An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

AGRI-FOOD
& BIOSCIENCES
INSTITUTE

All-Island Animal Disease Surveillance
2022

This document has been compiled in collaboration with:

- Department of Agriculture, Food and the Marine of Ireland (DAFM)
- Agri-Food & Biosciences Institute, Northern Ireland (AFBI)
- Animal Health Ireland (AHI)

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Introduction

To paraphrase the old proverb about rust – *disease never sleeps*. Although the threat posed by Highly Pathogenic Avian Influenza in Ireland and across Europe for the past couple of years is waning, at the time of writing, we face the arrival of a New Year acutely aware of the threat posed by the detection of Bluetongue Virus in south-east England. This comes after a year when the exotic disease threat level has already been elevated by the detection of multiple outbreaks of Bluetongue and Epizootic Haemorrhagic Disease on the continent. These factors remind us of the need for constant vigilance and the value of scanning surveillance for the detection of both known and unknown exotic/emerging disease threats. While active surveillance has a laser-like ability to target a pathogen or syndrome with statistical precision, scanning surveillance, as practiced by the two veterinary laboratory networks on the island, is more like radar. It can, and does, detect and diagnose a wide range of disease entities, whether infectious, genetic, nutritional or other. This unique ability of scanning surveillance to *answer a question we weren't asking* is its true power. The nature of this surveillance model, built on stakeholder participation, cost-sharing and the wholly voluntary submission of caseloads for testing provides a valuable link between farmers, vets and veterinary laboratory science. It underpins a key feature of our service – it must remain relevant to vets and to farmers and we must always remain responsive to the disease investigation needs of our stakeholders at an individual level as well as at an industry level.

Another special feature of this annual report is that it is entirely written, edited and reviewed before publication each year by the frontline veterinary professionals responsible for compiling the *post mortem* results and interpreting the laboratory findings that is analysed and summarised here. We thank them and all of the scientific and support staff in both jurisdictions for their work, and for producing this summary report of their work, as we face another year filled with uncertainties and challenges, but ready for whatever it may bring!

Barry McInerney
Head of Disease Investigation Branch
Agri-Food and Biosciences Institute
Northern Ireland

Mícheál Casey
Head of Regional Veterinary Laboratories
Department of Agriculture, Food and the Marine
Ireland

Preface

This All-Island Animal Disease Surveillance Report (AIADSR) is the seventeenth Animal Disease Surveillance Report and the twelveth 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 four years, most 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. This year we have constructed the AIADSR in Quarto, a multi-language, next-generation version of R Markdown from Posit that provide a convenient way to publish documents in a webpage format (HTML) and, in parallel a pdf format document with the same contents of the webpage.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, Food 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.

Some important topics have not been included in this edition for a variety of reasons; however, the issues depicted in this AIADSR represent a relevant example of the animal disease surveillance carried out by the RVLs, AFBI and AHI in the Island of Ireland.

Marie Claire McCarthy (Editor)
Research Officer
Cork Regional Veterinary Laboratory, DAFM
Department of Agriculture, Food and the Marine
Ireland

Cosme Sánchez-Miguel (Editor)
Senior Research Officer
Cork Regional Veterinary Laboratory, DAFM
Department of Agriculture, Food and the Marine
Ireland

Acknowledgements

The 2022 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 2022 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, for the advice provided and for patiently proofreading the text. Also, I would like to thank Maria Guelbenzu (AHI), Liam Doyle (AHI) and Siobhan Corry (AFBI) and their colleagues for their collaboration in the 2022 All-Island Animal Disease Surveillance Report.

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

Marie Claire McCarthy (Editor)
Research Officer
Cork Regional Veterinary Laboratory, DAFM
Department of Agriculture, Food and the Marine
Ireland

Cosme Sánchez-Miguel (Editor)
Senior Research Officer
Cork Regional Veterinary Laboratory, DAFM
Department of Agriculture, Food and the Marine
Ireland

Part I.

Cattle

1. Overview of Bovine Diseases

Alan Johnson , *Senior Research Officer*
Limerick Regional Veterinary Laboratory,
Knockalisheen, Limerick, Ireland

1.1. Introduction

The Department of Agriculture, Food and the Marine (DAFM), through its laboratory network carries out part of its surveillance role by gathering data from carcass and clinical sample submissions made by farmers through the network of private veterinary practices. Data presented in this section relates to the most-common causes of death diagnosed in bovine carcasses submitted for *post mortem* examination during 2022. The data reflects those cases where the private veterinary practitioner has deemed it appropriate for the farmer to submit a carcass for *post mortem* examination and where the farmer has then taken the time to travel to the laboratory.

During 2022, 1,997 bovine carcasses (excluding foetuses) were submitted for *post mortem* examination. In this section this year the farms submitting carcasses were categorised as *dairy*, *beef/suckler* and *other* depending on their herd type (as defined in DAFM's Animal Health Computer System, the database used to manage animal welfare and disease monitoring and control). The *other* category includes feedlot, dealer and herds whose dominant enterprise is neither dairy, beef, nor suckler.

Information Note

It should be noted that the examining veterinarian can only assign one cause of death to each animal submission. 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 end enteritis. If the lesions are not considered to be linked, as they might be in the case of a systemic infection (sepsis), then the pathologist 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 pathologists differ to a small extent. A detailed description of involved pathogens is provided in the chapters discussing the respective organ systems.)

1.2. Neonatal Calves (birth to one month of age)

Gastrointestinal tract (GIT) infections continue to be the most diagnosed cause of death in the neonatal calf category (Table 1.1 and Figure 1.2). At 31.7 *per cent* (38.9 *per cent* were dairy, 25.9 *per cent* were beef/suckler) the figure is slightly down on 2021 (37.3 *per cent* and up from 2020 (25.9 *per cent*). The common causes of the gastrointestinal infections are discussed in more detail in the chapter on neonatal enteritis.

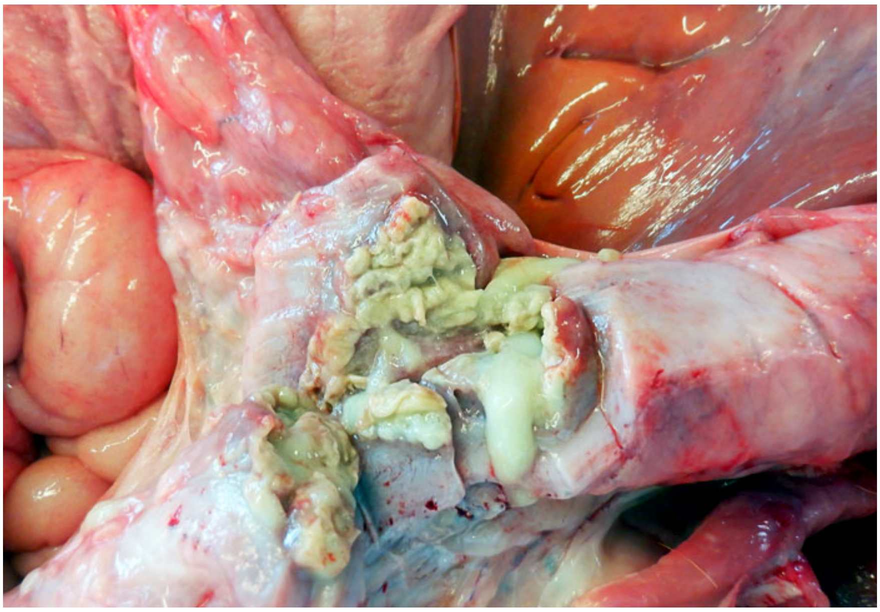


Figure 1.1.: Omphalophlebitis (navel infection) in a calf. Photo: Aideen Kennedy.

Table 1.1.: Conditions most frequently diagnosed on *post mortem* examinations of bovine neonatal calves in 2022 (n= 533).

Category	Beef/Suckler	Dairy	Other	Total	Percentage
GIT Infections	69	93	7	169	**31.7**
Systemic Infections	47	27	6	80	**15.0**
GIT ulcer/perforation/foreign body	27	22	2	51	**9.6**
Navel Ill/Joint Ill	27	14	3	44	**8.3**
Respiratory Infections	20	19	3	42	**7.9**
GIT torsion/obstruction	9	16	3	28	**5.3**
Hereditary and developmental abnormality	16	12	0	28	**5.3**
Other	15	8	1	24	**4.5**
Nutritional/metabolic conditions	7	11	1	19	**3.6**
Diagnosis not reached	6	10	0	16	**3.0**
Peritonitis	12	3	1	16	**3.0**
Cardiac/circulatory conditions	7	1	0	8	**1.5**
CNS	4	3	1	8	**1.5**

Note:
Categories that have less than five cases have been included in the 'Other' category.

Systemic infections were associated with 15 *per cent* of the neonatal calf deaths. A systemic infection is spread haematogenously and typically affects many organs. It is interesting to note that systemic infections are more commonly seen in beef/suckler calves than dairy calves (17.7 *per cent* beef/suckler, 11.3 *per cent* dairy).

Colostrum management plays a vital role in calf health, ensuring that the calf gets an adequate volume of high-quality colostrum in the first hours of life is an important management practice. Suckler cows can be more difficult to hand milk than dairy cows but tend to be managed under less intensive conditions, and therefore it is not surprising that the diseases associated with inadequate colostrum intake, poor absorption of colostrum antibodies and hypogammaglobulinaemia are more commonly seen in suckler calves. These diseases include navel ill/joint ill (Figure 1.1), systemic infections, respiratory infections and Central Nervous System (CNS) infections.

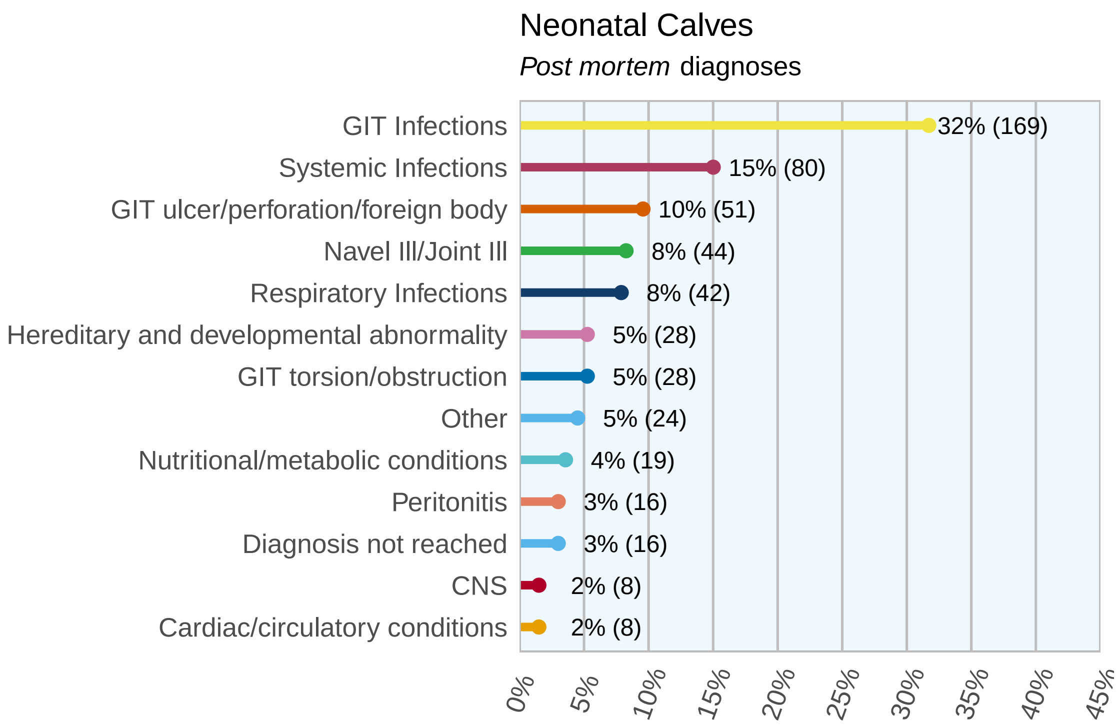


Figure 1.2.: Conditions most frequently diagnosed on *post mortem* examinations of bovine neonatal calves in 2022 (n=533). Note: Categories that have less than five cases have been included in the 'Other' category. The absolute number of cases is between brackets.

In the hereditary and developmental abnormality category, 28 cases were recorded in the birth-to-one-month age category. Of these 28, 11 were circulatory in origin, mostly defects in the ventricular septum (Figure 1.3a). 10 of the 28 were associated with the gastrointestinal tract (mostly atresia), 2 were musculoskeletal and two were renal in origin.

