to the mucosa there; this stage is considered to cause less mucosal damage and thus is not a significant cause of disease, although evidence of inflammatory changes in the rumen and reticular mucosa has been found.

Risk of infection of both trematodes varies with the effect of weather conditions upon the common host, *Galba truncatula*; DAFM issues a forecast on an annual basis that attempts to predict the likely danger of fluke infection based upon metrological data. The 2020 forecast may be found at gov.ie: Liver Fluke Forecast November 2020

Result	No. of samples	Percentage
Rumen fluke eggs not detected	2397	**70**
Positive rumen fluke eggs	1013	**30**

Table 23: Number of bovine faecal samples submitted in 2020 (all ages) for detection of rumen fluke eggs and breakdown of positive and negative results (n=3410).

Control of both flukes involves preventing access to the host, drainage of fields, and fencing off consistently wet areas, for example. A strategic dosing program can be implemented in herds with a known high liver fluke risk. The efficacy of the chosen flukicides on different stages of the fluke life cycle must be considered; if flukicides ineffective against immature fluke are selected, dosing may need to be delayed or repeated for full effectiveness. However, such a program must be designed to minimise the emergence of anthelmintic resistance in fluke populations, especially where fluke is likely to remain endemic; there is some evidence that resistance is emerging in some flukicides, such as triclabendazole. It must also be noted that regulatory changes mean some flukicides may not be used in dairy cattle.

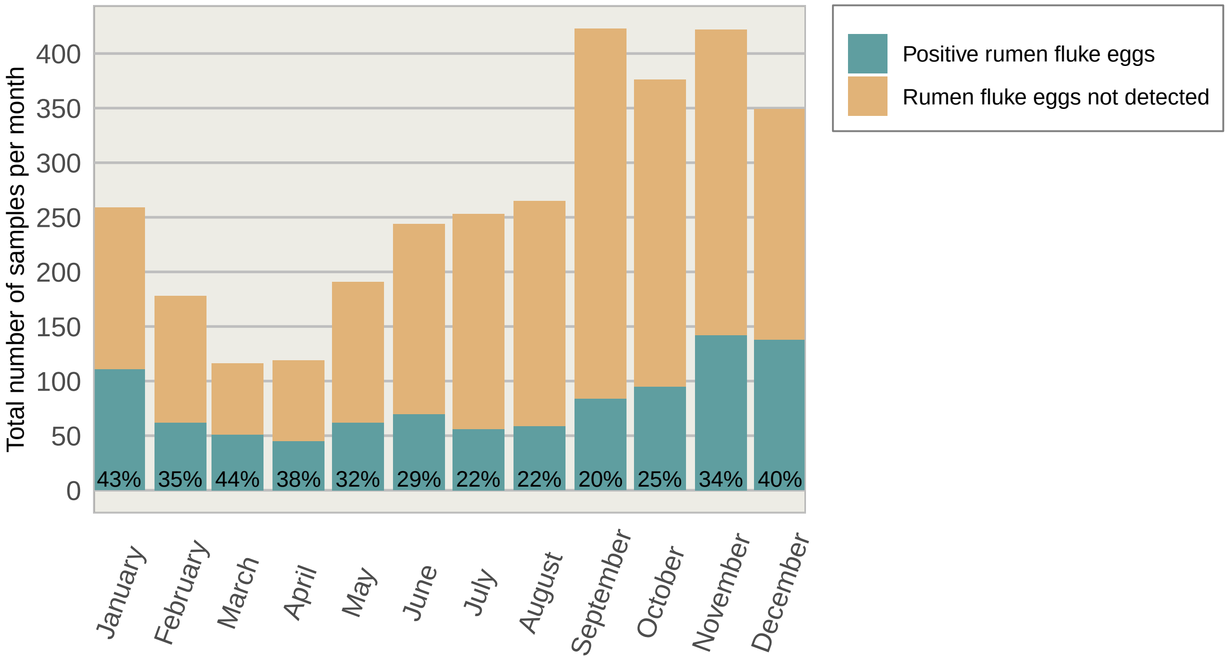

Figure 37: Stacked count of bovine faecal samples (all ages) tested for rumen fluke. The percentage in each bar represents positive samples (n=3410).

There is no licensed flukicide for use against paramphistomes in Ireland; however, oxyclozanide and closantel have been shown to have some efficacy in reducing faecal egg count (Arias et al., 2013), although it is possible only oral dosing is effective, and parenteral administration has not been shown to replicate these results (Malrait et al., 2015). Repeated dosing with oxyclozanide at a three-day interval has been suggested for severe acute rumen fluke infections.

Overview of Sheep Diseases

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In the Department of Agriculture, Food and Marine (DAFM) 2020 sheep census the population of sheep in the Republic of Ireland was just over 3.7 million with 35,186 flocks. This gives an average of 106 sheep per flock, but the flock size is skewed with many flocks below 100 and few above 300 (Gov.ie sheep goat census).

Lambs (under 12 months old)

Table 24: Conditions most frequently diagnosed on *post mortem* examinations of lambs in 2020 (n=527).

Disease	No. of Cases	Percentage
Systemic Infections	93	**17.6**
GIT Infections	89	**16.9**
Respiratory Infections	75	**14.2**
Clostridial disease	63	**11.9**
Other	32	**6.1**
Nutritional/metabolic conditions	30	**5.7**
Diagnosis not reached	29	**5.5**
CNS	27	**5.1**
GIT torsion/obstruction	16	**3.0**
Cardiac/circulatory conditions	12	**2.3**
Poisoning	11	**2.1**
Trauma	11	**2.1**
Liver disease	10	**1.9**
Navel Ill/Joint Ill	10	**1.9**
Urinary Tract conditions	10	**1.9**
Autolysis	9	**1.7**

Note:
The 'Other' grouping is a combination of multiple minor categories that have less than five cases.

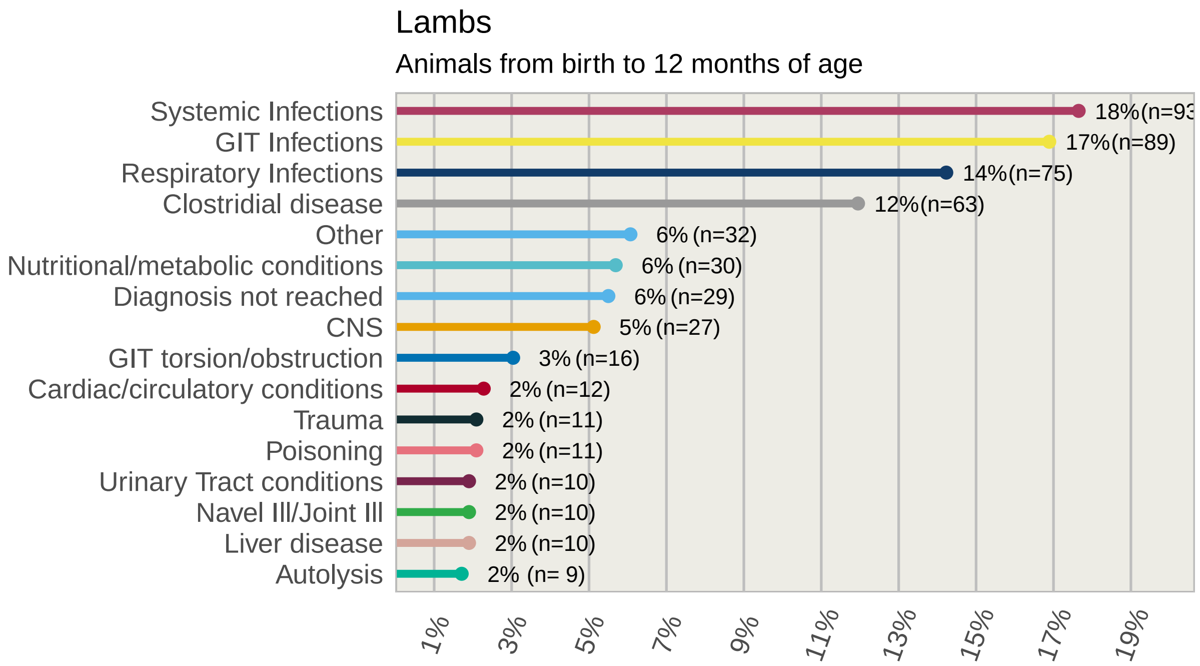

Figure 38: Conditions most frequently diagnosed on post mortem examinations of lambs in 2020 (n=527). Only categories with n greater than 8 are shown. Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

The health status of a flock has major implications for the welfare, productivity and profitability of sheep farming. The health status of the flock also affects the development of antimicrobial and anthelmintic resistance. Health issues which have a big effect on productivity of sheep farming include parasitism (internal and external), lameness, mastitis, teeth problems and the *iceberg diseases* (slow onset diseases which cause chronic wasting). Ovine pulmonary adenomatosis (OPA) (Figure: 39), Maedi Visna (MV), Caseous Lymphadenitis (CLA) and Johnes disease (JD) have been diagnosed in Ireland.

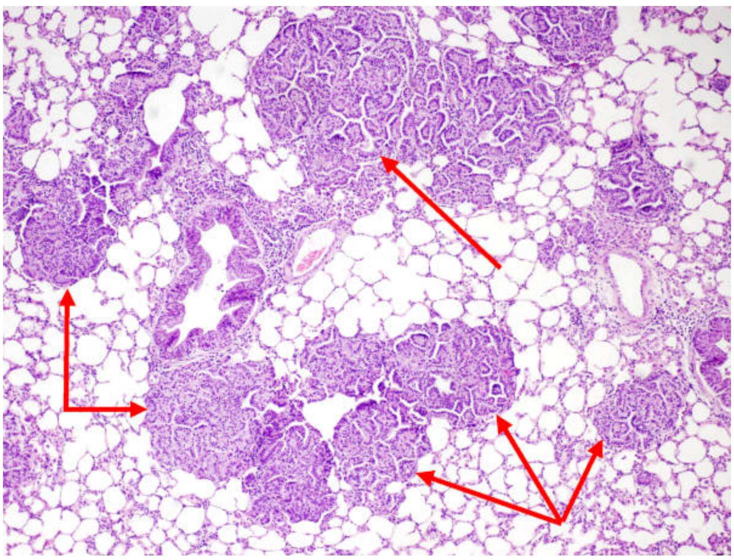

Figure 39: Section of sheep lung showing characteristic proliferative changes in epithelial type II cells along the alveolar walls consistent with Ovine Pulmonary Adenomatosis (Jaagsiekte). Photo: Cosme Sánchez-Miguel.

A mortality study of Irish flocks (n= 31) was carried out by DAFM laboratories in 2016 (Murray et al., 2019). The median overall submission rate of dead sheep of all ages from sentinel lowland flocks of 13.8 *per cent* is in line with other international studies.

Figure 40: Photograph of leaves and buds of Japanese pieris shrub. Photo: Alan Johnson.

In 2020 there were 240 cases of ovine abortion submitted for investigation. An abortion case is defined as a submission consisting of one or more ovine foetus(es) and/or foetal membranes on the same date.

Figure 41: Haemorrhages near the origen of the trigeminal nerve in the brainstem of a lamb with listerial encephalitis (*Listeria monocytogenes*). Photo: Cosme Sánchez-Miguel.

Tables 24 and 25 show the most frequent causes of sheep mortality for DAFM laboratories during 2020 on a disease category basis.

Copper poisoning (n=18) accounted for just over half of all poisoning cases. Plants such as yew tree and *Pieris spp.* (Figure 40) were next most common.

Adult Sheep (over 12 months old)

Mannheimia haemolytica (n=55) was the most frequently isolated pathogen in respiratory disease, however *Bibersteinia trehalosi* (n=40) was also isolated quite frequently. Sixteen cases of ovine pulmonary adenocarcinoma (*Jaagsiekte*), one of the *iceberg diseases* of sheep, were diagnosed. Seven cases of laryngeal chondritis were recorded.

Table 25: Conditions most frequently diagnosed on post mortem examinations of adult sheep (over one year of age) in 2020 (n=444). Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Disease	No. of Cases	Percentage
Respiratory Infections	72	**16.2**
Nutritional/metabolic conditions	45	**10.1**
Liver disease	44	**9.9**
Systemic Infections	43	**9.7**
CNS	31	**7.0**
GIT Infections	28	**6.3**
Other	25	**5.6**
Poisoning	24	**5.4**
Reproductive Tract Conditions	23	**5.2**
Cardiac/circulatory conditions	20	**4.5**
Autolysis	19	**4.3**
Diagnosis not reached	18	**4.0**
GIT torsion/obstruction	14	**3.1**
Peritonitis	9	**2.0**
Clostridial disease	8	**1.8**
Mastitis	7	**1.6**
Trauma	7	**1.6**
Urinary Tract conditions	7	**1.6**

Note:
The 'Other' grouping is a combination of multiple minor categories that have less than five cases.

The most important metabolic conditions diagnosed were twin lamb disease (N=17), hypocalcemia (milk fever) and hypomagnesaemia (grass tetany).

Enteric conditions (not including those caused by clostridial and parasitic organisms) most often encountered were ruminal acidosis (n=30) and mesenteric torsions/volvulus (n=19).

Listeriosis (Figure 41) accounted for approximately 60 *per cent* of CNS cases, with cerebrocortical necrosis (CCN) next most diagnosed.

Clostridial Diseases in Bovine and Ovine

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Clostridial disease remains an important cause of mortality in cattle and sheep submitted for *post mortem* examination to the Regional Veterinary Laboratories. Clostridial disease presents as acute disease or as sudden death, mortality approaches 100 *per cent* with most clostridial diseases.

It is important to submit carcases to your local Regional Veterinary Laboratory for *post mortem* if unexplained deaths occur on your farm.

The most commonly diagnosed clostridial diseases are Blackleg and Pulpy Kidney disease in cattle and sheep respectively. Since the risk factors for the different diseases vary, the diseases tend to occur all year round, albeit at varying levels. However, there are notable seasonal effects in the occurrence of the individual diseases. Blackleg is a good example. Occurrence of blackleg tends to peak in late summer and autumn. This is borne out by the RVL data which have been plotted below.

Figure 42: Fibrin clot in the pericardial sac of sheep with Pulpy Kidney Disease. Photo: Regional Veterinary Laboratories.

Pulpy kidney disease is diagnosed most frequently in April, this may reflect a waning maternal antibody protection and inadequate antibody production in lambs possibly due to delayed vaccination.

The consistently high diagnosis of clostridial disease in the Regional Veterinary Laboratories is despite the availability of vaccines

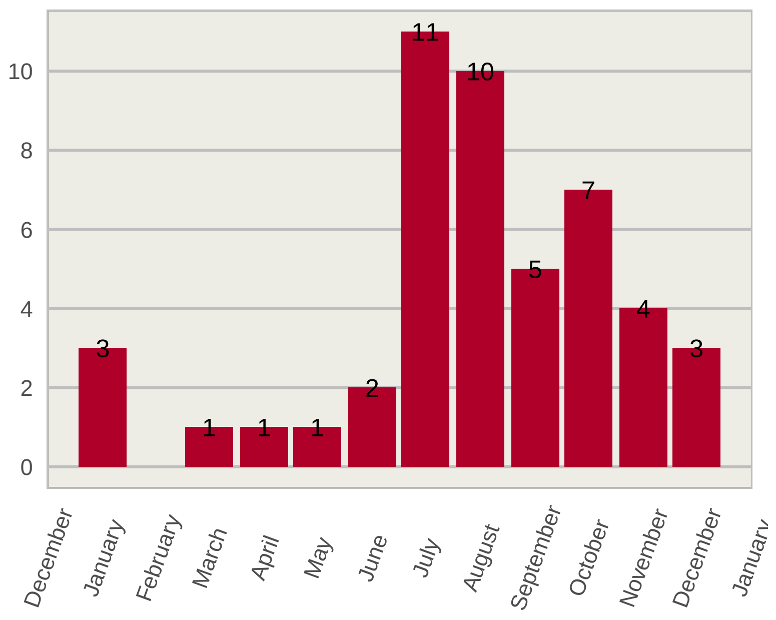

Figure 43: Occurrence of blackleg diagnoses in RVLs in 2020, by calendar month (n=48).

for most clostridial diseases. Multivalent clostridial vaccines (vaccines which cover the animal against a range of clostridial diseases) are available for both cattle and sheep. Although vaccination failure in individual animals is reported, these vaccines are very effective at herd or flock level when stored and used properly. Details of a vaccination programme should be discussed with the veterinary practitioner who cares for the herd or flock.

Table 26: Clostridial disease diagnosed in bovine carcasses in 2020 (n=64).

Disease	No. of Cases	Percentage
Blackleg	48	**75.0**
Black Disease	5	**7.8**
Enterotoxaemia	5	**7.8**
Malignant Oedema	3	**4.7**
Botulism	2	**3.1**
Pulpy Kidney Disease	1	**1.6**

Key Features of Major Ruminant Clostridial Diseases

Blackleg is associated with the detection of *Clostridium chauvoei*. The pathogenesis of this disease requires the pre-existence of the bacterium in tissue and circumstances such as trauma to establish anaerobic conditions to allow proliferation of the bacteria and production of toxins which cause local severe necrotizing myositis and a systemic toxaemia. Cases encountered in the *post mortem* room frequently have a typical rancid butter odour and can affect muscles of the limbs, but also tongue and heart muscle.

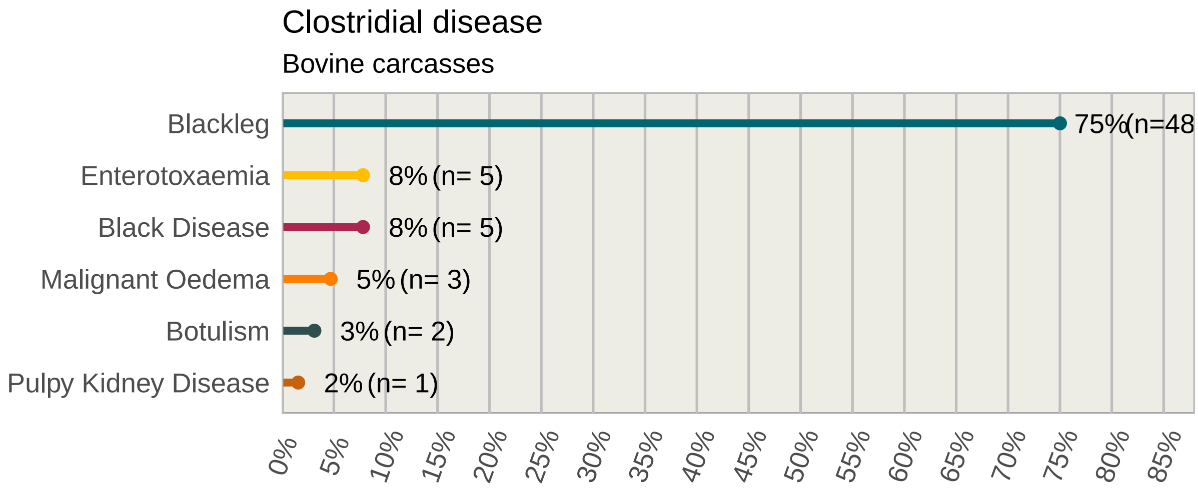

Figure 44: Clostridial disease diagnosed in bovine carcasses in 2020 (n=64) as a percentage of the total number of clostrial diseases.

A clostridial disease similar to Blackleg is Malignant oedema, this can be caused by a number of *Clostridial spp.* including *Cl. Septicum*, *chauvoei*, *sordellii* and *novyi*. The epidemiology and pathogenesis of this disease differs from blackleg, the bacteria is introduced through a wound and causes focally extensive skin gangrene and oedema of the sub-cutaneous and intra-muscular connective tissue, there is less involvement of underlying muscle.

Figure 45: Necrotising myositis: Blackleg. Clostridium chauvoei detected by Flourescent antobody technique. Photo: Regional Veterinary Laboratories.

Table 27: Clostridial disease diagnosed in ovine carcasses in 2020 (n=71).

Disease	No. of Cases	Percentage
Pulpy Kidney Disease	45	**63.4**
Clostridial Enterotoxaemia	25	**35.2**
Black Disease	1	**1.4**

Botulism: *Clostridium botulinum* toxin typically results in affected animals lying in sternal recumbency with the head on the ground or turned into the flank, similar to a cow suffering from *post parturient* hypocalcaemia/milk fever. However a range of clinical signs can be detected in an affected group and likely reflects the levels of toxin ingested, these can include restlessness, incoordination and knuckling. The association of this disease with the spreading of poultry litter has resulted in *Codes of Practice* being established for the disposal of such material. The laboratory service has been involved in the investigation of a number of cases where a direct link with poultry litter was not established. Carrion and forage associated botulism could not be ruled out in these cases.

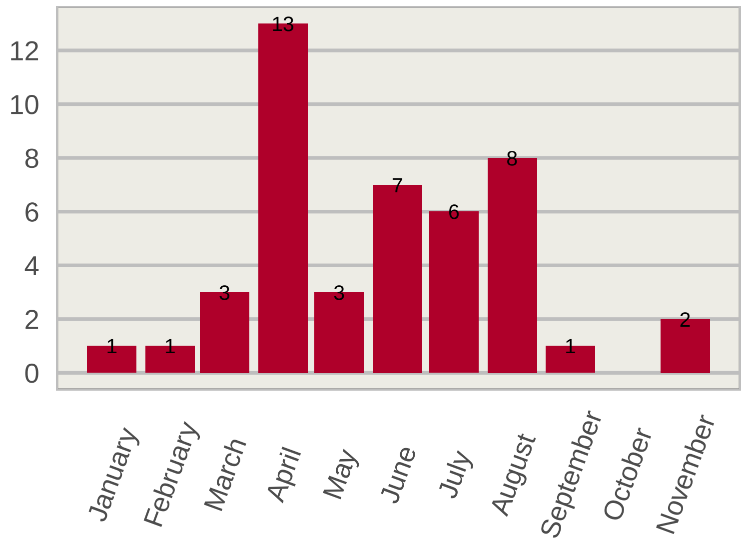

Figure 46: Occurrence of diagnosis of pulpy kidney disease in RVLs in 2020, by calendar month (n=45).

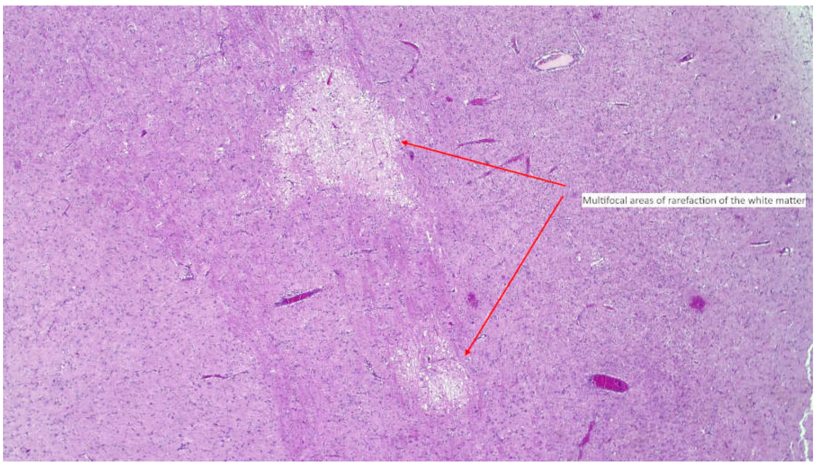

Figure 47: Multifocal symmetrical areas of rarefaction in the brain of a sheep: Focal Symmetrical Encephalomalacia. Photo: Regional Veterinary Laboratories

Pulpy kidney disease is caused by Epsilon toxin. *Clostridium perfringens* Type D produce epsilon toxin which causes vascular endothelial damage which results in the typical lesions of focal symmetrical encephalomalacia (FSE) in the brain [2] and the lesions of pulpy kidney. This disease has also been described in calves. In the PM room, the detection of fibrin clots in the fluid of the pericardial sac is a strong indicator of epsilon toxin involvement.

[2] This lesion is a consequence of epsilon toxin produced by Clostridium perfringens Type D.

Pulpy kidney disease and the other diseases caused by *Clostridium*

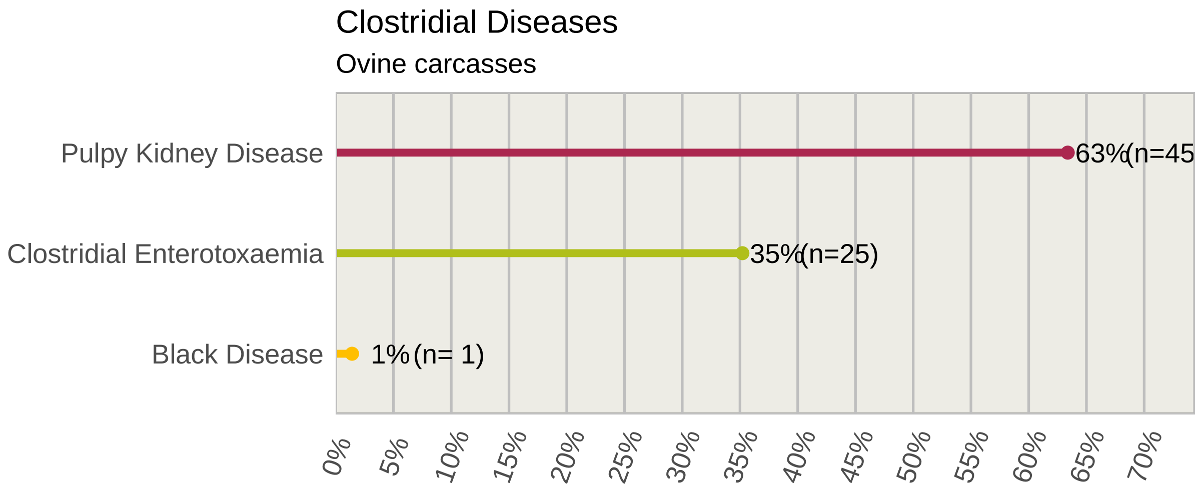

Figure 48: Clostridial disease diagnosed in ovine carcasses in 2020 (n=71) as a percentage of the total number of clostrial diseases.

perfringens are enterotoxaemias. *Clostridium perfringens* is a normal inhabitant of the intestine of most animal species including humans, but when the intestinal environment is altered by sudden changes in diet or other factors, *C. perfringens* proliferates in large numbers and produces several potent toxins that are absorbed into the general circulation or act locally with usually devastating effects on the host.

In sheep, *C. perfringens* type A (CPA) produces a rare form of acute enterotoxemia in lambs, also known as *yellow lamb disease* characterised clinically by depression, anemia, icterus and hemoglobinuria. The detection of CPA , caused by *Alpha toxin* and the exclusion of other causes of haemoglobinuria will aid diagnosis of this disease. The differential diagnoses for intravascular hemolysis in sheep in Ireland include toxic conditions (copper toxicosis, plant toxicosis such as that caused by onion [*Allicum cepa*] and *Brassica spp*), infectious conditions (leptospirosis) bacillary hemoglobinuria [*Clostridium haemolyticum* hepatitis]. Yellow lamb disease typically affects suckling lambs.

It is recommended to commence the vaccination programme well in advance of the anticipated risk period.

In cattle *Clostridium Perfringins* Type A has been associated with **haemorrhagic enteritis** indistinguishable from that caused by Types B and C. It has been proposed as a cause of **jejunal haemorrhage syndrome** in adult cows. This disease entity is sporadically diagnosed in the veterinary laboratory service, no definitive conclusions on its aetiology can be made. It has also been cited as a causative agent of acute abomasal deaths in calves (Van Kruiningen et al., 2009, ; Songer and Miskimins, 2005)

Figure 49: A necrotizing haemorrhagic focally extensive lesions in the liver caused by Clostridium novyi: Black's Disease. Photo: Regional Veterinary Laboratories

The occurrence of this disease is highest in the Northwest of the country, this is likely due to its association with liver fluke disease.

Blacks Disease is a less frequently diagnosed cause of acute or sudden death in cattle and sheep. *Clostridium novyi* proliferates in anaerobic conditions typically associated with liver tissue damage due to Fasciola hepatica migration. Multifocal areas of hepatic necrosis are observed during *post mortem*. The pathogenesis of bacillary haemoglobinuria are similar but in addition to multifocal hepatic necrosis and vascular damage the organism also produces a haemolytic toxin which causes haemoglobinuria. *Clostridium haemolyticum* should be included in the list of differential for haemoglobinuria which also includes Babesiosis, periparturient hypophosphataemia, copper poisoning in sheep and brassica poisoning amongst others.

Braxy caused by *Clostridium septicum* is typically seen in animals submitted after grazing frozen/snow covered pasture amd causes necrosis, ulceration, congestion and emphysema of the abomasal wall. **Abomasitis** caused by *Cl. Sordelli* has a similar *post mortem* presentation. Histopathology will reveal a severe necrotizing abomasitis with intra-lesional bacilli.

It is essential that gross signs and histopathology concur with the isolation/FAT detection of the bacteria as *Cl. Sordellii* and *septicum* are normal inhabitants of the gut.

Ovine Abortion

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Veterinarians describing abortion usually mean the spontaneous death and expulsion of the developing embryo or foetus from the uterus. Spontaneous abortion can occur in sheep when there are genetic anomalies in the developing lambs. These probably make up a significant portion of the cases seen in the RVLs, but they are difficult to diagnose.

The main focus of laboratory investigations when presented with aborted lambs is to determine if any of the infectious agents known to cause abortion in sheep are present and to discover any new agents that might be involved.

The laboratories rely on gross and histopathological examination of submitted material to check for the presence of lesions. In addition, a wide range of biological and molecular tests are used to identify infectious agents.

The RVLs examined 391 aborted lambs in 2020 (Table 31). In this number were carcasses from each trimester, some of which were mummified or macerated.

As in previous years the most prevalent causes of death were attributed to *Toxoplasma gondii* and *Chlamydophila abortus*. These agents were detected in about two fifths of submissions. *Chlamydophila abortus* and *Toxoplasma gondii* are both zoonotic pathogens which can pose a risk to the unborn child. Pregnant women should avoid all contact with sheep, especially at lambing time.

It should be noted that more than one agent may be involved in any particular flock. When submitting material to an RVL for investigation it is recommended that the placenta be included if possible.

Practical tips for when abortions are occurring include:

- Isolating aborting ewes from the rest of the flock until lambing is complete.
- Removing bedding for destruction and disinfecting lambing pens between ewes.
- Only fostering male lambs onto aborted ewes.

Toxoplasma gondii

Of the 211 ovine foetuses tested for *Toxoplasma gondii* (Figure 50) using a PCR test, 30 (14.2 *per cent*) were positive (Table 28). When combined with foetal serology (Agglutination Test) (n=280) the positive rate rose to 20.4 *per cent* (Table 29 and Figure 51). A sample was deemed positive when either one or both tests were positive. Serology titres of 1/30 and over were classified as positive. Inconclusive results were categorised as negative.

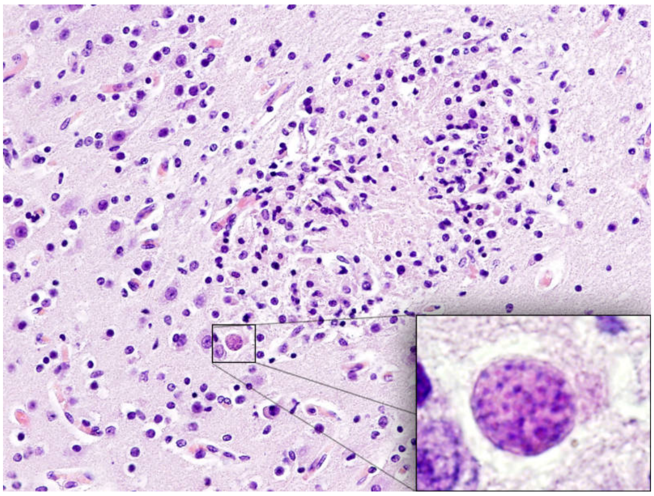

Figure 50: *Toxoplama gondii* taquizoito in the margin of a characteristic focus of necrosis surrounded by a rim of gliosis in the cerebrum of a lamb with toxoplasmosis. Photo: Cosme Sánchez-Miguel.

Table 28: Ovine foetuses examined by Toxoplasma PCR in 2020, (n=211).

PCR Result	No of Cases	Percentage
No Pathogen detected	173	82.0
Positive	30	14.2
Inconclusive	8	3.8

Table 29: Toxoplasma PCR and Toxoplasma serology (Agglutination Test) test results in 2020 (n=280).

Result	No of Cases	Percentage
Negative	223	80
Positive	57	20

Note:
A sample was deemed positive when either a single or both tests were positive.
Inconclusive results were categorised as Negative.

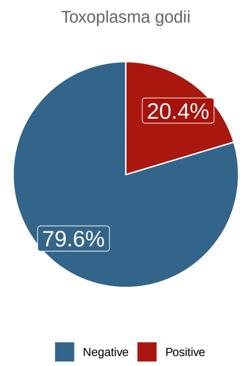

Figure 51: Toxoplasma PCR and Toxoplasma serology (Agglutination Test).

Chlamydophila abortus

Chlamydophila abortus infection causing Enzootic Abortion of Ewes (EAE) is spread between sheep at lambing time – uninfected female sheep can acquire infection from the foetal membranes and bedding contaminated by fluids from aborted ewes. The infection then becomes inactive, reactivating during the middle of the next pregnancy. This allows EAE to persist in flocks from year to year.

Of the 211 ovine foetuses tested for Chlamydophila abortus using a PCR test, 37 (17.5 *per cent*) were positive (Table 30 and Figure 52) and 6 (2.8 *per cent*) were inconclusive.

The zoonotic potential of infections causes of abortion should be communicated to flock owners and other persons working with sheep. In particular, pregnant women should avoid contact with sheep, particularly around lambing time. *Toxoplasma gondii* or *Chlamydia abortus* infections in pregnant women can have severe consequences for the health of the pregnant woman and her foetus.

Other Organisms

In addition to testing for *Toxoplasma gondii* and *Chlamydophila abortus*, culture is routinely carried out on RVL ovine foetal submissions, typically on stomach contents, and placenta if supplied. In the majority of cases in 2020 this resulted in no significant growth (58.8 *per cent*, Figure 31).

Table 30: Percentage of *Chlamydophila abortus* PCR results in ovine foetuses in 2020 (n=211).

PCR Result	No of Cases	Percentage
No Pathogen detected	168	**79.6**
Positive	37	**17.5**
Inconclusive	6	**2.8**

From the 391 ovine foetuses cultured, E. coli (22.8 *per cent*) was the most common isolate. While *E. coli* can cause abortion in sheep it can be difficult to determine in the individual case whether it is the abortefacient or just a contaminant. Pathogens associated with poor quality feed, and causes of sporadic abortion, such as *Listeria spp.* (4.1 per cent), *Bacillus spp.* (1.0 *per cent*) and *Aspergillus spp.* (0.8 *per cent*) were isolated occasionally. Salmonella Dublin (1.0 *per cent*) and *Campylobacter fetus* (0.3 *per cent*) were also identified rarely.

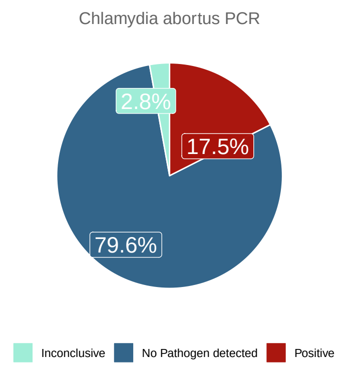

Figure 52: *Chlamydophila abortus* PCR results.

Organism	No of Isolates	Percentage
No Significant Growth	230	**58.8**
Coliforms	89	**22.8**
Listeria moncytogenes	12	**3.1**
Streptococcus spp	9	**2.3**
Trueperella pyogenes	6	**1.5**
Bacillus licheniformis	4	**1.0**
Listeria spp	4	**1.0**
Salmonella dublin	4	**1.0**
Aspergillus spp	3	**0.8**
Staph. spp	2	**0.5**
Campylobacter spp	1	**0.3**
Enterococcus spp	1	**0.3**
Mannheimia haemolytica	1	**0.3**
Pseudomonas spp	1	**0.3**
Yersinia pseudotuberculosis	1	**0.3**

Table 31: Combined frequency of detection of selected secondary abortion agents on routine foetal culture of ovine foetuses (n=391).

Prevention measures of abortion:

- Vaccination for the common causes of infectious abortion.
- Boundary biosecurity.
- Food biosecurity.
- Careful sourcing of replacement breeding stock.

Ovine Parasites

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Backweston Campus, Co. Kildare, Ireland

Trichostrongyles

The number of faecal samples that were categorised as either medium or high burden (≥ 500 *eggs per gram* of faeces) was 30 *per cent* which was similar to last year's figure of 28 *per cent*. Those in the high burden category for this year (16 *per cent*) are also similar to last year's value (17 *per cent*). Although it is beyond the scope of this report to fully interrogate these figures, it may simply reflect a selection bias.

Result	No. of samples	Percentage
Negative	563	37
Low (100-250 epg)	300	20
Medium (250-750 epg)	295	19
High (>750 epg)	361	24

Table 32: Number of ovine faecal samples tested for Trichostrongylidae eggs in 2020 and results by percentage (n=1519). The ranges assume the absence of *H. contortus* in the faecal sample.