(a) Cardiomegaly

(b) Dry gangrene

Figure 1.3.: Cardiomegaly (a) associated with a septal defect in a calf. Photo: Colm O'Muireagáin. (b) Terminal dry gangrene in a calf with *Salmonella* Dublin infection. Photo: Alan Johnson.

1.3. Calves (one to five months of age)

Respiratory infections were the most common cause of mortality in the one-to-five-month-old calf age category in 2022. At 34.2 *per cent* (37.5 *per cent* beef/suckler and 27.5 *per cent* dairy) of all diagnoses, the figure was slightly higher that was seen in recent years (Table 1.2 and Figure 1.4). The aetiology is discussed in more detail in the chapter *Bovine respiratory disease*.

Table 1.2.: Conditions most frequently diagnosed on *post mortem* examinations of calves (1-5 months old) in 2022 (n= 688).

Category	Beef/Suckler	Dairy	Other	Total	Percentage
Respiratory Infections	138	79	18	235	**34.2**
GIT Infections	50	51	4	105	**15.3**
GIT torsion/obstruction	32	34	2	68	**9.9**
Systemic Infections	28	23	2	53	**7.7**
GIT ulcer/perforation/foreign body	26	19	1	46	**6.7**
Other	16	13	1	30	**4.4**
Diagnosis not reached	8	10	2	20	**2.9**
Nutritional/metabolic conditions	9	10	0	19	**2.8**
Clostridial disease	8	10	0	18	**2.6**
Peritonitis	12	5	0	17	**2.5**
CNS	7	9	0	16	**2.3**
Hereditary and developmental abnormality	10	5	1	16	**2.3**
Navel Ill/Joint Ill	7	3	0	10	**1.5**
Tuberculosis	1	8	0	9	**1.3**
Urinary Tract conditions	6	1	1	8	**1.2**
Cardiac/circulatory conditions	4	2	0	6	**0.9**
Liver disease	3	2	1	6	**0.9**
Poisoning	3	3	0	6	**0.9**

Note:
Categories that have less than five cases have been included in the 'Other' category

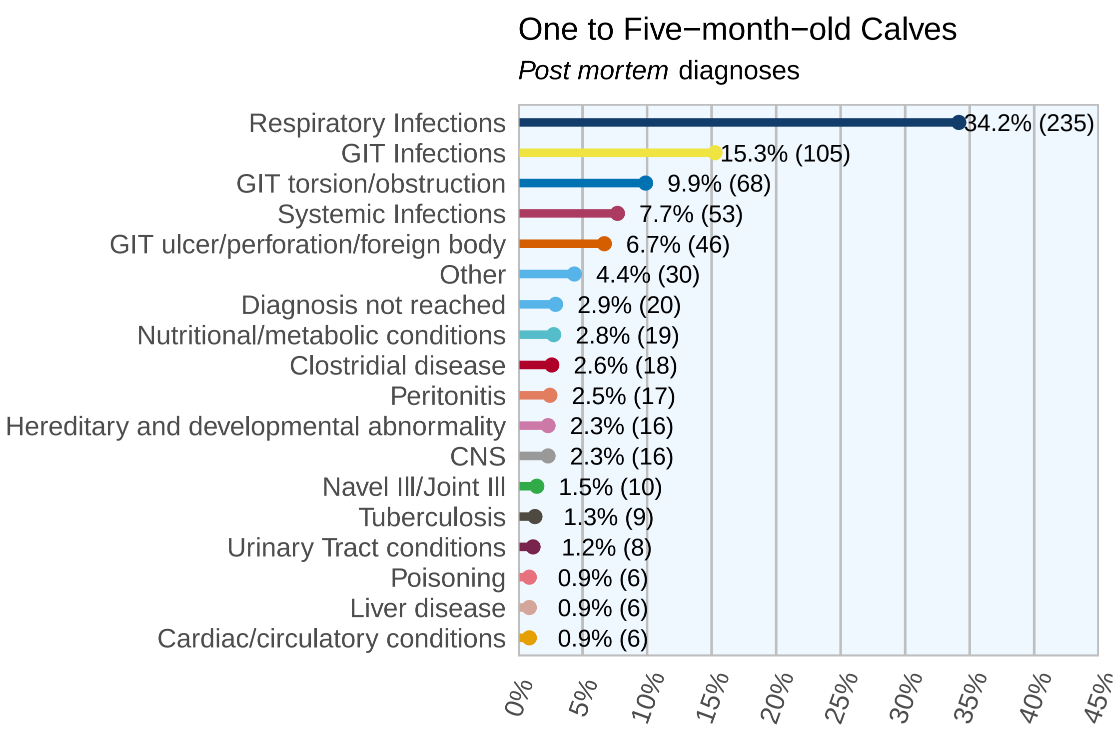


Figure 1.4.: Conditions most frequently diagnosed on *post mortem* examinations of calves (1–5 months old) in 2022 (n=688). Note: Categories that have less than five cases have been included in the 'Other' category. The absolute number of cases is between brackets.

Table 1.3.: Conditions most frequently diagnosed on *post mortem* examinations of weanlings (6-12 months old) in 2022 (n= 456).

Category	Beef/Suckler	Dairy	Other	Total	Percentage
Respiratory Infections	132	52	4	188	**41.2**
GIT Infections	44	32	3	79	**17.3**
Clostridial disease	12	17	1	30	**6.6**
Diagnosis not reached	10	7	4	21	**4.6**
Other	9	10	2	21	**4.6**
CNS	13	4	0	17	**3.7**
GIT torsion/obstruction	7	9	0	16	**3.5**
Nutritional/metabolic conditions	10	5	1	16	**3.5**
Cardiac/circulatory conditions	10	4	1	15	**3.3**
Systemic Infections	11	4	0	15	**3.3**
GIT ulcer/perforation/foreign body	7	7	0	14	**3.1**
Poisoning	4	6	0	10	**2.2**
Peritonitis	5	3	0	8	**1.8**
Liver disease	3	3	0	6	**1.3**

Note:
Categories that have less than five cases have been included in the 'Other' category.

Gastrointestinal infections (15.3 *per cent*) were the second most commonly diagnosed cause of death in 2022, slightly up on 2021. Of the 105 cases diagnosed, 30 were associated with coccidiosis and 13 were associated with gastrointestinal parasites. Salmonella Dublin was isolated from three of the cases. In 28 cases, a gastro-intestinal infection was diagnosed as the cause of death, a specific infectious agent was not identified. This is not unusual and may be attributed to a number of reasons such as autolysis of the carcass or antimicrobial treatment of the calf prior to death.

Gastrointestinal torsions were diagnosed in 68 cases (9.9 *per cent* of the total). In many of these cases the history described the calves as being found dead unexpectedly, with no prior clinical signs. GIT ulceration with or without perforation was diagnosed in 46 (6.7 *per cent*) calves. Once again, in many of these cases, the herdowner did not report any unusual clinical signs prior to death and on *post mortem* examination a perforated abomasal ulcer, acute peritonitis and toxic shock was diagnosed.

Systemic infections (53 cases, 7.7 *per cent*) were frequently associated with *E. coli* or *Salmonella spp.* infections. *Salmonella* Dublin infection was associated in some cases with lesions of terminal dry gangrene (Figure 1.3b)

Bovine tuberculosis was diagnosed in nine calves examined during 2022. These calves were typically euthanised and submitted to the RVLs as part of investigations into large outbreaks of bovine tuberculosis on dairy farms. In the hereditary and developmental abnormality category, 16 cases were recorded in the one-to-five-month age category. Of these, circulatory defects associated with defects in the ventricular septum were most common.

1.4. Weanlings (six months to one year of age)

Respiratory infections were the most common cause of mortality in the six-months-to-one-year-old cattle age category in 2022. 456 cattle in this age category were examined, a similar number to 2021 (442). At 41.2 *per cent*, the figure was higher that was seen in recent years. As mentioned above, involved pathogens are discussed in more detail in the chapter *Bovine respiratory disease*.

Gastrointestinal infections accounted for 79 (17.3 *per cent*) of the deaths in this age category. These include parasitic gastroenteritis (31 cases) and coccidiosis (4 cases).

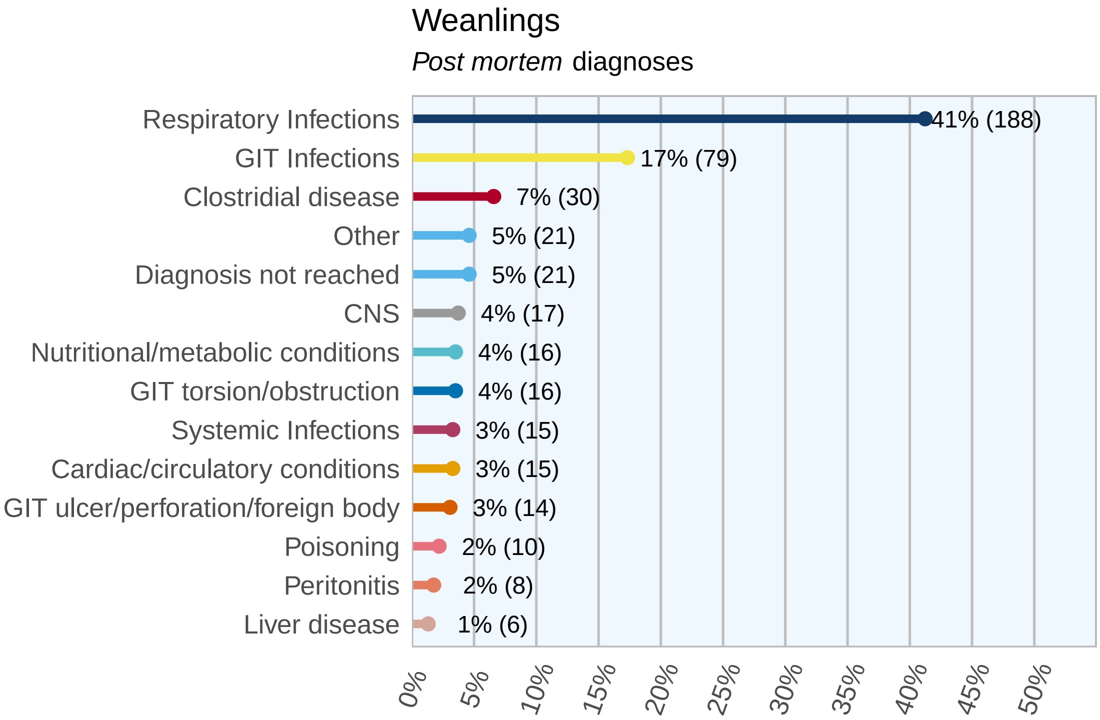


Figure 1.5.: Conditions most frequently diagnosed on *post mortem* examinations of weanlings (6–12 months old) in 2022 (n=456).Note: Categories that have less than five cases have been included in the 'Other' category. The absolute number of cases is between brackets.

Clostridial disease was a common diagnosis in this age category (30 cases, 6.6 per cent), with blackleg caused by *Clostridium chauvoei* diagnosed in 24 cases and enterotoxaemia caused by *Clostridium perfringens* diagnosed in 6 cases. Ten poisoning cases were diagnosed in weanling cattle in 2022, seven of which were lead related, two were associated with copper toxicity and one was associated with yew leaf/tree ingestion.

CNS conditions were diagnosed as the cause of death in 17 weanling carcasses, 10 of which were cerebrocortical necrosis (CCN), 6 were encephalitis/meningitis associated with bacterial infection and one was diagnosed as vacuolar encephalopathy possibly associated with parasitic gastroenteritis.

The most commonly diagnosed causes of death are presented in Table 1.3 and Figure 1.5. A diagnosis was not reached in 21 (4.6 *per cent*) weanling carcasses examined.

1.5. Adult Cattle (over 12 months of age)

The most commonly diagnosed causes of death are presented in Table 1.4 and Figure 1.6. A cause of death was not established in 41 (9.6 *per cent*) of adult cattle carcasses examined during 2022. This may have been the result of autolysis affecting the quality of the *post-mortem* examination or, as in the case of some metabolic conditions such as hypomagnesaemia, because the gross pathological changes may be minimal and biochemistry tests unreliable after death. Respiratory infections were associated with 81 (19.0 *per cent*) of the deaths of adult cattle submitted during 2022 and were more common in suckler/beef-type adult cattle. This is in line with previous years. The causes are discussed in more

Table 1.4.: Conditions most frequently diagnosed on *post mortem* examinations of adult cattle (over 12 months old) in 2022 (n=427).