However, given the current concerns over the threat of anthelmintic resistance in Irish sheep flocks, it is important that producers regularly faecal sample those at-risk categories over the course of the grazing season so that anthelmintic treatments can be used in a more targeted and sustainable fashion. Furthermore it is advised that faecal egg count reduction tests are conducted on farms so that the level of effectiveness of particular classes of anthelmintics can be readily determined.

Coccidiosis

Although a large majority of this year's samples (87 *per cent*) either did not have coccidial oocysts (Figure 55) detected in them or had

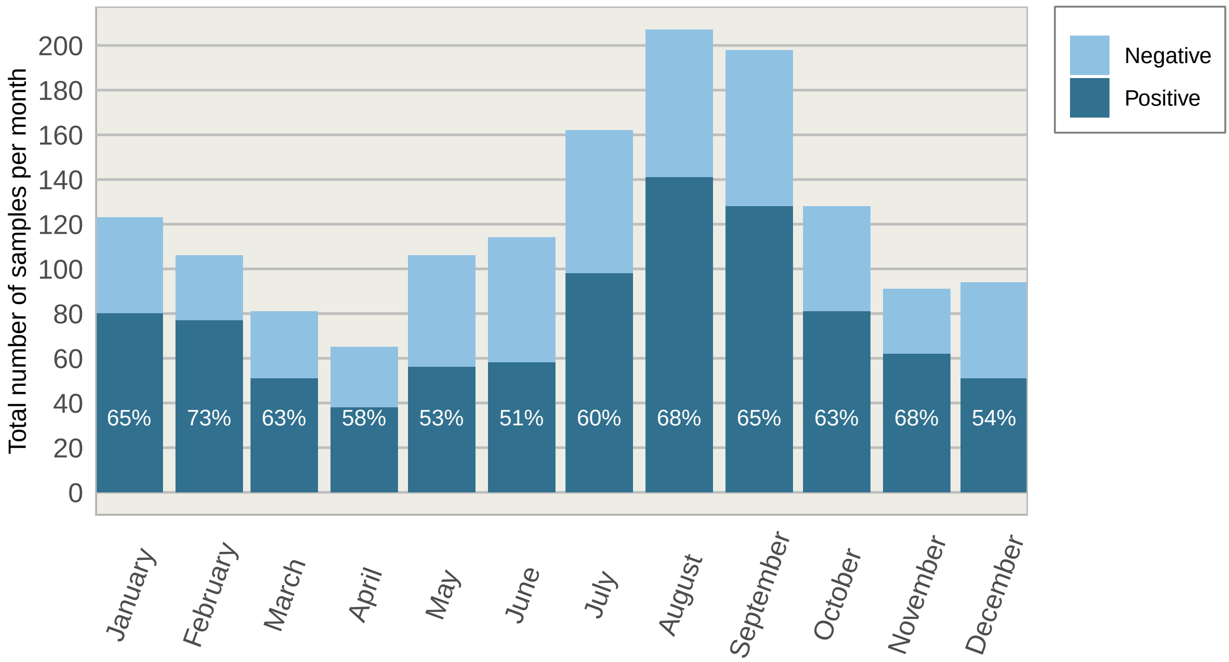

Figure 53: Stacked count of ovine faecal samples (all ages) tested per month for *Trichostrongylidae* during 2020. The percentage in each bar represents positive samples (n=1519).

very low counts, these results must be carefully interpreted. As peak oocyst shedding in faeces is not always coincident with clinical signs of disease, it is advised to sample a number of lambs in a group, both affected and unaffected, before any conclusion can be drawn on whether the observed clinical signs are due to coccidiosis.

Table 33: Number of ovine faecal samples submitted in 2020 (all ages) for detection of coccidial oocysts and results by percentage, (n=1490).

Result	No. of samples	Percentage
Not Detected	887	60
Light Infection	402	27
Moderate Infection	109	7
Heavy Infection	64	4
Severe Infection	28	2

With regards the small number of moderate to severe infections, these results must similarly be viewed with caution as some species of coccidia are far more pathogenic than others and the presence of their oocysts in faecal samples may be far more noteworthy. However, the speciation of coccidian, which is achieved by initially allowing oocysts to sporulate in the laboratory before their subsequent identification is not a service routinely offered by laboratories considering the huge time resources required.

With regard to control of disease in outdoor environments, rotation of pasture and frequent movement of feeding troughs or creep feeders to drier areas will help prevent coccidiosis in young lambs as localised poaching creates moist conditions suitable for the spread of coccidia. In indoor environments, hygiene and dryness are prerequi-

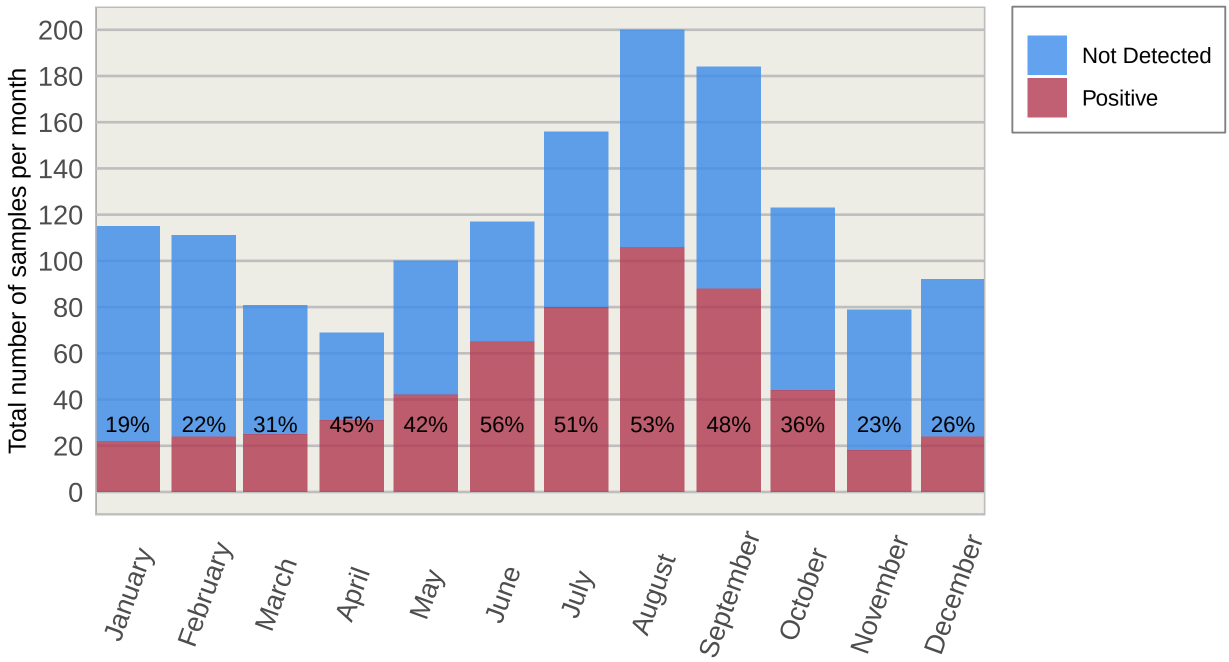

Figure 54: Stacked number of ovine faecal samples (all ages) tested for coccidial oocysts in 2020. The percentage in each bar represents the number of positives (n=1490).

sites and deep straw bedding, in addition to raising feed and water troughs will help control the disease.

Nematodirus

Nematodirus eggs were not detected in 89 *per cent* of samples tested. However, it still does not preclude this roundworm from being responsible for disease in certain cases, as much of the pathology associated with this roundworm occurs in the prepatent phase (i.e. before egg shedding commences). In addition, the female worm is a poor egg producer and faecal egg count values may not be of the magnitude that occurs with other roundworm infections. With this in mind, faecal egg counts alone do not provide a reliable basis for deciding on when to treat lambs. Other factors need to be considered such as lamb age (typically 6 — 12 weeks of age) and the time of year that clinical signs are observed (i.e. April, May and June).

Table 34: Number of ovine faecal samples tested for *Nematodirus* eggs in 2020 and results by percentage (n= (n=1518).

Result	No. of samples	Percentage
Negative	1352	89
Low (50-150 epg)	76	5
Moderate (>150-300 epg)	45	3
High (>300 epg)	45	3

Each year the Department of Agriculture, Food and the Marine produces a forecast on when peak larval hatch is expected to occur. This allows producers to instigate a programme to prevent clini-

Figure 55: Faecal sample with *Nematodirus* eggs (N) among a couple of strongyle eggs (S) and coccidial oocysts (O). Phto: James O'Shaughnessy

cal disease from occurring. It is also important to bear in mind that *Nematodirus* can be wrongly assumed to be the cause of severe diarrhoea in lambs when in fact the cause is a coccidial infection. In other cases, nematodirosis and coccidiosis can occur together, giving rise to severe disease.

Liver fluke and rumen fluke

The number of samples positive for liver fluke (8 *per cent*) is the same as last year. However, given that liver fluke infection in sheep can be an acute, subacute or a chronic condition, infection can result in significant pathology in the prepatent phase, and even death in cases of acute fluke.

Table 35: Number of bovine faecal samples submitted in 2020 (all ages) for detection of liver fluke eggs and breakdown of positive and negative results (n=1271).

Result	No. of samples	Percentage
Liver fluke eggs not detected	1166	92
Positive liver fluke eggs	105	8

With regard to the detection of liver fluke eggs in faecal samples, it should be noted that eggs are not consistently shed in faeces and numbers are often quite low. Therefore, where disease due to liver fluke is suspected in a flock, it is advised to always sample more than one animal in order to determine whether liver fluke infection is present or not.

The number of samples tested that had rumen fluke eggs present (22 *per cent*) is similar to last year's figure of 20 *per cent*. Although the detection of rumen fluke eggs in faecal samples has increased in the last 10 to 12 years, and continues to be more commonly detected in faecal samples in comparison to liver fluke, clinical disease is still an extremely rare occurrence.

Nonetheless, when disease does occur it is characterised by clinical signs such as severe diarrhoea and sudden weight loss (or death

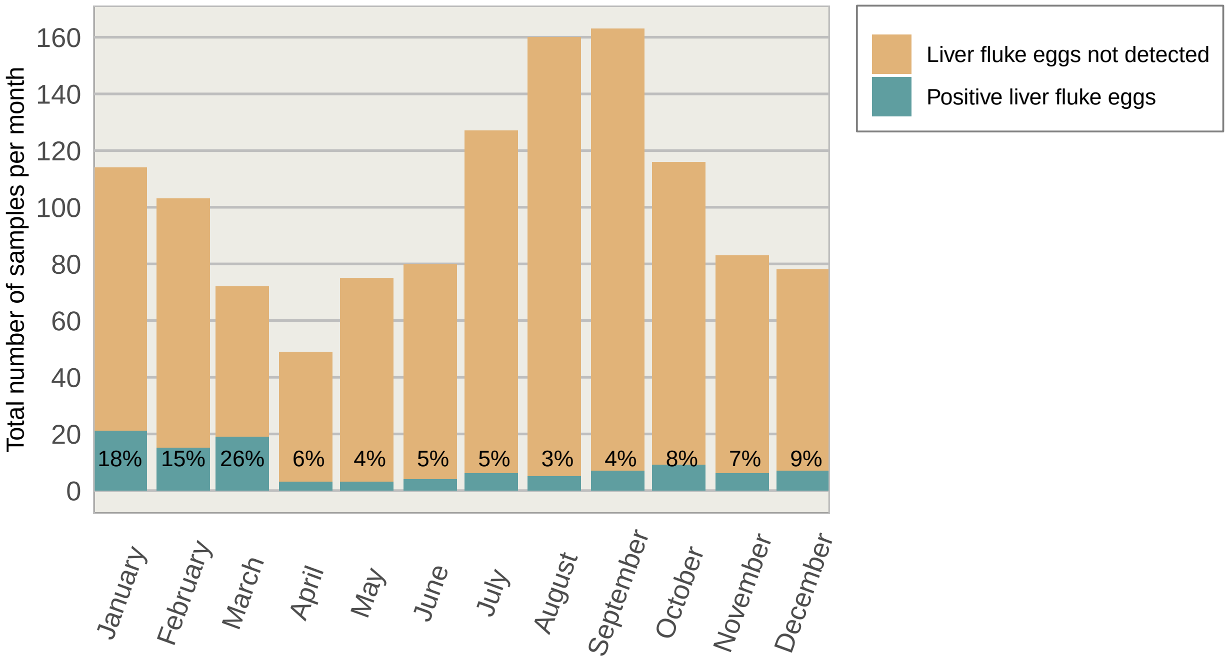

Figure 56: Stacked number of bovine faecal samples (all ages) tested for liver fluke in 2020. The percentage in each bar represents the number of positive samples per month (n=1271).

in some cases). This is a result of the pathology caused by the juvenile stages which attach themselves to the intestinal mucosa by their blind-ended posterior-placed suckers (known as the acetabulum) and draw plugs of mucosa into these suckers leading to haemorrhage and enteritis.

Table 36: Number of ovine faecal samples submitted in 2020 (all ages) for detection of rumen fluke eggs and breakdown of positive and negative results (n=1271).

Result	No. of samples	Percentage
Rumen fluke eggs not detected	988	78
Positive rumen fluke eggs	283	22

With regard to the significance of detecting liver and rumen fluke eggs in faecal samples, the detection of liver fluke eggs is always a significant finding and treatment is always warranted in this case. As adult rumen fluke are not associated with clinical disease, the detection of rumen fluke eggs in the faeces of animals that appear healthy does not indicate that treatment for rumen fluke is necessary. On rare occasions, acute rumen fluke disease may occur. This is due to the presence of large numbers of juvenile rumen fluke in the small intestine. If only juvenile stages are present in the animal at that time, no eggs will be detected in submitted faecal samples. If juvenile rumen fluke infection is suspected, it is important to state on laboratory submission forms that faecal samples are to be tested for the presence of juvenile rumen fluke as well as for routine egg analysis.

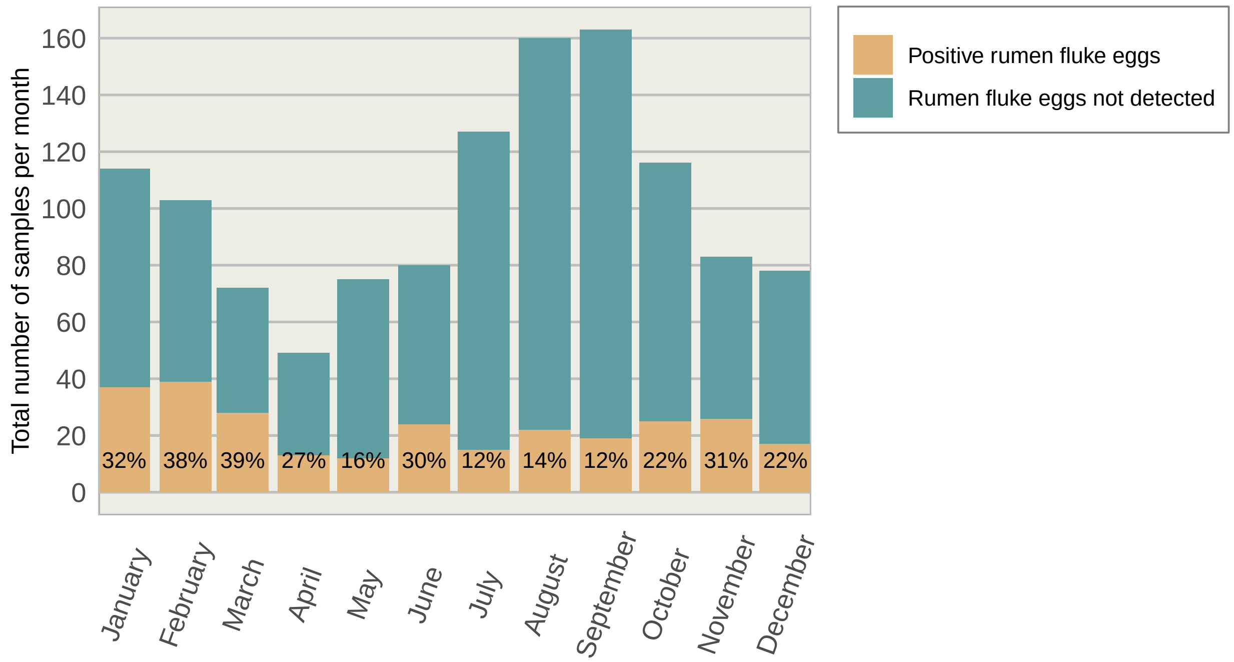

Figure 57: Stacked count of ovine faecal samples (all ages) tested for rumen fluke. The percentage in each bar represents positive samples (n=1271).

Diseases of Pigs

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In 2020, DAFM laboratories carried out necropsy examinations on 267 pig carcases, 3966 non-carcase diagnostic samples were submitted from pigs for a range of diagnostic tests. These figures compare similarly to 2019 submission rates, despite the difficulties imposed by the Covid-19 lockdown, such as pig carcase collection service having to be suspended.

Similar to previous years, pigs submitted for necropsy examination were predominantly from piglet (160) and weaner (104) stages of growth and almost exclusively from intensive, large scale pig farming units.

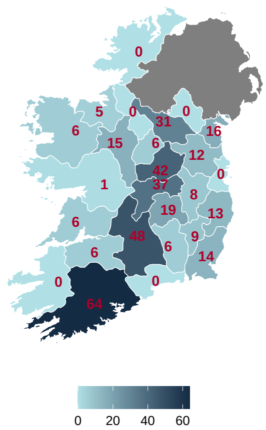

Figure 58: Number of carcasses per county submitted to the RVLs for *post mortem* examination during 2020.

Post mortem Diagnoses.

The most frequent diagnoses in pig necropsy submissions during 2020 are detailed below. This dataset reflects diagnoses reached in pigs submitted to DAFM laboratories, rather than incidence of disease in the pig population generally, as many factors will influence the decision to submit an animal for necropsy.

Similar to previous years, enteritis and pneumonia/pleuropneumonia remained the most commonly diagnosed diseases in pig carcases submitted for examination. This is consistent with pig production diseases prevalence worldwide, with both enteritis and pneumonia representing the most common disease categories impacting large scale pig production. It is also noteworthy that both of these disease categories often result in antibiotic interventions on farms when they occur.

Table 37: Conditions most frequently diagnosed on *post mortem* examinations of pig carcasses in 2020 (n=267).

Category	No. of Cases	Percentage
Other	56	**21.0**
Enteritis	49	**18.4**
Pneumonia	47	**17.6**
Arthritis	27	**10.1**
Meningitis	25	**9.4**
Diagnosis not reached	17	**6.4**
Trauma	16	**6.0**
Bacteraemia/septicaemia/toxaemia	10	**3.8**
Perinatal Mortality	8	**3.0**
Polyserositis	6	**2.2**
Rhinitis	6	**2.2**

Note:
The 'Other' grouping is a combination of
multiple minor categories that have less than five cases.

Enteritis

Enteritis accounted for the most common disease category diagnosed in pig carcases submitted to DAFM labs in 2020, representing 18.4 *per cent* of cases diagnosed. Most were from neonatal enteritis investigations. DAFM Labs operates a proactive porcine neonatal enteritis investigation service [3] for pig farms and veterinarians on account of the significant morbidity and economic loss along with increased use of antibiotics, cases of neonatal enteritis in pigs can cause in affected herds. Multiple agents can cause neonatal diarrhea in pigs and often more than one agent can be involved in an outbreak on a farm. The most commonly identified infectious agents in cases examined by DAFM Labs were *E. coli*, *Rotavirus*, *Clostridium difficile*, *Salmonella spp.* and enteroadherent bacteria.

[3] DAFM laboratories provide a comprehensive porcine neonatal workup on fresh submissions. Similar to other species, neonatal enteritis in pigs can be caused by multiple agents and often co-infection is observed in outbreaks.

All enteritis cases are routinely tested for Porcine Epidemic Diarrhoea (PED), a devastating newly emerging porcine disease, which has caused significant losses in the recent past in USA and continental Europe, but has not been detected here.

Pneumonia/Pleuropneumonia

Pneumonia and pleuropneumonia were among the most frequent diagnoses reached in DAFM labs pig *post mortem* investigations in 2020, accounting for 17.6 *per cent* of all diagnoses reached. All porcine respiratory disease investigations at DAFM labs undergo bacterial, viral and histopathological testing, to determine the pathogens and inflammatory pattern present.

Pneumonia in pigs typically is a result of many interacting risk factors including; infectious agents (viral and bacterial), environmental conditions, management factors and genetic factors. As pneumonia in pigs is rarely exclusively due to infection with a single pathogen,

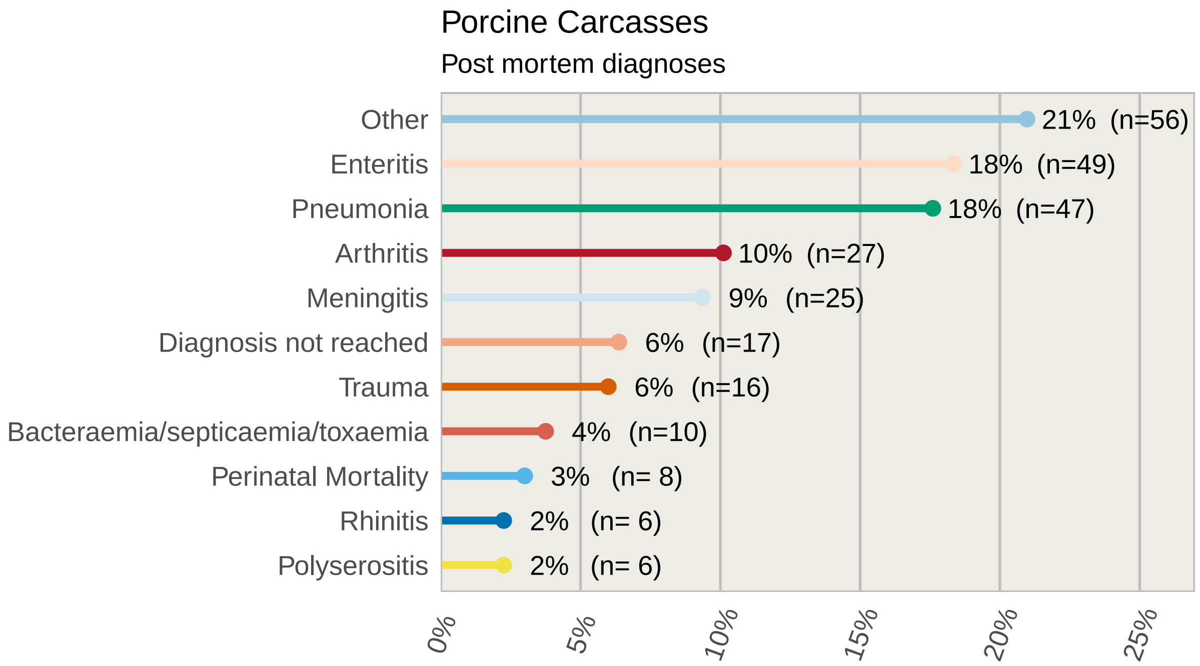

Figure 59: Conditions most frequently diagnosed on *post mortem* examinations porcine carcasses in 2020 (n=267). Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

the term Porcine Respiratory Disease Complex (PRDC) is used to describe this syndrome.

In DAFM investigated cases the most commonly isolated bacterial agent from pneumonia cases was *Actinobacillus pleuropneumonia* followed by *Trueperella pyogenes*, *Pasteurella multocida* and *Streptococcus suis*.

Influenza virus, porcine reproductive and respiratory syndrome virus and porcine circovirus 2 are routinely tested for and detected viruses in DAFM Labs.

Actinobacillus pleuropneumoniae is one of the most common prevalent bacterial pulmonary pathogens in pigs worldwide and was the most commonly detected bacterial pathogen in pneumonia/pleuropneumonia cases investigated by DAFM labs. *Actinobacillus pleuropneumoniae* can cause severe diffuse fibrinohaemorrhagic necrotising pleuropneumonia, which is rapidly fatal in all ages of pigs.

In 2020 five *Actinobacillus pleuropneumoniae* isolates were serotyped from various submitting farms and serotypes 8 & 7 were identified in the isolates examined. However, given the low number of isolates examined, this should not be interpreted as demonstrating which serotypes are more/less prevalent in Ireland at this time.

PRDC is a significant cause of morbidity, mortality and economic loss both at farm level and at meat factory level for the pig producers (as "pleurisy" is the most common cause of pig carcases being detained or condemned at slaughter in Ireland).

Streptococcus suis Diseases

Arthritis and meningitis diseases were also commonly investigated and detected by DAFM labs in 2020, and represent 10 *per cent* and 9.4 *per cent* of all cases diagnosed respectively. *Streptococcus suis* the most commonly diagnosed causative agent of both.

Streptococcus suis, is one of the most common pig pathogens worldwide. It is a common commensal bacterium of pigs typically passed from a sow to her litter. Both avirulent commensal and virulent disease causing strains exist. However, only the virulent strains are considered to be disease causing, resulting in bacteriaemia and attendant; polyserositis, meningitis, arthritis or pneumonia. Once virulent *Streptococcus suis* strains emerge within a herd, they cause a prolonged bacteraemia during which they are shed and thereby spread in the cohort group of pigs.

In 2020 twenty-two *Streptococcus suis* isolates were serotyped from various submitting farms and serotypes 1, 2, 3, 7, 9, 12 and 14 were identified in the isolates examined. However, given the low number of isolates examined and the farm specific nature of these isolates, this cannot be interpreted as demonstrating which serotypes are more/less prevalent in Ireland at this time. Streptococcus suis isolated from pig carcases in DAFM labs also routinely undergo antimicrobial sensitivity testing.

Investigations of a number of common pig production limiting diseases were also undertaken in 2020.

Atrophic Rhinitis

An acute outbreak of respiratory distress affecting 1–2 week old piglets was investigated, with two affected piglets submitted for *post mortem*. Both piglets were in fair body condition with milk ingesta in the stomach. In one piglet the nasal conchae were markedly congested and oedematous, with mild asymmetry. In the second piglet the nasal mucosa was oedematous with frothy exudates and the nasal conchae were distorted. On histopathological examination both piglets had marked-severe erosive and suppurative rhinitis with lymphohistiocytic submucosal infiltrates and cartilage necrosis. Bordetella bronchiseptica was isolated from the nasal cavity (Figure 60).

The main findings of rhinitis with *Bordetella bronchiseptica* isolated, is consistent with acute atrophic rhinitis.

Atrophic rhinitis can occur from 1 week of age, following colonisation of the nasal conchae by toxigenic *Bordetella bronchiseptica*, with exposure typically occurring via inhalation of droplets. Usually maternal antibodies acquired from colostrum protect exposed piglets from clinical disease, however, if the dam is unvaccinated or unexposed but infection exists on the unit, piglets may be colonised but not have protective maternal immunity, leading to clinical disease. Development of clinical atrophic rhinitis predisposes pigs to pneumonia. Additional risk factors for atrophic rhinitis include contact with asymptomatic carriers and poor ventilation.

Exudative dermatitis

Two separate outbreaks of epidermitis in weaner piglets were investigated. In both cases *post mortem* investigation revealed variably

Figure 60: Atrophic rhinitis. Photo: Margaret Wilson.

extensive skin lesions consisting of multifocal-to-coalescing raised areas of dark brown crusting particularly affecting the ear pinnae, head and neck areas (Figure 61).

On histopathology there was severe multifocal-to-coalesing intracorneal pustule formation with intralesional coccoid bacteria in bunches along with variable epidermal thickening and ulceration. There was diffuse moderate dermal oedema and superficial mononuclear cell infiltration.

Staphylococcus hyicus was isolated from the skin of affected cases. The gross lesions, histopathology and isolation of *Staphylococcus hyicus* are consistent with a diagnosis of exudative epidermitis or *Greasy Pig Disease*.

Figure 61: Greasy Pig Disease (*Staphylococcus hyicus*). Photo: Margaret Wilson.

Exudative epidermitis is the most common skin disease of pigs and affects piglets and early stage weaners. At its most severe the loss of fluids via disrupted epidermis can lead to dehydration and death. *Staphylococcus hyicus* strains possessing exfoliative toxins are the causative agents with skin colonisation demonstrated to originate from maternal skin flora within hours of birth. Typically traumatic injury to the skin surface allows penetration of the epidermis by the organism. Efforts to control exudative epidermitis on pig units are directed towards development of maternal immunity via vaccination to provide passive immunity to the piglets and towards minimising potential for skin trauma in piglets.

Erysipelas

An acute outbreak of respiratory disease with an increase in fatality in fatteners was investigated. The submitted pigs were in very good body condition. The main gross pathological findings were fibrinous pericarditis, vegetative endocarditis of the mitral valve (Figure 62) and fibrinous pleurisy. *Erysipelothrix rhusiopathiae* was cultured from the pericardium and heart valve. On histopathology haemosiderin laden macrophages termed *heart failure cells* were noted in the lung.

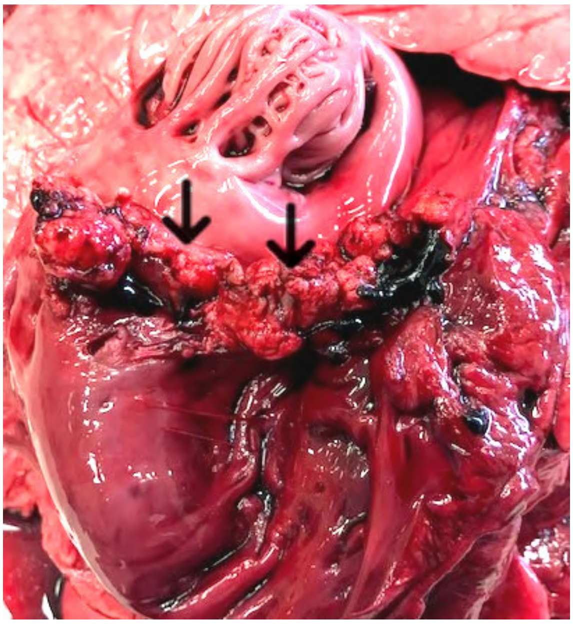

Figure 62: Heart: Vegetative Endocarditis of left atrio-ventricular valve. Photo: Aoife Coleman.

Erysipelas is an important globally present systemic disease of pigs, which when uncontrolled causes significant losses in intensive production systems. There are three clinical presentations of the disease; acute, subacute and chronic. The acute form is a septicaemia, where the classic lesion is the diamond skin lesions. The subacute form is a less severe septicaemia than the acute form, where animals do not appear sick and skin lesions are few and mild. Animals that survive either acute or subacute form may develop chronic erysipelas. The most common presentations of chronic erysipelas are arthritis with lameness and vegetative endocarditis of the mitral valve. The valvular endocarditis results in left-sided heart failure and consequent pulmonary oedema and respiratory distress, consistent with the clinical findings reported in the case investigated.

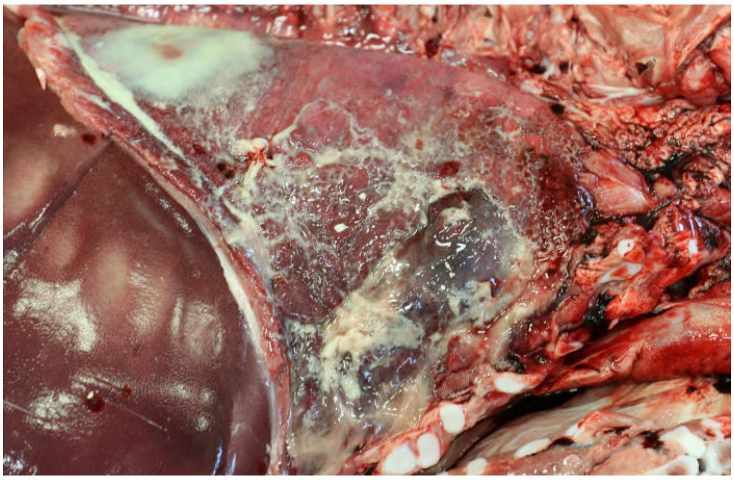

Figure 63: Severe diffuse fibrinous pleurisy. Porcine lung. Photo: Margaret Wilson.

Salmonella

Routine culture of porcine tissues from *post mortem* samples includes Salmonella culture. Eight animals were identified with *Salmonella* typhimurium infection in 2020 and one animal was identified with Salmonella enteritidis.

Commercial pig producers are obliged to have a Salmonella control program documented for their farms and slaughtered pigs are routinely screened for Salmonella antibodies throughout the year, with results fed back to the farm of origin and slaughter plants.

As Salmonella sp is capable of causing severe zoonotic disease in people, all confirmed *Salmonella* typhimurium or *Salmonella enteritidis* isolates are notified to the local District Veterinary Office (DVO).

African Swine Fever

The ongoing outbreak of African swine fever (ASF) in multiple European countries poses a risk to the Irish pig industry. To date Bulgaria, Estonia, Germany, Hungary, Italy, Latvia, Lithuania, Poland, Serbia, Romania, Slovakia and Ukraine have all confirmed the presence of ASF in wild boar and many of these listed countries have also recorded domestic pig ASF outbreaks. The most significant potential risk factor for entry into Ireland is feeding illegally imported infected pork products to pigs. DAFM veterinary laboratory service continues to focus on preparation and contingency planning to mitigate risk from a potential incursion of exotic disease such as ASF to the Irish pig population, through practical training of staff on outbreak investigations and pig sampling techniques.

An ASF factsheet for vets detailing the clinical signs of ASF is available on the African swine fever page on the DAFM website. DAFM also produced a biosecurity leaflet specifically aimed at non-intensive pig farms and an ASF factsheet for farmers, both of which are available to download from the African Swine Fever page on the website.

ASF is a notifiable disease and PVPs are reminded to notify DAFM if they suspect presence of the disease by contacting their local DVO or the National Disease Emergency Hotline at 1850 200 456.

Non-intensive or smaller pig herds as well as pet pig owners may have irregular veterinary input and are likely to contact their local veterinary practitioner for advice when faced with unexplained clinical signs or deaths. DAFM laboratories are aware of the difficulties in reaching a diagnosis in these cases, especially for veterinary practitioners who may not have previous experience in treating or diagnosing the range of diseases that may be present in pigs. All practitioners are reminded that, in any relevant pig disease outbreak, DAFM laboratories are available to offer advice on sampling and will carry out necessary testing, including necropsy free of charge, in order to confirm a diagnosis. Practitioners are also advised to encourage clients with small pig herds to submit any dead or fallen carcases to the DAFM laboratory network, as this will provide valuable disease surveillance material and will allow the submitting vet to assist in diagnosis and management of disease within the herd.

Exotic Disease Surveillance Data

During 2020, as part of a surveillance program on culled sows undertaken by the Blood Test Laboratory, 2220 samples were tested for Aujeszky disease. All these samples were also tested for Classical Swine Fever (CSF) and African Swine Fever (ASF). Any samples that produced a reaction for ASF were forwarded to Virology Division in the Central Veterinary

Research Laboratory (CRVL) for further testing. All the samples tested were negative for the three diseases.

In additional to that, 133 diagnostic samples were submitted to the Blood Test Laboratory for Brucellosis screening, all produced a negative test result for *Brucella sp.*.

Poultry Surveillance and Diseases

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Avian Influenza Surveillance

Avian influenza type A is a contagious disease caused by viruses which are naturally found in, and which are adapted to, populations of wild birds. Avian influenza viruses can also affect poultry and mammalian species (depending on the virus subtype) including rodents, pigs, cats, dogs, horses and humans.

Based on the severity of the disease Avian Influenza is divided into low pathogenic (LPAI) and high pathogenic (HPAI) strains. LPAI may present with mild or no clinical signs in poultry. Conversely, HPAI strains can cause severe clinical signs such as respiratory signs, reduced food intake, diarrhoea, and nervous signs; and in some cases, HPAI strains can cause sudden death without symptoms. In layers, drop in egg production and/or poor egg quality has been reported.

Avian Influenza viruses are classified into subtypes based on two surface proteins, haemagglutinin (HA) and neuraminidase (NA). There are approximately 16 HA subtypes and 9 NA subtypes which are used to identify avian influenza viruses e.g. H5N8, H5N6 etc.

All HPAI are notifiable to the European Commission and the World Organisation for Animal Health (OIE) within 24 hours of confirmation of the disease. These notifiable subtypes can be associated with acute clinical disease in chickens, turkeys, and other birds. Other subtypes such as LPAI H6- are not notifiable under the legislation, however they still can cause losses in production.

Active surveillance:

DAFM carries out two types of active surveillance for avian influenza.

Table 38: Avian influenza surveillance testing during 2020 in Ireland.

2020	No Animals tested	Non- notifiable AI subtypes	Notifiable H5 and H7 subtypes
Poultry- Poultry Health Programme (AGID test) (a)	10700	0	0
Poultry –H5 and H7-EU Surveillance (HI test) (b)	7806	0	0
Poultry - AI ELISA (diagnostics)	1254	157 (14 flocks x LPAI H6N1)	0
Wild birds - PCR	165	0	19 HPAI H5N8; 4 H5N8 (pathogenicity not determined)
Poultry - PCR (c)	519	•11 layer flocks (LPAI H6N1), 3 turkey flocks (LPAI H6N1)• 1 duck flock (AI-non H5, N7, N1)	1 turkey flock H5N8 (pathogenicity not determined)
Captive birds - PCR	27	0	0

[a] AGID: Agar Gel Immunodiffusion test;
[b] HI: Haemagglutination Inhibition test for H5 and H7;
[c] Poultry-PCR: includes individual and pooled swabs from different animals

1. **Avian influenza serology testing in poultry for the national Poultry Health Programme (PHP)**. The Poultry Health Programme is a DAFM surveillance programme to support trade in poultry, and to comply with EU regulations, including Regulation (EU) 2016/429 and Commission Delegated Regulation (EU) 2020/688. The PHP also includes testing for Mycoplasma and Salmonella. Last year, 10700 poultry samples were tested by AGID method for AI through this programme (Table 38).

2. **Avian influenza H5 and H7 serology testing of poultry under the EU Poultry Surveillance Scheme**. Ireland's avian influenza surveillance programme is based on representative sampling, which considers criteria in Annex II of Commission Delegated Regulation (EU) 2020/689 at a level reflective of Annex I of Commission Decision 2010/367/EU.

In 2020, 7806 samples were tested for H5 and H7 HAI. The categories sampled for the EU Poultry Surveillance Scheme included:

- Broilers - Free Range
- Broiler Breeders
- Layers - Free Range
- Layers - Non-Free Range
- Fattening Turkeys
- Turkey Breeders

- Fattening Ducks
- Fattening Geese

Passive surveillance of wild birds, poultry and other captive birds:

1. **Passive surveillance of wild birds.** Wild bird surveillance for avian influenza in Ireland is risk based. It is implemented as a passive surveillance scheme, as dead, moribund or sick birds are reported to DAFM by members of the public or the National Parks and Wildlife Service (NPWS) by ringing the Avian Influenza Hotline (076 1064403) or the after-hours number (1850 200456). Sick or dead birds can also be reported to DAFM directly using the Wild Bird-Avian Check App, which can be accessed via smart phones, tablets, PCs and laptops. The birds are collected by trained personnel and submitted to the Regional Veterinary Laboratories (RVL) for sampling. Samples are then submitted to the Central Veterinary Research Laboratory (CVRL) where Avian Influenza testing is carried out.

A list of species of wild birds to be targeted for surveillance for avian influenza is provided by the Commission Implementing Decision 2010/367/EU in accordance with the scientific opinion provided by EFSA. This list is amended according to the demographics of each country. See list here: List of wild bird species to be targeted for Avian Influenza.

In 2020, 165 wild birds were tested; from those 23 tested AI H5N8 positive, 19 with high pathogenic (HPAI) and 4 with pathogenicity not characterised (Table 38). The species where H5N8 was detected were 1x cormorant, 1x curlew, 1x Barnacle Goose, 7x Mute swans, 3x Peregrine Falcons, and 10x Whooper Swans.

2. **Passive surveillance of poultry and other captive birds**. Avian influenza is a notifiable disease in Ireland, meaning that anyone who suspects that an animal/bird may have the disease is legally obliged to notify DAFM.

Following notification, an official investigation will be carried out by DAFM with official samples submitted to the CVRL for testing. In addition, flock owners and PVPs are encouraged to engage with their Regional Veterinary Laboratory to aid with diagnosis of other avian disease conditions.

In 2020, an epizootic event caused by H6N1 LPAI in poultry flocks took place. 11 Layer flocks and 3 turkey flocks were affected (see H6N1 Epizootic in Ireland in 2020 on page 87).

In addition, one turkey flock tested positive for H5N8 and as part of sampling within the protection and surveillance zones one game duck flock tested AI positive (AI non-H5, H7 or N1) (Table 38). No further cases were detected after this and the OIE published Ireland's self-declaration of disease freedom from Avian Influenza in poultry (`https://www.oie.int/app/uploads/2021/05/2021-03-ireland-ai-recovery.pdf`)

Avian Mycoplasma Surveillance

Active surveillance

The Poultry Health Programme (PHP) operated by DAFM includes surveillance for poultry mycoplasmosis. *Mycoplasma spp.* in poultry, whilst of no public health concern, can present significant problems both commercially and potentially for bird welfare. Therefore, poultry are screened for *Mycoplasma Gallisepticum* (MG) and-or *Mycoplasma Meleagridis* (MM).

The DAFM Poultry Health Programme seeks to provide a surveillance platform for MG and MM in commercial flocks. As part of this programme breeding flocks of both turkeys and chickens are routinely tested for serological evidence of *Mycoplasma gallisepticum* or *Mycoplasma meleagridis* (turkeys only). The plan for each poultry subgroup varies but typically flocks are subject to serological testing at pre-movement (from rearing), exports, at point of lay, and during production (Typically every 12 weeks).

The frequency of sampling is set out in the 'Council Directive 2009/158/EC of 30 November 2009 on animal health conditions governing intra-Community trade in, and imports from third countries of, poultry and hatching eggs' , and the 'EU commission Decision 2011/214/EU'. The sample size is based on a representative sampling strategy: 60 birds per house in houses of 1000 birds or more, with design prevalence of 5 *per cent*.

In 2020, 24601 and 1301 serum samples were screened for *M. gallisepticum* and *M. meleagridis*, respectively, at the CVRL as part of DAFM PHP programme (Table 39).

Mycoplasma gallisepticum: This mycoplasma is associated with a chronic respiratory disease. Typically it is slow in onset and can result in significant commercial losses in production. This mycoplasma can infect chickens, turkeys and game birds. Ducks and geese can also become infected particularly when associated with infected chickens.

Mycoplasma meleagridis: With this mycoplasma vertical transmission in the egg can be a significant factor. It is a disease of breeding turkeys with clinical disease possible in the progeny chicks. Respiratory symptoms are the main cause of economic loss.

Table 39: Official Sampling for Poultry Health Programme and EU AI surveillance during 2020 in Ireland.

Type of submissions	Test	No. Tests	Positive
National-Poultry Health Programme	M. gallisepticum SPAT	24601	0
National-Poultry Health Programme	Avian Influenza AGID	10700	0
National-Poultry Health Programme	M. meleagridis SPAT	1301	0
National-Poultry Health Programme	Salmonella arizonae 'H' SAT	1190	0
EU-H5 H7 HI -Surveillance	Avian Influenza H5	7806	0
EU-H5 H7 HI -Surveillance	Avian Influenza H7	7806	0

Passive surveillance

In addition to *M. meleagridis* and *M. gallisepticum*, *Mycoplasma synoviae* is also tested as a part of passive surveillance. The 3 serotypes are notifiable diseases in Ireland, meaning that anyone who suspects that an animal may have the disease is legally obliged to notify DAFM.

Beyond disease reporting, DAFM operates a network of Regional Veterinary Laboratories, strategically located around the country. Farmers and private veterinary practitioners (PVPs) submit large numbers of samples from sick animals to the laboratories every week. Farmers are encouraged to report suspicions of mycoplasma infection to their local Regional Veterinary office, and to make use of their local Regional Veterinary Laboratory to aid with diagnosis of disease conditions.

Avian Salmonella surveillance

As part of the national Poultry Health Programme, serological testing to screen for *Salmonella arizonae* is carried out in turkey flocks in addition to Avian influenza and *M. Meleagridis* (Table 39). Last year, 1190 serum samples were screened for *S. arizonae*.

In parallel, DAFM carries out the EU Salmonella Surveillance by collecting samples on-farm and confirming detected serotypes by culture (Table 40). The programme operates as follows:

- In at least one flock of broilers in 10 per cent of commercial broiler premises with at least 5000 birds.
- Three times per production cycle for all flocks on all broiler breeder premises
- In at least one flock per year per layer holding comprising at least 1000 birds
- Once a year in at least one flock on 10 per cent of holdings with at least 500 fattening turkeys
- Once a year in all flocks with at least 250 adult breeding turkeys between 30 and 45 weeks of age
- All holdings with elite, great grandparent and grandparent breeding turkeys

In 2020, 1427 samples from farms and hatcheries were analysed; of these, Salmonella was detected in 1 layer flock (Table 40).

Newcastle Disease and pigeon PMV1

Newcastle Disease (ND) is a notifiable disease that affects poultry caused by virulent strains of Avian Avulavirus 1 -AAvV-1- (also called

Table 40: Number of Salmonella culture Tests from on-farm samples during 2020 in Ireland.

Avian Production Type	No. Samples	No. Positive Flocks
Broiler Breeder & Grandparent flocks	806	0
Layer	423	1 a
Broiler	110	0
Turkey Fattener	56	0
Turkey Breeder	8	0
Layer Breeder	24	0

[a] Salmonella Kentucky

Avian Paramixovirus type 1 -APMV1-). A similar variant, Pigeon AvV-1 (PPMV1) infects pigeons and other wild birds. AAvV-1 infections may present with a variety of clinical signs depending on the strain virulence, from lethargy and mild respiratory signs, to egg drop production, neurological signs and sudden death.

Table 41: Paramixovirus- 1 (PMV-1) testing during 2020 in Ireland.

PMV1 PCR testing 2020	No birds	PCR tests	positive events/cases	Strain virulence
wild birds	49	133	3	2 high virulent(a) , 1 not determined(b)
captive/racing	7	19	0	0
poultry	104	260	0	0

[a] Wild pigeons
[b] Sparrowhawk

Every year, samples from suspected cases and carcasses from poultry are submitted to the CVRL and RVLs for ND testing. In addition, certain wild bird species are screened by PMV1 as a means of passive surveillance.

In 2020, a total of 49 wild birds, 7 captive birds, and 104 poultry were tested. Two wild pigeons and 1 sparrowhawk tested positive for PMV1 (Table 41).

Disease Diagnostics

Beyond the active and passive surveillance for important notifiable diseases, DAFM carries out testing of other notifiable and non-notifiable diseases that have significant economic impact. Suspect and healthy animals -for monitoring purposes- from backyards and commercial flocks are tested. PVPs submit swabs directly to the CVRL (Table 42) and carcasses of animals are submitted to the RVLs where they are sampled (Figures 64 and 65).

Last year, 57 birds were confirmed positive for Marek's Disease, 19 for Infectious Bronchitis, 16 for M. synoviae, 6 for Infectious Laryngotracheitis (Table 42).

Table 42: PCR testing of submitted samples (PVP and RVL submissions) in 2020.

Pathogen	PCR	Animals tested	Positive
Avian pneumovirus	49	30	1
Chlamydia psittaci *	174	85	1
Infectious Bronchitis	101	76	19
Infectious laryngotracheitis *	48	34	6
Mycoplasma synoviae *	145	100	16
Marek's Disease	64	57	57
Mycoplasma gallisepticum *	147	95	4

* Notifiable diseases.

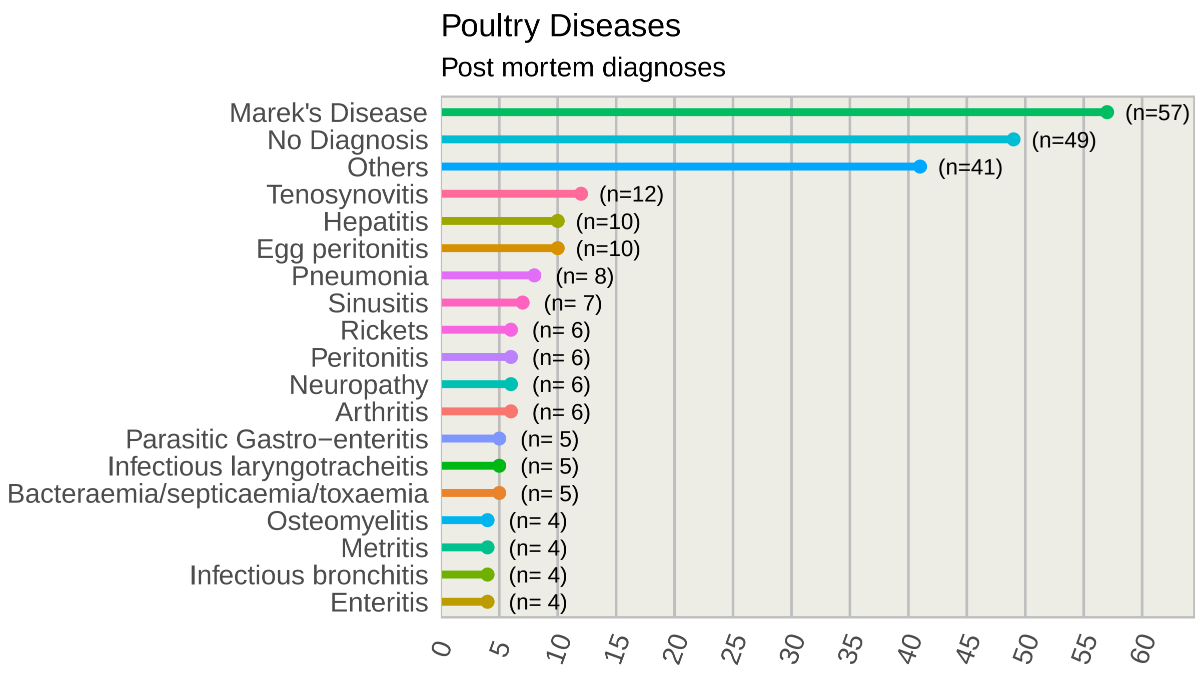

Figure 64: Disease diagnosed in poultry carcasses in 2020.

In 2020, the most common diagnosis in poultry carcasses diagnosed at the RVLs was Marek's Disease (Figure 64). In wild birds, toxicity due to carbofurans, rodenticides and lead poisoning, and Avian influenza infection were the most prevalent (Figure 65). In a number of cases, the cause of death was not determined.

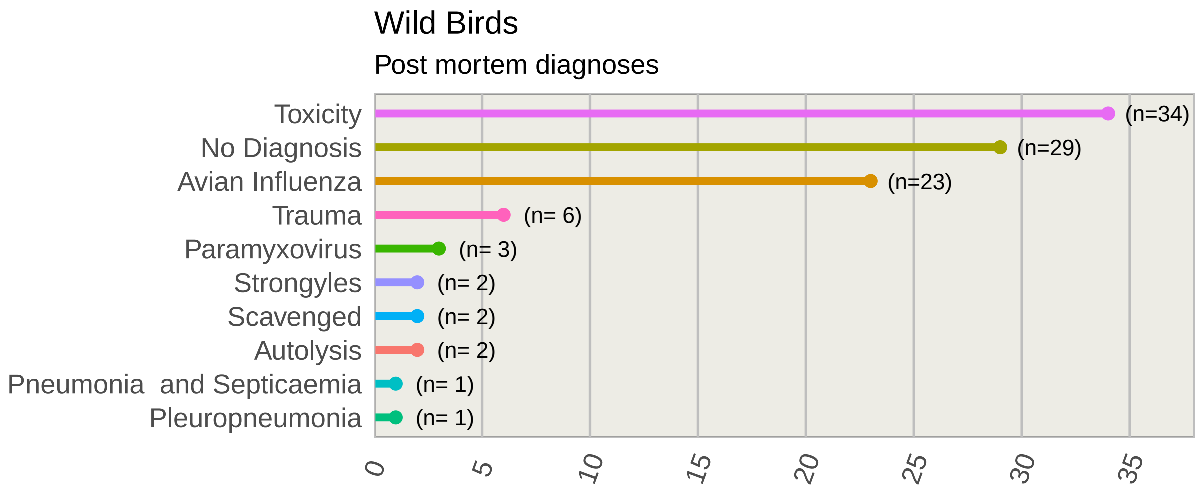

Figure 65: Diseases diagnosed in wild bird carcasses in 2020.

Case Reports in Poultry

Gizzard ulceration

During 2020, gizzard ulceration was seen in broilers and was usually associated with inclusion bodies in histopathology attributed to adenovirus infection. Other causes of gizzard erosions include mycotoxins (such as T2, MAS, DAS, oosperein), copper sulphate, biogenic amines, gizzerosine in fishmeal, vitamin B deficiency, and less commonly starvation, sulphur amino acid deficiency and quaternary ammonium compounds in water. T2 and DAS are considered the most caustic and are also associated with oral lesions and gastrointestinal haemorrhage.

Colisepticaemia

Colisepticaemia was diagnosed in a layer flock with increased mortality. Most birds examined had fibrinous peritonitis associated with bacteria while a few had fibrinous pericarditis. Fibrin thrombi were observed within the sinusoids of the liver. *E. coli* was isolated from the reproductive tract. Disease is generally considered to be a result of ascending infection via the cloaca. Pathogenic *E. coli* may also invade the bird's body from the respiratory tract following infection with other respiratory pathogens, especially when the bird's resistance is lowered by environmental stress and poor air quality (dust or high ammonia levels). Good litter management and properly ventilated houses are vital factors in the control. Live vaccines (e.g. Newcastle disease or IB), and intercurrent disease such as coccidiosis and nutritional deficiencies may all increase susceptibility.

Focal duodenal necrosis

Focal duodenal necrosis (FDN) was diagnosed in layers with decreased production, decreased appetite, and dark foci in the duodenum. FDN has a worldwide distribution and it is considered one of the top 5 disease concerns of the table egg layer industry in the USA and is also in Europe. It is observed in all layer strains (brown & white), all housing types, throughout the production cycle. Affected flocks exhibit lower egg weights and sometimes a drop in egg production. Decreased absorption of calcium due to a damaged duodenum may also affect shell quality and skeletal integrity. Affected birds may have pale combs. The cause is poorly understood. *Clostridium colinum* and *Clostridium perfringens* strains, either type A or type C harbouring the atypical allele of cpb2 and netB, are implicated. Management factors may also be involved, such as fly infestation, rodent infestation, and lack of environmental hygiene.

Fowl cholera

The acute form of fowl cholera was diagnosed in 2 different layer sites, one where the birds were 68 weeks old and the other where the birds were 28 weeks old. Both cases had originally presented as LPAI suspects. At *post mortem* examination, suppurative peritonitis, pericarditis and salpingitis were seen. Pasteurella multocida was cultured from the liver. *Pasteurella multocida* was also isolated in an outbreak of disease in ducks, where it caused high mortality. Fowl cholera is a highly contagious disease caused by *Pasteurella multocida* in a range of avian species including chickens, turkeys, and waterfowl. The disease can range from acute septicaemia to chronic and localised infections and the morbidity and mortality may be up to 100 *per cent*. The route of infection is oral or nasal with transmission via nasal exudate, faeces, contaminated soil, equipment, and people. Reservoirs of infection may be present in other species such as rodents and cats. Predisposing factors include high density and concurrent infections such as respiratory viruses.

Amyloid arthropathy

Amyloid arthropathy was seen in 16-week-old layers in a flock of uneven birds. Some birds were described as “holding up a leg”. This condition has been reported in layers and although the cause is unknown, it is postulated that it occurs secondary to infectious arthritis e.g. *Enterococcus faecalis*. Gram positive coccobacilli were associated with the pyogranulomatous tenosynovitis observed in one bird. All liver and joint swab cultures were sterile except for one liver which yielded a growth of *E. coli*.

Inclusion body hepatitis

Inclusion body hepatitis was diagnosed, on histopathology, in 12-day old broilers, with high mortality. The birds had been uneven on placement. The livers were slightly enlarged, mottled and pale. They had originated from 26-week-old parent stock. Chicks from another producer but from the same source were also similarly affected. Inclusion body hepatitis is a disease of chickens characterised by acute mortality, often with severe anaemia, caused by an adenovirus. A number of different sero-types have been isolated from disease outbreaks but they may also be isolated from healthy poultry. Infected birds remain carriers for a few weeks. Transmission may be vertical or lateral and may involve fomites. Immunosuppression, for example due to Infectious Bursal Disease (IBD) or Chicken Anaemia virus (CAV) infection may predispose birds to infection. Interestingly, many field cases contain eosinophilic inclusions that do not appear to have adenovirus particles. The differential diagnoses include CAV, sulphonamide intoxication, IBD, vibrionic hepatitis, fatty liver syndrome, and biotin deficiency (Fatty Liver and Kidney syndrome).

H6N1 Epizootic in Ireland in 2020

Index case

On the 20th of February 2020, the first confirmed case of Low Pathogenic Avian Influenza (LPAI) H6N1 in the Republic of Ireland was confirmed in a flock located right on the Monaghan/Fermanagh border.

This farm was situated less than 1km from a known LPAI H6N1 positive flock in Northern Ireland. The first signs of the disease noted were:

- Egg drop - initially 34 *per cent* reduction, rising to 96 *per cent* reduction over 6 days.
- Abnormal eggs - soft, misshapen, thin-shelled.
- Small increase in mortality (0.01 *per cent* increased to 0.03 *per cent* over 8 days)
- Decreased feed and water intake.

Avian influenza viruses are classified as either low pathogenic (LPAI) or highly pathogenic (HPAI) depending on the severity of the disease. Up to now all HPAI strains isolated in nature have been either of the H5 or H7 subtype. HPAI or LPAI of the subtypes H5 or H7 (or any other HPAI if found) are notifiable under the EU and OIE legislation.

After notification to the authorities, restriction of the farm and farm investigation took place. In parallel, sampling was carried out as follows:

- 20 oropharyngeal swabs, 20 cloacal swabs and 20 bloods were collected per house.
- 5 bird carcasses were collected per house for *post mortem* examination

Samples and carcasses were brought to the CVRL and DRVL, respectively, for processing. At *post mortem* examination, sections from intestine, lungs and brain tissue were collected from each bird.

Tissues and swabs were tested by molecular methods, and blood by serological techniques. Tissues tested positive for AI MP on PCR, H6, and N1 on PCR but negative for H5, H7 on PCR. Serum tested positive for AI on AGID and AI on ELISA but negative for AI H5 and AI H7 on HAI.

In addition, virus amplification and isolation were carried out. Sequencing of virus fragments (HA -haemagglutinin-protein) and preliminary phylogenetic analysis indicated that the virus structure was very similar to one of the strains in the Northern Ireland outbreak.

Subsequent cases

The second case occured in a commercial turkey unit where animals showed lethargy and with some mortalities. In addition, 4 cases were identified in confined layers, 7 cases in layers with outdoor access and 3 cases in turkey farms.

The clinical signs in those cases in general were mild with the predominant presentation being a severe drop in egg production in the case of egg layers. However, one or more of the following symptoms were present:

- Egg drop – significant egg drop occurring suddenly (<48 hr) or gradually (e.g. 7 days)
- Abnormal eggs - soft, misshapen, thin-shelled
- Watery diarrhoea +/- green colouration
- Small increase in mortality (<2 *per cent*)
- Decreased feed and/or water in take
- Dullness, depression.

For each of the suspected outbreaks, 20 birds from different areas of the poultry house were selected by the visiting VI/RO (as per NDCC guidelines) and delivered to Pathology Division, for *post mortem* examination and collection of samples as follows:

- 20 Oropharyngeal swabs, pooled in 4 or 5
- 20 Cloacal swabs, pooled in 4 or 5
- Blood from 20 birds
- Brain tissue from 5 carcasses
- Lung tissue from 5 carcasses
- Intestine tissue from 5 carcases

Next, the oropharyngeal & cloacal swabs and tissues were tested using molecular methods, and the blood serum by serological methods (Table 43).

Overall results

Oropharyngeal/cloacal swabs, intestine and lung tissue tested positive for AI MP, H6N1 PCR with low tropism for brain tissue in all

Table 43: Sampling and testing protocol for suspect H6N1 cases.

Sample type	Samples	AI MP PCR	H5 PCR	H7 PCR	H6 PCR	N1 PCR	AI ELISA	AI AGID	VI
Oropharyngeal swabs	20	x	x	x	x	x	-	-	x
Cloacal swabs	20	x	x	x	x	x	-	-	x
Brain tissue	5	x	x	x	x	x	-	-	x
Lung tissue	5	x	x	x	x	x	-	-	x
Intestine tissue	5	x	x	x	x	x	-	-	x
Blood serum	20	-	-	-	-	-	x	x	-

cases. Samples all tested negative for H5, and H7 on PCR. Serum tested positive for AI on ELISA and AI on AGID.

At *post mortem* examination, layers had no or partially formed eggs in the oviduct in some cases. Egg peritonitis was identified in one case. Oviducts appearance was empty, with active follicles, and suppurative peritonitis in a few hens.

Turkeys showed marked pulmonary congestion and visceral oedema.

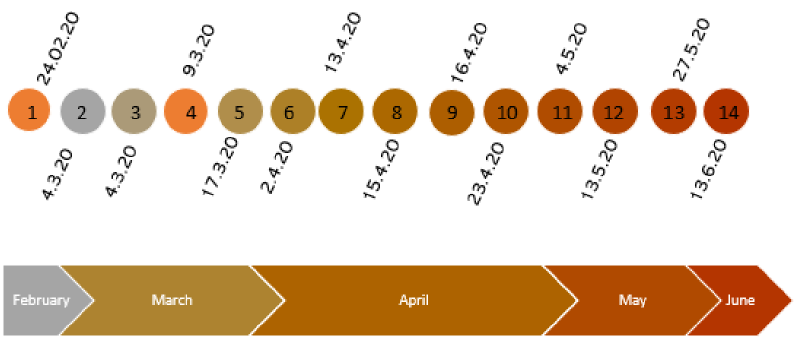

Figure 66: Timeline of the confirmed cases of LPAI H6N1 in commercial poultry flocks in Ireland in 2020

In conjunction with clinical signs, LPAI H6N1 was confirmed in the 14 commercial poultry flocks in County Monaghan between 24/02/2020 and 17/06/2020 (Figure 66). All flocks were treated as an HPAI or LPAI H5 or H7 avian influenza suspect case (as per the EU Directive) until confirmation of LPAI H6N1 ruled it out.

In addition to the 14 flocks, 5 more flocks were suspect to be infected with LPAI H6N1 and the same protocol was applied; however H6N1 was ruled out after test results came back negative.

Initial phylogenetic analysis of the first index case, based on the HA (haemagglutinin) fragment sequence indicated that the virus structure was 99.8 *per cent* similar to the closest LPAI H6N1 isolate from Northern Ireland.

Whole genome sequencing and phylogenetic analyses on the later cases carried out by the OIE/FAO/European Reference Laboratory for AI, IZSVe (Italy) showed that the Irish H6N1 strains had the highest identity with LPAI viruses collected in Wild Birds in Europe during 2019. That analysis also indicated that the index case was situated as the progenitor of the phylogenetic trees, suggesting a single entry of the virus into Ireland rather than multiple parallel incursions from wild birds. Further analyses are underway by collaborators in the OIE/FAO Reference Laboratory for AI, APHA (UK).

Conclusions and actions

All 14 holdings were derestricted under the Avian Influenza Legislation as the H6N1 subtype is not notifiable under the EU and OIE definition — it is not a H5 or H7 subtype or any other highly pathogenic strain. Therefore, there was no legal requirement to cull affected flocks. Nevertheless, culling of birds occurred as directed by industry on behalf of the flock owners.

Early notification of AI suspect cases, AI surveillance and high biosecurity standards are of critical importance to limit the spread of the disease.

Antimicrobial resistance 2020 Veterinary Clinical Isolates

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The testing of veterinary clinical isolates was carried out by the DAFM veterinary diagnostic laboratories (RVL and Pathology Division in Backweston) using the disc diffusion method. Results were interpreted using clinical breakpoints set by the Clinical and Laboratory Standards Institute (CLSI), using both a combination of *in vitro* microbiological and *in vivo* pharmacological data and isolates were classified as susceptible, intermediate or resistant to each antimicrobial. Isolates with a significant resistance pattern underwent confirmatory testing, including, in some cases, whole genome sequencing (WGS), at the National Reference Laboratory for Antimicrobial resistance in Backweston.

Pathogenic bacteria were tested using panels of antimicrobials that are either licensed for use in animals or are used exclusively in humans but were included for surveillance purposes to detect significant resistance patterns. In some cases, a *class representative* drug was included in the testing panels and this can be used to predict susceptibility to other members of the antimicrobial class.

The AST results for only the first isolate from an individual herd have been included in the following analysis.

Unlike surveillance of AMR in healthy animals which is mandated by 2020/1729/EU, there is no harmonized surveillance programme for AMR in veterinary pathogens in Europe. Considerable variation in microbiological methods exists, making direct comparison of results difficult between different laboratories and published studies.

AMR from zoonotic bacteria, including *Campylobacter* and *Salmonella* is not discussed in this report but data for both sick and healthy animals from are included in the national One-Health reports on antimicrobial use and antimicrobial resistance.

Isolates from Milk Samples

The majority of isolates that undergo AST are mastitis pathogens, most of which are tested in the Cork and Limerick laboratories that are located in the most dairy – intensive regions.

Gram positive mastitis pathogens include *Staphylococcus aureus*, *Streptococcus agalactiae*, *Streptococcus dysgalactiae* and *Streptococcus uberis*. These bacteria are tested using discs containing penicillin, ceftiofur, pirlimycin, erythromycin and tetracycline.

In addition, ***Staphylococcus aureus*** is tested using trimethoprim-sulfamethoxazole and cefoxitin; the latter is included as a screen for Methicillin Resistant *Staphylococcus aureus* (MRSA) and the results of cefoxitin testing can be used to predict susceptibility to cloxacillin, amoxicillin-clavulanate and cephalosporins. Similarly, the result of penicillin testing can be used to predict susceptibility to ampicillin and amoxicillin in *S. aureus* (Figure 68).

Figure 67: Individual milk sample submitted to one of the Regional Veterinary Laboratorues. Photo: Pat Sheehan

Staphylococcus aureus

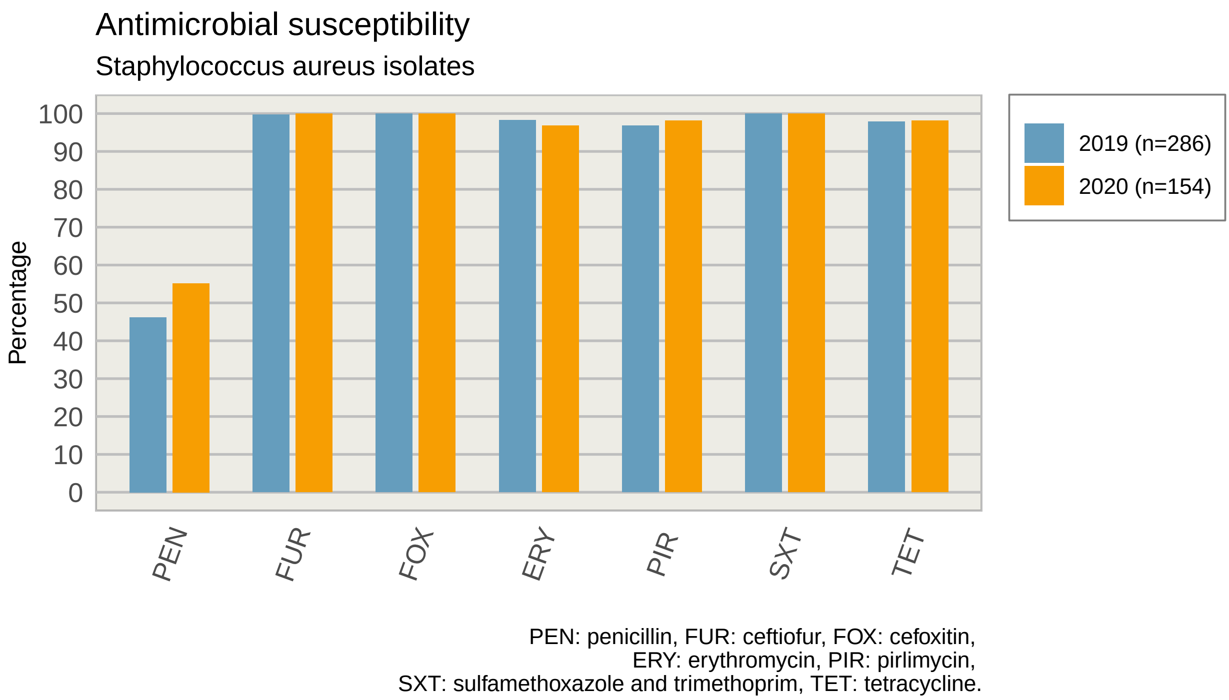


Figure 68: Percentage of antimicrobial susceptibility among *Staphylococcus aureus* isolates from bovine mastitis samples in 2019 and 2020.

A total of 154 *S. aureus* were examined. Eighty-two (53.24 *per cent*) isolates were susceptible to all antimicrobials tested. Eighty-six isolates (55.2 *per cent*) were susceptible to penicillin, which is an increase since 2019 when 46.2 *per cent* isolates were susceptible. In a recent study from eight European countries, 74.5 *per cent* of *S. aureus* from milk were susceptible to penicillin (El Garch et al., 2020).

All isolates were susceptible to ceftiofur, which is similar to the findings in other countries (de Jong et al., 2018). As in 2019, resistance to cefoxitin, which indicates methicillin resistant *S. aureus*

(MRSA), was not detected. Levels of MRSA in Europe are overall below 1 *per cent* (El Garch et al., 2020) in *S. aureus* isolated from mastitic bovine milk samples.

Overall, 96.8 *per cent* and 98.1 *per cent* isolates were susceptible to erythromycin and pirlimycin, respectively. The level of susceptibility to these antimicrobials in Europe is also high and similar to that found in Ireland (El Garch et al., 2020). Genes that encode macrolide resistance in Gram positive bacteria, including *Staphylococcus* and *Streptococcus* frequently also encode resistance to lincosamide and three of the 5 erythromycin-resistant strains were also resistant to pirlimycin.

Finally, 100 *per cent* were susceptible to trimethoprim-sulfamethoxazole. High levels of susceptibility to this antimicrobial combination have been reported by other European countries (Hendriksen et al., 2008).

1.1 Streptococcal species

S. uberis **and** ***S. dysgalactiae*** are commonly found in the environment of the dairy farm and can act as opportunistic pathogens of the mammary gland.

S. uberis and *S. dysgalactiae* isolates were tested for resistance to ß-lactams (penicillin, ampicillin, ceftiofur), macrolides (erythromycin), lincosamides (pirlimycin), and tetracyclines (tetracycline). In *Streptococcus*, the penicillin result can be used to predict susceptibility to ampicillin, amoxicillin, amoxicillin-clavulanate and cephalosporins and pirlimycin predicts susceptibility to other lincosamides.

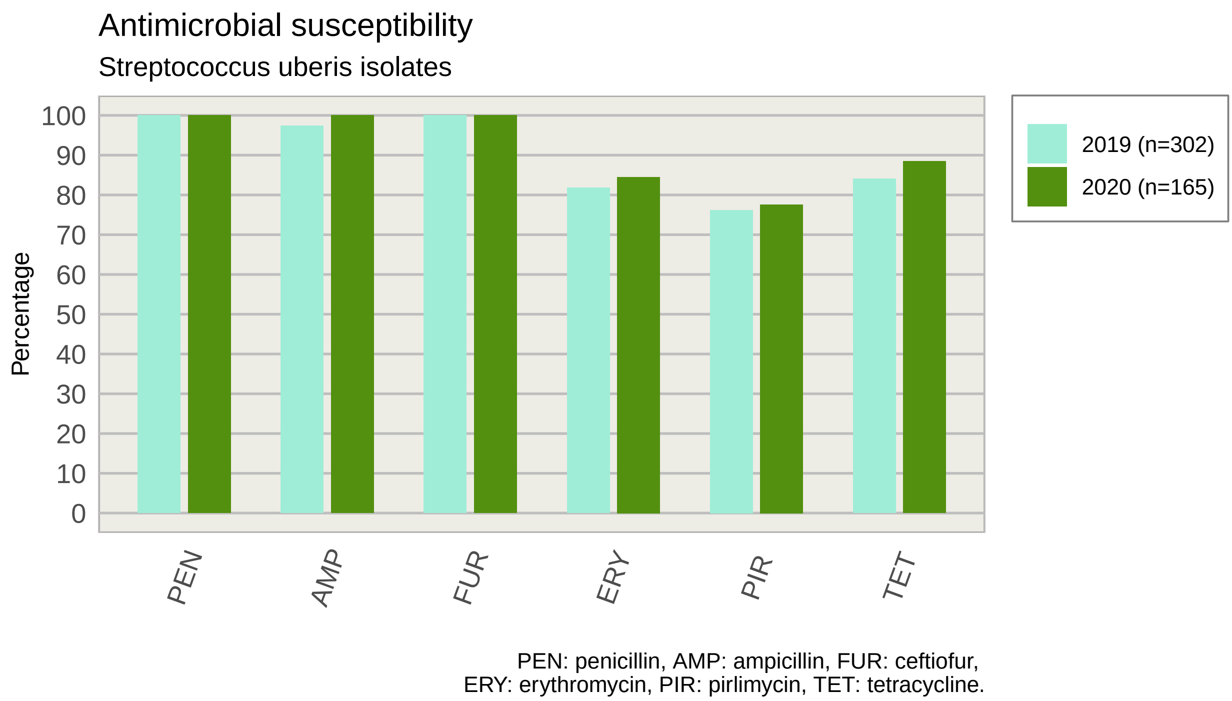


Figure 69: Percentage of antimicrobial susceptibility among *Streptococcus uberis* isolates from bovine mastitis samples in 2019 and 2020.

One-hundred and sixty-five *S. uberis* isolates were obtained and 116 (70.3 *per cent*) were susceptible to all antimicrobials tested. All *S. uberis* isolates were susceptible to penicillin or ampicillin and ceftiofur. Resistance to ß-lactam antimicrobials in *Streptococcus* is uncommon and levels in other European countries are similar to those found in Ireland (Botrel et al., 2010, Persson et al. (2011), Rato et al. (2013) and Tenhagen et al. (2006)).