Category	Beef/Suckler	Dairy	Other	Total	Percentage
Respiratory Infections	46	29	6	81	**19.0**
Other	28	20	1	49	**11.5**
Diagnosis not reached	19	21	1	41	**9.6**
Nutritional/metabolic conditions	21	18	2	41	**9.6**
Cardiac/circulatory conditions	18	20	0	38	**8.9**
GIT Infections	13	11	3	27	**6.3**
Systemic Infections	11	14	0	25	**5.9**
GIT ulcer/perforation/foreign body	8	14	1	23	**5.4**
Clostridial disease	16	4	1	21	**4.9**
Poisoning	16	4	0	20	**4.7**
Peritonitis	9	10	0	19	**4.4**
CNS	9	6	1	16	**3.7**
Liver disease	5	7	0	12	**2.8**
GIT torsion/obstruction	3	4	0	7	**1.6**
Integument/Musculoskeletal	4	3	0	7	**1.6**

Note:
Categories that have less than five cases have been included in the 'Other' category.

detail in the 'Bovine Respiratory Disease' chapter.

Nutritional/metabolic conditions were diagnosed in 41 (9.6 *per cent*) cases presented during 2022. Ruminal acidosis (18 cases) was the most common cause of death in this category, followed by hypomagnesaemia (11 cases), fatty liver (4 cases), bloat (4 cases), hypocalcaemia (3 cases) and hypophosphataemia (1 case).

Clostridial disease was a relatively common diagnosis in adult cattle (21 cases, 4.9 *per cent*), with the majority of cases seen in beef/suckler cattle. Blackleg caused by *Clostridium chauvoei* was diagnosed in 9 cases, black disease caused by *Clostridium novyi* in 8 cases and botulism caused by *Clostridium botulinum* in 2 cases. In one case of bovine botulism the source was thought to have been a dead cat which was discovered in one of the silage bales being fed to the cow group before the clinical signs developed (see the section of *Clostridial Disease in Bovine and Ovine*).

CNS conditions were diagnosed in 16 cases (3.7 *per cent*). Of these, two were associated with cerebrocortical necrosis (CCN), three were associated with *Listeria spp.* infection and three with *Histophilus somni* infection. Non-suppurative meningoencephalitis was diagnosed in two cases. A viral aetiology was suspected and Louping-ill virus was detected in one of the two. Hepatic encephalopathy associated with ragwort poisoning was diagnosed in one case.

Of the 20 cases (4.7 *per cent*) of poisoning recorded in adult cattle during 2022, 9 were linked with lead, 7 with ragwort, 3 with yew and 1 with copper. Lead poisoning can have significant implications for a farm, and in particular dairy farms, where milk is being collected regularly. Entry of lead to the food chain (via milk or meat) must be avoided for public health reasons. When a case of lead poisoning is diagnosed a risk assessment is carried out on the farm to determine the risk of entry of lead-contaminated food products into the food chain. Steps are then taken which may involve the dairy inspectorate, district veterinary office, milk processor and the laboratory service to ensure that the risk is minimised. Movement restrictions may be placed on animals in the herd until it is determined that lead levels have returned to a safe level.

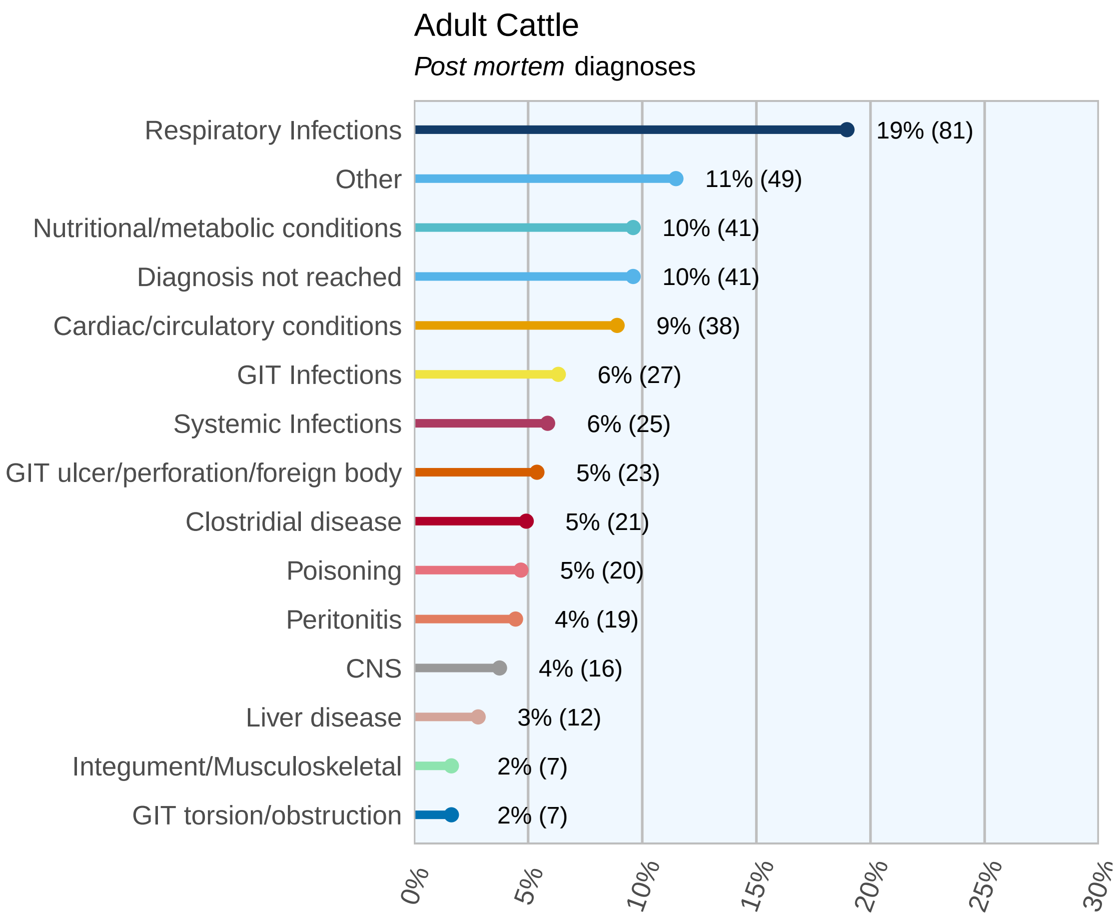


Figure 1.6.: Conditions most frequently diagnosed on *post mortem* examinations of adult cattle (over 12 months old) in 2022 (n=427). Note: Categories that have less than five cases have been included in the 'Other' category. The absolute number of cases is between brackets.

Eleven of the 23 cases of GIT ulcer/perforation/foreign body diagnosed in adult cattle during 2022 were associated with traumatic reticulo-pericarditis (Figure 1.7) and another 8 were associated with ulceration of the abomasal mucosa and haemorrhage or with abomasal ulceration and perforation/peritonitis.

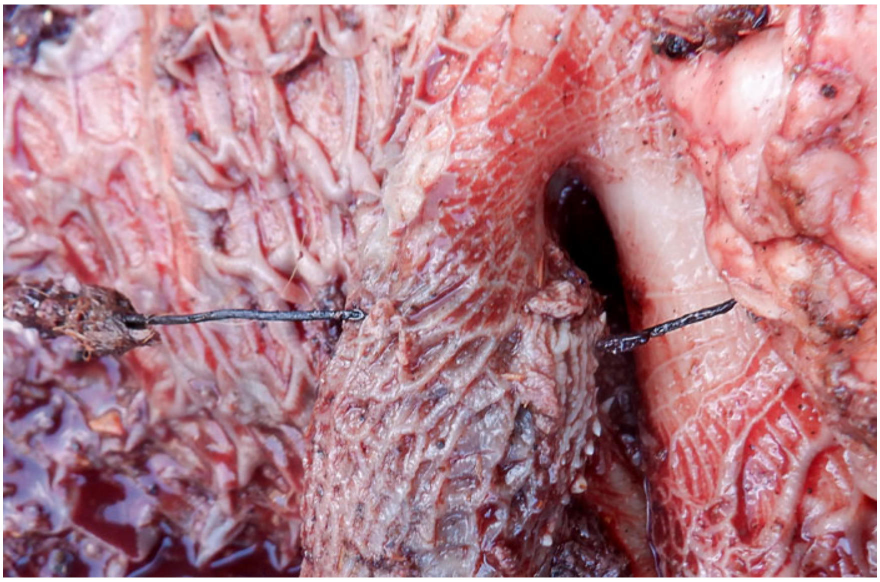


Figure 1.7.: Metal wire in the reticulum of a cow (traumatic reticuloperitonitis, hardware disease). Photo: Maresa Sheehan.

2. Bovine Abortion

Ciara Hayes, *Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

2.1. Introduction

Bovine abortion, stillbirth and perinatal mortality are common issues in cattle populations worldwide. A widely accepted definition of abortion is foetal death after 42 days and before 260 days' gestation. Stillbirth is defined as birth of a dead, full term (i.e. 260 days or more in gestation) calf. Perinatal mortality encompasses death of a calf during parturition or up to 48 hours afterwards, so there is some overlap between this and stillbirth. These distinctions can be important factors when considering the aetiologies of these conditions.

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.

A certain rate of foetal and perinatal loss can be considered 'normal'. An abortion rate of 3–5 *per cent* or greater is generally cited as the point at which an investigation should be launched. However, if a smaller number of losses occur within a herd over a short space of time, investigation may still be 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 environment and management and peripartum management, as appropriate.

Although the findings reported here are primarily the results of testing for infectious disease, it is important to note that not all foetal or perinatal death is due to infectious agents. There are a wide range of non-infectious causes, including dystocia, dam nutrition, plant and mycotoxin ingestion, hormonal, physical and genetic factors.

There were 1212 abortion, stillbirth or perinatal mortality cases submitted to the Veterinary Laboratory Service (VLS) in 2022. 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 2.1).

2.2. Bacterial pathogens

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

Salmonella spp.

Salmonella Dublin is a common cause of bovine foetal death in Ireland. In 2022, *S.* Dublin was cultured from 58 or 4.8% of foetal cultures (Table 2.1). As in previous years, the proportion of cases with an *S.* Dublin diagnosis peaked in the second half of the year (Figure 2.1), emphasising the importance of appropriate timing of vaccination against this disease.

Table 2.1.: Number of Salmonella Dublin isolates in foetal material in 2022 (n= 1212).

Total Submissions	No. of Cases	Percentage
1212	58	**4.8**

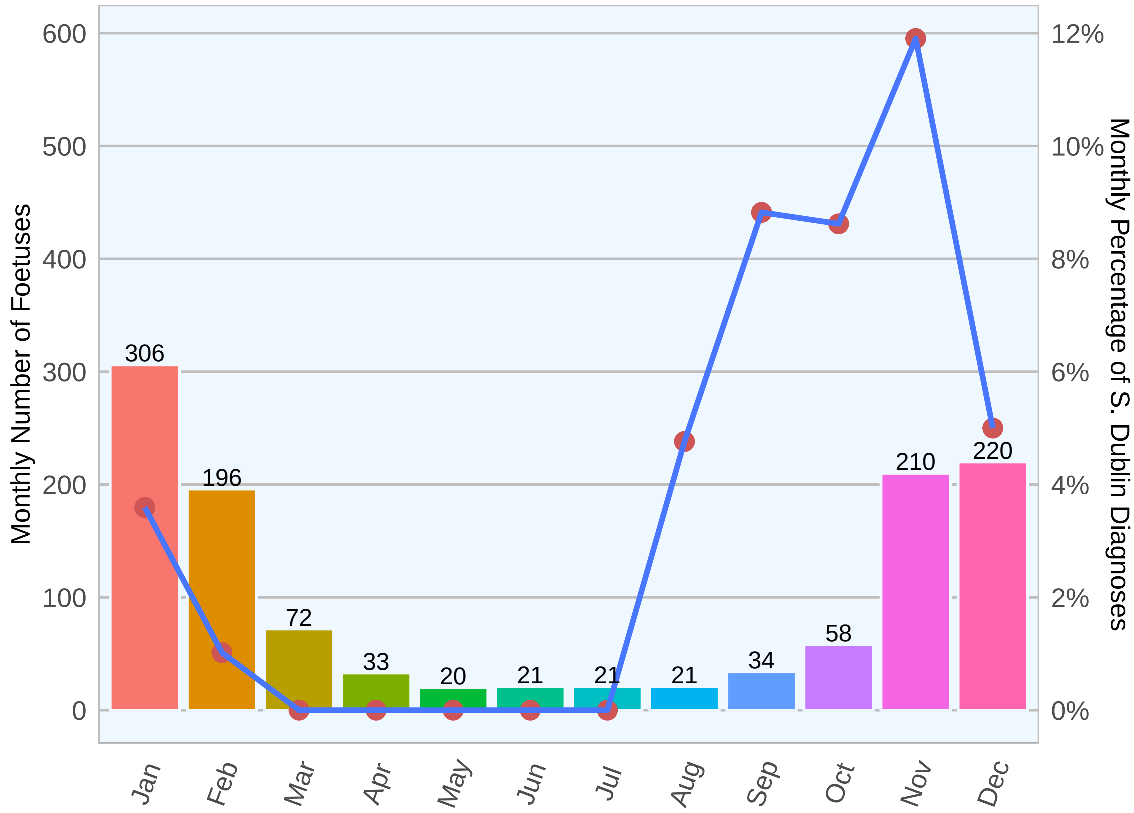


Figure 2.1.: Annual distribution of foetal submissions (bars,number of submissions) and *Salmonella* Dublin isolates (line plot, as percentage) from foetal bacterial cultures as a percentage of monthly bovine submission (n= 1212).