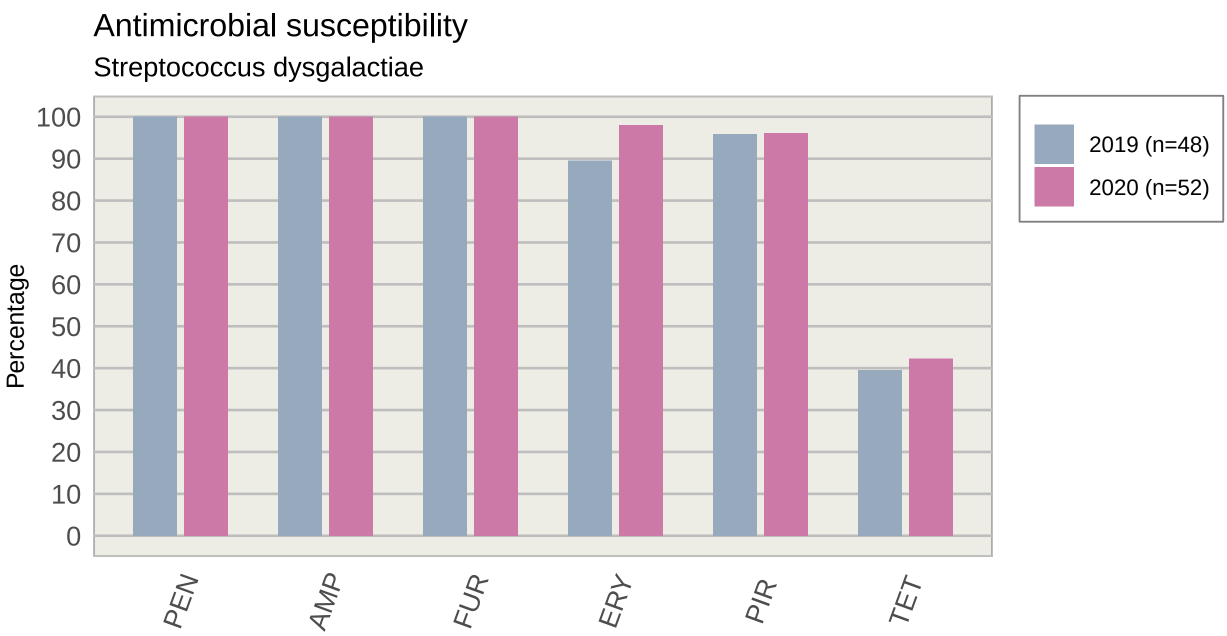
Overall, 84.9 *per cent*, 77.6 *per cent* and 88.5 *per cent* of *S. uberis* were susceptible to erythromycin, pirlimycin and tetracycline respectively. Eighteen (10.9 *per cent*) isolates were co-resistant to erythromycin and pirlimycin, and 8 of these were also resistant to tetracycline. These results show a slight increase in susceptibility as compared to 2019 data (Figure 69).

The levels of susceptibility to erythromycin and tetracycline are higher than or comparable to those reported in other European countries but susceptibility to pirlimycin was slightly lower in Ireland (Botrel et al., 2010, Persson et al. (2011), Rato et al. (2013) and Tenhagen et al. (2006)).

Multiple drug resistance (MDR, resistance to 3 or more antimicrobial classes) was identified in 4.8 *per cent* of the isolates.

Streptococcus dysgalactiae

Fifty-two *S. dysgalactiae* isolates were tested for antimicrobial sensitivity, with 20 (38.5 *per cent*) showing susceptibility to all antimicrobials. All were susceptible to the ß-lactam antimicrobials tested, including penicillin. High levels of penicillin susceptibility in *S. dysgalactiae* have been reported in other European countries (Botrel et al., 2010, Persson et al. (2011), Rato et al. (2013) and Tenhagen et al. (2006)).



PEN: penicillin, AMP: ampicillin, FUR: ceftiofur, ERY: erythromycin, PIR: pirlimycin, TET: tetracycline.

Figure 70: Percentage of antimicrobial susceptibility among *Streptococcus dysgalactiae* isolates from bovine mastitis samples in 2019 and 2020.

Overall, there was 98.1 *per cent* susceptibility to erythromycin and 96.2 *per cent* to pirlimycin. Two isolates were resistant to pirlimycin, one of which was also resistant to erythromycin. In contrast, tetracycline susceptibility was moderate (42.3 *per cent*), a slight increase with respect to 2019 data (Figure 70). No MDR *S. dysgalactiae* isolates were detected.

The levels of pirlimycin and erythromycin susceptibility were higher than recent reports from other countries, but tetracycline susceptibility was lower (de Jong et al., 2018).

Escherichia coli

Escherichia coli mastitis occurs when bacteria from the cow's faeces or environment infect the mammary gland; the response of these infections to antimicrobial treatment is variable.

Escherichia coli isolates were screened using ampicillin, amoxicillin-clavulanate, ceftiofur, enrofloxacin, kanamycin, streptomycin, tetracycline and trimethoprim-sulfamethoxazole, as well as cefpodoxime which was included to screen for resistance to extended spectrum cephalosporins, a critically important antimicrobial class.

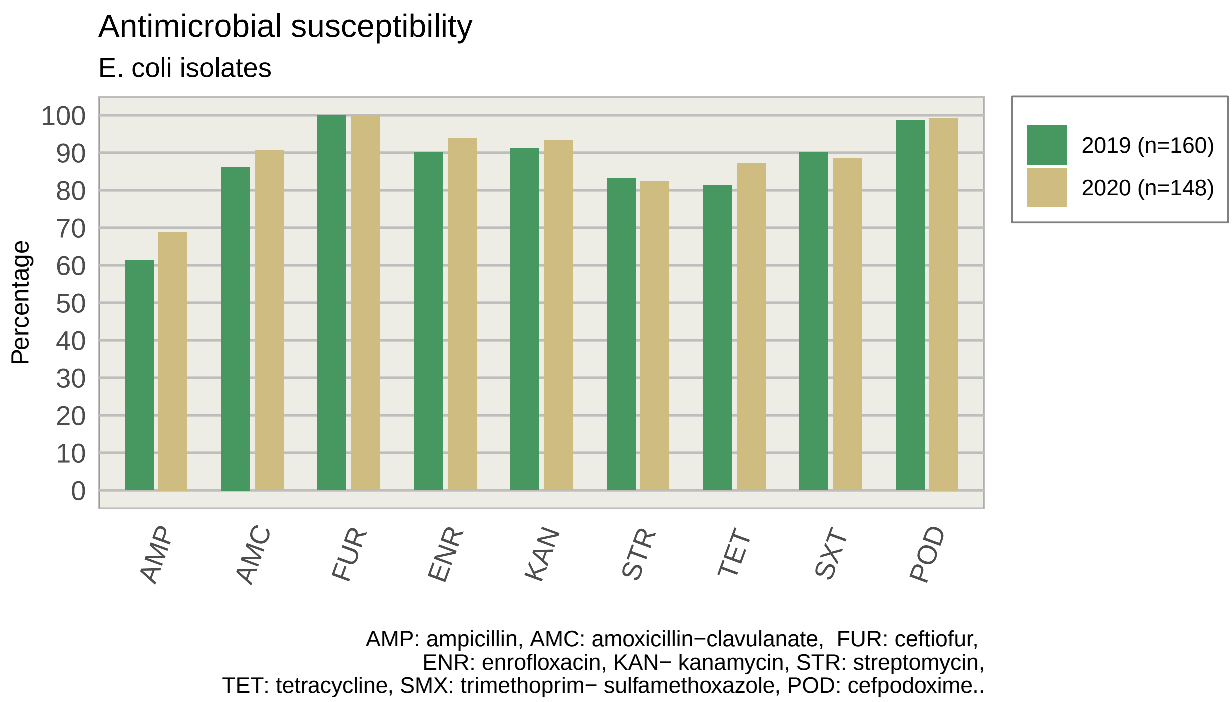


Figure 71: Percentage of antimicrobial susceptibility among *E. coli* isolates from bovine mastitis samples in 2019 and 2020.

E. coli from milk (n=148) were least susceptible to ampicillin (68.9 *per cent*), streptomycin (82.4 *per cent*), tetracycline (87.2 *per cent*) and trimethoprim-sulfamethoxazole (88.5 *per cent*) (Figure 71). The levels of resistance to these antimicrobials were slightly lower (ampicillin, tetracycline) or comparable to (streptomycin, trimethoprim-sulfamethoxazole) those observed in 2019. Resistance levels in UK isolates in 2019 were also similar, except for ampicillin, which was significantly higher (39.4 *per cent*) among *E. coli* isolates from Ireland (UK Veterinary Antibiotic Resistance and Sales Surveillance Report).

Enrofloxacin (fluoroquinolone) resistance halved from 10 *per cent* in 2019 to 5 *per cent* in 2020. However, fluoroquinolone resistance was not detected in UK isolates and reported at extremely low levels in France in 2019 UK Veterinary Antibiotic Resistance and Sales Surveillance Report and Mader et al. (2021). Resistance to this antimicrobial class is of concern because it is used to treat some severe cases of coliform mastitis and is of critical importance in human medicine. A single isolate was resistant to cefpodoxime, an extended spectrum beta-lactam antimicrobial.

Respiratory Pathogens of cattle and sheep

Bovine respiratory disease outbreaks can lead to substantial economic losses on farms and compounds from antimicrobial classes that are considered of higher (macrolides) or critical (extended spectrum beta-lactams, fluoroquinolones) importance in human medicine are marketed for the treatment of bovine respiratory bacterial infections.

Pasteurella multocida and ***Mannheimia haemolytica*** are bacteria that form part of the normal flora on the mucous membranes of the respiratory tract of healthy cattle. However, they can act as primary or secondary pathogens if an animal is stressed, immunosuppressed or infected with respiratory viruses.

Ninety-six isolates of *P. multocida*, that were cultured from nasal swabs or necropsy samples (lung tissue) were screened for susceptibility to ampicillin, ceftiofur, enrofloxacin, florfenicol, trimethoprim-sulfamethoxazole, tetracycline and tilmicosin. Florfenicol and tulathromycin were also used to test 88 of these isolates.

As in 2019, most isolates were susceptible to all antimicrobials and resistance was only detected to tetracycline in 2 isolates. Resistance in bovine *Pasteurella* was rarely reported in other European countries during 2020 and 2019. Resistance to macrolides or fluoroquinolones was very rarely detected, if at all (UK Veterinary Antibiotic Resistance and Sales Surveillance Report, Sales of antibiotics and occurrence of antibiotic resistance in Swede and Mader et al. (2021)).

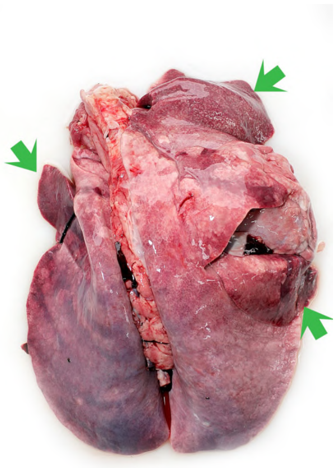


Figure 72: Consolidation (green arrows) of the cranial lung lobes of a sheep infected with Mannheimia haemolytica. Photo: Cosme Sánchez-Miguel

All 56 isolates of *Mannheimia haemolytica* from bovine lungs were susceptible to ceftiofur, enrofloxacin and tilmicosin. Florfenicol resistance was confirmed in a single isolate using broth micro-dilution and whole genome sequencing; this isolate also harboured tetracycline resistance genes. The UK also recorded florfenicol resistance in a single isolate between 2017 and 2019 as well as low levels of ampicillin and trimethoprim-sulfamethoxazole resistance (UK Veterinary Antibiotic Resistance and Sales Surveillance Report).

Thirty-seven *M. haemolytica* from sheep with a history of sudden death or respiratory disease were tested and all were susceptible to the antimicrobials in the panel (ceftiofur, enrofloxacin, florfenicol, tulathromycin and tilmicosin).

AMR in bacterial pathogens of pigs

P. multocida can also act as respiratory pathogen of pigs and cause diseases such as pneumonia.

P. multocida, which were recovered from brain, heart and lung swabs of 10 pigs underwent susceptibility testing in 2020. All were susceptible to ampicillin, ceftiofur, enrofloxacin and tilmicosin. A single isolate was resistant to both florfenicol and tetracycline and also possessed genes for sulphonamide and streptomycin resistance. Resistance was not detected in the remainder of the isolates.

The resistance levels of Irish isolates are comparable to those reported in pigs in France and the UK in 2019 (UK Veterinary Antibiotic Resistance and Sales Surveillance Report, Sales of antibiotics and occurrence of antibiotic resistance in Swede and Mader et al. (2021)).

Streptococcus suis may cause a variety of diseases in pigs, including pneumonia, arthritis, meningitis, endocarditis and polyserositis.

In 2020, 18 isolates of *S. suis*, most of which originated from lung and brain swabs, were tested using penicillin, ampicillin, ceftiofur, erythromycin, trimethoprim-sulfamethoxazole and tetracycline. All isolates were susceptible to penicillin (which is the traditional treatment of choice for *S. suis* infections), ampicillin and ceftiofur. Isolates were most frequently resistant to erythromycin (50 *per cent*), but this was at a similar level to other countries. Tetracycline resistance was also common (44 *per cent*), but levels in Irish isolates were favourable compared to those that have been reported elsewhere in Europe (greater than 80 *per cent*) since 2012 (Mader et al., 2021, and van Hout et al. (2016)) (see Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark).

Fifteen isolates of ***E. coli***, which were from serotypes associated with disease in pigs were tested; these originated from the organs or intestinal content of animals with a history of sudden death or enteritis. Susceptibility to several antimicrobials, in particular those commonly used in veterinary medicine, was only moderate in these isolates. Resistance to ampicillin (53 *per cent*), tetracycline (53 *per cent*), streptomycin (47 *per cent*) or trimethoprim-sulfamethoxazole (40 *per cent*) was most common. A single isolate was resistant to enrofloxacin, a critically important antibiotic (CIA). No resistance was detected to the other CIAs-extended spectrum beta-lactams (ceftiofur and cefpodoxime) and most isolates (80 *per cent*) were susceptible to the potentiated beta-lactam, amoxicillin-clavulanate. Similar resistance trends have been observed in pathogenic *E. coli* from pigs across Europe (UK Veterinary Antibiotic Resistance and Sales Surveillance Report, Sales of antibiotics and occurrence of antibiotic resistance in Sweden and Mader et al. (2021)).

Multiple drug resistance (MDR) is of concern in pathogenic *E. coli* in particular, as infections may be severe and require antimicrobial treatment whereas the carriage of commensal *E. coli* tends not to be associated with disease. Half of isolates were MDR, which compares unfavourably to Sweden, where 11 *per cent* of pathogenic *E. coli* from pigs were MDR in 2020 (Sales of antibiotics and occurrence of antibiotic resistance in Swede). Only 29 *per cent* of *E. coli* from Irish pigs were fully susceptible to all antimicrobials in 2020.

Future Developments

The further development of the national AMR surveillance system in the animal health sector is a strategic intervention that will form part of the second Irish national action plan on antimicrobial resistance (iNAP). As part of this, it is planned to expand the current testing programme of animal pathogens to include additional antimicrobials that are of "one health" significance and increased surveillance of AMR genes in these bacteria.

Since 2019, DAFM laboratories have been involved in European initiatives to improve surveillance in the veterinary sector. The first, an EU joint action on AMR and healthcare associated infections (EU-JAMRAI) recommended the establishment of a European AMR surveillance network in veterinary medicine (EASR-VET). Ireland is currently collaborating with other member states and neighbouring third countries to build this network, which will establish a baseline of AMR, monitor resistance trends and detect emerging AMR in bacterial pathogens of animals in Europe (Mader et al., 2021).

Zoonotic Diseases

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Zoonotic diseases, or zoonoses, can be defined as by the World Health Organisation (WHO)

> "any disease or infection that is naturally transmissible from vertebrate animals to humans".
>
> — World Health Organisation

Transmission occurs as a consequence of direct contact, indirect environmental contact, or through food. According to the World Organization for Animal Health (OIE), 60 *per cent* of existing human diseases are zoonotic and 75 *per cent* of emerging infectious human diseases are of animal origin.

The WHO describes *One Health* as

> "an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes."
>
> — World Health Organisation

One Health provides an opportunity to protect public health by developing policies to control pathogens in the animal population, thereby reducing transmission of zoonotic pathogens to humans. Some examples of zoonotic diseases include Salmonellosis, Campylobacteriosis, Listeriosis, Tuberculosis, Brucellosis, Yersiniosis, Toxoplasmosis, Coxiellosis, Leptospirosis and Cryptosporidiosis. During 2020, DAFM and AFBI laboratories isolated and identified a number of zoonotic agents, some of which are discussed below.

Campylobacteriosis

During 2020, DAFM Laboratories isolated *Campylobacter jejuni* in 152 bovine herds, including one bovine foetus. It was also isolated from 18 ovine flocks and two porcine herds. Campylobacteriosis caused by *Campylobacter jejuni* is usually asymptomatic in animals but it can cause gastrointestinal disease in humans. In animals, *Campylobacter spp.* can be found in both healthy and diarrhoeic animals. It can cause acute enteritis in many domestic animals. In cattle and sheep, some species of Campylobacter are reported to cause abortion (*C. jejuni*, *C. fetus* subs. *fetus*).

Campylobacteriosis is recognised as the most commonly reported cause of gastrointestinal disease in humans in the European Union (EU) since 2005. In 2019, there were approximately 220,000 confirmed cases of human campylobacteriosis in the EU. In food-borne outbreaks of campylobacteriosis the most common sources of infection are contaminated broiler meat and milk. Symptoms of disease in humans include diarrhoea, pyrexia, abdominal pain, nausea and vomiting.

Coxiellosis

During 2020, DAFM tested 361 bovine sera for antibodies to *Coxiella burnetii*, the causative agent of *Q fever*. 46 sera from 23 different herds were positive. Of the 124 ovine sera, one equine serum, and nine goat sera tested, there were no positive samples.

C. burnetii is the aetiological agent of *Q fever*, a zoonotic bacterial infection associated primarily with parturient ruminants. *C. burnetii* has a wide host range, infecting many hosts from arthropods to humans. Zoonotic infections originate from bacteria circulating in animal reservoirs, mainly domestic ruminants. Certain occupational groups, predominantly those in contact with animals or animal products such as farmers, veterinarians and abattoir workers, are at a higher risk of exposure. Transmission of *C. burnetii* occurs primarily by the aerosol route via inhalation of aerosolised bacteria shed by infected animals, primarily after giving birth or aborting. The greatest risk of infection occurs at parturition by inhalation, ingestion or direct contact with birth fluids or placenta. *C. burnetti* is also shed in milk, urine and faeces.

In animals, the predominant reservoir hosts are cattle, sheep and goats. Other species reported to shed *C. burnetii* include domestic mammals, marine mammals, reptiles, ticks and birds. Infection in animals is usually subclinical, but animals will still shed the bacteria and become long-term carriers. Shedding can persist for months, and infection may persist for years and is probably lifelong. Clinical manifestations in animals mainly relate to reproductive disorders such as infertility, stillbirth, abortion, endometritis or mastitis.

Disease manifestation in humans varies in severity from asymptomatic infection to fatal disease, with a range of acute or chronic symptoms such as fever, pneumonia, hepatitis, endocarditis or fatigue. In humans, the majority of outbreaks have been associated with wind dispersal of contaminated, desiccated, reproductive materials. Risk factors for zoonotic transmission of *C. burnetii* have been identified and include an association with small ruminants, proximity between animals and humans particularly around parturition, and dry, windy weather.

Listeriosis

During 2020 in DAFM Laboratories, *Listeria spp.* were isolated from 59 bovine samples, mainly from cultures of foetal fluids. In ovines, it was isolated from 25 submissions, 16 of which were ovine foetuses. *L. monocytogenes* was the main species isolated, but *L. ivanovii* was isolated in one bovine foetus, two ovine foetuses, and three lambs (Table 44).

Table 44: Number of Listeria spp. isolated in DAFM Laboratories in 2020.

Species	Bovine herds	Ovine herds
L. monocytogenes	57	17
L. ivanovii	1	5
Listeria spp.	1	3

Listeriosis is a sporadic bacterial infection that affects humans and a wide range of animals. One of the most pathogenic species is *Listeria monocytogenes*. The natural reservoirs of *L. monocytogenes* are soil and the mammalian intestinal tract, which contaminates the environment.

In adult ruminants, encephalitis and meningoencephalitis are the most common forms of listeriosis. Other clinical manifestations in animals include abortion, perinatal mortality and septicaemia. Aborted foetuses and necropsy of septicaemic animals present the greatest infection risks to human handlers; there are reported cases of fatal meningitis, septicaemia and papular exanthema on arms after handling infected aborted material. Pregnant women should be protected from infection due to the danger to the foetus, and the possibility of abortion, stillbirth and neonatal infection. While human listeriosis is rare, mortality can reach 50 *per cent*, particularly among the elderly, the immunocompromised and pregnant women.

Salmonellosis

During 2020, DAFM Laboratories isolated *Salmonella* from 101 bovine foetuses; the most common serotype was *Salmonella* Dublin, isolated in 100 of these foetuses. *Salmonella* Dublin was also isolated from four ovine foetuses. In bovine samples other than foetuses submitted during 2020, DAFM Laboratories isolated *S.* Dublin in ten bovine carcasses, four ovine carcasses and one caprine carcass. *S.* Typhimurium was identified in one alpaca carcass and five porcine herds.

Other *Salmonella* serotypes isolated in DAFM Laboratories during 2020 included *S.* Montevideo, which was isolated in one bovine herd, *S. Newport*, which was isolated in one bovine herd, and *S. Brandenburg*, which was isolated in two ovine flocks.

Salmonellosis is caused by many species of *Salmonella*, the majority of animal and human disease is associated with serovars of *Salmonella enterica*. The clinical presentation in animals varies from an asymptomatic chronic carrier state to acute/chronic enteritis to the more severe presentation of systemic septicaemia. Young animals usually develop the septicaemic form, adult animals commonly develop acute enteritis, and chronic enteritis is more often seen in growing pigs and occasionally in cattle. *Salmonella* also causes abortion in pregnant animals. Asymptomatic carriers are a zoonotic risk in all host species. The most common pathogenic serotypes of *S. enterica* are *S.* Dublin and *S.* Typhimurium.

Infection of food-producing animals with *Salmonella* presents a serious public health risk because food products of animal origin are considered to be a significant source of human infection. In 2019 in the European Union there were approximately 88,000 confirmed cases of human salmonellosis. Transmission of Salmonella to humans occurs via direct contact with infected animals, indirect contact with their environment, or the consumption of contaminated water and foodstuffs; poultry and eggs are a significant source of infection, and milk and dairy products have been associated with outbreaks of human salmonellosis. Symptoms tend to be more severe in the very young, the elderly and those who are immunocompromised. Symptoms in humans include diarrhoea, vomiting, pyrexia and inappetence, and in more severe cases it can cause septicaemia.

Yersiniosis

During 2020, DAFM Laboratories isolated *Yersinia spp.* from seven submissions. *Yersinia pseudotuberculosis* was the species most commonly isolated. *Y. pseudotuberculosis* causes enteric infections which

Figure 73: Multifocal to coalescing white foci scattered throughout the liver in a bird with Yersiniosis. Photo: Cosme Sánchez-Miguel.

are often subclinical in wild and domestic animals, and humans. It is reported as a sporadic cause of abortion; in 2020 it was isolated from two bovine foetuses and one ovine foetus. It was also isolated from one monkey and one bird (Figure 73.

Three species of *Yersinia* are pathogenic for animals and humans; *Y. pestis* (aetiological agent of plague), *Y. enterocolitica* and *Y. pseudotuberculosis*. The majority of human infections are caused by *Y. enterocolitica*, and *Y. pseudotuberculosis* is relatively uncommon in humans. Yersiniosis in humans is usually related to consumption of raw/undercooked pork as pigs are the main carriers of *Y. enterocolitica*, but disease can also occur after direct contact with infected animals. In humans, *Yersinia spp.* cause gastrointestinal disease and mesenteric lymphadenitis, and complications such as reactive arthritis, erythema nodosum, bacteraemia and sepsis are reported.

Tb Suveillance in Deer

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Wildlife reservoirs have been implicated as a source of infection for grazing cattle. Infected badgers are considered a maintenance host and are directly implicated in the transmission of *Mycobacterium bovis* to cattle in Ireland (Griffin et al., 2005).

Table 45: Wild deer submissions to DAFM RVLs by county of origin from 2016 to 2020 inclusive (n=739); the total number of deer positive for TB during period was, 45 animals.

County	Wild deer*	TB positive
Clare	44	0
Cork	19	1
Donegal	4	0
Dublin	3	1
Galway	2	2
Kerry	234	1
Kildare	1	0
Kilkenny	13	0
Laois	1	0
Leitrim	30	1
Limerick	3	0
Mayo	1	0
Offaly	55	1
Roscommon	2	0
Sligo	17	0
Tipperary	14	0
Waterford	19	2
Wexford	5	1
Wicklow	272	35

Note:
*Wild deer sampled on post mortem examination in the RVLs.

With respect to deer, their role in acting as a maintenance host for *Mycobacterium bovis* is considerably less clear, in most areas of Ireland there is no evidence in support of deer acting as maintenance host for TB (More, 2019). In certain areas of County Wicklow, a higher prevalence of TB in deer has been found.

Figure 74: A red deer stag in its natural habitat. Photo: Pat Sheehan.

Where there are local concerns around the country that wild deer may be involved in spreading TB, landowners may cull deer and DAFM will test those deer for TB free of charge through the department's regional veterinary laboratory network.

Table 45 shows the number of wild deer *post-mortems*, and number of those testing positive for *Mycobacterium bovis*, the causative agent of bovine TB. These *post-mortems* were carried out in DAFM Regional Veterinary Laboratories over the five years 2016 to 2020 inclusive by reported county of origin of the deer. While the full deer carcass has not always been submitted for *post-mortem*, the head and contents of the thoracic cavity have been consistently submitted for analysis and it is at these two sites that TB is most likely to be found.

The results in Table 45 do not represent a random survey of wild deer, but rather focussed investigations of deer populations in areas where there was local concern regarding transmission of TB between deer and cattle, prompting these targeted submissions.

Wildlife

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DAFM's Veterinary Laboratories examined a number of wildlife species in 2020 both as part of wildlife disease surveillance exercises and also in assisting the National Parks and Wildlife Service (NPWS) in investigating suspected wildlife crimes.

In 2020, DAFM veterinary laboratories examined 101 rabbits and 12 hares. The rabbits examined included wild and some domesticated rabbits e.g., from pet farms. The primary reason for their submissions was ongoing surveillance for Rabbit Viral Haemorrhagic disease 2 (RHD2). RHD2 was first identified in France in 2010 and has subsequently spread worldwide. It was first confirmed in Irish rabbits in Co. Cork in 2016 and was first detected in an Irish hare from Co. Wexford in the summer of 2019. Since then, a number of positive identifications were made across Ireland amongst both wild and domesticated rabbit and wild Irish hare populations. Rabbits are the primary host of this virus and hares are believed to be a *spill over* host. In 2020, 25 *per cent* (n=3) of hares and 36.5 *per cent* (n=37) of rabbits tested were positive for RHD2. The positive hares were from Wexford and Kildare while the positive rabbits were from counties Carlow, Clare, Cork, Galway, Kilkenny, Laois, Louth, Mayo, Offaly, Tipperary, Westmeath and Wexford.

Echinococcus multilocularis is a zoonotic tapeworm that infects the red fox and other canids (dogs, wolves etc.) as a definitive host. The adult tapeworm passes eggs into the intestine, which are excreted in the faeces and ingested by intermediate hosts (mice, voles and shrews typically) which in turn infect the definitive hosts. Infections in the definitive host are generally benign but humans can become infected by ingesting the eggs of the parasite. i.e., an intermediate host

Ireland must provide scientific evidence to the EU of our *E. multilocularis* free status, therefore DAFM undertakes an annual survey of wild fox population from across the country to assess the prevalence of this parasite. In 2020, 404 foxes were sampled and tested and

The island of Ireland is considered free from *E. multilocularis* and therefore it is a requirement under the EU Pet Travel Scheme (PETS) that all dogs entering the country are treated with an anthelmintic effective against *Echinococcus spp.* prior to entering the country.

there was no evidence of infection with this parasite.

Figure 75: Peregrine falcon presented for *post-mortem* examination in the Regional Veterinary Laboratory. Photo: Cosme Sánchez-Miguel.

Since 2011, the DAFM Veterinary Laboratories, the NPWS and the State Laboratory have been managing suspected wildlife crimes through the RAPTOR (Recording and Addressing Persecution and Threats to Our Raptors) Programme. *X-rays*, *post-mortem* examination and toxicology testing are all essential components of this programme.

In 2020, 43 birds were examined in the DAFM veterinary laboratories under the RAPTOR programme, most of which were buzzards (n=32) but also included owls and an osprey. Where preservation allowed, samples were collected at *post-mortem* and were submitted to the State Laboratory for toxicology testing and carbofurans, a widely used pesticide, were detected in 14 cases and anticoagulant rodenticides including difenacoum, flocoumafen and brodifacoum were detected in 6 cases. The confirmation of carbofuran poisoning in twelve buzzards related to submissions from a single incident of multiple deaths in Co Cork. At *post-mortem* examination, carcases were in good to fair body condition with fresh contents in the crop of some birds which was suspected to be chicken meat. The State Laboratory reported that carbofuran was found in excess of the upper point of the calibration range (300 *ug/kg*) and in certain instances significantly above this level.

Animal Health Ireland
Irish Johne's Control Programme

Lawrence Gavey
Johne's disease Programme Manager
Animal Health Ireland

The Irish Johne's Control Programme (IJCP) is a long-term approach to the voluntary control of Johne's disease (JD) in Ireland, strongly supported by Irish dairy industry leadership.

The programme provides a standardised set of activities, technical support from trained veterinary practitioners, and funding. These enable every participating Irish dairy farmer to overcome the complexities of JD and effectively reduce the likelihood and impacts of infection.

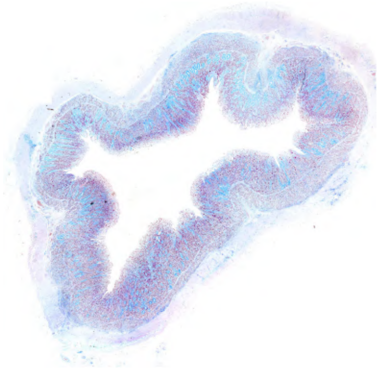

Figure 76: Intestinal section of epithelium showing numerous MAP acid-fast bacilli stained red (Ziehl-Neelsen stain). Photo: Cosme Sánchez-Miguel.

Background

Johne's disease is a concern for livestock industries, particularly dairy. The disease presents as severe wasting of body condition and diarrhoea leading eventually to death, but these overt clinical cases are relatively infrequent. Infected herds also suffer reduced productivity and increased incidence of other conditions such as lameness, mastitis and infertility.

JD also adversely impacts animal welfare and increases use of antimicrobial medications, and greenhouse gas production could adversely affect the social license for dairy production. There is also an association, but not a proven causality, of the bacterium responsible for Johne's disease *Mycobacterium avium* subsp. *paratuberculosis* (Map) (Figures 76 and 77) with human diseases.

The cost to individual herds of Johne's disease varies: an average infected Irish dairy herd which is not showing clinical disease will lose in the order of €2,000 annually in reduced performance, premature culling and lost value for cull animals; but the losses rise sharply once the signs of disease are seen, and these tend to increase in numbers of animals and severity over time.

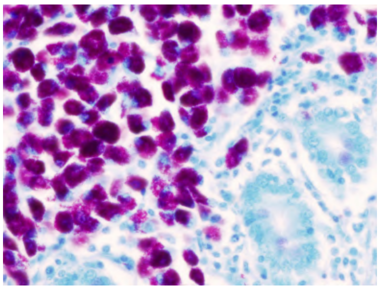

Figure 77: Higher marnification of figure 76 depicting numerous MAP acid-fast bacilli (stained red with Ziehl-Neelsen stain). Photo: Cosme Sánchez-Miguel.

A notable feature of Johne's disease is that Map grows very slowly, either in host animals or in the laboratory. The effects of the slow growth are that the disease has a very long incubation period, the immune response of an infected animal is slow, and laboratory tests for detecting infected animals are relatively poor until late in the course of infection. Cattle are most susceptible to infection as calves. Map infects the intestinal tract and associated lymph nodes. Progression of infection is usually promoted by stress, typically leading to overt disease in dairy cows during the second or later lactations; shedding of Map in faeces to spread infection will usually precede clinical disease.

There is no effective treatment for JD, and vaccination is not currently available. JD is notifiable in Ireland for surveillance purposes; there is no formal regulatory approach to control or eradication.

The prevalence of JD in Ireland appears to have been low, until significant movements of dairy cattle from western Europe following establishment of the single European Market from 1992 and dairy expansion since quotas were removed in 2015. The herd prevalence of JD in the Irish dairy industry is currently estimated at 30 *per cent*. Within infected herds, typically 10 *per cent* of animals are infected.

The programme

In this context of 70 *per cent* of herds not being infected, but herds that are infected suffering clinical and sub-clinical losses, the IJCP has four objectives:

1. Enhance the ability of participating farmers to keep their herds clear of JD.
2. Assist participating farmers to reduce the level of infection in their herds, where present.
3. Provide additional reassurance to the marketplace in relation to Ireland's efforts to control Johne's disease.
4. Improve calf health and farm biosecurity in participating farms.

These objectives are addressed by a combination of herd testing and herd management. The protocol of testing at the herd level deals with the uncertainty of the tests at the individual animal level target.

Eradication of JD is not a realistic target with currently available tools for most farms, although it may be attained on some. The programme aims to protect herds from becoming infected and to minimise spread and impacts of JD in infected herds.

Two key requirements of the IJCP that apply to every participating herd are an annual veterinary risk assessment and management plan (VRAMP), and an annual whole herd test (WHT) by ELISA testing of blood or milk samples.

The purpose of the VRAMP is to review farm management to identify and mitigate the risks of Johne's disease being introduced and spread within the herd. This review is conducted by an approved veterinary practitioner (AVP), a practitioner who has completed training delivered by AHI in Johne's disease and the IJCP. The VRAMP is customised to the circumstances of the herd, such as whether infection is known to occur and farm priorities and capacities to implement changes.

Each annual VRAMP concludes with up to three actions for the farmer to take to reduce the risks of JD. For test-negative herds, those actions might focus on preventing entry of infection by stopping or reducing the movement of animals or slurry onto the farm. For test-positive herds, the actions will focus on minimising spread of infection within the herd, particularly to calves, by removing or isolating high-risk cows, rigorous hygiene especially in calving pens and calf-raising areas, early removal of calves after calving, and providing low-risk colostrum, milk or milk replacer. These hygiene measures are also recommended for test-negative herds.

The purposes of the WHT are to either detect infection if it is present and identify infected animals to guide decisions about isolating or culling animals likely to spread infection; or to provide assurance that a herd is not infected and guide decisions about keeping infection out of the herd.

Herd testing requires every animal on the farm aged two years or more to be tested by ELISA using a sample of blood or milk. Blood samples are collected by a veterinary practitioner, whereas milk samples are typically those collected for milk recording so can be cheaper and more convenient.

An animal for which the ELISA test result is positive or inconclusive is usually then tested by an ancillary faecal PCR test (unless infection is already known to occur in the herd). The purpose of the ancillary PCR test is to confirm the presence of Map in the herd. Positive and inconclusive ELISA results are usually due to an animal's immune response to Map infection, but recent TB testing will commonly cause false-positive ELISA results, and there may be other environmental factors as well.

While a positive ancillary test result confirms infection in the herd and most likely also in the test-positive animal, a negative ancillary test does not prove that an animal is not infected; it only shows that the tested animal was not shedding detectable Map or its DNA on the sampling date. In a herd where infection is confirmed, a positive or inconclusive ELISA test result is very likely due to infection and a PCR test is not supported.

The IJCP also provides a Targeted Advisory Service on Animal Health (TASAH) assessment of infected herds. The TASAH assessment aims to identify the likely source, spread and impacts of infection, and to inform future risk assessments and mitigation measures through subsequent VRAMPs. AVPs undertake additional training to be able to conduct TASAH investigations.

There are pathways for assurance of herds with continuing negative tests and for management of test-positive herds.

The programme provides funded supports for these activities under agreed cost-sharing by stakeholders. For dairy herds, there is very little cost to participate: annual herd ELISA testing is subsidised by each herd's respective milk processor, at a rate approximately equal to the cost of testing using milk samples but decreasing over three years for test-negative herds; also for dairy herds, VRAMPs are funded by DAFM. For all herds (dairy or beef), ancillary PCR testing where required and TASAH assessments are funded under the programme by DAFM and the Rural Development Programme respectively.

Progress

At the end of June 2021, there were 1869 herds registered in the IJCP, comprising 1854 dairy and 15 beef herds. This compares to 1,661 registered herds at the end of 2019, and 1,760 at the end of 2020. Recruitment of herds into the programme slowed during 2020 due to COVID-19 distractions but has resumed in 2021. More than 220,000 tests are conducted each year.

Of the herds that have completed at least one annual WHT, 58 *per cent* are test-negative and 18 *per cent* have confirmed infection. The remaining 24 *per cent* have positive or inconclusive ELISA results without ancillary PCR testing and are considered by the programme to be infected although infection has not been confirmed.