Other bacterial pathogens

Trueperella pyogenes is a common cause of sporadic foetal death, identified in 93 cases (7.8 *per cent*) in 2022 (Table 2.2). 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 (7 *per cent*) and *Listeria monocytogenes* (1.8 *per cent*) abortions are often associated with feeding of poorly preserved silage (see Table 2.2).

Table 2.2.: Frequency of detection of other primary abortion pathogens in foetal culture during 2022 (n= 1212).

Organism	No. of cases	Percentage
Trueperella pyogenes	93	**7.8**
Bacillus licheniformis	83	**7.0**
Aspergillus spp	22	**1.8**
Listeria monocytogenes	21	**1.8**

Other bacteria isolated from cases in 2022 are listed in the Table 2.3. The significance of some of these isolates can be difficult to determine. Some, particularly coliforms, may be the result of faecal or environmental contamination of the sample. Others may be secondary pathogens which have had the opportunity to cross the placenta due to compromise for another reason. Species such as *Proteus spp*. proliferate rapidly *post mortem*, and may obscure the presence of a pathogen which was actually responsible for foetal or perinatal death.

Table 2.3.: Combined frequency of detection of selected secondary abortion agents on routine foetal culture.

Organism	No of Cases	Percentage
No Significant Growth	840	**70.5**
Coliforms	248	**20.8**
Other minor organisms	48	**4.0**
Streptococcus spp	39	**3.3**
Yeasts and Fungi	19	**1.6**
Staph. spp	12	**1.0**
Pseudomonas spp	11	**0.9**
Bacillus spp	10	**0.8**
Listeria spp	7	**0.6**
Campylobacter fetus	2	**0.2**
Campylobacter jejuni	2	**0.2**
Mannheimia haemolytica	2	**0.2**
Yersinia pseudotuberculosis	2	**0.2**

2.3. Viral pathogens

Foetal tissue is tested for viral pathogens associated with bovine abortion, stillbirth and perinatal mortality if considered appropriate by the investigating research officer. These viruses include bovine herpesvirus-1 (BHV-1), bovine herpesvirus-4 (BHV-4), and Schmallenberg virus (SBV). Of the 71 cases tested for BHV-1 via PCR, one positive (1.4 *per cent*) result was returned (Table 2.4).

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. No cases tested positive for BHV-4 or SBV. The role of BHV-4 in reproductive disorders of cattle is currently unclear, and there are no vaccines available against the virus.

Table 2.4.: Frequency of detection of viruses in foetal material during 2022.

Virus	No virus detected	Positive	Percentage
BHV-1	70	1	**1.4**
BHV-4	63	0	**0.0**
SBV	63	0	**0.0**

2.4. Fungal pathogens

Aspergillus spp. were isolated from 22 cases (1.8 *per cent*)(Table 2.2). This is also often associated with feeding of contaminated foodstuffs.

2.5. 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, the major route through which infection is maintained in a herd is vertical, 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. It cannot be used to conclusively diagnose *N. caninum*. Detection of these lesions is also dependent on the specific sections of foetal tissue examined. Antibody ELISA results can be affected by degree of autolysis of the sample and age and immunocompetence of the foetus. In 2022, *N. caninum* was diagnosed in 35 cases. This figure may be falsely reduced, as samples are not submitted for histopathology or antibody ELISA in all cases.

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).

Zoonotic risks

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.

3. Bovine Respiratory Disease

Aideen Kennedy *, Research Officer*
Kilkenny Regional Veterinary Laboratory, DAFM
Leggatsrath, Hebron Road, Kilkenny, Ireland

3.1. Overview

Bovine respiratory disease (BRD) remained a significant cause of morbidity and mortality in cattle throughout 2022, with 545 cases diagnosed on *post mortem* examination. BRD typically has a multi-factorial aetiology and results from complex interactions between pathogens, environmental factors and host factors. Stressors such as transportation, overcrowding, weaning, mixing and inadequate ventilation can negatively affect host defence mechanisms. Numerous infectious agents are associated with BRD. Often an initial pathogen (e.g. viral agents) will alter the defence mechanisms of the animal, allowing the colonisation of the lower respiratory tract by additional agents, e.g. bacteria.

There are limitations however, to identifying the agents involved by *post mortem* examination (7.2 *per cent* of BRD cases had no agent identified in 2022 - see Table 3.1). Limiting factors include; 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, or antibiotic treatment *ante mortem* may confound attempts to isolate bacteria.

Table 3.1.: Number of cases and percentage (%) by age of the general pathogenic groups detected in the BRD cases diagnosed on post mortem examination (n= 545).

Aetiology	Neonatal (0-1 month old)	Calves (1-5 months old)	Weanling (6-12 months old)	Adult Cattle (over 12 months old)	Total
Bacterial	33 (78.6)	153 (65.4)	94 (49.7)	51 (63.8)	**331 (60.7)**
Parasitic	0 (0.0)	39 (16.7)	58 (30.7)	13 (16.2)	**110 (20.2)**
Viral	4 (9.5)	22 (9.4)	27 (14.3)	8 (10.0)	**61 (11.2)**
No agent identified	5 (11.9)	18 (7.7)	9 (4.8)	7 (8.8)	**39 (7.2)**
Fungal	0 (0.0)	0 (0.0)	1 (0.5)	1 (1.2)	**2 (0.4)**
Other	0 (0.0)	2 (0.9)	0 (0.0)	0 (0.0)	**2 (0.4)**

3.2. Bacterial respiratory agents

Bacterial agents were identified as the leading cause of BRD across all age groups (60.7 *per cent* of BRD cases- Table 3.1) It should be noted that when interpreting the results, 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, multiple agents may have been identified (see Figure 3.1), with the pathologist acknowledging the possibility that an undetected primary viral infection could have preceded the development of the bacterial infection.

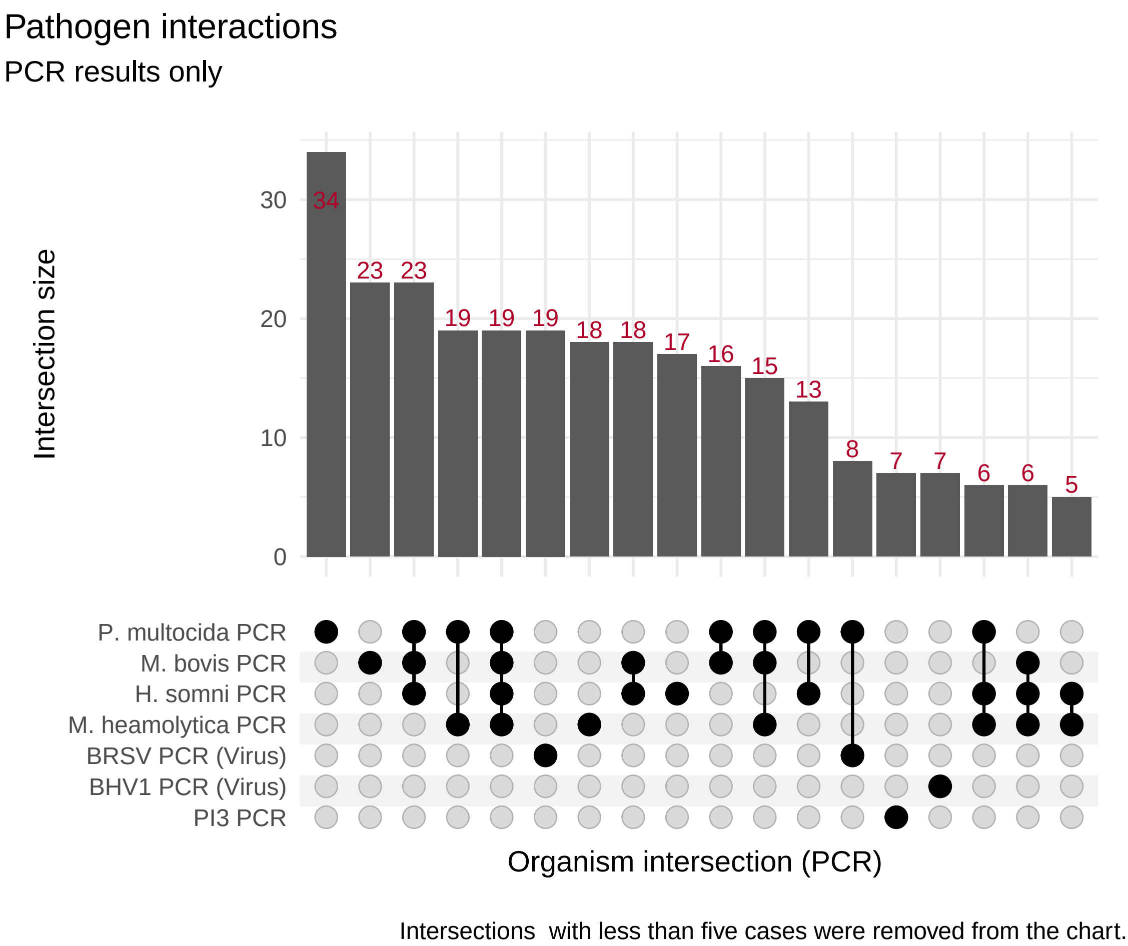


Figure 3.1.: Upset plot depicting the interaction of different organisms in BRD cases diagnosed on *post mortem* examination based on PCR results during 2022.

The most frequently identified bacterial agents were *Mannheimia haemolytica* (17.1 *per cent*) and *Pasteurella multocida* (11.6 *per cent*). Both agents are commensals of the nasopharynx, as is *Biberstinia trehalosi* (identified in 1.8 *per cent* of cases) (Figure 3.2). When animals are stressed (e.g., at housing or during transportation) and/or become infected with viruses, replication can occur, and the pathogens can be inhaled into the lower respiratory tract, invading the tissues of an immunocompromised animal. While *M. haemolytica* is well recognized as a principal bacterium in BRD of younger animals, reports from Europe have identified *M. haemolytica* as a pathogen of emerging significance in adult dairy cows with a number of outbreaks of acute pleuropneumonia. These outbreaks sometimes resulted in fatalities of many highly productive dairy cows within a short time period (Biesheuvel et al. 2021). *M. haemolytica* was the most frequently identified agent in BRD in adult cattle in 2022, with a higher number of cases reported in dairy cattle compared to beef (21 cases versus 11 cases).

Mycoplasma bovis is a bacterium that can affect dairy and beef cattle of all ages and in different ways including pneumonia, otitis, mastitis and lameness. *Mycoplasma bovis* was detected in 10.5 *per cent* of BRD cases in 2022. *Mycoplasma bovis* has sophisticated virulence factors which can help it to evade an animal's immune response, additionally many antibiotics do not work against *Mycoplasma bovis* due to its structure (lack of a cell wall) making it difficult to treat. *Histophilus somni* was detected in 8.8 *per cent* of cases of BRD. *H. somni* is a Gram-negative member of the *Pasteurellaceae* family. It causes septicemic infections with clinical presentations, including pneumonia, polyarthritis, myocarditis, abortion and meningoencephalitis. All age groups of animals can be infected with *H. somni*. Clinical signs include depression, high temperatures, dyspnoea, discharge from the eyes and nose, and some animals can display stiffness.

Trueperella pyogenes was identified in 1.8 *per cent* of cases; usually, it is a secondary pathogen in pneumonia where other pathogenic respiratory agents have previously acutely damaged tissues.

Fungal agents were identified in small numbers, typically these are opportunistic infections and only cause disease in those who are immunocompromised.

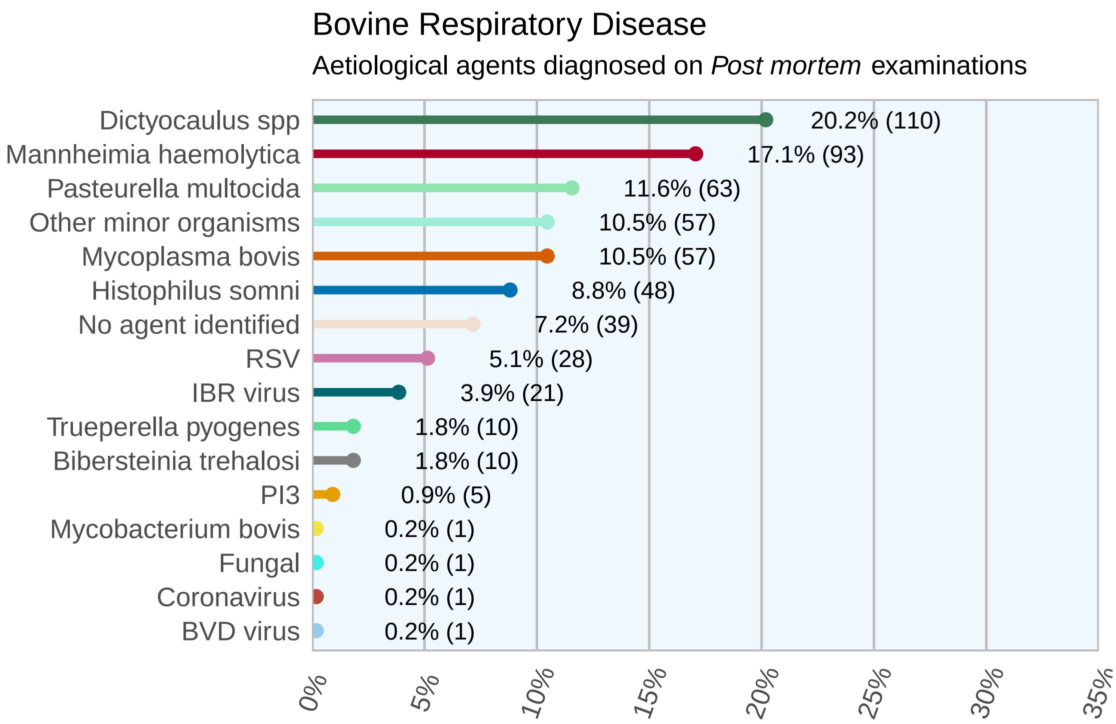


Figure 3.2.: Relative frequency of the top ten pathogenic agents detected in BRD cases diagnosed on *post-mortem* examination, (n=545).

3.3. Parasitic bovine respiratory disease

Dictyocaulus spp. was the aetiological agent in *20.2 per cent* cases of respiratory disease (an increase from 18.3 *per cent* of BRD cases in 2021). Surprisingly a peak of cases was reported in November (Figure 3.3), later than previous years and may represent a prolonged grazing season due to favorable weather conditions. Dictyocaulosis or hoose is typically associated with dairy calves in their first grazing season, as they have no previously acquired immunity. Lungworm was the agent most frequently identified in cases of BRD in both the weanling age group and calves aged 1- 5 months (30.7 *per cent* and 16.7 *per cent* respectively (Table 3.2). Older animals, lacking immunity, can also show signs of the disease. Typical reasons for lack of immunity include previous intensive anthelmintic treatment or grazing animals on newly sown pasture. Immunity against the larval stages (*L3*) only lasts for a few months, depending on the level of challenge. This larval immunity requires a persistent challenge to be maintained.

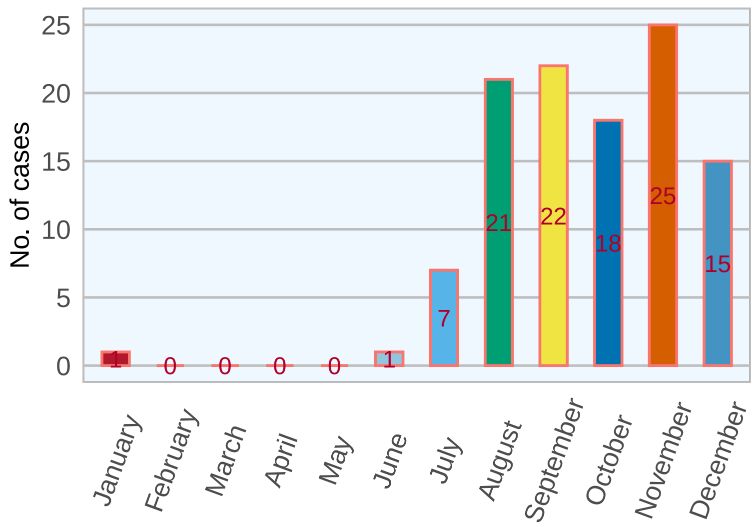


Figure 3.3.: Number of diagnoses of parasitic bronchopneumonia by month during 2022 (n=110).63

Immunity against adult lungworm lasts for two to three years, depending on the level of infection. Immunity to adult stages is strong and prevents the maturation of larvae into the adult stages. Re-infection syndrome occurs when older animals are introduced to a pasture with a heavy lungworm burden and become infected with L3 larvae around the time larval immunity waned. A severe inflammatory response can occur. This can lead to severe dyspnoea and milk drop in dairy animals. When submitting faecal samples for lungworm examination, it is essential to remember that clinical signs can occur in the *pre-patent* period, so a negative Baermann test result doesn't rule out lungworm.

3.4. Viral Bovine Respiratory Disease

Viral agents were implicated as the primary cause of almost 11.2 *per cent* of BRD cases diagnosed on *post mortem* examination during 2022, with the highest frequency reported in weanlings (6–12 months of age) (14.2 *per cent*) (Table 3.1). Bovine respiratory syncytial virus (BRSV) and bovine herpesvirus-1 (BHV1) were counted among the most frequently identified viral pathogenic agents, found in 5.1 and 3.9 per cent of all BRD cases diagnosed, respectively (Figure 3.2).

BRSV typically affects cattle younger than one year and occasionally adults. Initial exposure to BRSV can produce acute pneumonia, with subsequent exposure usually resulting in milder disease. Gross lesions can include caudally diffuse pneumonia with subpleural and interstitial emphysema and intralobular oedema. Bovine herpesvirus 1 (BHV-1) is associated with several diseases in cattle: infectious bovine rhinotracheitis (IBR), infectious pustular vulvovaginitis, conjunctivitis, abortion and encephalomyelitis, The respiratory form of IBR (BHV1) is characterised by severe hyperaemia and focal necrosis of nasal, laryngeal and tracheal mucosa. Secondary infection of the necrotic areas results in the formation of fibrino-necrotic material (diphtheritic) in the airways. Pneumonia is a common sequel to IBR infection either by direct aspiration of exudate or by impairment of the pulmonary defences. Clinical signs include fever, coughing, depression, loss of appetite, inflammation of the mucosae, nasal/ ocular discharge, conjunctivitis, drop in milk production, abortion, and occasionally nervous signs. Clinical signs can range from mild to severe and are usually most apparent during primary infection. After recovery from the clinical signs, the animal remains persistently infected. Reactivation can occur when the animal is stressed.

Table 3.2.: Count and percentage by age goup of the general specific organisms detected in BRD on post mortem examination, (n= 545).

Aetiology	**Neonatal (0-1 month old)**	**Calves (1-5 months old)**	**Weanling (6-12 months old)**	**Adult Cattle (over 12 months old)**	**Total**
Bibersteinia trehalosi	2 (4.8)	3 (1.3)	5 (2.6)	0 (0.0)	10 (1.8)
BVD virus	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.2)
Coronavirus	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.2)
Dictyocaulus spp	0 (0.0)	39 (16.7)	58 (30.7)	13 (16.2)	110 (20.2)
Fungal	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.2)	1 (0.2)
Histophilus somni	4 (9.5)	25 (10.7)	13 (6.9)	6 (7.5)	48 (8.8)
IBR virus	1 (2.4)	3 (1.3)	12 (6.3)	5 (6.2)	21 (3.9)
Mannheimia haemolytica	8 (19.0)	27 (11.5)	26 (13.8)	32 (40.0)	93 (17.1)
Mycobacterium bovis	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.2)	1 (0.2)
Mycoplasma bovis	6 (14.3)	32 (13.7)	15 (7.9)	4 (5.0)	57 (10.5)
No agent identified	5 (11.9)	18 (7.7)	9 (4.8)	7 (8.8)	39 (7.2)
Other minor organisms	7 (16.7)	29 (12.4)	16 (8.5)	5 (6.2)	57 (10.5)
Pasteurella multocida	5 (11.9)	37 (15.8)	19 (10.1)	2 (2.5)	63 (11.6)
PI3	1 (2.4)	2 (0.9)	1 (0.5)	1 (1.2)	5 (0.9)
RSV	2 (4.8)	15 (6.4)	10 (5.3)	1 (1.2)	28 (5.1)
Trueperella pyogenes	1 (2.4)	3 (1.3)	4 (2.1)	2 (2.5)	10 (1.8)

4. Bovine Mastitis

Marie-Claire McCarthy , *Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

From January 2022 onwards, implementation of updated EU veterinary medicine regulations (*Regulation EU 2019/6*) has resulted in stricter control over antimicrobial use in Ireland. The consequences for mastitis prevention and treatment are multiple. Blanket dry cow therapy can no longer be used as a preventative measure in mastitis control, with farmers required to adopt selective dry cow strategies. Additionally, use of high priority critically important antibiotics (such as 3rd and 4th generation cephalosporins, fluoroquinolones and macrolides) is not permitted as first line therapy or for prophylaxis. As a result, milk culture and sensitivity results are more important than ever to inform mastitis prevention and treatment decisions on Irish dairy farms. Milk culture and sensitivity testing is offered by DAFM laboratories and several private laboratories (AHI Cellcheck Partner Laboratories[1]).

Table 4.1.: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2022 (n=2210)

Result	No. of cases	Percentage
Contaminated	587	**26.6**
Staphylococcus aureus	401	**18.1**
No Significant Growth	338	**15.3**
Streptococcus uberis	306	**13.8**
E. coli	248	**11.2**
Other Isolates	121	**5.5**
Bacillus spp.	67	**3.0**
Non-aureus staphylococci	63	**2.9**
Streptococcus dysgalactiae	47	**2.1**
Trueperella pyogenes	28	**1.3**
Streptococcus agalactiae	3	**0.1**
Listeria monocytogenes	1	**0.0**

Mastitis is inflammation of the udder caused by microorganisms (most commonly bacterial pathogens) that enter the gland through the teat canal. Mastitis results in significant economic losses owing to direct and indirect costs including diagnostic tests, veterinary fees, wasted milk, labour, poor fertility and premature culling of affected animals. Mastitis pathogens can be broadly categorised as contagious or environmental. Contagious pathogens are host-adapted and are spread between cows during the milking process while environmental pathogens are present in the cow's environment and are highly influenced by management practices.

Bovine mastitis can be classified as clinical, subclinical and chronic. Clinical infections are characterised by a wide range of symptoms including inflammation of the udder (heat, swelling, pain), abnormal

[1] https://animalhealthireland.ie/programmes/cellcheck/cellcheck-partner-laboratories/

appearance of milk, fever and inappetence. In contrast, subclinical mastitis is not associated with overt visible abnormalities, with reduced milk yield and elevated somatic cell count being the only indicators of infection. Subclinical mastitis occurs at a much higher incidence than clinical mastitis and due to the difficulty in detection of affected cows, it represents a major source of economic loss for farmers. Where treatment is ineffective, some mastitis pathogens can induce chronic mastitis with substantial negative effects on subsequent fertility and cow welfare. The first step in any mastitis control programme is to identify the predominant bacteria by culturing milk from affected animals. Individual cow or quarter sampling is recommended for improved diagnostic accuracy.

4.1. Milk submissions in 2022

Bacteriological examination was carried out on 2210 milk samples in 2022. The relative frequency of detection of the most common mastitis pathogens is outlined in Table 4.1 and Figure 4.1.

Contaminated samples

During 2022, 26.6 *per cent* of milk samples were deemed to be contaminated. These findings are consistent with those of recent years (16–30 *per cent* of samples were categorised as contaminated between 2018 and 2021). Contaminated samples yield mixed bacterial growth and present a considerable challenge to result interpretation and renders samples unsuitable for sensitivity analysis. Contamination arises when bacteria from the udder, skin, teats, hands of the sampler or the environment inadvertently enter the sampling container. Proper aseptic sampling technique is therefore critical to prevent contamination. Samples should be collected in sterile containers and sent to the laboratory as soon as possible after collection. Where a delay in transportation to the laboratory is anticipated, samples should be refrigerated.