DAFM conducts animal disease surveillance on bulk tank milk samples, testing for a range of diseases including JD. Although this level of testing is considered inaccurate, herds with positive bulk milk results are encouraged by DAFM to register in the IJCP to clarify the true infection status and implement appropriate controls, because if the positive result is true then the level of infection in the herd is likely to be high. Fourteen herds with positive bulk milk results have registered to date.

Information

The programme provides all the information that herdowners and their veterinary advisors need to successfully control JD.

Herd testing and VRAMP data is held on the Irish Cattle Breeding Federation (ICBF) database. This makes it readily accessible, secure, and linked to other relevant herd information, and the format and navigation of the dashboard screen (Figures 78, 79 and 80) is familiar to most farmers. This screen shows test results as a table or interactive chart, highlights in red font outstanding actions, and provides reports on testing and animal movements. Further details on animals' test histories are also presented (Figure 79).

Although the fundamental programme requirements (VRAMP, WHT, ancillary testing and TASAH assessment) are conceptually simple, on-farm variables can make implementation nuanced and complicated. The programme provides a simple overview as a flowchart, with hyperlinks to detailed explanatory notes to ensure that farmers and their advisors have ready access to all they need to know at any step.

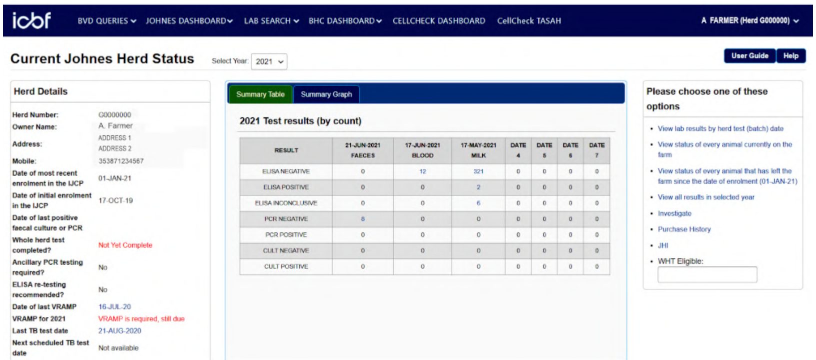

Figure 78: Example ICBF screen.

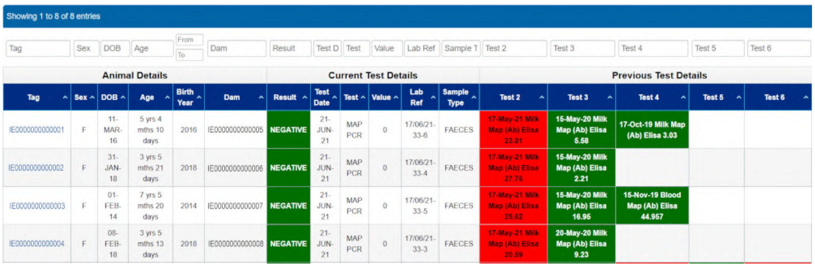

Figure 79: Animal test details on ICBF.

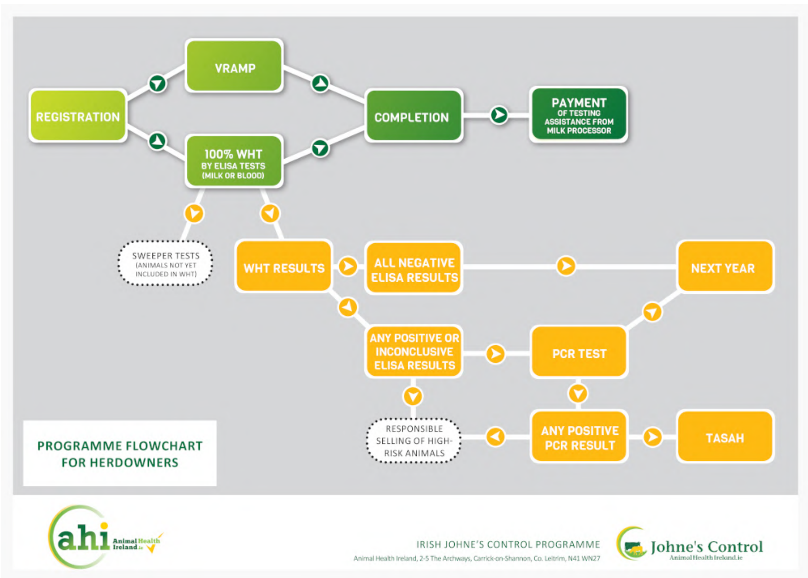

Figure 80: Flowchart, with links to details.

The programme also provides SMS alerts to owners of outstanding requirements whenever results are uploaded, and programme bulletins, leaflets, videos and podcasts. The most recent leaflet explains 10 Good Reasons why every dairy farm in Ireland will benefit from joining the IJCP.

For these and more information, visit the Animal Health Ireland website

Conclusion

The programme continues to evolve as new information and tools become available.

It offers the opportunity now, with generous funding and technical support, for dairy farmers to get on top of an emerging health problem that reduces productivity. Herds that choose not to participate can expect to see JD worsening at the levels of individual animal, herd and industry.

The programme is now also available to beef herds, which will mostly benefit if they are seeing clinical disease or if they seek to provide test-based assurance to market animals as low-risk (primarily applicable to pedigree herds).

Participation in the IJCP is entirely voluntary. However, the benefit-cost ratio with the current funding supports clearly favours control, so all dairy farmers should consider joining. If in doubt, talk to your veterinary practitioner, Teagasc herd advisor, milk quality advisor, milk recorder, or Animal Health Ireland.

Animal Health Ireland
Bovine viral diarrhoea (BVD) Eradication Programme & Infectious Bovine Rhinotracheitis

Maria Guelbenzu
BVD & IBR Programme Manager
Animal Health Ireland

BVD Eradication Programme

A compulsory programme for BVD eradication has been in place in Ireland since 2013[4]. The programme is based in the identification and removal of animals persistently infected (BVD+) with bovine viral diarrhoea virus (BVDV). This is carried out with the use of official identification ear tags that take a tissue sample from each of the calves born on farm.

[4] National Eradication Programme for BVD

Over 2.37 million calves were born in 2020.

Table 46: Animal-level prevalence (%) of BVD+ calves born during each year of the programme by herd type.

Year	Total	Beef	Dairy	Dual
2013	0.66	0.78	0.55	0.80
2014	0.46	0.54	0.37	0.60
2015	0.33	0.39	0.26	0.52
2016	0.16	0.21	0.12	0.23
2017	0.10	0.13	0.08	0.20
2018	0.06	0.07	0.04	0.09
2019	0.04	0.05	0.03	0.07
2020	0.03	0.04	0.02	0.06

As in previous years, a high level of compliance with the requirement to tissue tag test these calves was observed, with results available for over 99.1 *per cent* of these calves. The overall prevalence of births of BVDV positive animals (BVD+) in 2020 continues to decline, with only 0.03 *per cent* of calves tested in the year being considered to be BVD+ with BVDV (Table 46 and Figure 81), with these being located in 0.55 *per cent* of circa 83,000 breeding herds. This represents a decrease in calf level prevalence of 25 *per cent* from that seen in 2019 and is a reduction of more than twenty-two-fold when compared to the prevalence at the start of the compulsory phase of the programme in 2013, when 0.66 *per cent* of the calves born were BVD+. At the end of the year only a handful of BVD+ remained alive, with many counties not containing any virus positive animals (Table 47 and Figure 82).

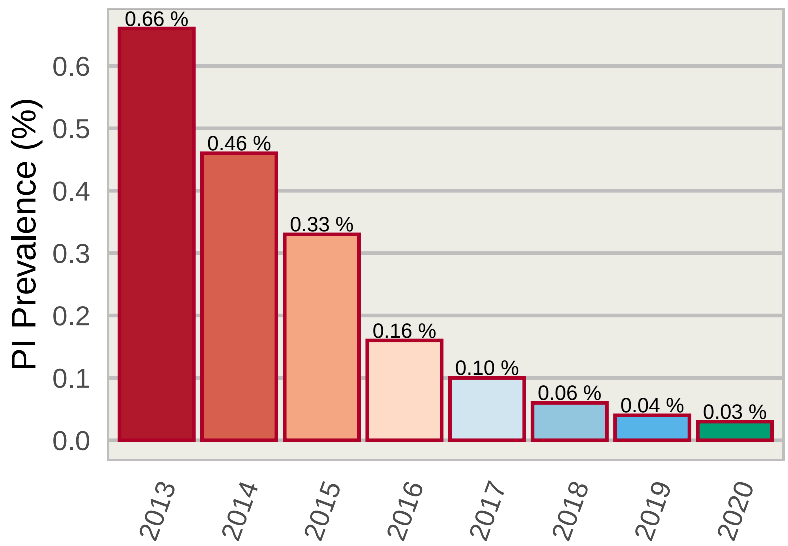

Figure 81: Herd-level prevalence of BVD+ calves born during each year of the programme.

Programme enhancements put in place over the last few years by the BVD Implementation Group (BVDIG), in combination with a decreasing prevalence, have had a significant impact on the prompt removal of BVD+ calves. Whilst in 2018 the median time in days between a positive test result and the removal of the animal was 12 days, in 2019 this was 7 days and in 2020, 6 days. Enhancements introduced include increased levels of financial support for removal of BVD+s within a reduced period of time, the automation of the imposition of restrictions of herds retaining BVD+ calves for more than three weeks after the date of their first result, and mandatory herd investigations within three months of the disclosing result (funded through the Rural Development Plan under the Targeted Advisory Service on Animal Health [TASAH]). Funded, targeted sampling to detect any unidentified BVD+ animals also had to be conducted within 2 months of the positive result. Analysis of results obtained showed that it helped discover the virus source in a number of investigations.

Negative herd status

A herd may qualify for negative herd status (NHS) by meeting the following requirements:

Table 47: Breeding herd-level prevalence (%) of BVD+ calves born during each year of the BVD eradication programme.

Year	Total	Beef	Dairy	Dual
2013	11.3	8.8	20.3	14.1
2014	7.6	5.9	13.2	11.0
2015	5.9	4.4	10.4	9.3
2016	3.3	2.4	5.7	5.1
2017	2.0	1.4	3.9	3.5
2018	1.1	0.8	1.2	1.9
2019	0.8	0.5	1.4	1.7
2020	0.5	0.4	1.0	1.1

1. Existence of a negative BVD status for every animal currently in the herd (on the basis of either 'direct' or 'indirect' results).
2. Absence of any animal(s) deemed to be persistently infected with BVD virus from the herd in the 12 months preceding the acquisition of NHS.

By the end of 2020, over 95.3 *per cent* of herds had acquired NHS, with a further 3,484 only being ineligible due to the presence of a small number of untested animals. While an important programme milestone for any herd, NHS also brings with it an economic benefit, with the number of laboratories that use the RTPCR test method offering testing at reduced costs to herds with NHS.

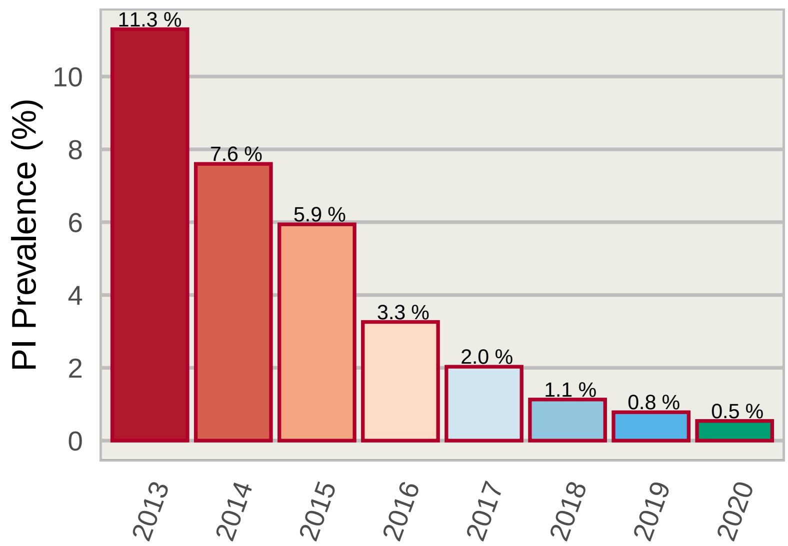

Figure 82: Breeding herd-level prevalence of BVD+ calves born during each year of the programme.

Legislation was amended in May 2020 (Statutory Instrument No. 182/2020 (Bovine Viral Diarrhoea (Amendment) Regulations 2020) making compulsory the testing of all cattle, including animals born before the 1st of January 2013, for the presence of BVD virus. This excludes female animals that have had one or more calves which have been tested for BVD.

The status of almost all animals (99.6 *per cent*) in the 83,000 breeding herds in Ireland is now known, with the main exception being a decreasing number of animals born before the start of the compulsory programme in 2013 that have neither been tested nor produced a calf. At the end of 2020 the number of these animals was approximately 1,700. The majority of these animals are in beef herds, and the majority are also male.

The number of animals born since January 2013 that do not have a valid test result and are therefore not compliant with the requirements of the legislation has also reduced to 10,400 at the end of 2020. The majority of these have never been tested, while a small number have had an initial empty result and not been retested. Most of these animals are 2020-born (88 *per cent*), with smaller numbers from preceding years. During the last few months of 2020 DAFM issued letters to these herds and the BVD Helpdesk also made contact, informing them of the need to test these animals.

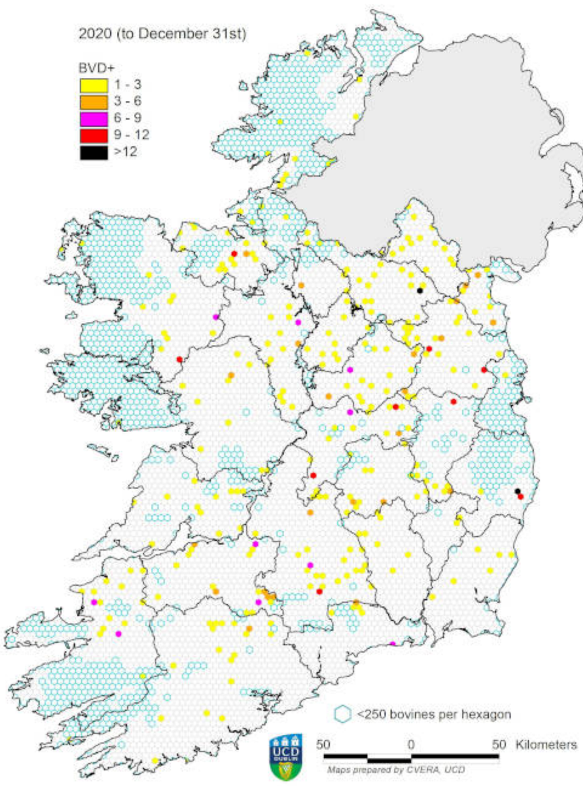

Figure 83: Distribution of calves born persistently infected (BVD+) with BVD virus in 2020. Each hexagon covers an area of approximately 10 km^2. Hexagons in which there are fewer than 250 cattle (e.g. mountainous/urban areas and lakes) are shown with blue border.

Targeted Advisory Service on Animal Health (TASAH)

Since 2017 all herds with positive results are required to undergo an RDP-funded TASAH herd investigation by a trained veterinary practitioner within 3 months of the initial positive result. These investigations, conducted through the Targeted Advisory Service on Animal Health (TASAH) and funded through the Rural Development Plan (2014-2020), seek to review herd biosecurity, identify a plausible source or sources of infection, ensure that the herd is left free from BVDV and agree farm-specific measures to prevent its re-introduction. By the end of 2020, 336 investigations had been completed, biosecurity recommendations provided to herd owners and the results reported to AHI.

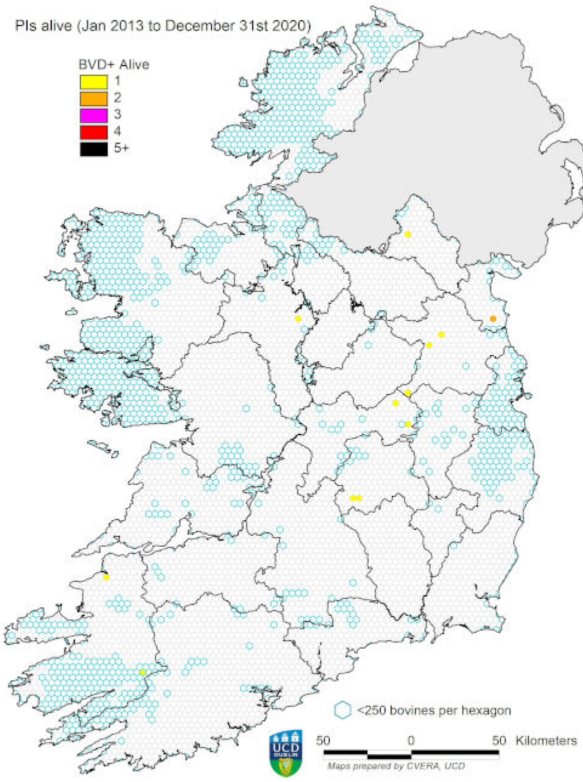

Figure 84: Distribution of persistently infected (BVD+) calves alive in 2020. Each hexagon covers an area of approximately 10 km^2. Hexagons in which there are fewer than 250 cattle (e.g. mountainous/urban areas and lakes) are shown with blue border.

Infectious bovine rhinotracheitis

During 2020 the IBR Implementation Group (IG) was convened for the first time and the IBR Technical Working Group (TWG) developed options for a national IBR programme. In addition, herds in the 19/20 phase of the Pilot IBR Programme carried out whole herds tests and progress was made on the modelling work that will support the programme development.

Over this period, the IBR TWG finalised a first draft of a proposal for a national IBR programme. This aligns with the requirements of the new Animal Health Law Regulations which comes into effect in April 2021. Therefore, the proposed programme would allow Ireland to seek and obtain approval of the programme at EU level and, with time, recognition of freedom. Having an EU-approved programme would facilitate both the export of animals to the increasing number of European countries with either approved IBR programmes, or recognised freedom, as well as the introduction of enhanced IBR requirements for animals coming into Ireland. In addition to the impact of clinical disease on farm, milk yield in IBR-positive herds can also be affected. An Irish study estimated a reduction of 250.l per cow per year in IBR-positive herds, which amounts to an annual cost of €62 million to the Irish dairy industry (Sayers, 2017). A key tool for control that will be included as part of an IBR programme proposal is vaccination.[5]

The IBR IG is composed of representatives from Animal Health Ireland relevant stakeholder bodies. The overall objective is to decide

[5] Currently in Ireland there is a continued high level of expenditure on IBR vaccination. During the 19/20 year, close to 2.7 million IBR vaccine doses were sold, nearly 5 *per cent* more than in the previous 12 months.

on the merits or otherwise of developing a national IBR Programme. During 2020, the group initiated the review of the available evidence on IBR with technical support from the IBR TWG.

BETTER Farm IBR Pilot Programme

Sixteen herds have carried out whole herd tests, which involve sampling and testing of all the animals over 9 months-old in the herd. A total of 2,510 samples were collected and tested with an IBR gE (marker) test. This marker test allows differentiation between animals infected with the virus and those vaccinated with a marker vaccine. The whole herd testing gives a clear picture of the IBR status of the herd and provides key information to develop a strategy to control IBR within infected herds or, for those which are free, to protect them from IBR.

The IBR-trained private veterinary practitioners (PVPs) applied a second on-farm veterinary IBR risk assessment and management plan (VIBRAMP). The VIBRAMP consisted of a questionnaire that captures details of the farm structure, animal movements, biosecurity and vaccination history, with the focus on identifying risky biosecurity practices that may impact the IBR status of the herd. The objective was that the vet and herd owner would review progress against previously agreed biosecurity recommendations and agree up to three changes to improve biosecurity.

Modelling work

A DAFM-funded PhD student, working with the Helmholtz Centre for Environmental Research (Germany) continued working during 2020 on the development of a national IBR model. One of the outputs consisted of a new classification system for Irish herds that was developed as part of this work by combining expert knowledge and a machine-learning algorithm called self-organising-maps (SOMs) (Brock et al., 2021). This approach was applied to the cattle sector in Ireland, generating a detailed understanding of herd classification which will assist with on-going discussions on control and surveillance for both infectious bovine rhinotracheitis (IBR) and bovine viral diarrhoea (BVD). In total, seventeen herd categories were identified (Figure 85). Having demonstrated its representativeness of the national herd, a decision was made to evaluate a regional model of county Kerry which includes 5,000 farms and 400,000 animals.

The model has been calibrated and now the process of simulating the spread of IBR in Kerry and identifying primary, latently infected and naïve animals initiated, with the intention to progress to testing different strategies and their effects on the success, duration and cost of such a programme.

As part of this work, an analysis of seroprevalence data from dairy herds taken during two Irish seroprevalence surveys conducted between 2010 and 2017 was also carried out (Brock et al., 2020)

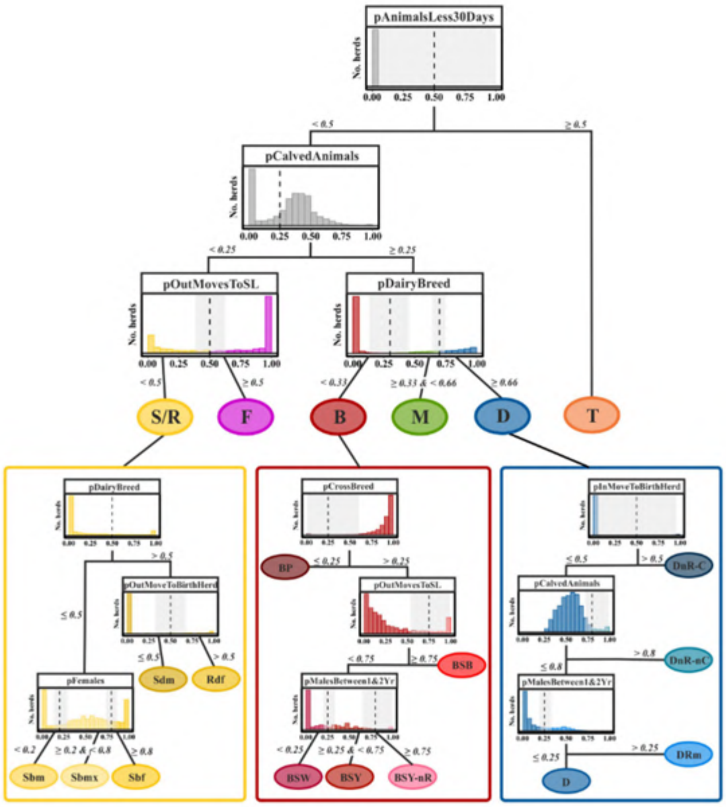

Figure 85: Decision tree for the classification of the Irish cattle sector. Histograms represent herds remaining at the respective node. Numbers and dashed line demarcate thresholds for class assignment. Main herd types: dairy (D), beef (B), mixed (M), store/rearing (S/R), fattening (F), and trading (T) herds. Dairy sub-types: dairy (D), dairy no rearing—contract (DnR-C), dairy no rearing—no contract (DnR-nC), dairy rearing male calves (DRm). Beef sub-types: beef pedigree (BP), beef suckling to weanlings (BSW), beef suckling to youngstock (BSY), beef suckling to youngstock—no rearing (BSY-nR), beef suckling to beef (BSB). Store/rearing sub-types: store dairy males (Sdm), store beef males (Sbm), Store beef females (Sbf), store beef mixed (Sbmx), rearing dairy females (Rdf). The grey rectangles among the thresholds indicate the range in which the classification threshold would have to be moved in order to assign 10 *per cent* of the herds classified in the respective step to the other class.

Age-dependent seroprevalence profiles were constructed for herds that were seropositive and unvaccinated. Analysis showed that IBR outbreaks in dairy herds affect animals independent of age and lead to almost 100 *per cent* seroconversion in all age groups, or at least in all animals within a single epidemiological unit, such as the milking cows. In the absence of circulating infection, there is a year-on-year increase in the age-cohort at which seroprevalence changes from low to high (Figure 86).

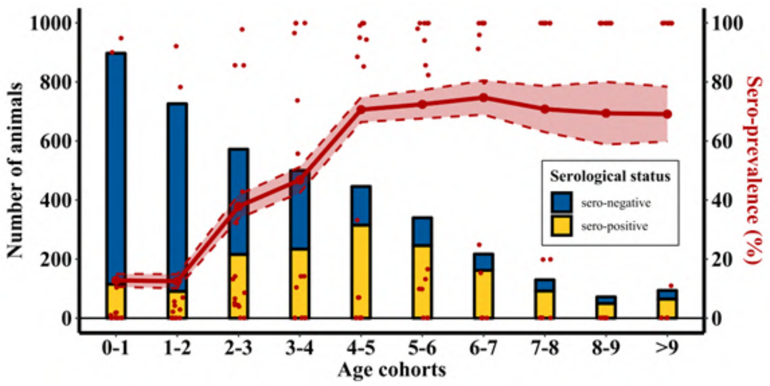

Figure 86: Animal-level seroprevalence in 15 unvaccinated seropositive dairy herds by age cohort. For each, the dataset is shown as the absolute number of seropositive/negative cattle (yellow/blue bar chart, left y-axis); and as a proportion of seropositive animals (red line, right axis, with its 95 *per cent* confidence interval). Red dots (right axis) refer to herd-level seroprevalence for each herd, again by age-cohort. (Note: Across the early and late age-cohorts the individual herds' prevalence values (red dots) tend to dichotomies between zero and 100 *per cent*).

Agri-Food and Bioscience Institute
Bovine Diseases

Diseases of Cattle

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Neonatal Calves (0-1 month old)

As in previous years, enteric infections were the most frequently diagnosed cause of death in the neonatal calf group up to one month of age accounting for 40 *per cent* of cases. Commonly recorded infectious causes of diarrhoea included *E. coli*, *Salmonella* Dublin, rotavirus, coronavirus and *Cryptosporidium*. Inadequate colostrum intake, stress and, poor hygiene contribute to the severity of scour outbreaks. Pathogenic *E. coli* infections usually cause watery diarrhoea in very young calves from about 15 hours to three days of age. Rotavirus is a common cause of diarrhoea in both dairy and beef suckler herds and it usually affects calves from about 4 days to 2 weeks of age. Transit of calves through markets increases the likelihood of exposure to *Salmonella*.

Respiratory tract infections were the next most frequently diagnosed cause of mortality in neonatal calves, accounting for 18 *per cent* of cases. *Mannheimia haemolytica* was the most frequently diagnosed bacterium causing respiratory disease being recovered in 12 of the 67 cases (18 *per cent*) of respiratory infection, followed by *Mycoplasma bovis*, which was detected in 11 of the 67 cases (16 *per cent*) of neonatal respiratory infections. Less frequently identified bacteria included *Arcanobacterium pyogenes* (four cases), *Pasteurella multocida* (three cases) and *Histophilus somni* (two cases).

RSV (Figures 99 and 88) was the most frequently viral respiratory pathogen diagnosed (six cases), followed by PI3 (two cases) and BVDV (two cases). Aspiration pneumonia accounted for seven cases

Table 48: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for post mortem in 2020 (n=363).

Category	No. of cases	Percentage
Enteric infections	147	**40.5**
Respiratory infections	67	**18.5**
Septicaemia / toxaemia	38	**10.5**
Nutritional / metabolic conditions	34	**9.4**
Navel ill / Joint ill	25	**6.9**
Non-infectious gastrointestinal conditions	16	**4.4**
Other diagnoses	12	**3.3**
Peritonitis	9	**2.5**
Diagnosis not reached	7	**1.9**
Central nervous system	4	**1.1**
Heart / circulatory system	4	**1.1**

(10 *per cent* of respiratory infections). Cases of aspiration pneumonia occur most frequently after careless drenching or passage of a stomach tube but cases may also occur if weak or acidotic calves inhale regurgitated stomach contents.

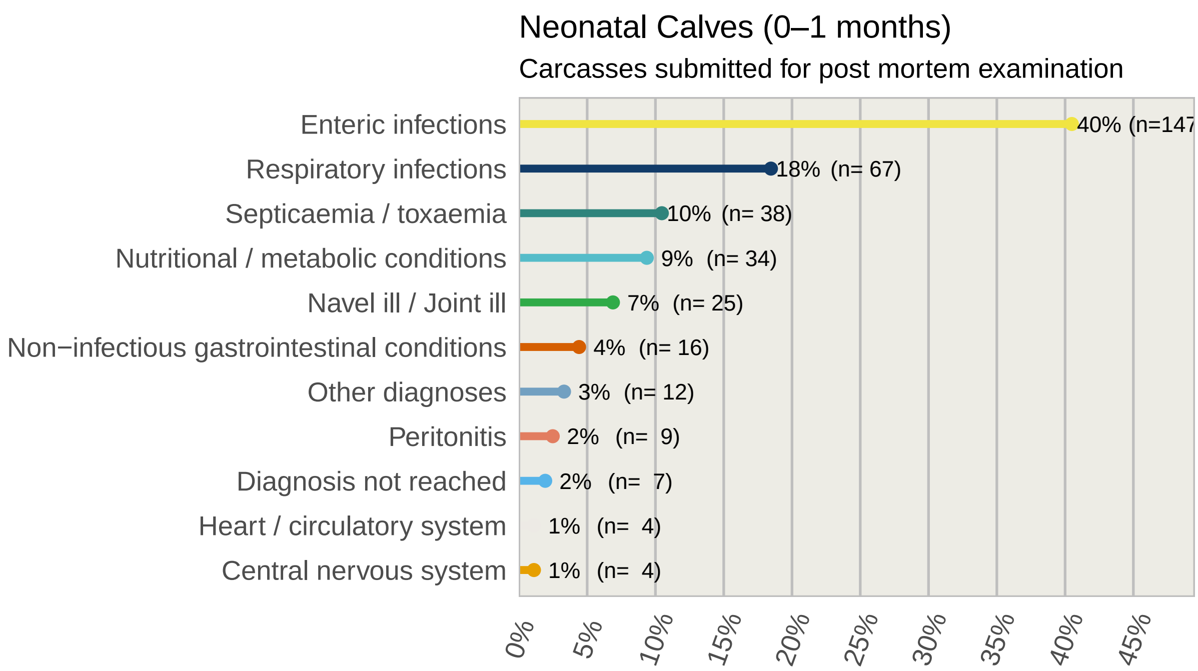

Figure 87: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for *post mortem* in 2020 (n=363).

Death due to septicaemic or toxaemic conditions represented 10 *per cent* (38 cases) of deaths in neonatal to one-month-old calves. Colisepticaemia was the major cause of death in this group, accounting for 26 cases (68 *per cent* of the septicaemic / toxaemic conditions) and emphasises the need for good hygiene in calving pens and neonatal calf areas, adequate disinfection of the umbilicus of new-born calves and of course adequate feeding of good quality colostrum to new-born calves in the first six hours of life.

Hypogammaglobulinaemia due to inadequate absorption of

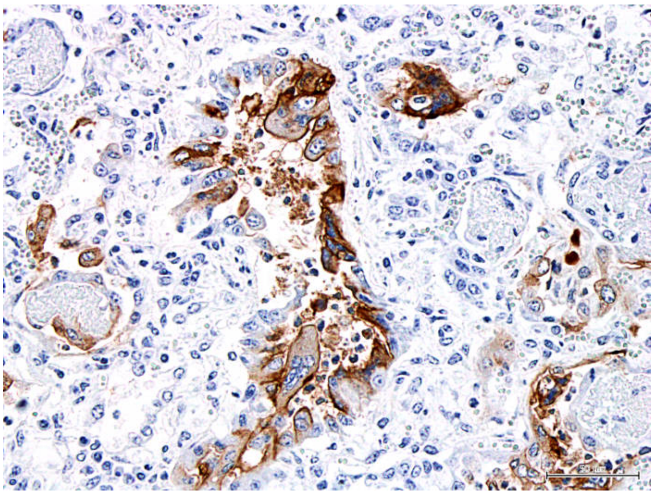

Figure 88: Positive immunostaining (brown colouration) for bRSV in bronchiolar epithelium in a case of bRSV pneumonia in a calf. Photo: Seán Fee.

colostral antibody was recorded in 18 cases and was the most frequently recorded nutritional/metabolic condition (accounting for 53 *per cent* of the diagnoses in this category), followed by 10 cases of ruminal feeders (29 *per cent* of the 34 cases in this category). Ruminal feeders develop in calves where there is a failure of closure of the oesophageal groove, and rather than bypass the rumen as it should milk enters and sours in the rumen. Good husbandry practices are important to prevent the development of ruminal feeders. These include using standardised feeding regimes, feeding calves at the same time each day, feeding the correct volume of milk at a consistent temperature, preparing milk replacer according to the manufacturer's instructions and mixing thoroughly at the advised temperature. Calves should be in an unstressed state when fed and should not be moved, handled or dehorned immediately prior to feeding. Feeding bucket fed calves through teats should help with closure of the oesophageal groove. Clean water should be available to calves at all times.

Calves 1-5 months old

As was the case in previous years, respiratory tract infections and pneumonia were by far the most commonly recorded cause of death in calves from one to five months of age and were recorded in more than 50 *per cent* of cases. Bacterial respiratory infections were most frequently diagnosed. *Mycoplasma bovis* was the most frequently detected pathogen and was recorded in 31 cases (representing 25 *per cent* of the 125 recorded respiratory infections), *Mannheimia haemolytica* was detected in 19 cases (15 *per cent*) and *Pasteurella multocida* was detected in 14 cases (11 *per cent*). *Histophilus somni* was recorded in nine cases (7 *per cent* of respiratory infections) and *Arcanobacterium pyogenes* was recorded in five cases (4 *per cent* of respiratory diagnoses). Parasitic pneumonia due to lungworm was recorded in seven cases. BRSV was the most commonly recorded viral respiratory infection (ten cases) followed by two cases of both IBRV and BVDV pneumonia. There was a single case of PI3.

Category	No. of cases	Percentage
Respiratory infections	125	**52.1**
Enteric infections	20	**8.3**
Other diagnoses	17	**7.1**
Nutritional / metabolic conditions	16	**6.7**
GIT torsions /obstruction	13	**5.4**
GIT ulcer / perforation	9	**3.8**
Septicaemia / toxaemia	8	**3.3**
Diagnosis not reached	7	**2.9**
Peritonitis	7	**2.9**
Clostridial disease	6	**2.5**
Urinary tract conditions	5	**2.1**
Nervous disease	4	**1.7**
Cardiovascular conditions	3	**1.2**

Table 49: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for post mortem in 2020 (n=240).

Conditions affecting the gastrointestinal tract including infections, metabolic conditions such as ruminal acidosis, bloat, gastrointestinal torsion, obstruction, ulceration and/or perforations were recorded in 58 cases and thus represented almost one quarter of the 240 conditions recorded in calves from one to five months old. Enteric infections were the most important of these gastrointestinal conditions (20 cases or 8 *per cent* of diagnoses in this age group). Coccidiosis was the most frequently recorded enteric infection (seven cases or 35 *per cent* of the enteric infections recorded) followed by *Cryptosporidium* (two cases).

Coccidiosis may occur in contaminated conditions such as damp, dirty straw bedding indoors or around feeding and drinking troughs contaminated with faeces outdoors. Diarrhoea is sometimes accompanied by straining and blood may frequently be observed in the faeces. Veterinary advice on treatment should be sought and attention should be paid to the hygiene of calf pens and the cleanliness and positioning of feeding troughs.

Of the nutritional and metabolic conditions recorded, ruminal acidosis was most frequent (seven cases) and there were five cases of bloat.

Gastrointestinal ulcers and perforations were the next most common cause of disease in this age group. Three cases of perforation of the abomasum were recorded and a further five cases of abomasal ulceration were recorded. The causes of abomasal ulceration and perforation are non-specific and include calf stress, as well as husbandry and nutritional factors. There were 12 cases of gastrointestinal torsion. Gastrointestinal torsion may occur subsequent to increased or decreased gastrointestinal motility which in turn is affected by nutritional changes and upsets, gas accumulation and bloat, carbohydrate overload and acidosis.