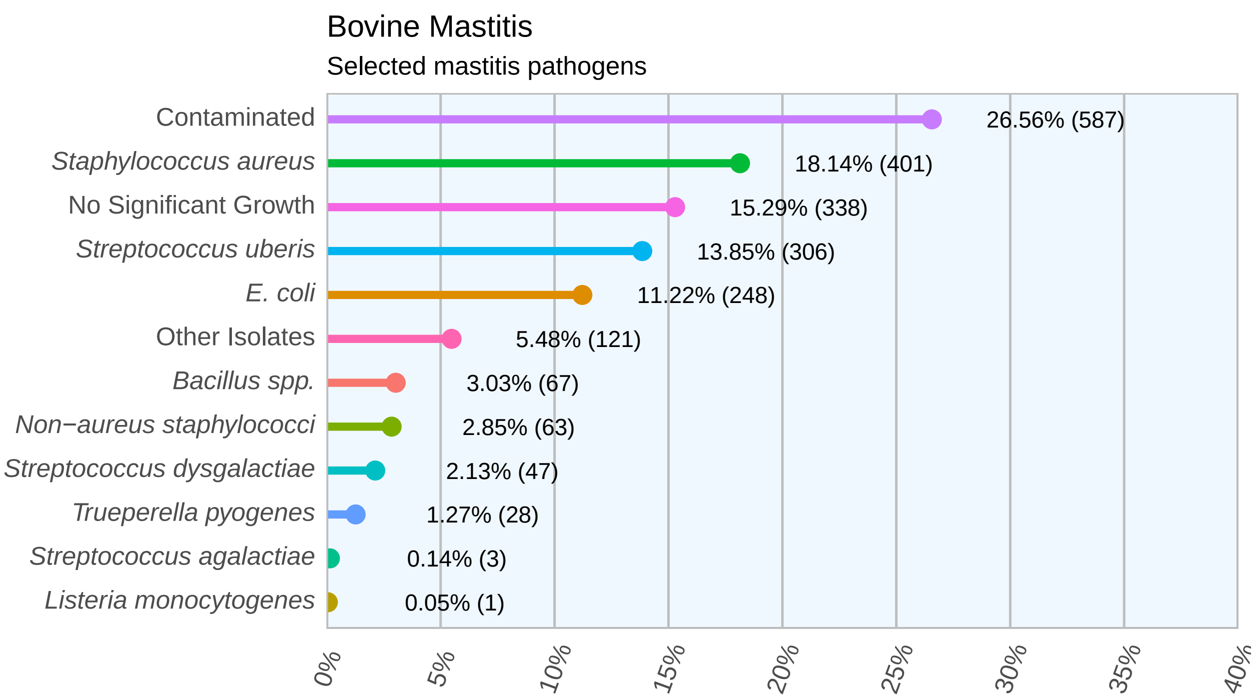


Figure 4.1.: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2022 (n=2210).

No significant growth

Where milk samples yield no colonies or a small number of dissimilar colonies, results are reported as *no significant growth*. Possible reasons for this include: the infection has been cleared by the cow's immune system, milk sampling was done after antibiotic therapy, improper handling/transport of samples resulting in reduced numbers of viable pathogenic organisms, organisms are present but below detectable levels, sampling of cows post milking and intermittent shedding of pathogens. To maximise the chance of obtaining a clinically significant result, cows should be sampled before milking using aseptic technique.

Quality of milk samples

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.

4.2. *Staphylococcus aureus*

Figure 4.2.: Pure growth of Staphylococcus aureus on a blood agar plate. Photo: Alan Johnson.

S. aureus was the most common mastitis-associated pathogen isolated in 2022 (18.1 *per cent* of milk sample submissions) (Figure 4.2). This represents a slight decline in detection frequency of this pathogen compared to 2020 and 2021 levels (18.7 and 21.4 *per cent* respectively) and generally continues the trend of declining *S. aureus* detection since 2016 (Figure 4.3). *S. aureus* is an opportunistic, contagious pathogen most frequently associated with subclinical infections and associated elevated SCC. Infection is spread between cows during milking (by milking equipment or *milker's hands*). Treatment of *S.aureus* mastitis can be challenging and as a result, focus should be on prevention through implementation of appropriate hygiene measures at milking. Chronic carriers should be identified and culled.

4.3. *Streptococcus uberis*

S. uberis was the second most frequently detected mastitis-associated pathogen in 2022 (13.8 *per cent* of milk sample submissions). These findings are consistent with those of recent years (Figure 4.3). *S. uberis* is an environmental pathogen, capable of surviving in diverse environments including bedding, pasture, faeces, various body sites of cows and in the mammary gland. The dry period represents the period of greatest risk for *S. uberis* mastitis. While it is predominately considered an environmental pathogen, *S. uberis* can also be transmitted between cows when chronic infection develops from persistence of the bacteria in the udder. *S. uberis* mastitis can be difficult to treat, as a result, efforts should be focused on optimising environmental and milking hygiene to minimise contact between cows and the contaminated environment.

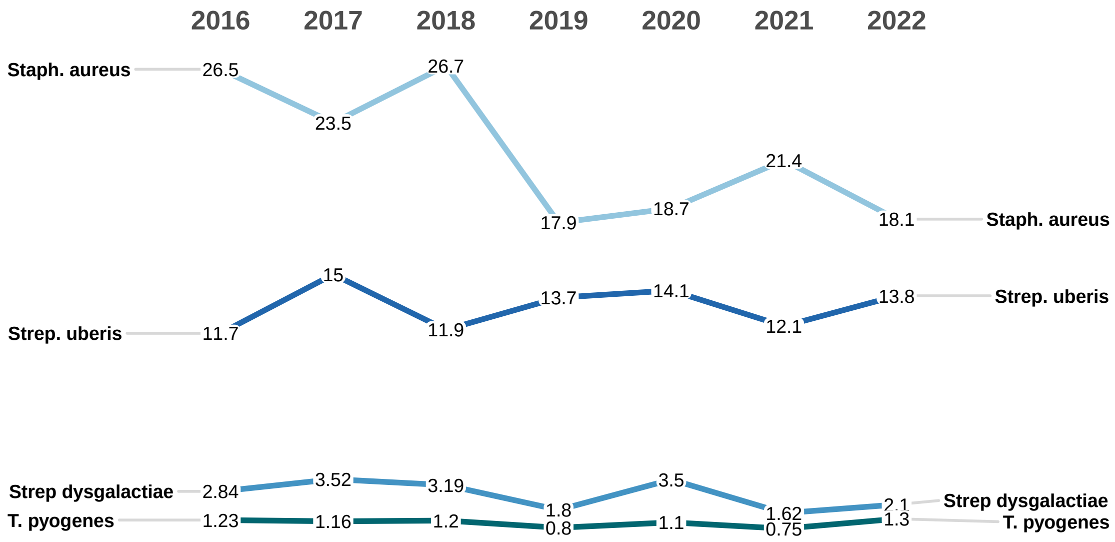


Figure 4.3.: Mastitis-associated organisms isolated in milk based on bovine milk samples submitted to RVLs between 2016 and 2022.

4.4. *E. coli*

E. coli was detected in 11.2 *per cent* of milk sample submissions in 2022, in line with detection rates in 2020 and 2021. Caution should be exercised when interpreting *E. coli* positive milk samples however, due to the possibility of contamination. Results should be interpreted considering the presence of other isolates cultured and taking the clinical presentation into account. *E. coli* mastitis is predominately an acute infection most commonly affecting cows in the late dry and early post-partum periods. Systemic signs are usually present with toxaemia, fever and a dramatic reduction in milk production. Severe acute infection is associated with poor prognosis.

4.5. *Streptococcus dysgalactiae*

S. dysgalactiae was identified in 2.1 *per cent* of milk samples during 2022, consistent with isolation rates in recent years. Although *S. dysgalactiae* is primarily considered an environmental mastitis pathogen, it shares similar characteristics with contagious mastitis pathogens. The periods of greatest risk for *S. dysgalactiae* mastitis are the post-partum and early dry periods. *S. dysgalactiae* is also associated with summer mastitis in dry cows and heifers, with the common cattle fly (*Hydrotaea irritans*) known to play a role in its transmission.

4.6. Other mastitis pathogens

Mastitis associated pathogens detected at low relative frequencies in 2022 include *Bacillus* species (3 *per cent*) non-aureus *Staphylocci* (coagulase-negative *Staphylococci*) (2.8 *per cent*), *Trueperella pyogenes* (1.3 *per cent*), and *Streptococcus agalactiae* (0.1 *per cent*).

Milk Sample Collection for Bacteriology: Sampling Technique

1. Take the sample before milking and before any treatment is given.
2. Label the tubes prior to sampling with name/creamery number/herd number, cow number, quarter and date.
3. Using a hand or paper towel brush any loose dirt, straw or hair from teat or underside of the udder. Washing should be avoided if possible. However, if teat is soiled it should be washed and carefully dried with paper towels.
4. Put on gloves.
5. Soak a number of cotton wool balls in alcohol.
6. Clean teat thoroughly with alcohol soaked cotton wool or the medicated wipes until it is thoroughly clean.
7. Remove cap from sampling tube. Place cap on a clean surface with closing side up. Hold open tube at an angle of 45° (holding it straight up will allow dust etc. to fall inside). Using your other hand, discard first few streams of milk on to the ground before collecting three or four streams in the tube.
8. Replace cap on sampling tube.
9. If you feel that some contamination has occurred, discard sample and use a new tube.
10. Place labelled tube in a fridge and cool to 4 ▯C. This is very important. 11. Sample should be taken to the laboratory as quickly as possible. If sample is handed to milk tank driver for delivery, ensure that it is placed in a cool box.
11. If sample is not going to a laboratory immediately, it must be refrigerated until delivery

5. Bovine Neonatal Diarrhoea

Marie-Claire McCarthy , *Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

Enteritis represents the most common cause of calf mortality in the neonatal period (calves up to 1 month old). In 2022, the enteropathogens most frequently detected in faecal samples from calves up to one month of age were Rotavirus (27 *per cent*) and *Cryptosporidium parvum* (20.3 *per cent*)(Table 5.1). These findings are broadly consistent with those of previous years (Figure 5.2).

5.1. Rotavirus

Rotavirus is the aetiological agent most frequently associated with enteric infections resulting in calf morbidity and mortality in Ireland and internationally. Young calves (less than 2 weeks old) are most at risk of infection, particularly those with insufficient colostral immunity. Infected calves typically excrete large titres of virus and calf houses can rapidly become heavily contaminated, especially where overcrowding is an issue. The virus is transmitted via the faecal-oral route and the infectious dose is low. The severity of infection is dependent on the virulence of the strain, the quantity of virus ingested and the immune status of the calf. The virus infects enterocytes at the tips of the villi in the small intestine, with the resultant inflammatory response resulting in malabsorption of fluid from the intestine lumen and diarrhoea. Prevention of rotaviral enteritis is best achieved through implementation of appropriate colostrum feeding practices (at least 3L of colostrum fed within 2 hours of birth), a dam vaccination program and by maintaining good hygiene in calf pens.

Table 5.1.: Number of tests and relative frequency of enteropathogenic agents identified in faecal samples of calves up to one month of age in 2022.

Organism	No. of Tests	Positive	Percentage
Rotavirus	1205	325	**27.0**
Cryptosporidia	1271	258	**20.3**
Campylobacter jejuni	1029	86	**8.4**
Giardia	779	45	**5.8**
E.Coli K99	856	12	**1.4**
Salmonella Dublin	1185	16	**1.4**
Coronavirus	1185	3	**0.3**

5.2. *Cryptosporidium parvum*

Cryptosporidium parvum was the second most frequently detected pathogen in faecal samples from neonatal calves in 2022 (20.3 *per cent*)(Figure 5.1). These findings are broadly in line with detection rates in previous years. *C. parvum* is a protozoan parasite capable of infecting a wide range of species. Transmission is through the faecal-oral route, with large numbers of oocysts excreted by infected calves. Calves are most susceptible to infection at around 10 days of age. Infection results in destruction of the small intestinal microvilli through atrophy and villous fusion, resulting in malabsorption, fluid loss and dehydration. The clinical signs associated with infection are variable, ranging from inapparent infection in carrier animals to profuse diarrhoea and associated dehydration in severely affected animals. While morbidity associated with *C. parvum* is generally high, mortality is rare. Several factors can influence the outcome of infection including the immune status and age of the calf and synergistic co-infection with other enteropathogens.

Prevention of *C. parvum* infection is dependent on reducing exposure of calves to infected oocysts through appropriate hygiene. *C. parvum* oocysts are resistant to many commonly used disinfectants, but are susceptible to temperatures above 60°C. As a result, the most effective way to reduce the environmental burden of oocysts is using high-pressure steam cleaning following by drying over a prolonged period. Treatment is supportive with fluid and electrolytes with continued feeding of milk advised. As with rotaviral enteritis, prevention of cryptosporidiosis is based on maintaining a strict hygiene program in calf houses, prompt isolation of sick calves, keeping calves in groups of similar ages and feeding adequate quantities of good quality colostrum.