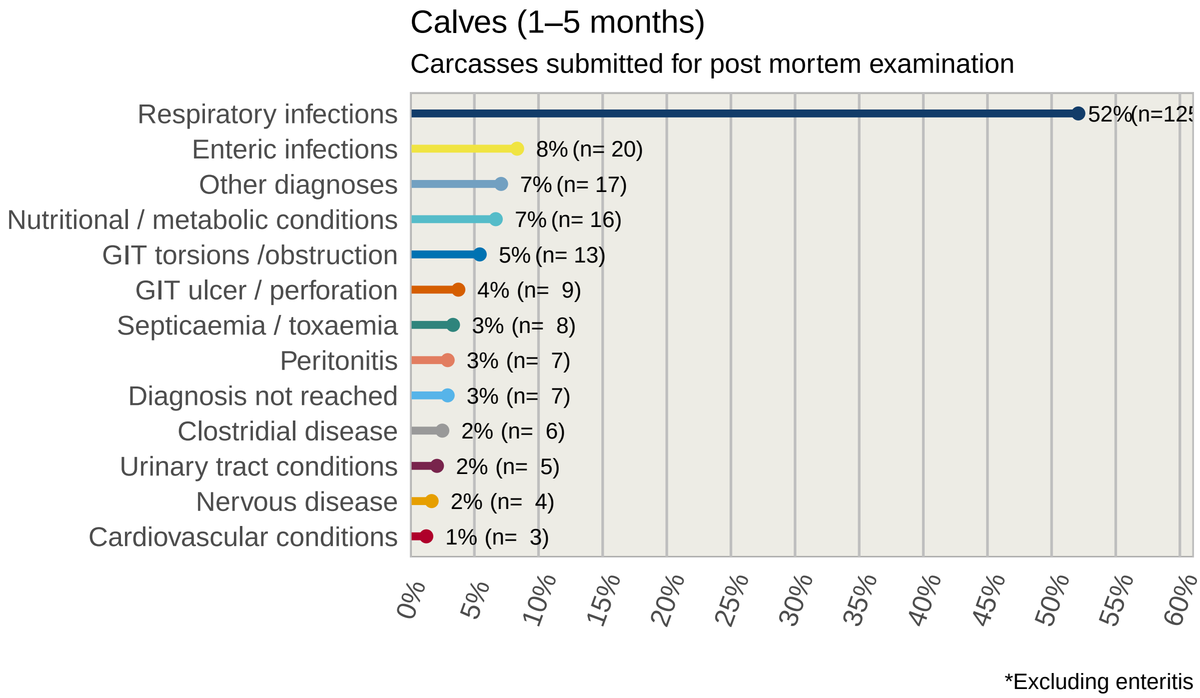

Figure 89: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for *post mortem* in 2020 (n=240).

Weanlings 6–12 months old

Pneumonia was the main cause of death in older calves (from six to 12 months old) followed by clostridial infections and then gastrointestinal conditions. Bacterial infections were again the most frequently recorded cause of respiratory infections. *Mycoplasma bovis* was detected in 15 cases representing 20 *per cent* of respiratory diagnoses, *Pasteurella multocida* was detected in seven cases (9 *per cent* of respiratory diagnoses), *Haemophilus somni* in four cases and *Mannheimia haemolytica* in four cases. Parasitic pneumonia due to lungworm infection was recorded in 17 cases. Lungworm was the most frequently detected infectious agent causing respiratory disease in this age group (representing 23 *per cent* of respiratory infections). Respiratory infections caused by viruses were detected in 14 cases (19 *per cent* of respiratory infections) with BRSV most frequently recorded (six cases), followed by BVDV (five cases), PI3 infection (two cases) and a single case of IBR also detected in this age group.

Table 50: Conditions most frequently diagnosed in calves six to twelve months old submitted to AFBI for post mortem in 2020 (n=133).

Category	No. of cases	Percentage
Pneumonia	74	**55.6**
Clostridial disease	19	**14.3**
Gastrointestinal conditions	17	**12.8**
Other diagnoses	8	**6.0**
Cardiovascular conditions	6	**4.5**
Diagnosis not reached	4	**3.0**
Liver disease	4	**3.0**
Poisoning	1	**0.8**

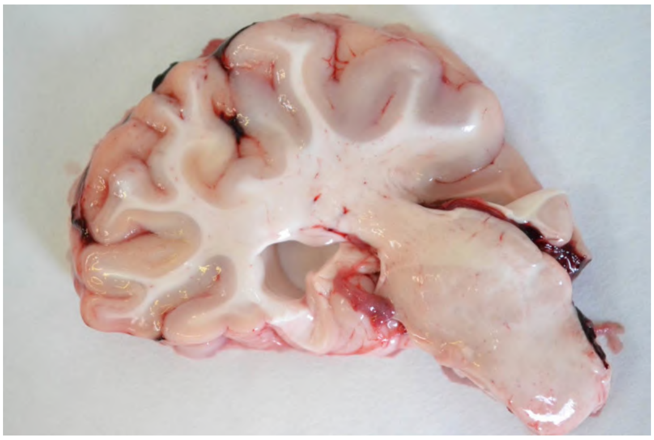

Figure 90: Cerebrocortical necrosis (CCN) in a five month old calf. Note the pale cerebral cortex. This calf presented staggery and 'as if drunk' and died despite treatment. Photo: Seán Fee.

Nineteen cases of clostridial disease were recorded (16 *per cent* of diagnoses in this age group) with most of these being cases of blackleg (18 cases or 95 *per cent* of the clostridial infections recorded). The remaining clostridial infection detected in this age group was a single case of botulism.

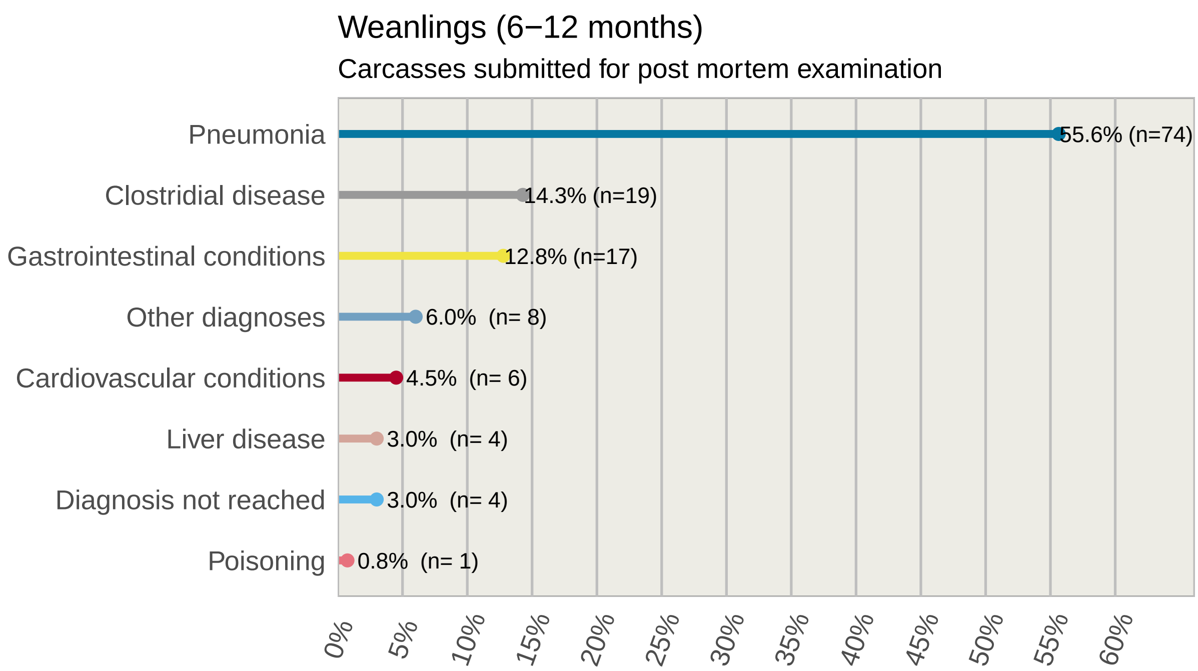

Figure 91: Conditions most frequently diagnosed in calves six to twelve months old submitted to AFBI for *post mortem* in 2020 (n=133).

Gastrointestinal conditions represented 14 *per cent* of cases (17 cases) recorded in weanlings. BVDV/Mucosal disease was the most frequently recorded condition (recorded in seven cases) and it accounted for 41 *per cent* of the gastrointestinal conditions recorded. Other significant gastrointestinal conditions recorded included parasitic gastroenteritis (three cases) and bloat (two cases).

Adult Cattle (older than 12 months)

As has been the case in previous years, respiratory infections were the most frequently diagnosed cause of death in adult cattle (greater than 12 months old). *Mannheimia haemolytica*, an increasingly important cause of pneumonia, particularly in adult cows, was the most frequently reported respiratory pathogen and 15 cases of this infection were recorded (23 *per cent* of respiratory infections in adult bovines). *Mycoplasma bovis* was the second most common respiratory pathogen recorded with eight cases recorded (12 *per cent* of the 66 respiratory infections). Other bacterial respiratory infections recorded were *Trueperella pyogenes* (seven cases) and *Pasteurella multocida* (four cases). Six cases of viral respiratory infection were detected comprising two cases of IBR, two cases of BRSV, and a single case each of PI3 and BVDV infection.

Figure 92: Rhinitis due to IBR virus in a 12 month old Charolais heifer. Photo: Seán Fee.

Parasitic pneumonia (hoose) remains an important cause of death in adult cattle with six cases detected on *post mortem* examination. Hoose may occur in older cattle grazing contaminated pasture where anthelmintic regimes or grazing practices are not conducive to acquiring protective immunity at a younger age.

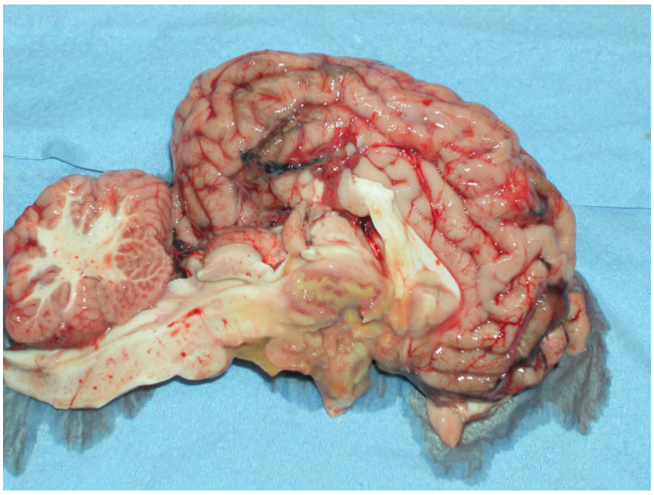

Figure 93: Pituitary abscessation in a ten year old bovine which presented stiff, reluctant to rise and slabbering at the mouth. Photo: Seán Fee.

Table 51: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for post mortem in 2020 (n=306).

Category	No. of cases	Percentage
Respiratory infections	66	**21.6**
Cardiac / circulatory system	38	**12.4**
Diagnosis not reached	38	**12.4**
Nutritional / metabolic conditions	29	**9.5**
Other diagnoses	20	**6.5**
Reproductive / mammary conditions	18	**5.9**
Clostridial disease	14	**4.6**
Enteric infections	13	**4.2**
Liver disease	13	**4.2**
GIT ulceration / perforation / foreign body	12	**3.9**
Urinary tract conditions	10	**3.3**
Intestinal or gastric torsion / obstruction	8	**2.6**
Peritonitis	8	**2.6**
Nervous system conditions	7	**2.3**
Poisoning	7	**2.3**
Skeletal conditions	5	**1.6**

Diseases of the heart and circulatory system (38 cases) accounted for 12 *per cent* of the conditions recorded in cattle older than 12 months. There were 12 cases of vegetative endocarditis, which was the most frequently reported cardiovascular diagnosis, three cases of pericarditis, three cases of cardiac abscessation and three cases of thrombosis of the caudal vena cava. Thrombosis of the caudal vena cava is an occasional complication of liver abscessation and liver abscessation is predisposed to by repeated bouts of ruminal acidosis. Two cases of death due to aneurysm and rupture of a major artery were recorded with the aorta and the uterine artery being respectively involved.

Nutritional and metabolic conditions accounted for 29 cases (9 *per cent* of the cases in adult cattle) which represents an increase on the 25 cases (6 *per cent* of the cases in adult cattle) recorded in 2019. The main conditions encountered included hypomagnesaemia (14 cases), hypocalcaemia (eight cases), acidosis (four cases) and ketosis (two cases).

Clostridial disease was responsible for 5 *per cent* of deaths in adult cattle in N Ireland. Blackleg and botulism were the most commonly diagnosed clostridial diseases in adult cattle in N Ireland (five cases of each were recorded) and black disease was diagnosed in four cases .

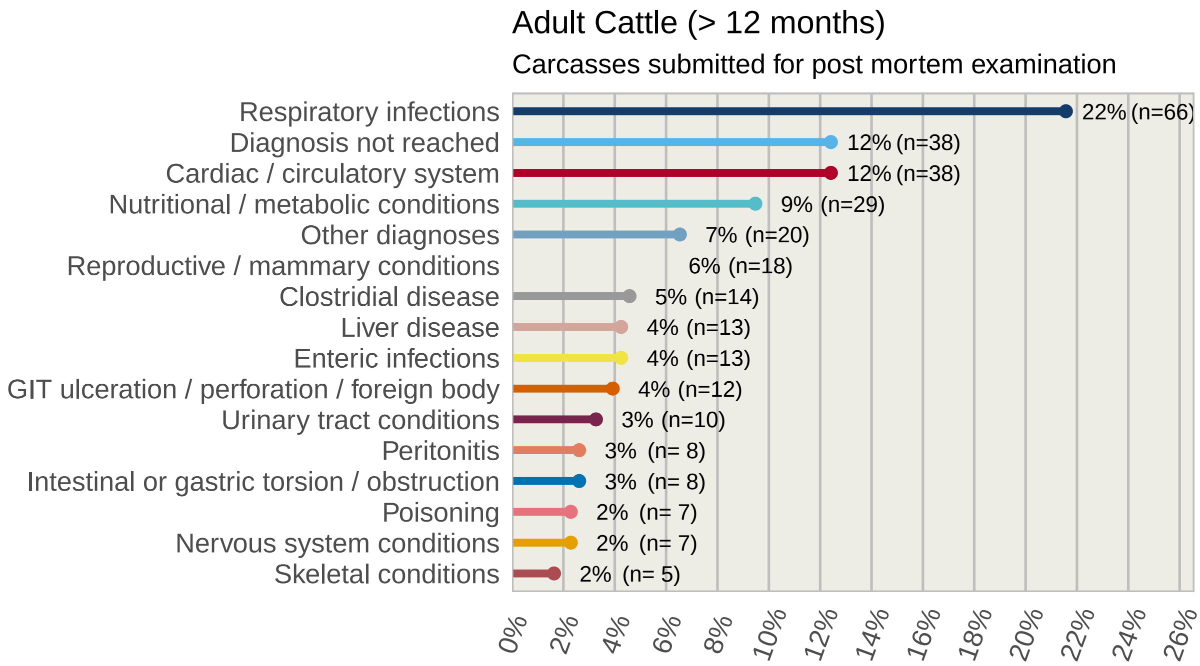

Figure 94: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for *post mortem* in 2020 (n=306).

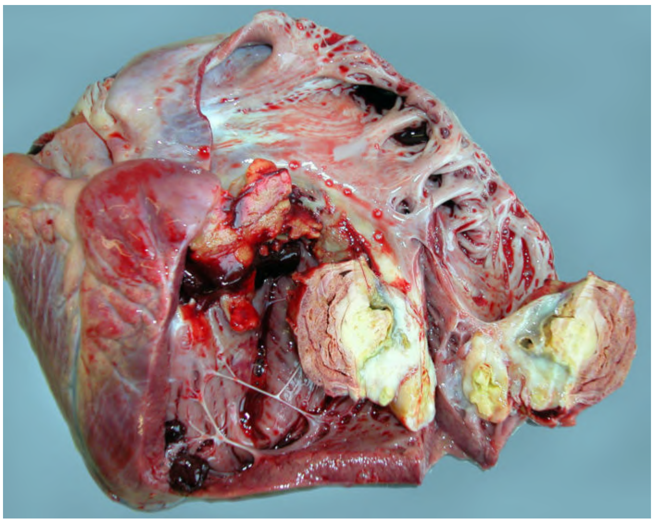

Figure 95: Vegetative endocarditis affecting heart valves of a 15 month old bull. Photo: Seán Fee.

Bovine Respiratory Diseases

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Bovine respiratory disease remains one of the most significant causes of morbidity and mortality in bovines greater than one-month-old with a slight increase in numbers in 2020 compared to 2019. 36 *per cent* of total bovine carcases received at AFBI labs in 2020 succumbed to respiratory infections.

Table 52: Relative frequency of the different aetiological agents identified in cases of pneumonia diagnosed during post mortem by AFBI in 2020 (n=212).

Category	No. of cases	Percentage
Mycoplasma bovis	57	**26.9**
Pasteurella haemolytica	43	**20.3**
Dictyocaulus viviparus	27	**12.7**
Pasteurella multocida	24	**11.3**
Bovine Respiratory synthical virus BRSV	20	**9.4**
Histophilus somnus	14	**6.6**
Trueperella pyogenes	13	**6.1**
Bovine Viral Diarrhoea (BVD)	8	**3.8**
Infectious Bovine Rhinotracheitis (IBR)	5	**2.4**
Fungal	1	**0.5**

Due to bovine respiratory disease being a multiple aetiology syndrome the specific cause of respiratory symptoms is virtually impossible to pinpoint on clinical signs alone, hence the necessity for post mortem examination to get a more specific diagnosis which can then be used to treat and prevent future cases on the farm where possible.

Animals on every farm will inevitably be carrying some infectious agents within the respiratory tract however disease usually manifests when natural defences are low or when the burden of infection in the environment is overwhelming.

Mycoplasma bovis is by far the most commonly diagnosed bacterial agent and continues to provide a challenge to veterinary practitioners due to its well-recognised characteristics of having the ability to evade the animal's immune system and exist without necessarily causing clinical signs. It is important to reiterate that although infection with *Mycoplasma bovis* can manifest as a chronic caseonecrotic bronchopneumonia, a positive result on PCR testing must be interpreted with caution as it may not be the reason for mortality or indeed morbidity in a particular case. As with all cases the result should be interpreted in conjunction with the clinical picture and findings of

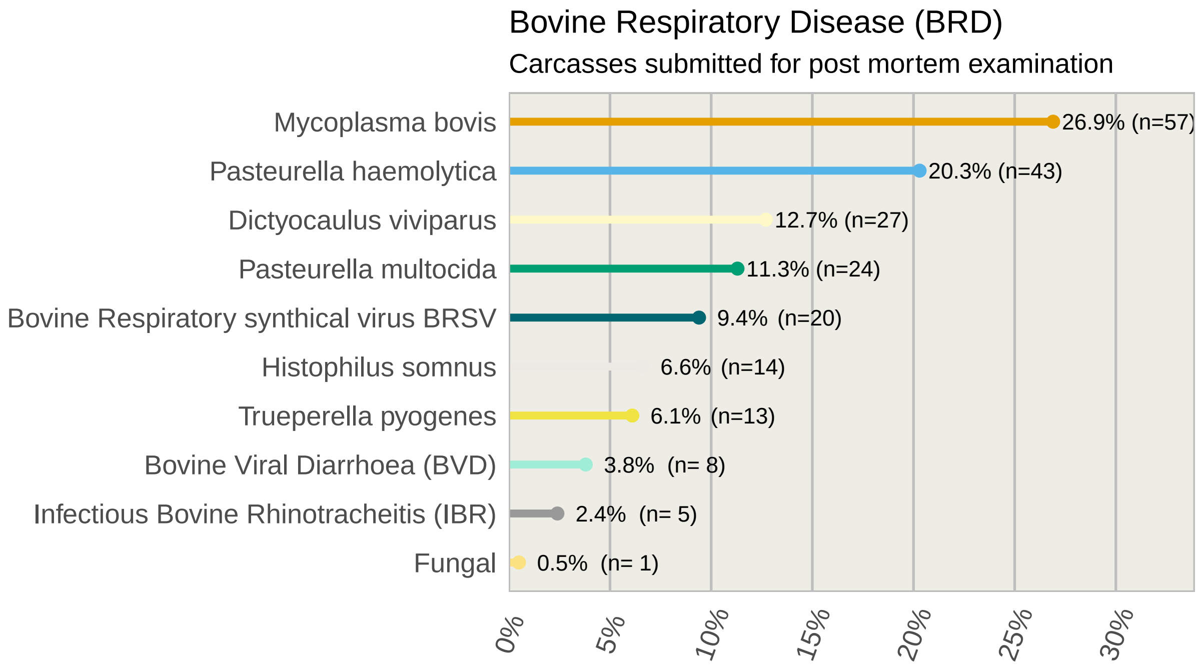

Figure 96: Relative frequency of the different aetiological agents identified in cases of pneumonia diagnosed during *post mortem* by AFBI in 2020 (n=212).

post mortem examination. There are no commercial vaccines available however some commercial companies are licensed to produce autogenous vaccines.

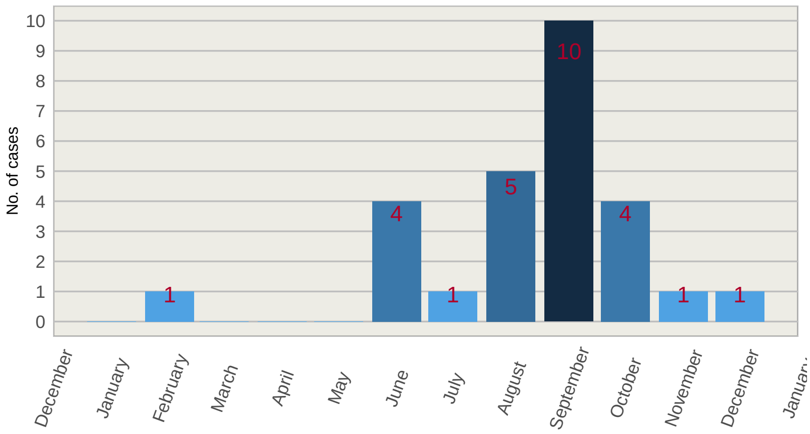

Figure 97: Number of lungworm cases diagnosed during *post mortem* by AFBI per month in 2020, (n=212).

Mannheimia haemolytica, at 20.3 *per cent* of all respiratory cases comes second to *Mycoplasma bovis*. *Mannheimia haemolytica* is often considered to be stress or management induced with generally the involvement of a primary infectious agent underlying. Animals are usually dull and inactive with a marked fever and cough which progresses to dyspnoea with abdominal breathing and death. Gross post mortem often reveals a fibrinous pleurobronchopneumonia.

Respiratory Syncytial Virus (RSV) remains the commonest cause of bovine viral respiratory disease. The condition is spread mainly by aerosol and tends to favour young naive cattle. On gross PM affected sections of lung have a firm rubbery texture. The virus impairs alveolar macrophage function and attacks the mucociliary apparatus with the formation of syncytial cells (Figure 99). It reduces mucociliary clearance allowing subsequent invasion by secondary bacterial invaders which in some instances can obscure RSV diagnosis. By itself RSV infection symptoms range from mild disease to fatal.

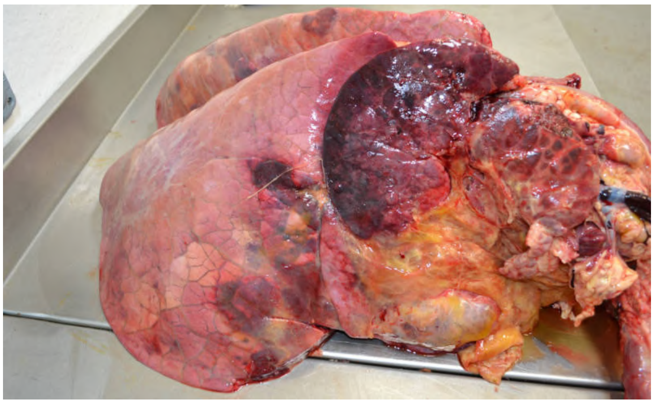

Figure 98: *Mannheimia haemolytica* in a bovine lung. Photo: AFBI.

Lungworm also known as *Dictycaulus viviparous* causing a parasitic bronchitis continues to be a significant cause of respiratory disease during summer and autumn with peaks in June and September. Typically infection affects young cattle during their first grazing season with clinical signs occurring during the pre-patent and patent phases of infection. Animals exposed to infection usually develop resistance to re infection however lack of exposure due to animals being housed all year round and/or anthelmintics with extended period of action allows an opportunity for infection in often older animals with inadequate immunity. Outbreaks of lungworm are often unpredictable causing severe losses on the farm even at low pasture levels. Worm control strategies should be carefully discussed on an individual farm basis with lungworm vaccination a consideration. All bought in stock should ideally be treated and quarantined to minimise risks.

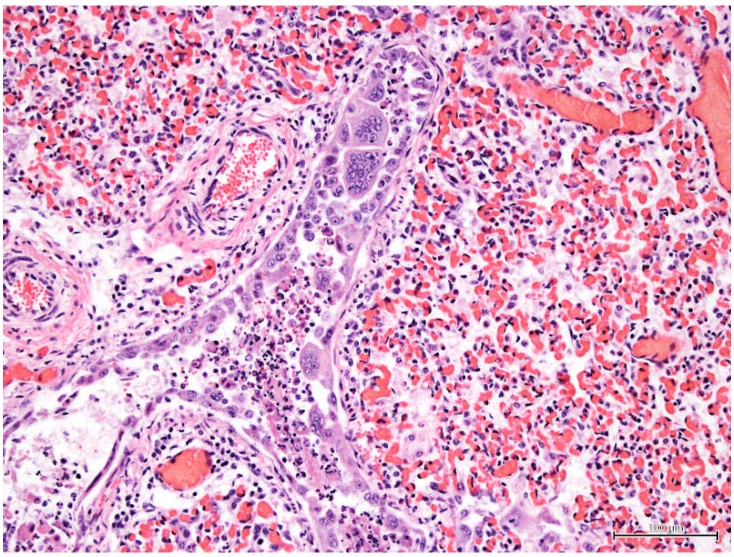

Figure 99: Bronchiolar epithelial syncytia (white arrows) in a case of pneumonia due to bRSV infection in a three-week-old calf. Photo: Seán Fee.

Sampling to achieve best results for respiratory disease in the field

To achieve a successful diagnosis of respiratory disease the entire fresh carcase should be submitted if at all possible. If this is not possible samples taken in the field should include a sample of fresh unfixed diseased tissue in a plain pot for culture, immunofluorescence and PCR and also a section of tissue fixed in formalin for histopathology. The samples chosen for sampling in the field should be representative of the affected tissue. A detailed history including clinical signs, duration, numbers affected and treatment administered will all add value when interpreting test results and histopathology.

Bovine Mastitis

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Mastitis is a hugely important production disease of the dairy industry in Ireland. It causes significant losses due to reduction in milk yields and potential future yields, milk quality penalties, costs associated with treatment of infections, losses due to culling cows with chronic infections and casualties from severe acute cases.

Table 53: Bacterial isolated in milk submitted to AFBI in 2020 (n=637).

Category	No. of cases	Percentage
E.coli	235	**36.9**
Streptococcus uberis	179	**28.1**
Staphylococcus aureus	95	**14.9**
Bacillus licheniformis	35	**5.5**
Streptococcus dysgalactiae	32	**5.0**
Yeast	20	**3.1**
Bacillus cereus	16	**2.5**
Trueperella pyogenes	15	**2.4**
Corynebacteria	3	**0.5**
Pasteurella multocida	3	**0.5**
Steptococcus agalactiae	2	**0.3**
Fungi	2	**0.3**

Identification of a mastitis pathogen is important as different pathogens require different mastitis management strategies and targeted treatment. Pathogens causing mastitis tend to be categorized into contagious and environmental causes. Contagious pathogens are those for which udders of infected cows serve as the major reservoir. They spread from cow to cow primarily during milking and tend to result in chronic sub clinical infections with occasional flare ups. Environmental pathogens are those whose primary reservoir is in the environment. They tend to cause clinical disease of shorter duration.

A total of 637 isolates were cultured from milk submitted to the lab from acute and chronic mastitis cases. The significance of the organism will depend on the cell count, the level in which the organism was isolated and whether or not it was isolated in pure culture. Isolation of 3 or more species in samples submitted suggests contamination during the sampling procedure. Interpretation of mastitis results should therefore be undertaken with care

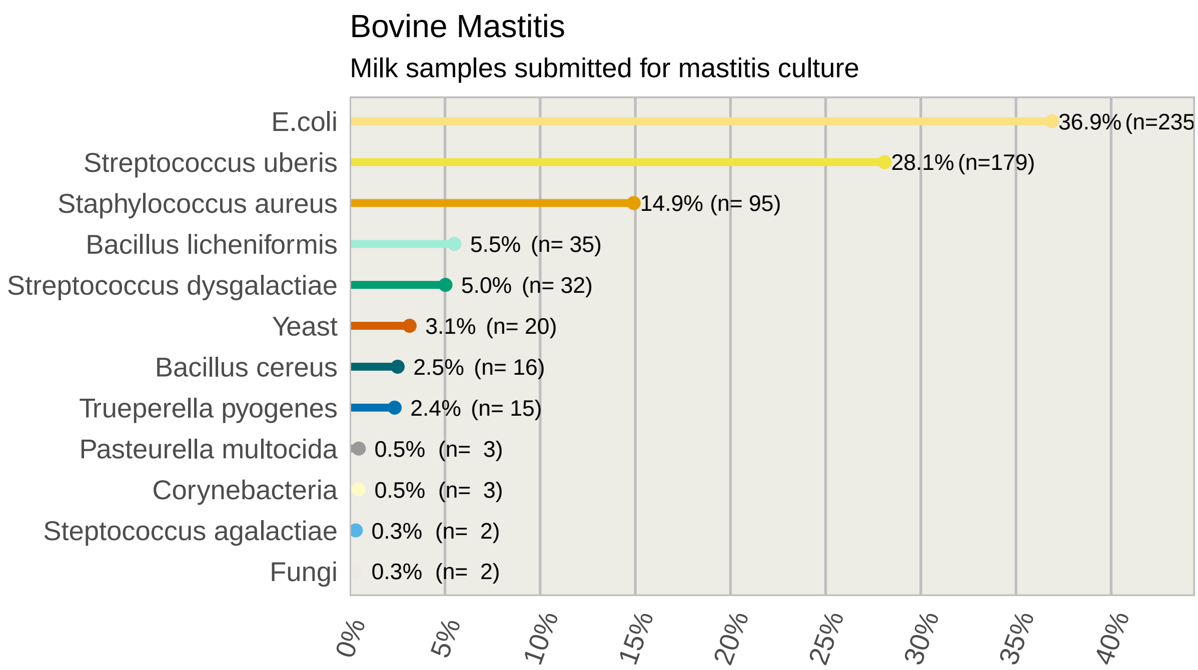

Figure 100: Bacteria isolated in milk samples submitted to AFBI in 2020 (n=637)

E.coli, an environmental cause of mastitis was the most frequently isolated organism in 2020 accounting for 36.9 *per cent* of isolates cultured. Risk factors include poor hygiene, suboptimal milking machine function, teat end damage and lactation.

Another frequently identified environmental organism, *Streptococcus uberis* was identified in 28.1 *per cent* of submitted samples.

Staphylococcus aureus, a *contagious* cause of mastitis typically spreads from cow to cow via the milking equipment or milker's hands. It was identified in 14.9 *per cent* of samples submitted in 2020. This was the third most frequently cultured mastitis associated bacterium.

Bovine Abortion

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Cases of bovine abortion comprised 33 *per cent* of all AFBI bovine *post mortem* submissions in 2020, compared with 31.3 *per cent* in 2019, with similar monthly trends of increasing abortion submissions during the winter months.

An infectious agent was identified in 48.9 *per cent* of submissions and this reflects that infections of dam or foetus are not the only causes of abortions, and non-infectious causes include: genetic anomalies in the foetus; maternal conditions such as dehydration, fever, malnutrition, nutrient deficiency; and toxic insults for instance plant, fungal or chemical toxins.

Therefore, to increase the likelihood of diagnosing the cause of an abortion it is important to examine and sample the dam, the placenta and the foetus. Placental damage or infection may occur without spread of the infectious agent to the foetus, particularly with fungal placentitis and Ureaplasma infections, and as many placental lesions are focal, a large portion of placenta should be examined, with the tip of the pregnant horn being a frequent site for placental lesions in cattle. Retained placenta is also useful as there will be less environmental contamination present. While a freshly dead foetus significantly increases the opportunities to recover a pathogen, many foetuses have been dead for a period of time before they are expelled and in these circumstances serum from the dam and any available placenta are of value, as are further abortion cases from the same farm.

In 2020, AFBI investigated 380 bovine abortion submissions, with infectious agents identified in 48.9 *per cent* of abortion cases and of these, bacterial agents comprised 80 *per cent* of infectious diagnoses. Both jurisdictions in Ireland are officially free of *Brucella abortus* and all bovine abortions submitted to AFBI are cultured for *B. abortus* to assist confirming that disease free status is maintained. As in 2019, *Bacillus licheniformis*, *Trueperella pyogenes* and *Salmonella spp* were the most frequently diagnosed agents occurring in 22 *per cent* of all bovine abortion submissions. Numbers of cases due to *Neospora caninum* were similar between the years, while the proportion of abortions attributed to *Leptospira sp.* had decreased from 2019.

Bacillus licheniformis is a primary abortifacient, not requiring prior compromise of the dam or placenta to infect and cause abortion, and is mostly frequently recovered from abortions during winter. The dam becomes bacteraemic with *B. licheniformis*, which invades the placenta and causes placental necrosis and inflammation, then invading

Table 54: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2020, (n=323).

Category	No. of cases	Percentage
No infectious agent identified	165	**51.1**
Trueperella pyogenes	25	**7.7**
Bacillus licheniformis	25	**7.7**
Salmonella spp	23	**7.1**
Other	20	**6.2**
Neospora caninum	19	**5.9**
E.coli	18	**5.6**
Streptoccocal spp	8	**2.5**
Pasteurella spp	5	**1.6**
Leptospirosis	5	**1.6**
Bovine Viral Diarrhoea	4	**1.2**
Listeria monocytogenes	3	**0.9**
Aspergillus spp	3	**0.9**

the foetus causing a multifocal suppurative pneumonia. Fibrin coating the foetal lungs is sometimes seen at *post mortem*. Abortion associated with *Bacillus licheniformis* is often sporadic, however outbreaks on farm can occur if levels of the organism in the farm environment are high, and high levels have been detected in pit silage and water troughs, particularly when water troughs have been soiled by silage or faeces. Control measures include ensuring rapid drops in pH in silage during ensiling, feeding good quality silage to pregnant animals, removal of stale or spoiled silage from feed passages before replenishing and regular cleaning of drinkers and water troughs.

In 2020 *Trueperella pyogenes* was diagnosed in 7.7 *per cent* of the bovine abortions submitted to AFBI. It is a commensal organism of bovine skin and mucous membranes, but is also an important opportunistic pathogen and often recovered from suppurative infections. Apart from uterine infection isolates, few differences in virulence factors have been detected in commensal strains of *T. pyogenes* compared with strains isolated from sites of infection, supporting an opportunistic mode of action, and as endometrial stromal cells are particularly sensitive to the pyolysin toxin of *T. pyogenes*, the uterus is a vulnerable site during a *T. pyogenes* bacteraemia or from ascending infection from the vagina, should the barrier of the cervix be incomplete. *T. pyogenes* associated abortions are typically sporadic, with a suppurative placentitis, oedematous cotyledons and congested foetal lungs, while histologically there may be numerous bacteria with a limited inflammatory response.

Salmonella spp were associated with 7.1 *per cent* of the bovine abortion submissions to AFBI in 2020, with diagnoses peaking in the second half of the year, a trend recognised in both spring and autumn calving dairy herds. *S.* Dublin, a cattle adapted serotype of Salmonella enterica subspecies enterica, can also cause disease in humans, with endemic infections in a cattle herd persisting for

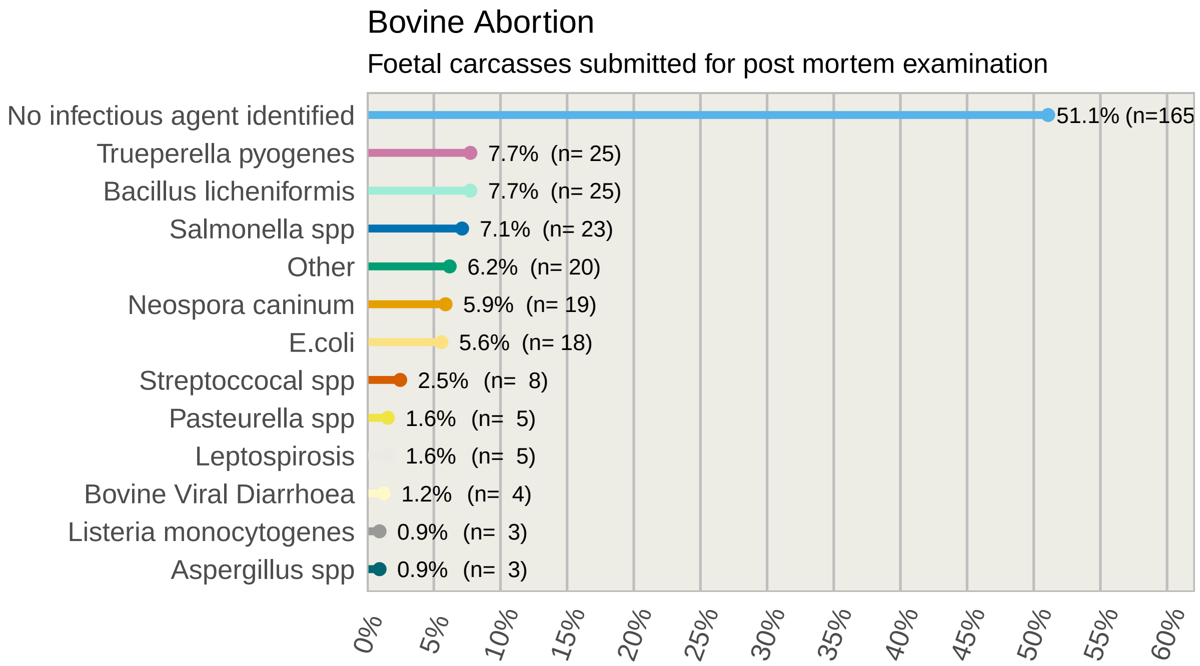

Figure 101: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2020 (n=323).

many years in carrier animals and manifesting in a wide range of clinical signs from abortion, diarrhoea, ill thrift, sudden death to bone infections and gangrene.

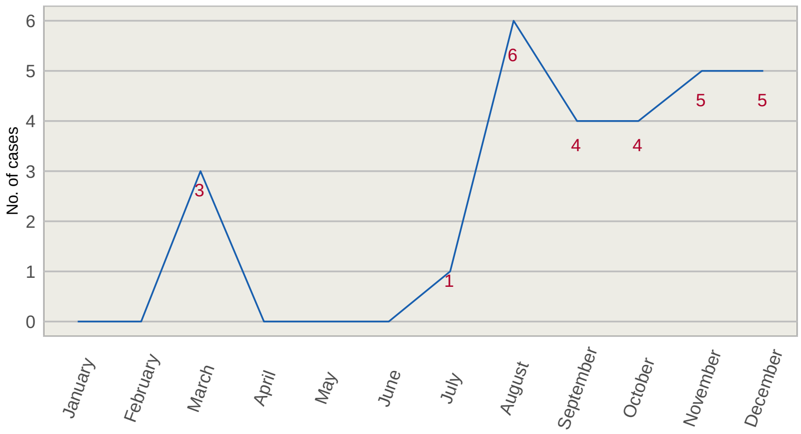

Figure 102: Number of abortions with a diagnosis of S Dublin per month in 2020, showing the seasonal trend of increasing incidence during the summer and autumn months.

Cattle can be infected via the feed, water, bedding or equipment, or introduction of carrier animals into the herd, with abortions being sporadic or epizootic and often preceded by a stressful event such as transport or change of feed, usually occurring in late gestation. The abortion follows a bacteraemia in the dam and the cow may appear well or show signs of ill-health in the previous week such as enteritis. The bacteraemia leads to destruction of the foetal placental villi and the placenta may appear thickened, with exudate of the cotyledons, and possibly there may be portions of caruncle still attached, but it is often retained after the abortion. The foetus may not be invaded by the Salmonella organism at the time of abortion and samples such as placenta and maternal serum would be necessary to confirm the diagnosis.

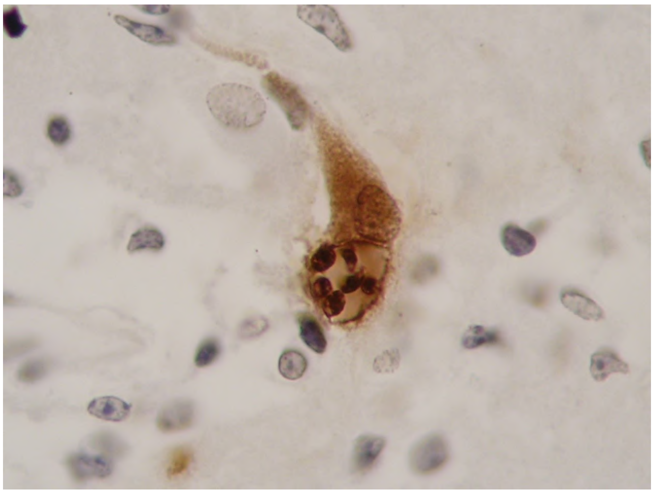

Figure 103: *Neospora caninum*in the brain of a bovine foetus, stained by immunohistochemistry. Photo: AFBI.

Neospora caninum was detected by AFBI in 5.9 *per cent* of bovine abortions during 2020. *N. caninum* is associated with abortions late in gestation, although it may also have a role in early embryonic loss and increased rate of return to service. A cow can be infected by ingesting oocysts shed by recently infected dogs (horizontal transmission) or from the dam before birth as the parasite crosses over the placenta and into the foetus. Placental and foetal infection may result in abortion, birth of weak calves, or birth of viable calves which are infected for life by the parasite and subsequently an infected heifer may pass the parasite to her offspring, perpetuating the infection down the generations. The risk of an infected cow aborting is greatest in the first pregnancy after infection, and other risk factors include, a previous abortion, a purebred pregnancy, poor quality fodder particularly mouldy feed and natural water sources such as ponds.

Fungal infections were rarely diagnosed in the bovine abortion submissions, reflecting the few placental submissions received for investigation, with the placenta being the main target of fungal infection.

A range of bacterial agents were recovered from sporadic cases of bovine abortion, including *Streptococcus sp* and *Staphylococcus sp*, while *Escherichia coli* was diagnosed in 5.6 *per cent* of abortion submissions. In many instances these bacteria, normal gut and mucosal commensal organisms may have been opportunistic infections when the dam's innate defences were lowered.

Zinc Sulphate Turbidity Testing

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The Zinc Sulphate Turbidity Test is a means of identifying a failure of passive transfer of maternal immunoglobulins to calves and lambs in the immediate *post-natal* period. The nature of the ruminant placenta is such that there is little or no passive transfer of immunoglobulins in utero and so the offspring relies on absorption of immunoglobulins present in colostrum through the intestinal wall to provide passive immunity to infections in the first weeks of life, such as those causing enteric diseases and septicaemia.

The test indirectly measures the concentration of immunoglobulins in serum, particularly IgG, through a salt precipitation reaction in which the resulting turbidity is proportionate to the concentration of immunoglobulins, which is measured by colorimetry.

The ZST is best utilised to assess colostrum management on a herd basis. Several healthy calves/lambs should be sampled (approx. 10) as individual results can vary and not be representative of the herd situation. In addition, sick animals can have lowered levels of immunoglobulin due to antigen binding or protein loss, or falsely elevated levels due to dehydration. Neonates should be sampled between 1 and 7 days of age, but not within the first 24 hours as it takes some time following colostrum ingestion to reach peak circulating immunoglobulin levels.

AFBI carries out ZST tests on serum samples submitted by veterinary surgeons, and on samples collected at *post mortem* examination on calves up to two weeks of age. A ZST result of 20 units is considered to represent adequate immunoglobulin absorption from colostrum; anything below this is considered inadequate, and indicates likely failure of passive transfer of immunity.

In 2020, a total of 698 serum samples were tested; of these 574 were diagnostic samples submitted from live calves, and 124 were obtained at *post mortem* examination. This represents a decrease from total number of samples tested in 2019, which were 761 and 232 respectively. The explanation for this is likely to be that the laboratory did not receive samples between mid-March and early June 2020 due to the global Coronavirus pandemic, and it is during this period of the year that the majority of herds are calving and most samples are received.

The 2020 results are shown in figures 104 and 105 where it can be seen that, of the diagnostic samples tested, 22 *per cent* were inadequate while 78 *per cent* were adequate, whereas the results of those obtained at *post mortem* showed that 53 *per cent* of samples were adequate and 47 *per cent* were inadequate. This frequent finding of inadequate ZST levels in neonatal calves submitted for *post mortem* would suggest a link between failure of passive transfer and neonatal

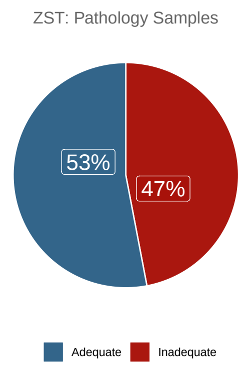

Figure 104: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2020 from bovine calf serum samples taken at *post mortem*(n=124). Adequate colostral immunity is defined as greater than or equal to 20 units.

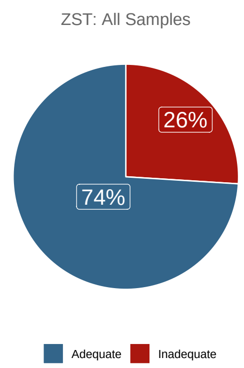

Figure 105: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2020 from bovine calf serum samples (n=574). Adequate colostral immunity is defined as greater than or equal to 20 units.

mortality.

These results indicate that failure of passive transfer of immunity to neonates continues to be a problem in herds, and so highlights the need to continue to reiterate the importance of good colostrum management. Colostrum absorption has been shown to be most efficient in the first four hours after birth, and decreases rapidly after 12 hours of age, and it is recommended that all calves receive 3 litres of good quality colostrum within the first 2 hours of life. Studies have shown that failure of passive transfer is more likely in calves allowed to suckle than calves that are hand fed colostrum, for example by bottle or oesophageal tube. This is likely to be related to a longer interval before suckling, which is prolonged further by dystocia, and therefore the calf does not have enough time to suckle a sufficient volume within 12–24 hours of birth. Absorption of immunoglobulins may also be affected by bacteria in colostrum which is ingested whilst searching for the teat.

Figure 106: A useful on farm tool for measuring the concentration of immunoglobulins in colostrum is a Brix refractometer and so can aid in the overall picture of colostrum management in the herd.

Bovine Neonatal Enteritis

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Enteritis continues to be the most commonly diagnosed condition in submissions from calves less than one month of age to AFBI; submissions are made up of both faecal samples submitted by PVPs and carcases of calves submitted for *post mortem* examination. Diarrhoea, which results in dehydration, metabolic acidosis and electrolyte depletion, is the usual presenting sign but in some cases death can occur without significant diarrhoea. Differentiation of the specific cause cannot be made on clinical signs, or on gross *post mortem* findings alone and ancillary tests are necessary. Often in the case of a herd outbreak, mixed infections occur with multiple pathogens being present, so in order for a comprehensive diagnosis to be made and appropriate preventative and prophylactic measures to be taken, it is important that submissions are made from multiple untreated calves in the early stages of clinical disease that are representative of the herd problem. Often the disease agents are only transiently present and the changes produced are rapidly obscured by autolysis, so in the case of carcases submitted for *post mortem* examination, these should be as fresh as possible to get the maximum diagnostic value. As with all diagnostic samples, a good clinical history which includes farm type, calves affected, age of calves when first affected and management practices can improve the diagnostic value of the submission.

Table 55: The frequency of common enteropathogenic agents identified in calf faecal samples tested by AFBI in 2020.

Organism	No. Tested	Positive	Percentage
Cryptosporidium species	515	**163**	31.7
Rotavirus	541	**173**	32.0
Coronavirus	543	**24**	4.4
Escherichia coli K99	352	**29**	8.2

Similarly to the pattern that has been reported in the previous few years, in 2020 *Cryptosporidium spp* and Rotavirus were the two agents most frequently detected. In 2020, the proportion of samples tested positive for both these agents was very similar, at 31.6 *per cent* and 32 *per cent* respectively. *E. coli* expressing the K99 fimbriae was once again the third most commonly reported agent at 8.2 *per cent* of samples tested, an increase again from 2019 (6.8 *per cent*), followed by Coronavirus, which was as in previous years, the fourth most commonly detected pathogen at 4.4 *per cent*. Frequently, more than one pathogen is detected in a single sample, or from different samples from the same outbreak, and often where mixed infections are present the disease severity and mortality rate is greater than where single infections are present.

Cryptosporidiosis, most commonly caused by *Cryptosporidium parvum*, a single-celled parasite, produces a watery diarrhoea in calves between 7 and 13 days of age. The organism infects cells of the small intestine and heavy colonisation occurs quickly through rapid replication. Animals are infected through ingestion of oocysts produced in large numbers by other infected calves. The oocysts have a tough outer shell and can survive for long periods in the environment, being resistant to many commonly used disinfectants and able to withstand a wide range of temperatures, thus are difficult to remove from the environment. In addition, only a small number of oocysts are required for infection to occur, and oocysts shed by infected calves are immediately infective for other susceptible calves. To put this into perspective, a 2013 study demonstrated that as few as 17 oocysts was sufficient to cause diarrhoea and oocyst shedding, and infected calves can shed up to $3x10^{10}$ oocysts over a six day period.

The only licensed product for treatment of Cryptosporidiosis in calves is halofuginone lactate, and it is approved for both prevention and treatment, however it cannot be used if animals have had signs of diarrhoea for more than 24 hours. It must be administered within 48 hours of birth for use as a prophylactic agent, and for use as a treatment it must be given within 24 hours of the onset of diarrhoea, and administered daily for seven consecutive days, which can be difficult to manage particularly for beef calves kept with their dams. It does not completely prevent or cure disease but can reduce oocyst shedding and the duration of diarrhoea.

These factors make it difficult to control exposure to the parasite on farm. Infection is usually self-limiting when present as a single pathogen, however when present with another agent, often Rotavirus, mortality can be high, and in recovered calves there have shown to be long term detrimental effects on weight gain for several months following infection. Control of infection relies on strict hygiene measures, separating infected and non-infected calves and proper cleaning and disinfection of calf accommodation using an ammonia based substance, followed by drying out and ideally leaving empty for a prolonged period.

Cryptosporidium spp can cause zoonotic infections in humans, particularly young children, elderly people and those who are immunocompromised, so a diagnosis of Cryptosporidiosis should be accompanied by advice regarding zoonotic precautions.

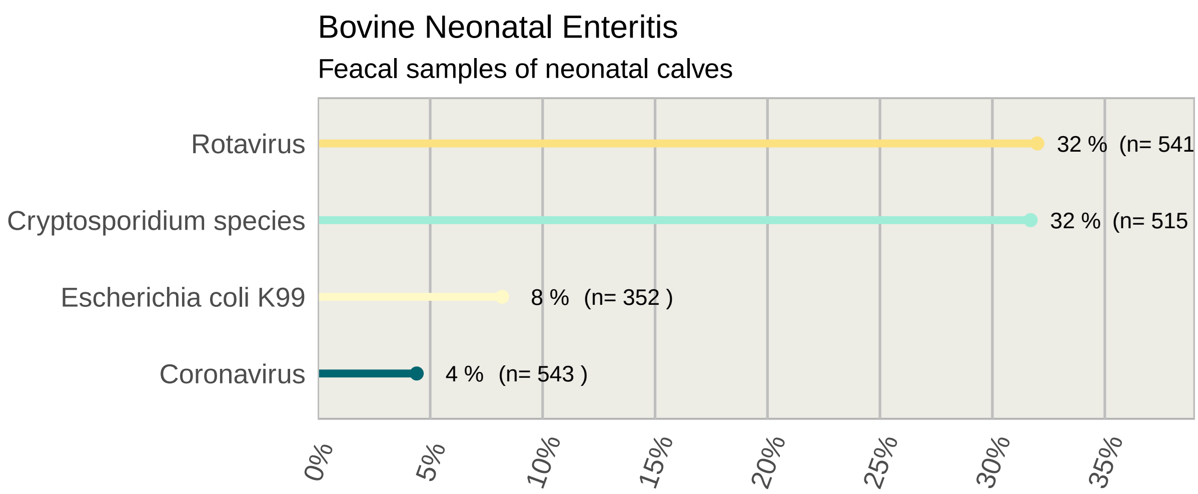

Figure 107: Frequency of common enteropathogenic agents identified in calf faecal samples tested by AFBI in 2020.

Rotavirus and Coronavirus are ubiquitous in the environment and are passed by adult cows. Both cause villous atrophy which results in diarrhoea due to maldigestion and malabsorption in calves 1 to 3 weeks old. Maldigestion leads to undigested food in the colon which causes bacterial overgrowth and increased osmotic pressure which exacerbates the diarrhoea. Rotavirus affects the upper small intestine whereas Coronavirus affects a larger proportion of the small intestine, and also frequently causes necrosis of the epithelial cells lining the colon and so causes a more severe diarrhoea.

E. coli K99 is so-called due to the fimbrial antigen it possess which allows it to attach to the epithelial cells of the small intestine. Here it produces a toxin which causes an efflux of fluid into the small intestinal lumen. The attachment factors are only present on the cells of the very immature small intestinal villi, and so the organism usually causes disease in the first 6 days of life. The severity of the fluid loss into the intestine can be such that the calves die of dehydration and electrolyte imbalance before diarrhoea is detected. Faecal samples submitted to AFBI from calves less than two weeks old are routinely tested for *E. coli* K99. In 2019, the method for testing samples for *E. coli* K99 was changed to an Enzyme Linked Immunosorbent Assay (ELISA) which detects the K99 attachment factor; this means that the attachment factor can be detected on dead bacteria and therefore is useful on calves which have received antibacterial therapy. This may account for the increase in the proportion of positive results from previous years.

Bovine Parasites

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Parasitic gastroenteritis

Ostertagia ostertagi, *Cooperia oncophora* and *Trichostrongylus spp.* are parasitic nematodes which can cause gastroenteritis in cattle. The main source of infection for calves is L3 larvae of *O. ostertagi* on the pasture, derived from eggs shed earlier in the year by older cattle harbouring infection that they acquired the previous year. Infection with *Trichostrongylus spp.* and *C. oncophora* is usually acquired from *L3* larvae on the pasture that have survived from the previous autumn due to mild over-winter conditions.

In calves, cycles of autoinfection in the summer and early autumn (June to September) are associated with *Type 1* parasitic gastroenteritis (PGE: persistent watery diarrhoea and weight loss up to 100 *kg*). Later in the season, from September onwards, *L4* larvae of *O. ostertagi* become inhibited in the abomasal lining, and will give rise to next year's crop of adult worms. Maturation of these worms is associated with *Type 2* PGE (intermittent diarrhoea and anorexia in yearling calves in spring, with shedding of eggs on early pasture). Diagnosis of PGE is carried out by Faecal Egg Counts (FEC) on diarrhoeic faeces samples, and ideally several individual samples (up to 10) should be submitted from each group of scouring calves. Samples with a FEC of 500 *eggs per gram* (*epg*) and greater indicate clinically significant PGE.

In 2020, 5.1 *per cent* (number of samples examined, n=1790) of bovine faeces samples submitted to AFBI for parasitological examination had a FEC ≥ 500 *epg* (Figure 108), compared to 3.9 *per cent* of samples submitted in 2019 and 4.9 *per cent* of samples submitted in 2018. As in 2019 and 2018, the peak months for clinically significant gastrointestinal nematode infection were August and September

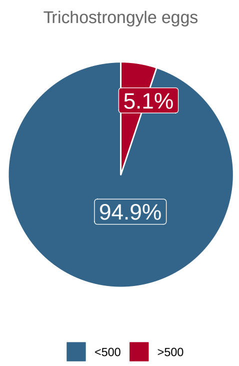

Figure 108: Relative frequency of detection of trichostrongyle eggs in bovine faecal samples examined by AFBI in 2020 (n=1790).

(perhaps corresponding with incidence of *Type 1* PGE in calves, having reached the limit of anthelmintic cover by long-acting products administered early in the year). Often a lower peak occurs earlier in the year (presumably corresponding with *Type 2* PGE in yearlings), but the record for 2020 was incomplete due to Covid-related closure in the late spring.

Control of PGE in calves is usually carried out using anthelmintic drugs which may be administered therapeutically (to treat calves when scouring and immediately eliminate clinical signs of infection) or prophylactically. In the latter situation, calves are usually grazed until July, then treated with a long-acting anthelmintic to reduce faecal egg output and avoid subsequent rise in infective larvae on pasture. Anthelmintic treatment would normally be repeated at housing, but when using long-acting products, care should be taken not to inhibit the normal development of immunity. Whilst at present resistance of cattle nematode parasites to commonly-used anthelmintic drugs is not a major problem in Northern Ireland, it is advisable for stockholders to be aware of best practices for sustainable use of anthelmintics on their premises.

Up-to-date guidelines regarding sustainable control of parasitic worms in cattle is provided by the COWS initiative.

Liver fluke

In 2020, *Fasciola hepatica* incidence dropped to 6.0 *per cent* (n = 1628) of bovine faecal samples submitted to AFBI (Figure 109), compared to 6.6 *per cent* in 2019 and 12.5 *per cent* in 2018. It is likely that this reflects the availability of the infective metacercarial cysts on pasture in the late autumn and early winter of 2019. This, in turn, relates to the influence of rainfall and surface moisture in the preceding 6 months on the abundance and spread of the intermediate host, *Galba truncatula* (Figure 110), and the development of the fluke infective stages within it. The risk of fluke infection each year, based on climatic data, is predicted by AFBI staff and published in the farming press in October. Pathogenesis of liver fluke depends on the number of metacercariae ingested and the stage of parasite development within the liver.

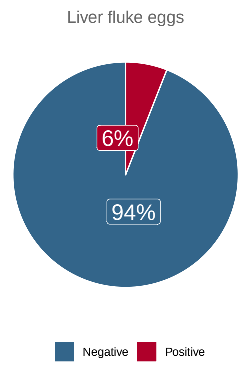

Figure 109: Relative frequency of detection of liver fluke eggs in bovine faecal samples examined by AFBI in 2020 (n=1628).

The acute phase of infection, which is rarely symptomatic in cattle, occurs while parasites migrate through the hepatic parenchyma. Fluke eggs are not present in faecal samples during this phase, and diagnosis of infection rests on blood testing for evidence of liver damage. The chronic phase of infection corresponds to the presence of adult parasites residing in the bile ducts, leading to characteristic calcification of ducts and the pipe-stem liver appearance visible on *post mortem* (Taylor et al., 2015).

Fluke eggs are present in faecal samples at this stage, and diagnosis is often confirmed by ELISA testing to demonstrate fluke coproantigens in the faeces. Liver fluke infection, fasciolosis, has major economic implications for livestock productivity due to the resulting morbidity and mortality (McCann et al., 2010). Carcases that have been infected by liver fluke have poorer conformation and lower cold weight than those free of liver fluke (Sanchez-Vazquez and Lewis, 2013). When clinically significant fasciolosis has been diagnosed in a herd by examination of representative faecal samples by FEC or coproantigen testing (10 individual samples is recommended for each group of cattle sharing common pasture), treatment is usually recommended using any of several products containing anthelmintic active against the mature flukes (eg. clorsulon, oxyclozanide, albendazole, nitroxynil), bearing in mind the relevant withdrawal periods. Triclabendazole, while active against all stages of fluke including the early migrating immatures, may not be fully effective on many farms, particularly where sheep are also kept, due to the widespread occurrence of fluke resistance to the drug (Hanna et al., 2015). It is important to treat infected cattle prior to turn-out in spring, in order to prevent pasture contamination with fluke eggs (Fairweather et al., 2020).

Figure 110: Galba truncatula, intermediate host of liver flukes on wet pasture. Photo: AFBI.

Rumen fluke

Adult *Calicophoron daubneyi* flukes (also known as paramphistomes) (Figure 112) are found in the reticulum and rumen and are generally well tolerated, even with heavy burdens. Any pathogenic effect is usually associated with the intestinal phase of infection, where immature flukes, hatched from ingested metacercariae, attach to the duodenal mucosa before migrating to the forestomachs; diarrhoea, anorexia and rectal haemorrhage may be noted.

Young animals at pasture in late summer or autumn may be affected if the climatic conditions earlier in the year, or localised flooding, have favoured population build-up of the snail intermediate host, *Galba truncatula* (the same as for *F. hepatica*). However, a large number of animals with rumen fluke eggs detected in their faeces show few, if indeed any, clinical signs of disease. Incidence of positive bovine faecal samples at 48.5 *per cent* (Figure 111) (n = 1630) shows a slight decline compared with that in 2019 (52.6 *per cent*) and 2018 (55 *per cent*). In faecal examinations, the eggs of *C. daubneyi* can be distinguished from those of *F. hepatica* by their characteristic

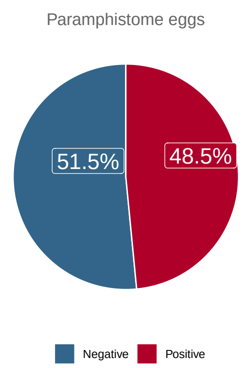

Figure 111: Relative frequency of detection of Paramphistome eggs in bovine faecal samples examined by AFBI in 2020 (n=1630).

clear appearance (Figure 114). Treatment of animals for paramphistomosis is not usually considered necessary, although occasional reports, mainly anecdotal, have indicated an improvement in condition and productivity of dairy cattle following administration of oxyclozanide in response to positive FEC diagnosis. In the event of acute outbreaks of clinical infection in calves, the use of oxyclozanide is indicated.

Figure 112: Mature paramphistomes in the rumen of a cow. Photo: AFBI.

Coccidiosis

Calves are usually infected by ingesting oocysts from contaminated pasture. Coccidiosis can cause significant economic losses to farmers due to reduced performance and mortality in younger animals. During 2020, coccidian oocysts were seen in 21.6 *per cent* (n=1794) of bovine faecal samples examined in AFBI (Figure 113). This level is similar to that recorded in 2019 (21.3 *per cent*) and 2018 (22 *per cent*), and indeed in most recent years, but it should be noted that in many samples a low level of oocysts was recorded, with only 2.3 *per cent* in the moderate or high categories. This may be because the peak of oocyst shedding from the infected animals had passed before the samples were collected.

Examination of the faeces for oocysts of coccidians is an important element of diagnosis, and it may be significant to distinguish the species of parasite present (usually on the basis of the dimensions of the oocysts), and thus predict the likely pathogenicity of the infection. In cattle, coccidiosis caused by *Eimeria zuernii*, *E. bovis* and *E. alabamensis* usually affects calves under one year old, but occasionally yearlings and adults are infected if they have not experienced infection in early life. Disease occurs following a massive intake of oocysts from the environment, and this would be associated with large numbers of animals sharing unhygienic yards, or where animals congregate at pasture round water troughs and feeders.

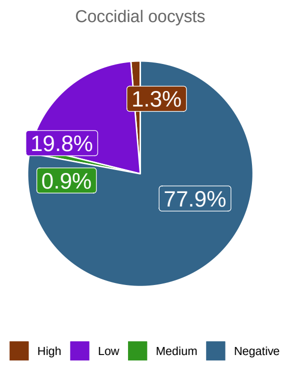

Figure 113: Results for bovine faecal samples tested for coccidial oocysts during 2020 (n=1794).

The parasitic infection attacks the caecum and colon, producing

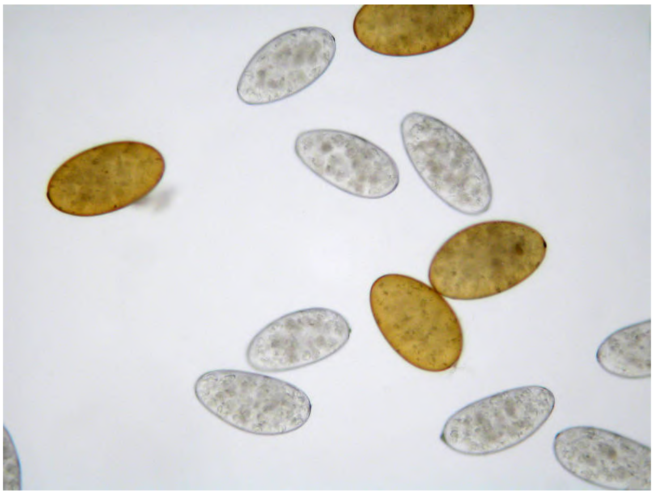

Figure 114: Clear eggs of C. daubneyi alongside darker eggs of F. hepatic. Photo: AFBI.

severe blood-stained diarrhoea (dysentery) with straining. Massive asexual multiplication of the parasite takes place, and following a sexual phase, oocysts are shed in the faeces in large numbers for a short period of time. After this, the host animal develops substantial immunity to the particular species of coccidian with which it was infected. However, subclinically infected animals often have a low level of intermittent shedding of oocysts and can act as a reservoir of infection for younger näive individuals.

Environmental conditions have to be right for development of the oocysts to the infective stage. The presence of moisture is essential for this to occur, and the speed of development of the oocysts depends on temperature, but typically takes 2–4 days.

Prevention of coccidiosis in cattle is based on good management practices, in particular the avoidance of wet underfoot conditions in houses and at pasture. Food troughs and water containers need to be moved regularly to avoid local build-up of oocyst numbers, and bedding should be kept dry. Avoidance of stress, especially due to overcrowding, is important for prevention of coccidiosis in young animals, and adequate uptake of colostral antibodies will also help prevent overwhelming coccidial infection.

Lungworm

Bovine lungworm, *Dictyocaulus viviparus* is the cause of parasitic bronchitis (husk/hoose) in cattle. The disease is characterised by coughing and respiratory distress, and typically affects young cattle during their first grazing season, following which the surviving animals usually develop a strong immunity. Occasionally, if an older animal with acquired immunity is suddenly exposed to a massive larval challenge from a heavily contaminated field, severe clinical signs may result. In 2020, AFBI tested 210 bovine faecal samples for the presence of lungworm larvae, and of these 27 (12.9 *per cent*) were positive. Amongst 291 *post mortem* diagnoses of pneumonia where the aetiological cause was identified, 27 cases (9.3 *per cent*) involved *D. viviparus* infection. The peak incidence of lungworm infection was in September. In recent years there has been a tendency for lungworm infection to occur in older cattle because treatment with long-acting anthelmintics during the first grazing season has prevented calves from being sufficiently exposed to lungworm infection to develop immunity.

BVD testing as part of the Northern Ireland BVD eradication programme

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An industry led eradication programme for Bovine Viral Diarrhoea (BVD) managed by Animal Health and Welfare Northern Ireland (AHWNI) has been operating voluntarily in Northern Ireland since 2013, turning compulsory in March 2016. The programme aims to remove BVD persistently infected (PI) cattle from the population through:

- Testing of all new-born calves including those stillborn calves for the presence of BVD virus primarily through the use of ear notch samples taken at the time of ear tagging
- Identification of cattle with non-negative BVD results and isolation of high infectious risk animals
- Improving stakeholder knowledge of BVD and awareness of biosecurity principles through a continuous flow of information
- Private veterinary practitioner involvement through the provision of herd test information, advice to herd owners and follow-up testing
- Restrictions on the movement of non-negative animals (and a voluntary abattoir ban on the slaughter of BVD Positives)
- Voluntary removal of BVD Persistently Infected cattle

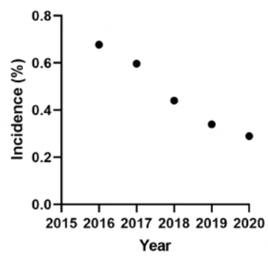

Figure 115: The annual incidence of animals disclosing as BVD Positive.

In 2020, 527,185 animal tests were carried out with 1,588 (0.3 *per cent*) returning an initial positive or inconclusive result. Of these, 1,016 (64.0 *per cent*) were retested to ensure they were *PI* animals rather than transiently infected (TI) animals, and 83.4 *per cent* remained positive. It is important to ensure that at least 3 weeks has passed between the 1st and 2nd sample to allow the virus to reduce and be eliminated in TI animals. If retesting these animals it is important that they are quarantined appropriately during this time to minimise risk to the rest of the herd especially to female cattle that are less than 120 days in calf.

Through the above methods the BVD incidence has reduced from 0.68 *per cent* in 2016 (March to December of the first year of the compulsory phase of the eradication programme) to 0.29 *per cent* in 2020 (Figure 115). This is a reduction of more than half, showing that the measures in place have reduced the BVD incidence in Northern Ireland. Related to this the percentage of testing herds that had BVD positive animals has reduced from a peak of 11.3 *per cent* for the period March 2016 to Feb 2017 to 5 *per cent* in 2020 (Figure 116).

In 2020 the NI Farm Quality Assurance Scheme introduced a non-conformance for the retention of a BVD Positive animal on farm for more than 5 weeks. This has helped to improve the timeframes of removal of *PI* animals. Enhanced measures as seen in the AHI BVD eradication programme e.g. neighbour notifications, herd restrictions and officially recognised BVD herd status, have not yet been incorporated into the NI programme. These additional measures would potentially allow the BVD eradication programme to reach the point of eradication earlier.

At the end of 2020, 97.7 *per cent* of all cattle alive in NI had an ascribed Negative or Indirect Negative BVD status. Of the animals born before the start of the compulsory phase approximately 8,500 (0.53 *per cent*) did not have a direct or indirect (dam of a BVD negative calf) BVD status at the end of 2020.

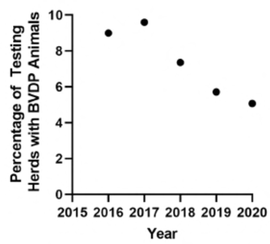

Figure 116: The annual incidence of testing herds with animals disclosing as BVD Positive.

To ensure that fast reliable results are reported herd owners should post the samples as soon as possible after sampling and also ensure that the correct postage has been applied to the envelope to ensure the samples arrive to the laboratory without unnecessary delays.

Johne's Disease

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14,176 bovine blood samples were tested by AFBI for *Mycobacterium avium* subspecies *paratuberculosis* (MAP) antibody (ELISA) and 1,190 (8.39 *per cent*) were positive, with a further 187 (1.32 *per cent*) returning inconclusive results.

1,406 faecal samples were submitted to AFBI for MAP PCR screening. MAP was identified in 231 of the 1,365 (16.92 *per cent*) bovine samples tested, with a further 6 (0.44 *per cent*) recorded as inconclusive. MAP infection was also confirmed in 2 out of 9 caprine faecal samples tested, and 8 of 36 ovine faecal samples tested. The Dairy Standards of the UK based Red Tractor Assurance Scheme was updated in October 2019 and now requires that for every member dairy herd, Johne's disease must be managed through the implementation of the National Johne's Management Plan or equivalent scheme such as the AHWNI Johne's Control Programme. Farms operating in Northern Ireland were given a derogation until October 2020 to comply with this standard, to ensure access to all of the required elements.

Agri-Food and Bioscience Institute
Ovine Diseases

Diseases of small ruminants

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Small ruminants under 12 months

Two hundred and twenty four conditions were diagnosed in small ruminants under the age of 12 months during 2020. Parasitic disease remains the most frequently diagnosed condition in this age of animals at 59 (26.3 *per cent*) Figure 56.

Table 56: Condition most frequent diagnoses in small ruminants aged under 12 months submitted for post mortem in 2020 (n=224).

Diagnoses	No. of cases	Percentage
Parasitic disease	59	**26.3**
Other diseases	36	**16.1**
Digestive diseases	34	**15.2**
Respiratory diseases	23	**10.3**
Clostridial diseases*	22	**9.8**
Pasteurellosis	16	**7.1**
Diagnosis not reached	15	**6.7**
Neurological diseases	10	**4.5**
Urinary diseases	5	**2.2**
Poisoned	4	**1.8**

* Including pulpy kidney

Small ruminants over 12 months

As like adult cattle, respiratory conditions were the most frequently condition diagnosed in adult small ruminants (those over 12 months)

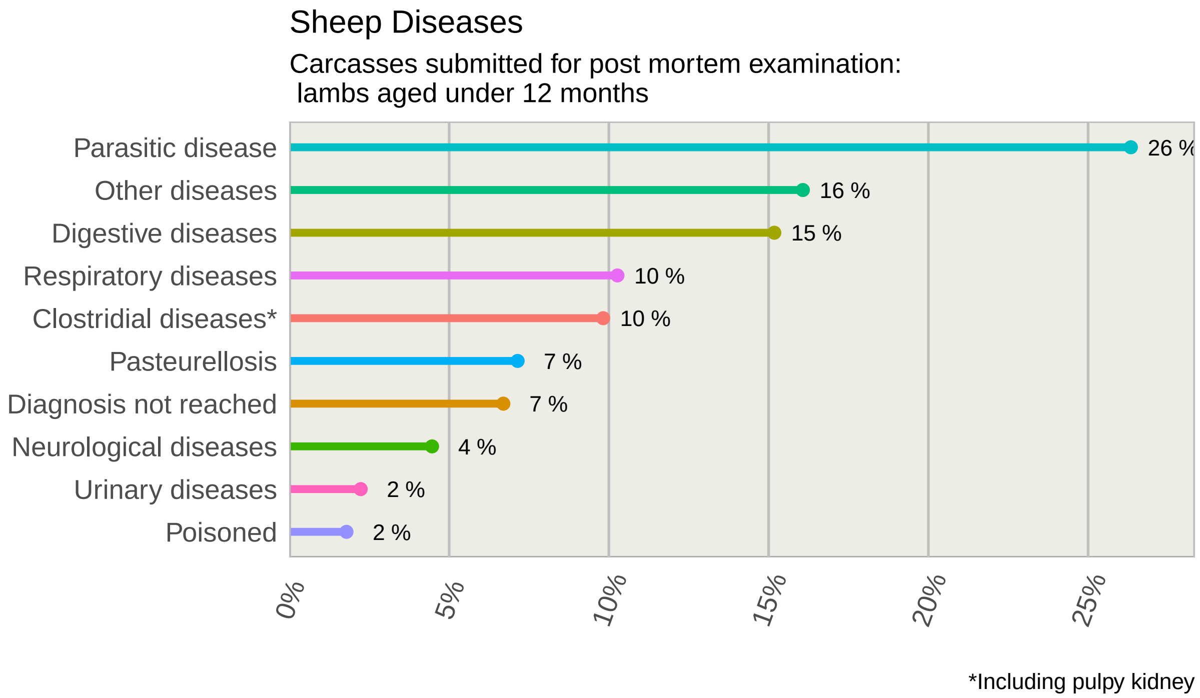

Figure 117: Conditions most frequently diagnosed in small ruminants aged under 12 months submitted for *post mortem* by AFBI in 2020. (n=224).

submitted for *post mortem* examination during 2020 (Figure 56). Of the 191 cases diagnosed in this group of small ruminants, 50 cases (26.2 *per cent*) were diseases of the respiratory tract. Thirty three cases (17.3 *per cent*) were due to parasitic disease. Seventeen cases of ovine pulmonary adenocarcinoma were diagnosed in adult small ruminants in 2020. An image of the pale, firm lesions seen on *post mortem* examination can be seen in Figure 118.