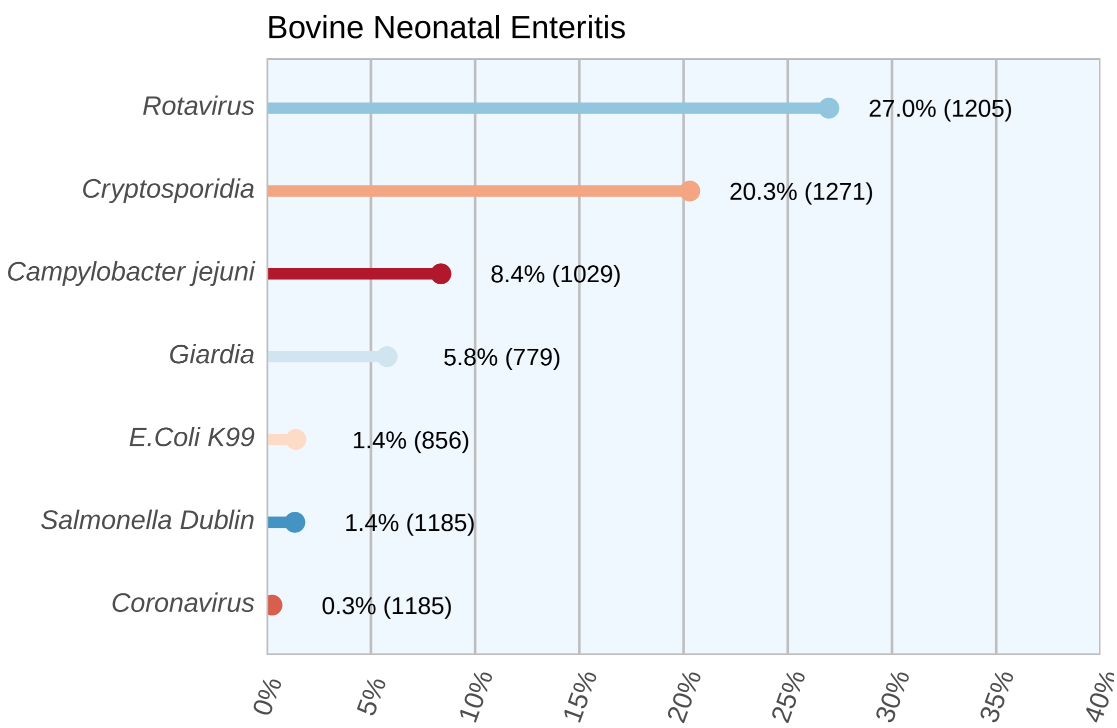


Figure 5.1.: Relative frequency of enteropathogenic agents identified in calf faecal samples (neonatal enteritis package) tested in 2022. Percentage of positive results. Total samples examined varies with the agent, see Table 5.1 .

5.3. *Escherichia coli* K99

E.coli K99 was detected in less than 2 *per cent* of neonatal faecal sample submissions to RVLs in 2022, in line with trends in previous years (Figure 5.2). *E.coli* K99 is an enterotoxigenic *E.coli* associated with enteritis in calves in the first week of life (ETEC adhesin receptors are only present on enterocytes in calves less than 7 days old). As a result, faecal samples from calves older than one week are not tested for this *E.coli* K99. This bacterium colonises the distal small intestine by attaching to enterocyte receptors resulting in the production of toxins that stimulate hypersecretory diarrhoea and fluid malabsorption. As with rotaviral and cryptosporidial diarrhoea, prevention of *E.coli* K99 infection depends on good colostrum feeding practices and maintaining a hygienic environment in calf houses to prevent build-up of pathogenic *E.coli* strains.

5.4. *Salmonella enterica* subspecies *enterica* serovar Dublin

S. Dublin was detected in a small percentage of calf faecal samples in 2022 (1.4 *per cent*) continuing the trend of declining detection frequency observed in recent years (Figure 5.2). This may be attributed to increased uptake of herd vaccination programs. In cattle of all ages, *S.* Dublin infection can have several clinical manifestations including enteritis, pneumonia and septicaemia. *S.* Dublin infection is most common in immunodeficient calves as a result of poor colostrum feeding practices. Clinical signs include fever, diarrhoea (often bloody and mucoid) and rapid dehydration. Surviving calves can become carriers, shedding *S.* Dublin in their faeces for the duration of their lives.

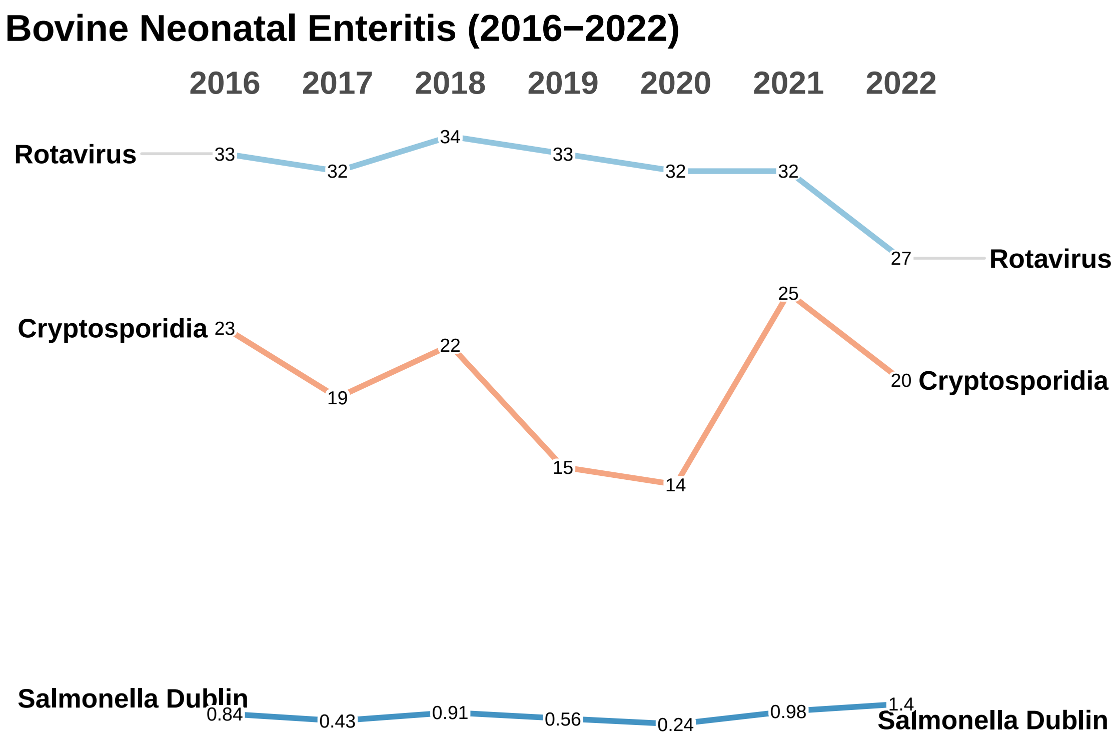


Figure 5.2.: Trends in the incidence of Rotavirus, Cryptoporidia and *Salmonella* Dublin enteritis in calves less than one month.

5.5. *Campylobacter jejuni* and *Giardia*

The significance of *C.jenui* and *Giardia* spp. as enteropathogens in neonatal calves is uncertain, however they are zoonotic pathogens, and thus pose a risk to human health. Both pathogens are important causes of gastroenteritis in humans. Where either of these agents are detected in faecal samples, hygiene precautions should be exercised by calf handlers, particularly immunocompromised individuals.

5.6. Coronavirus

In accordance with previous years, the relative frequency of detection of coronavirus in calf faecal samples continues to be low in 2022 (less than one *per cent*). The virus replicates and destroys mature enterocytes in the small intestine and colon, resulting in a malabsorptive diarrhoea. As with other enteropathogens, prevention of coronavirus infection is dependent on maternal vaccination, good colostrum management and implementation of appropriate hygiene practices to minimise the viral load in the calf housing environment.

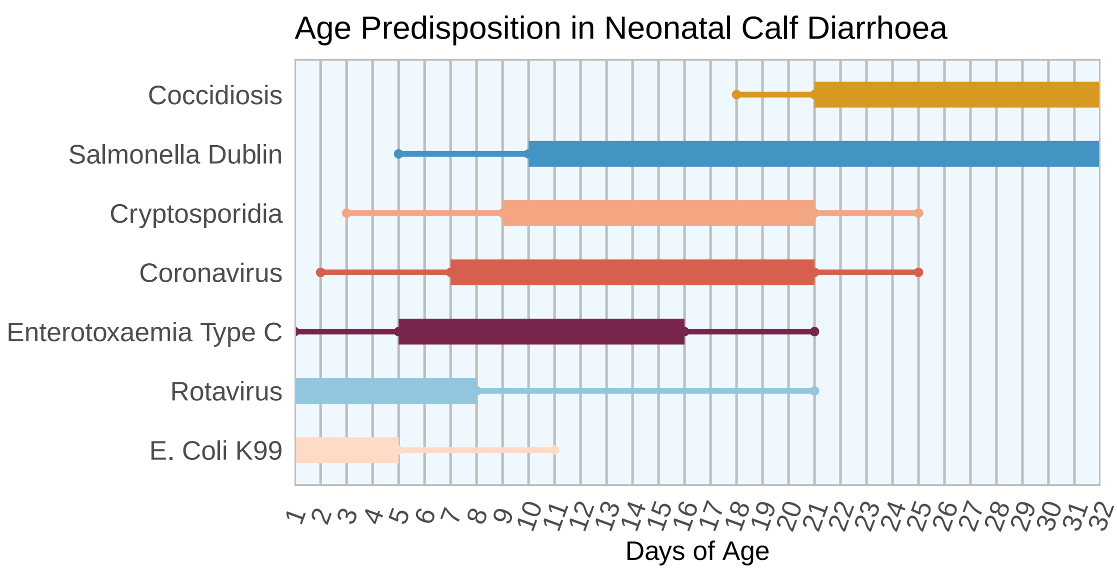


Figure 5.3.: Agent and age predisposition in neonatal calf diarrhoea, the thick area represents the most likely period of disease.

5.7. Coccidiosis

Coccidia spp. (Figure 5.4) were detected in 19 *per cent* of faecal samples from calves under one month of age in 2022. Coccidiosis is a parasitic enteritis caused by one or more species of coccidia. The pathogenic species of importance in calves between three weeks and nine months of age are *Eimeria zuernii* and *Emeria bovis*. Transmission of infection occurs through ingestion of oocysts and infection manifests clinically as bloody diarrhoea, with or without tenesmus. Subclinical infections are also common and may result in poor growth of affected animals. Due to the potential presence of many non-pathogenic species of coccidia in faecal samples from calves, caution should be exercised when interpreting positive results. Diagnosis is based on the clinical history, the age of the animal and faecal sampling.

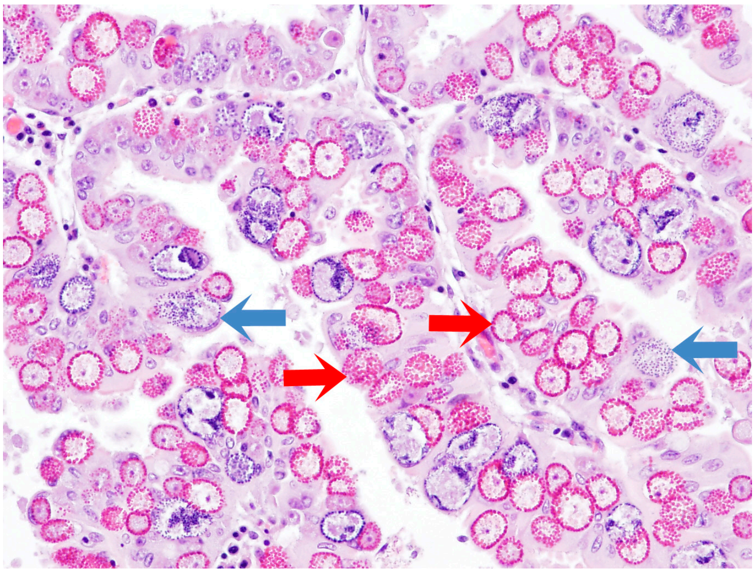


Figure 5.4.: Macrogametes (red arrows) and microgametes (blue arrows) in the gametogonia phase of coccidia in the intestinal epithelium of a ruminant. Photo: Cosme Sánchez-Miguel.