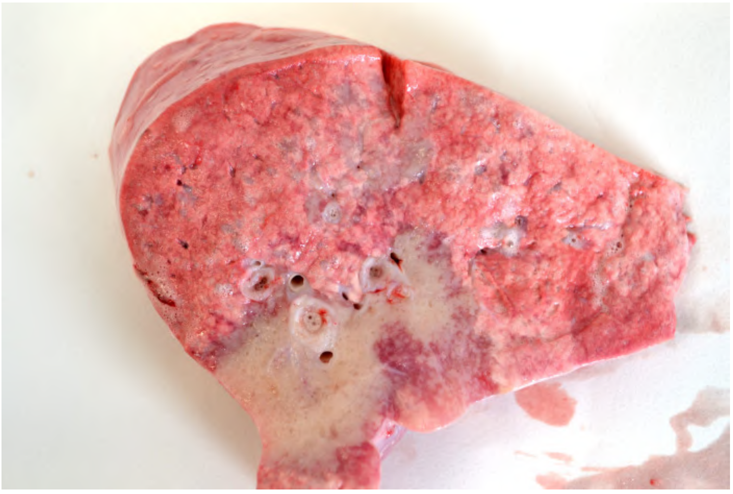

Figure 118: A lesion due to ovine pulmonary adenocarcinoma in an ovine lung. Photo:Seán Fee.

Diagnoses	No. of cases	Percentage
Respiratory tract diseases	50	**26.2**
Parasitic diseases	33	**17.3**
Other diseases	29	**15.2**
Digestive tract diseases	23	**12.0**
Diagnosic not reached	15	**7.9**
Reproductive diseases	10	**5.2**
Neurological diseases	8	**4.2**
Clostridial diseases	7	**3.7**
Cardivascular diseases	6	**3.1**
Poisoned	6	**3.1**
Urinary diseases	4	**2.1**

Table 57: Condition most frequent diagnoses in small ruminants aged over 12 months submitted for post mortem in 2020 (n=191).

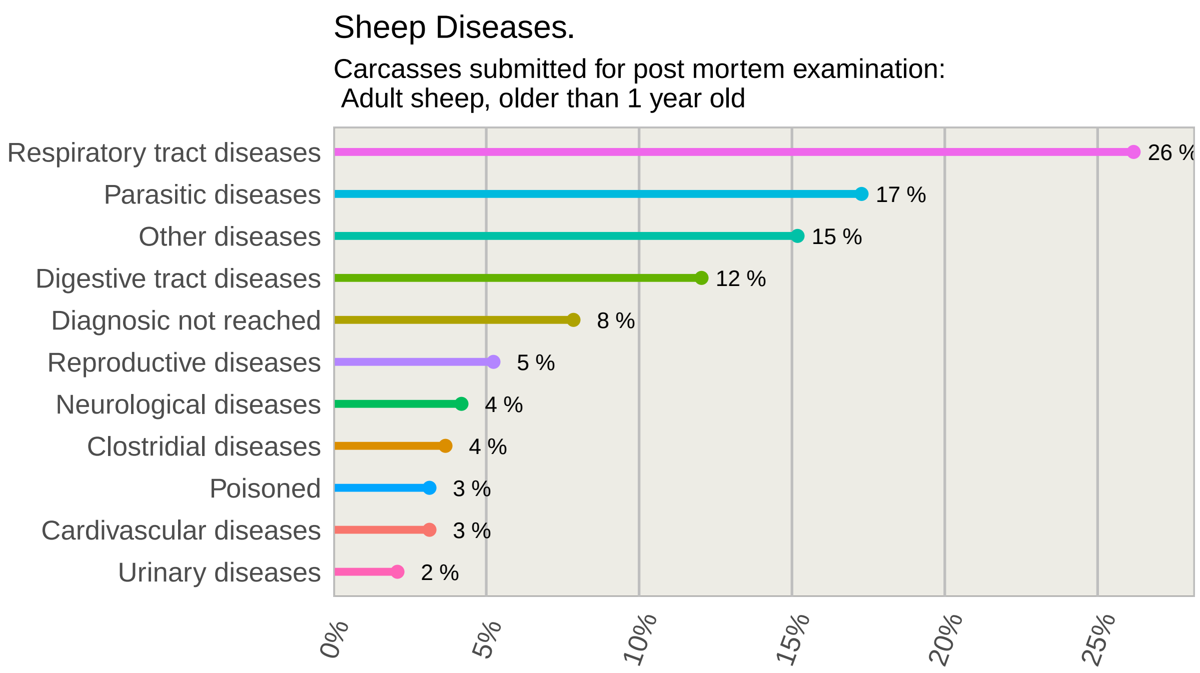

Figure 119: Relative frequency of the different aetiological agents identified in cases of parasitic disease of small ruminants over 12 month of age diagnosed during *post mortem* by AFBI in 2020 (n=191).

Ovine Abortion

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Specimens from 148 ovine abortions and stillbirths were examined during 2020. A reduction of submissions compared to previous years would have reflected the closure of the laboratory to routine submissions as a result of the Covid-19 lockdown that occurred from the middle of March of 2020.

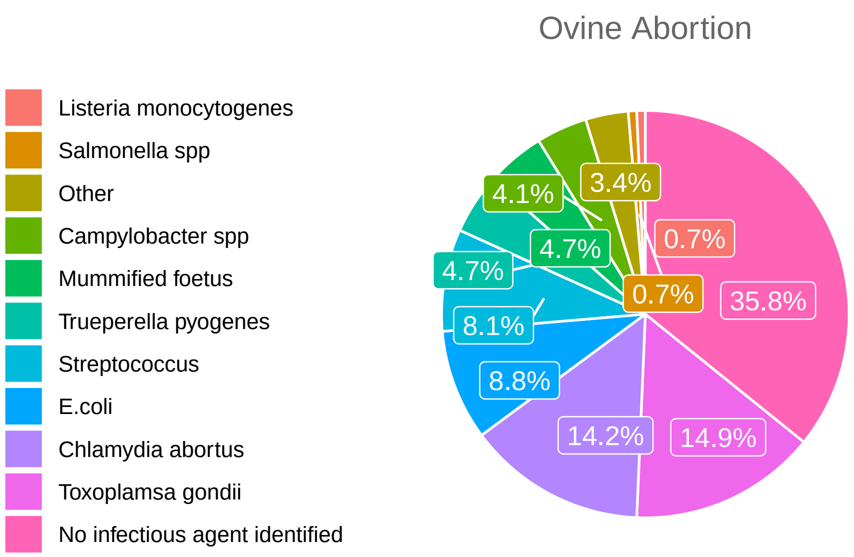

Figure 120: Relative frequency of the identified infectious agents of ovine abortion from submitted foetal *post mortems* in 2020 (n= 148).

Significant pathogens were detected in 88 cases (81.5 *per cent*). Pathogens identified included *T. gondii* (22 cases, 14.9 *per cent*), *C. abortus* (21 cases, 14.2 *per cent*), *E. coli* (13 cases, 8.8 *per cent*), *T. pyogenes* (7 cases, 4.7 *per cent*) and *Campylobacter* species (6 cases 4.1 *per cent*) (see Figure 120).

Ovine Parasites

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Parasitic gastroenteritis

The nematode parasites mainly responsible for causing parasitic gastroenteritis in sheep in Northern Ireland are *Teladorsagia circumcincta*, *Trichostrongylus spp.*, *Cooperia spp.* (all of which produce trichostrongyle-type eggs) and, in young lambs, *Nematodirus battus*. Faecal samples from sheep are examined in the Parasitology laboratory, AFBI, for trichostrongyle eggs, *Nematodirus* eggs, and for coccidial oocysts (Figure 121).

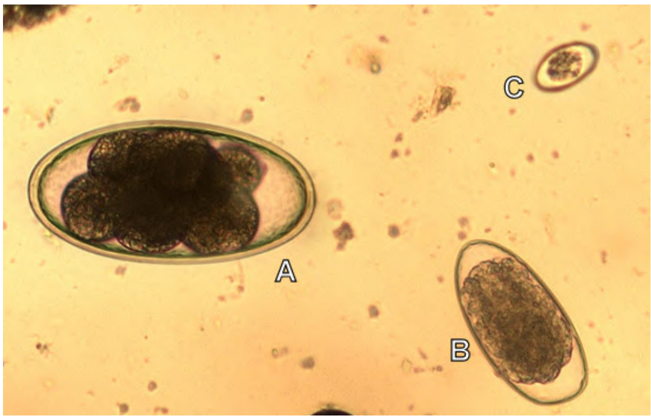

Figure 121: *Nematodirus* egg (A), textitTrichostrongylus egg (B) and Coccidial oocyst (C). Photo: AFBI.

The number of trichostrongyle eggs detected is consistently higher in sheep when compared to cattle (Figures 122 and 108 respectively). There may be a number of reasons for this, such as inherent resistance, age profile of the animals sampled, type of pasture grazed and the fact that it is more common for sheep to be out-wintered than cattle. Furthermore, the number of ovine samples tested each year is much smaller than the number of bovine samples. It is likely that sheep farmers are more selective in the submission of samples, which therefore are more likely to contain worm eggs. However, the data may also point towards a greater focus on parasite control in cattle herds and suggests that this is an area which requires further attention among sheep producers.

The percentage of ovine samples containing ≥ 500 trichostrongyle eggs per gram increased from 24.2 *per cent* in 2019 to 29.1 *per cent* in 2020 (number of samples examined, n, =636; Figure 122), a similar figure to that recorded in 2018 (30.5 *per cent*). Peak Faecal Egg Counts (FECs) occurred in July to November (corresponding to parasitic gastroenteritis in lambs at pasture). The spring peak in FECs

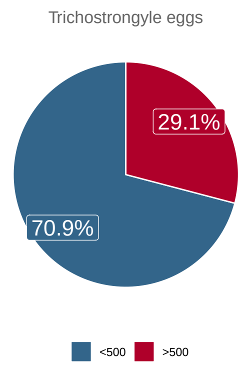

Figure 122: Relative frequency of detection of trichostrongyle eggs in ovine faecal samples examined by AFBI in 2020 (n=636).

recorded in previous years (corresponding to increased egg shedding by periparturient ewes) was not recorded in 2020 because of exceptional closure of the laboratory due to Covid restrictions. It has been noted that the rates of diagnoses for *Teladorsagia* and *Trichostrongylus* are tending towards a uniform year-round distribution, suggesting consistent levels of larval survival throughout the year, with extension of the traditionally-expected seasonal windows of transmission. Changes in the temporal and spatial distribution pattern of nematode parasites that cause parasitic gastroenteritis in sheep can be related to recent changes in local temperature and rainfall, with year-on-year prolongation of conditions suitable for worm egg and larval development and enhanced over-winter survival of infective larvae (McMahon et al., 2012).

Anthelmintic resistance testing throughout the province has indicated that worm resistance to benzimidazoles, levamisole, avermectins and milbemycin is 81 *per cent*, 14 *per cent*, 50 *per cent* and 62 *per cent*, respectively, amongst the sheep flocks tested. *Trichostrongylus* was found to be the most resistant worm genus (McMahon et al., 2013a). As yet, no resistance has been recorded against the newer anthelmintic categories, the amino-acetonitriles (orange drenches) and the spiroindoles (purple drenches). On particular farms, the resistance status of nematode populations in groups of sheep can be determined by submission of 10 individual faecal samples prior to treatment (pre-treatment samples) followed by a further 10 individual samples (ideally from the same sheep) at a pre-determined period of time after anthelmintic treatment (post-treatment samples). Comparison of FECs in the pre- and post-treatment samples will enable determination of anthelmintic efficacy. Advice on sample submission and interpretation of findings is available from the Parasitology laboratory, AFBI.

Farmers' responses to questions relating to the management of emerging anthelmintic resistance on their premises have revealed that the published SCOPS guidelines have not been widely adopted in practice, and that there is a need for improved stockholder education and closer interaction with informed veterinary practitioners, sheep advisers and laboratory staff (McMahon et al., 2013b). [6]

[6] The latest edition of the SCOPS (Sustainable Control of Parasites in Sheep) guidelines is accessible at SCOPS

Nematodirus

Nematodirosis can be a significant cause of diarrhoea in sheep, particularly in young lambs. Development to the L3 larval stage takes place within the egg, and in the case of *Nematodirus battus* (the most significant species seen in Ireland), a prolonged cold period is usually required before hatching from the egg occurs. It is common therefore that large numbers of L3 larvae appear in April, May and June on those pastures where lambs have grazed the previous year. When lambs are weaned and are beginning to eat more grass, these L3 larvae are ingested. If enough larvae are ingested, severe clinical disease can result. Faecal egg counts of more than 200 characteristic *Nema-*

todirus eggs per gram are considered clinically significant in sheep, and in late spring and early summer, deaths of lambs due to enteritis are common. It is advisable that any carcases are submitted to Veterinary Science Division for *post mortem* examination in order to determine if the cause of enteritis is nematodirosis, other nematode infection, coccidiosis or bacterial infection, since this information is necessary to inform appropriate treatment. Of 632 faecal samples examined for Nematodirus* eggs in 2020, 8.4 *per cent* were found to contain ≥ 200 *epg* (Figure 123), a marked increase from the level recorded in 2019 (4.6 *per cent*), but similar to the level recorded in 2018 (8 *per cent*).

A recent limited study has revealed that in Northern Ireland anthelmintic resistance in *Nematodirus battus* populations to benzimidazoles, levamisole, avermectins and moxidection is present in, respectively, 36 *per cent*, 50 *per cent*, 33 *per cent* and 75 *per cent* of flocks tested (McMahon et al., 2017). Benzimidazole administration, on a therapeutic or prophylactic basis, remains the preferred treatment option, and the timing of dosing is guided by annual prediction of the peak egg hatching period, calculated by AFBI parasitologists using climatic data.

In recent years, a trend seems to be emerging for a second autumnal peak in *Nematodirus battus* infection in sheep. The reason for this appears to be flexibility in the hatching behaviour of the eggs, with a significant proportion hatching in autumn, in response to climatic change (McMahon et al., 2017).

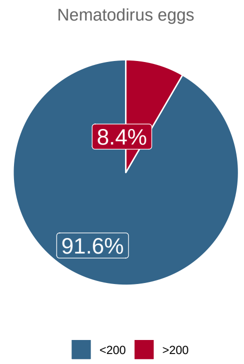

Figure 123: Relative frequency of detection of Nematodirus eggs in ovine faecal samples examined by AFBI in 2020 (n=632).

Coccidiosis

In 2020, as in previous years, coccidial oocysts were detected more frequently in sheep than in cattle faecal samples. Of the sheep samples examined in 2020, 69.2 *per cent* (n=639) were positive for oocysts (compared to 69.4 *per cent* in 2019 and 66.5 *per cent* in 2018), but only 24.0 *per cent* exhibited moderate or high levels (Figure 124). However, as with infections in cattle, the oocyst count may not accurately reflect the pathological significance of the infection because the peak of shedding may have passed before samples were collected, and because there is variation in the pathogenicity of the various species of *Eimeria* involved.

Coccidiosis is an insidious disease and is frequently associated with poor thrive in lambs and calves as well as with more serious clinical disease. In sheep, the important pathogenic coccidians in Northern Ireland are *E. crandallis* and *E. ovinoidalis*. As in calves, infection can cause severe diarrhoea, often with blood, and the caecum and colon are the main parts of the intestine affected. If the animals recover, chronic damage to the intestine can lead to malabsorption problems later, with associated failure to thrive. During the acute phase of the disease the integrity of the intestinal lining is disrupted (Figure 125), and deaths may result from septicaemia caused by ingress of bacteria through the damaged intestine wall.

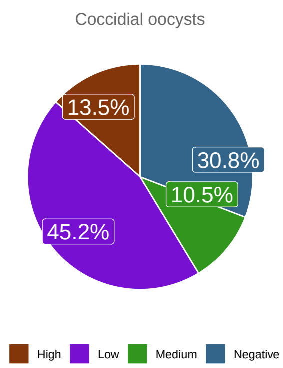

Figure 124: Results for ovine faecal samples tested for coccidial oocysts during 2020 (n=639).

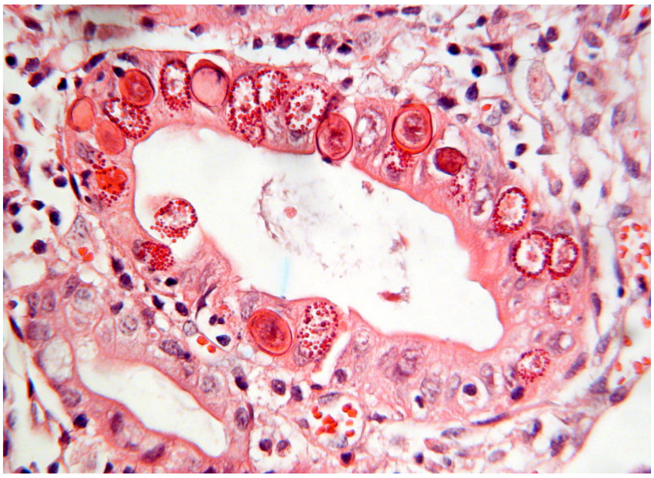

Figure 125: Intestinal wall infected with coccidial oocysts. Photo: AFBI.

Lambs are usually affected between four and seven weeks of age, and outbreaks of disease are usually associated with intensive housing or grazing of ewes and lambs in unhygienic and wet conditions. Adult sheep, especially ewes in the periparturient period, often shed low numbers of oocysts, and these can be the primary source of infection for lambs, although oocysts on the pasture can survive over-winter and infect näive animals in springtime. Feeding of concentrates in stationary troughs around which high concentrations of oocysts build up, can be a precipitating factor.

Prevention of coccidiosis in sheep, as in cattle, is based on good management practices, in particular the avoidance of wet underfoot conditions in houses and at pasture. Food troughs and water containers need to be moved regularly to avoid local build-up of oocyst numbers, and bedding should be kept dry. Avoidance of stress, especially due to overcrowding, is important for prevention of coccidiosis in young animals, and adequate uptake of colostral antibodies will also help to prevent overwhelming coccidial infections. Lambs with severe diarrhoea will need supportive rehydration. It is always advisable to avoid grazing young and older lambs together, and if possible young lambs should not be grazed on pasture that has carried ewes and lambs in the past 2-3 weeks.

While prophylactic treatment of ewes around the lambing period with anticoccidial drugs such as toltrazuril or decoquinate can help reduce pasture contamination by oocysts, it should be remembered that the promotion of natural immunity in young animals needs to be safeguarded by strategic dosing and by the choice of a product that controls disease while permitting development of immunity. The timing of treatment of lambs should be adjusted depending on the management practice (indoor, outdoor, pasture etc.) and the history of disease occurrence in previous years.

Treatment is usually given to lambs as soon as diarrhoea is seen in several individuals. If it is delayed until most lambs are affected, recovery time can be prolonged due to intestinal damage.

Liver fluke and Rumen Fluke

In the ovine faecal samples examined in 2020, rumen fluke eggs were more frequently detected than liver fluke eggs (positive FECs were recorded in 24.1 *per cent* and 17.1 *per cent* of 584 faecal samples respectively; Figures 126 and 127). The percentage with liver fluke eggs detected showed an increase from 2019, when 8.3 *per cent* of samples examined yielded positive results, but was still significantly lower than the figure for 2018 (29.5 *per cent*). In 2020, 24.1 *per cent* of 584 faecal samples tested positive for rumen fluke eggs (compared to 25 *per cent* in 2019 and 20.5 *per cent* in 2018). Bearing in mind that the molluscan intermediate host (*Galba truncatula*) is the same for both types of fluke, the perceived decline in liver fluke incidence is difficult to explain. It is possible that there is increased awareness of triclabendazole resistance in flukes in Northern Ireland, resulting in a shift towards control of *Fasciola hepatica* by use of alternative products (containing for example closantel) to kill adult liver fluke in sheep and cattle in late winter and early spring (McMahon et al., 2017, ; Fairweather et al., 2020). This may have resulted in a recent decline in pasture contamination by liver fluke eggs. Of the available drugs, only oxyclozanide has proven efficacy against rumen fluke. On the other hand, the findings may reflect local climatic differences or changes in stockholder behaviour in sample submission between 2018 and 2020. The possibility of intra-molluscan competitive effects between liver fluke and rumen fluke larval stages has yet to be fully researched.

Liver fluke disease can occur in either acute or chronic forms. The acute form occurs in sheep in the autumn and early winter of those years when the climatic conditions from April to September have favoured the breeding and resulting population expansion of the intermediate host. Disease is caused by the migration of large numbers of immature flukes through the liver, frequently resulting in fatal haemorrhage (Figure 128). Chronic liver fluke disease is more common than the acute form and occurs in both sheep and cattle, usually during the winter and spring, although infection can persist throughout the year (Figure 129). Chronic fluke infection can cause a reduction of 30 *per cent* in the growth of fattening animals and can also predispose to metabolic conditions and infectious diseases such as salmonellosis and clostridial infection. Cattle and sheep in fluke-affected areas should be fully vaccinated against clostridial disease.

All sheep farmers should review their fluke control measures in autumn. Access to snail habitats (wet and poorly drained areas) should be reduced or sheep taken off the potentially infected land and housed or moved to new clean pasture. However, in most cases, control will be based on the strategic use of anthelmintics, employing a product effective against the life cycle stages likely to be present in the flock or herd at the time of treatment.

Resistance to fluke treatments is an emerging problem and has been detected in Northern Ireland (Hanna et al., 2015). On some

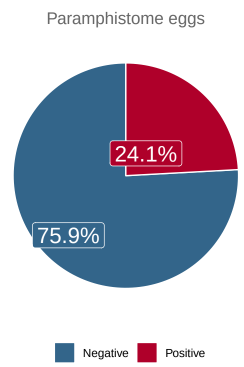

Figure 126: Relative frequency of detection of Paramphistome eggs in ovine faecal samples examined by AFBI in 2020 (n=584).

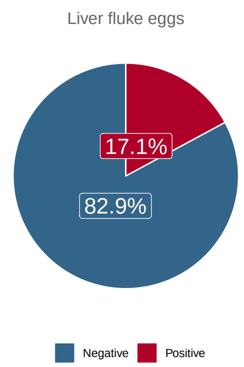

Figure 127: Relative frequency of detection of liver fluke eggs in ovine faecal samples examined by AFBI in 2020 (n=584).

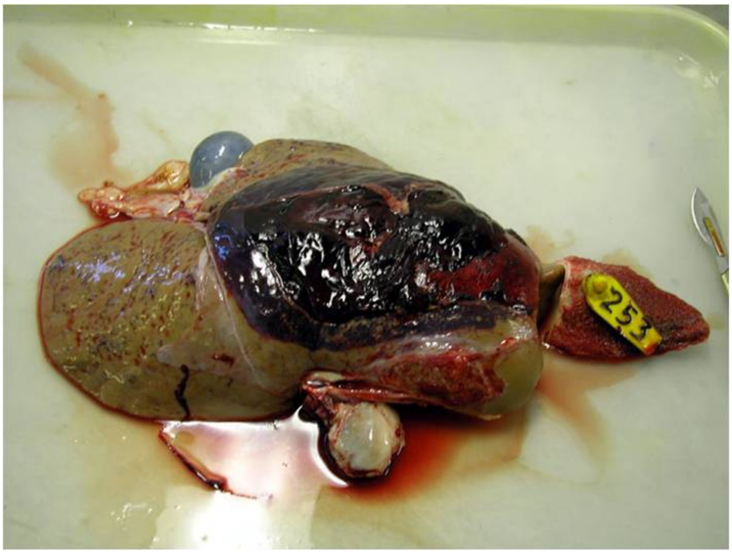

Figure 128: Haemorrhage of the liver as a result of the migration of immature liver fluke. Photo: AFBI.

premises, products containing triclabendazole (the only flukicide currently licensed in UK and Ireland that is effective against the immature stages of liver fluke) have been used almost exclusively for many years. On such farms it is likely that triclabendazole-containing products will now be less effective in controlling fluke infection, and for treating acutely-ill animals. The effectiveness of anthelmintic treatment on individual farms can be checked by taking faecal samples 3 weeks after treatment, from approximately 10 animals in each affected group, and submitting them for laboratory examination. Further information is available from the Parasitology laboratory, AFBI.

Treatment of chronic (adult) infections in cattle as well as sheep during the winter and/or early spring is important to help reduce pasture contamination with fluke eggs, and this is particularly relevant if triclabendazole is no longer effective in controlling fasciolosis on the premises (Fairweather et al., 2020). Use of an anthelmintic with activity mainly against adult flukes (closantel, nitroxynil, albendazole, oxyclozanide) is likely to be appropriate in these circumstances. However the flukicide programme used has to be on a 'know-your-farm' basis and no one set of recommendations will cover all flocks or herds.

Adult rumen flukes are less damaging to sheep and cattle than liver flukes, but heavy infections of immature rumen fluke may cause diarrhoea, ill-thrift and, exceptionally, death in young animals. Heavy burdens of adult rumen fluke have been reported to result in poor productivity in dairy or meat-producing animals, but few scientific studies have been completed. Liver fluke, particularly in acute infections, is potentially a much more serious risk to the welfare and productivity of sheep than rumen fluke, and the choice of which flukicide to use must reflect this. Oxyclozanide is the only locally available flukicide with proven efficacy against immature and adult rumen flukes, but treatment should be first aimed at liver fluke in mind and only then, if required at rumen fluke.

Figure 129: Adult liver fluke in the hepatic biliary tract. Photo: AFBI.

Case series: Urolithiasis in ruminants

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Urolithiasis is a disease of economic and welfare importance in ruminant production, particularly on those farms where multiple animals are affected every year. Urolithiasis occurs when mineral deposits form within the urinary tract leading to uroliths (urinary stones) and clinical disease is seen when these deposits lead to partial or complete obstruction of the urinary tract. Uroliths may form in both the male or female urinary tract with equal frequency though clinical disease relating to obstruction or partial obstruction of the urinary tract is much more common in male animals owing to the longer and narrower lumen of the urethra and especially so in young immature or castrated animals. Cases of urolithiasis in ruminants may commonly affect sheep, cattle or goats but cases recorded in AFBI are seen most frequently in sheep, followed by cattle.

Figure 130: Magnesium ammonium phosphate urinary stones obstructing the penile urethra of a one-year-old bull. Photograph: Seán Fee.

Intensive husbandry systems with high levels of concentrate feeding are most frequently associated with urolithiasis. Cereal based diets contain high levels of phosphorus predisposing to urolith formation. Certain sheep breeds such as Texels are more efficient at absorbing dietary phosphorus and excreting phosphorus in urine and may therefore be more susceptible to urolithiasis depending on the management system. As saliva is rich in phosphorus, husbandry systems which encourage rumination and salivation can reduce the risk of urolithiasis by promoting faecal excretion of phosphorus and reducing urinary phosphorus excretion. Diets rich in roughage fibre

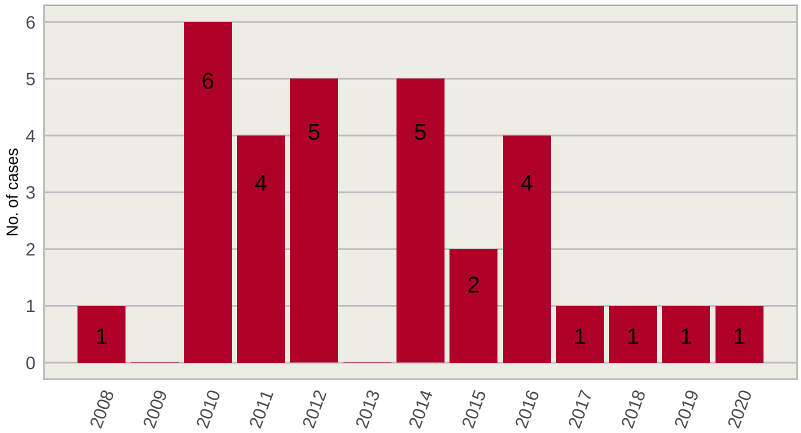

Figure 131: Cases of urolithiasis in sheep by year recorded by AFBI from 2008 to 2020

encourage rumination and salivation and therefore reduce the risk. Pelleted concentrates however are associated with decreased salivation and therefore increased risk of urolithiasis when compared to non-pelleted forms of concentrate feeding such as loose meal or whole grain forms. When concentrate is fed in one or two meals per day risk of urolithiasis is elevated compared to systems where the concentrate is available throughout the day. Decreased fluid intake is also associated with an increased risk as may occur after abrupt weaning or change of milk replacer.

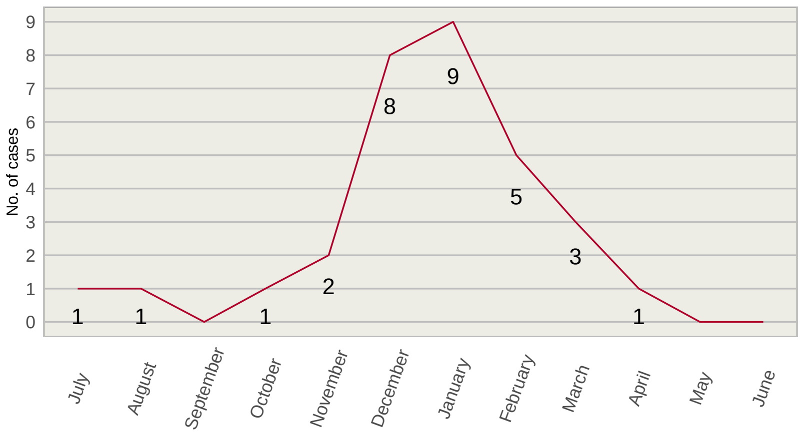

Figure 132: Cases of urolithiasis in sheep by year recorded by AFBI from 2008 to 2020. Cases peak significantly in the winter months.

Most cases of urolithiasis recorded at AFBI relate to struvite crystals or uroliths composed of magnesium ammonium phosphate. Deposits may be sandy granules or may form stones. Most cases are recorded during the winter months and are seen in younger animals. Although most cases in the twelve years up to 2020 were recorded in male animals a few cases were observed in females.

Clinical signs of urolithiasis commonly include dullness, straining to urinate or straining of the anus, inappetance, colic or signs of abdominal pain, kicking at the abdomen and presenting with a hunched back or stiffness. Animals may dribble blood stained urine or mineral crystals may be observed at the prepuce. If the urethra or bladder

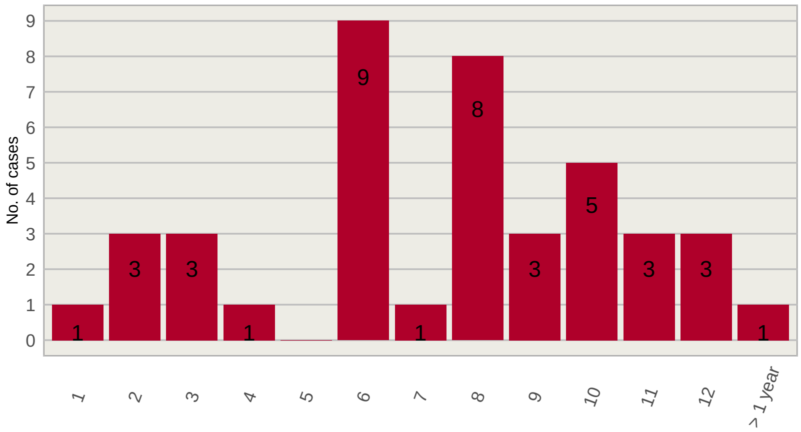

Figure 133: Age in months of cases of urolithiasis in sheep recorded by AFBI from 2008 to 2020. Most cases are recorded in lambs.

ruptures there may be swelling of the abdominal floor or of the abdomen. Goats may vocalise loudly.

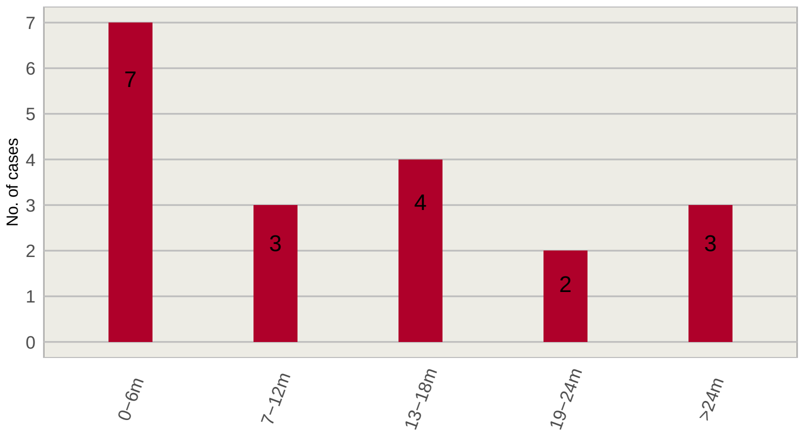

Figure 134: Age in months of cases of urolithiasis in cattle recorded by AFBI from 2008 to 2020. Most cases are recorded in young cattle less than two years old.

Medical and surgical treatments are often without success but veterinary attention should be sought because of the substantial welfare implications of the disease and also for valuable animals. As urolithiasis is a husbandry disease very often other animals in the batch will be subclinically affected (40–60 *per cent* of the batch may be subclinically affected) and efforts should be focussed on preventing further clinical cases. Urinary acidifiers such as ammonium chloride may be fed in cases where urolithiasis is due to struvite to lower urinary pH in an attempt to increase solubility of urinary salts. Salt may be included in the diet up to four *per cent* of daily dry matter intake to promote water intake and promote urine production and thus reduce the risk of minerals precipitating out in urine.

On farms where problems occur yearly efforts should be made to prevent disease. Attention should be given to maintaining good water supply, there should be sufficient water drinkers for the number of animals in the pen, water drinkers should be at an appropriate height and should be cleaned regularly. Sufficient roughage should be fed to promote salivation. An appropriate breed of animal should

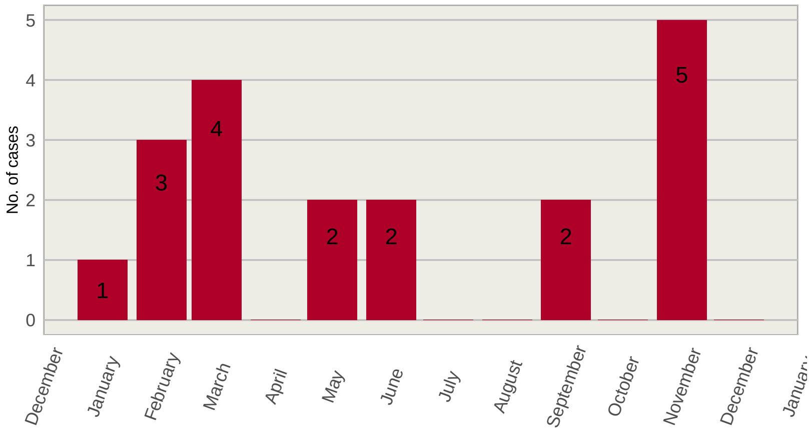

Figure 135: The monthly distribution of cases of urolithiasis in cattle recorded by AFBI from 2008 to 2020.

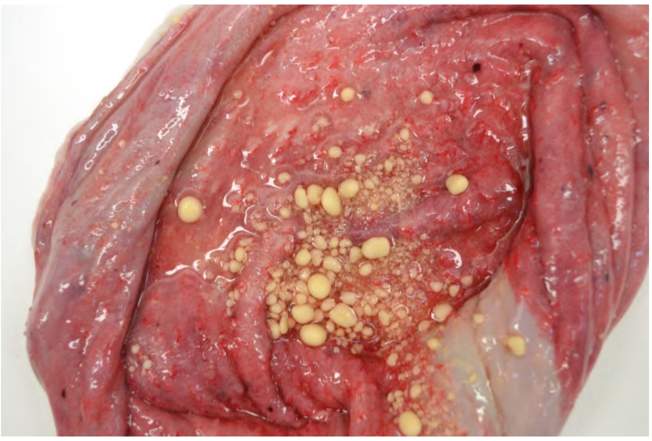

Figure 136: Magnesium ammonium phosphate urinary stones in the bladder of a one-year-old bull. Photograph: Seán Fee.

be selected for the management system. Castration should not be performed too early on farms which habitually experience problems. Calcium should be supplemented in cereal diets if necessary to maintain the calcium to phosphorus ratio at 2:1 to reduce excess phosphorus absorption and phosphorus should not exceed 0.6 *per cent* of the diet.

Appendix

R packages and LaTeX

The analysis, construction of graphics and visualisation of data for this 2020 All-Island Animal Disease Surveillance Report have been conducted by using the R programming language, R version 3.5.1 (2018-07-02) (R Core Team, 2018), and the RStudio integrated development environment. An adaptation of the package tint of Dirk Eddelbuettel and Jonathan Gilligan (Eddelbuettel and Gilligan, 2019) has provided the template for this report.

Extensive use of the package bookdown (Xie, 2021a) and rmarkdow (Allaire et al., 2021, ; Allaire et al., 2021) and LaTeX language were utilised in this report for formatting and typesetting the final LaTeX bookdown document.

Most of the charts were plotted using the package *ggplot2* (Wickham et al., 2020) and the tables constructed with *kableExtra* (Zhu, 2021) and *finalfit* (Harrison et al., 2019).

Many other packages were also used in the preparation of this report, for further information see the references below.

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