Faecal samples should be taken from several affected and unaffected animals (older than two weeks of age) in the cohort to maximise the likelihood of detecting Coccidia spp. Control of coccidiosis is challenging due to the highly resistant nature of infective oocysts. Treatment outcomes are usually poor, as usually by the time diarrhoea develops, the parasite is at the end of the life cycle and severe damage to the intestine has already occurred. Use of prophylactic drugs during the risk period is therefore recommended. Preventative measures to reduce transmission of this infection are based on reducing build up of contaminated faeces in the calf environment.

Important points

- Where possible, take faecal samples from untreated calves early in the course of infection.
- Feeding an adequate quantity of good quality colostrum is essential for calves to develop immunity to enteropathogens.
- Maintaining hygiene of calf rearing facilities is imperative to reduce environmental contamination and breaks the transmission cycle of enteropathogens.

6. Zinc Sulphate Turbidity Test

***Marie-Claire McCarthy**, Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

The zinc sulphate turbidity (ZST) test gives a useful indication of the adequacy of passive transfer of colostral immunoglobulins in neonatal calves (less than 10 days old). As new-born calves are immunologically incompetent and incapable of mounting an active immune response, colostral antibodies provide the only protection to calves from infectious disease in the post-natal period. Poor passive immunity is associated with increased calf morbidity and mortality, but also can have lifetime effects on animal performance including reduced average daily weight gain, lower milk production and increased culling rate when compared to calves with adequate transfer of colostral immunity (Elsohaby et al. 2019; Faber et al. 2005).

ZST interpretation

A ZST value of 20 units or greater is considered optimal, a value between 19 and 12.5 units is considered adequate but sub-optimal, and values of 12 units or below are considered inadequate.

In 2022, ZST analysis was carried out on 712 blood samples (Table 6.1). These were made up of 459 diagnostic submissions, sent by private veterinary practictioners. The remaining 253 submissions were obtained from calves submitted for post-mortem examination to the veterinary laboratory service (carcase submissions). The percentage of diagnostic samples with optimal ZST values was 59 *per cent*, down from 61 *per cent* in 2021 (Figure 6.1). Inversely, the percentage of diagnostic samples with inadequate ZST values increased from 16 *per cent* in 2021 to 21 *per cent* in 2022. Of the 253 carcase submissions, 52 *per cent* had inadequate ZST values (Figure 6.1).

Table 6.1.: Zinc Sulphate Turbidity Test Results in 2022.

Submission type	Status	No. of samples	Mean	Percentage
Diagnostic	Optimal	271	28.4	**59**
Diagnostic	Adequate	93	16.3	**20**
Diagnostic	Inadequate	95	6.6	**21**
Carcass	Optimal	60	26.3	**24**
Carcass	Adequate	61	15.8	**24**
Carcass	Inadequate	132	5.8	**52**

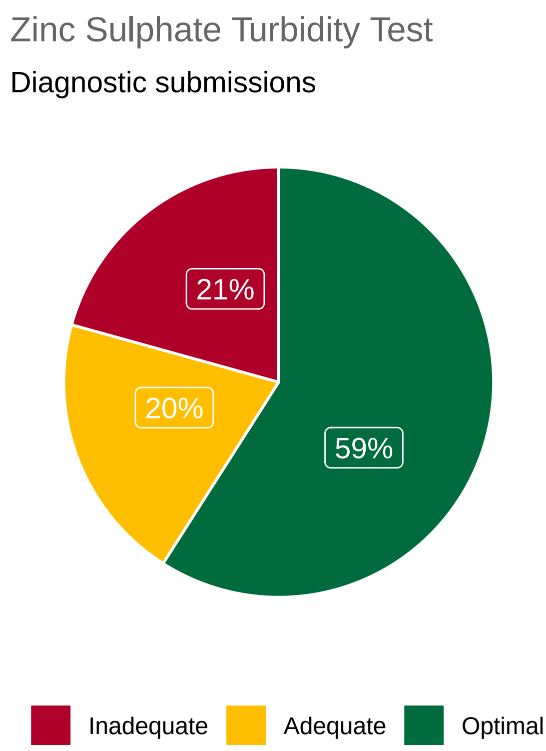


Figure 6.1.: Results of ZST from submitted bovine blood samples in 2022 (n=459).

Ensuring adequate transfer of immunoglobulins is dependent on optimising colostrum feeding practices i.e., feeding an adequate quantity of colostrum as soon as possible after birth. Best practice guidelines recommend feeding a minimum of 3 litres of good quality ($\geq$ 50g/L concentration of IgG), hygienic colostrum within the first two hours after birth. The ability of neonates to absorb colostral antibodies declines within 4–6 hours of birth and ceases entirely beyond 24 hours.

The composition and quality of colostrum is influenced by many factors, including feeding and management practices for dry cows. To enhance colostrum quality in dairy cows, a dry period of at least 4 weeks should be observed with cows being fed an appropriate plane of nutrition to ensure a BCS of 3.25 at calving. Appropriate colostrum management represents the first and most crucial component of rearing healthy calves. By ensuring all calves receive adequate colostrum, the likelihood of infection and subsequent shedding of pathogens is reduced, thus also reducing environmental contamination.

The ZST test is performed on serum and indirectly measures serum immunoglobulin concentration. ZST values of 20 units or greater are optimal and indicate adequate transfer of immunity. Values of between 12.5 and 19 units are suboptimal but adequate. Values below 12 units are considered inadequate and indicate failure of passive transfer of colostral antibodies. When used to assess on-farm colostrum management, it is advisable to sample at least 12 healthy calves between 2–10 days of age. Regular testing throughout the calving season is also advised. ZST is not a useful test in calves less than 2 days old or greater than 14 days. Erroneous results can be observed in sick, dehydrated calves and ZST results from these calves cannot be used to draw wider conclusions on farm colostrum management practices. A herd level prevalence of FPT in greater than 20 *per cent* of calves is indicative of poor colostrum management and a further analysis of herd health management practices should be conducted.

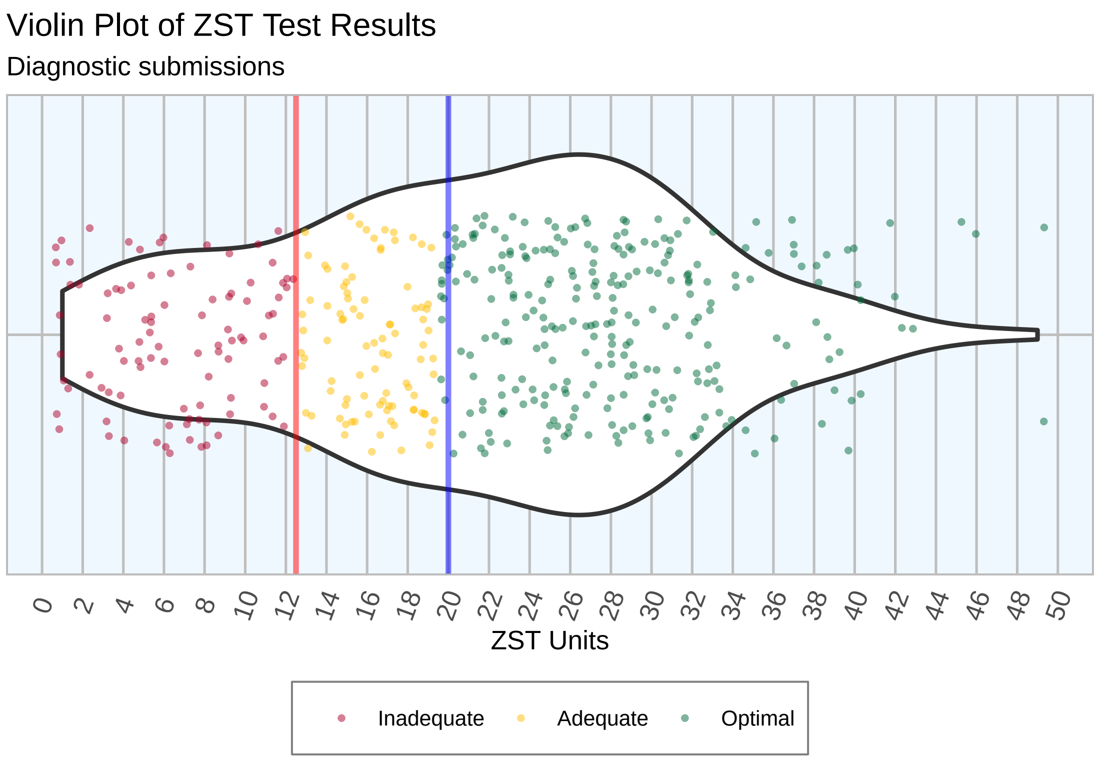


Figure 6.2.: Distribution of ZST test results during 2022. Optimal colostral immunity is defined as greater than 20 units (blue line), adequate between 12.5 and 20 units and inadequate less than 12.5 units (red line). The width of the white area at each point of the x-axis is proportional to the number of samples returning a ZST result of that value (n=459).

Benefits of colostrum

- Provides essential immunoglobulins and immune factors to calves to reduce their susceptibility to infectious diseases.
- Contains considerably more fat than milk, essential for maintaining body temperature in newborn calves.
- Contains essential fat-soluble vitamins that cannot be absorbed across the placenta.
- Acts as a heat source when fed at the correct temperature (~38.5–39 °C).
- Hydrates the calf, increases blood volume and improves circulation resulting in improved survival.

7. Clostridial Diseases in Bovine and Ovine

Cosme Sánchez-Miguel , *Senior Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

Clostridial diseases are a group of bacterial infections caused by various species of the *Clostridium* genus, which are widely distributed in the environment and can be found in soil, faeces, and decaying organic matter. They have the ability to form highly resistant spores that can survive for long periods, representing a persistent challenge in livestock management and animal health. Clostridial diseases are typically characterised by rapid onset and severe clinical signs, often leading to high mortality rates. They naturally produce potent toxins that cause tissue damage and systemic effects, leading to specific clinical syndromes. The profuse clostridial growth of different Clostridial species after death leading to decomposition may present a challenge in reaching a definitive diagnosis of clostridial disease or even in the differential diagnoses of other diseases.

The clostridial diseases of pathological significance in animals can be grouped into three major groups: the *enterotoxaemic* group (among others *C. perfringes* and *C. sordellii* causing enterotoxaemia and abomasitis respectively), the *histotoxic* group (among others *C. chauvoei* and *C. novyi*, agents of black-leg and black disease respectively) and the *neurotoxic* group (such as tetanus and botulism caused by *C. tetani* and *C. botulinum* respectively) (Otter and Uzal 2020a; Otter and Uzal 2020b).

In the RVLs, the detection of the most common clostridial species (obligate anaerobes) is carried out by anaerobic culture, the fluorescent antibody test (FAT) on impression smears of tissues (usually *histotoxic* clostridial species) and the detection of α, β and ϵ toxins in suspected cases of *C. perfringes* enterotoxaemia. The histopathological examination of the affected tissues is also undertaken. Occasionally, some species may be detected or confirmed by MALDI TOF mass spectrometry or specific techniques (mouse bioassay), as with the botulinic toxic (*C. botulinum*).

7.1. Clostridial disease in cattle

Blackleg

The most common clostridial disease diagnosed in the RVLs in cattle is Blackleg disease (*C. chauvoei*), a highly fatal clostridial infection primarily affecting young cattle, typically between six months and two years of age (Table 7.1 and Figure 7.2) . Forty-eight cases, almost 69 *per cent* of all the 70 cases of clostridial diseases detected in cattle, were recorded in 2022. *Clostridium chauvoei* is a soil-borne bacterium that produces highly resistant spores that can survive in the soil for extended periods. When grazing animals ingest the spores by direct contact with contaminated soil, the bacteria can colonise the skeletal muscle and myocardium and, following a period of quiescence, they can potentially multiply in damaged muscle tissues (clostridial myositis, Figure 7.1) and, by toxin production, lead to the development of blackleg disease.

Figure 7.1.: Portion of a hindleg muscle with dark, dry necrohaemorrhagic inflammation and emphysema in a weanling with clostridial myositis (blackleg). Photo: Cosme Sánchez-Miguel.

Table 7.1.: Clostridial disease diagnosed in bovine carcasses in 2022 (n= 70).

Disease	No. of Cases	Percentage
Blackleg	48	**68.6**
Clostridial Enterotoxaemia	12	**17.1**
Black Disease	8	**11.4**
Botulism	2	**2.9**

As expected of a soil-borne bacterium, the distribution of the blackleg disease during the year corresponds to the grazing season in Ireland (Figure 7.3), with a peak of cases in August. However, due to an extensive period of quiescence of the spores, in some instances, they may occasionally be diagnosed after the animals have been housed.

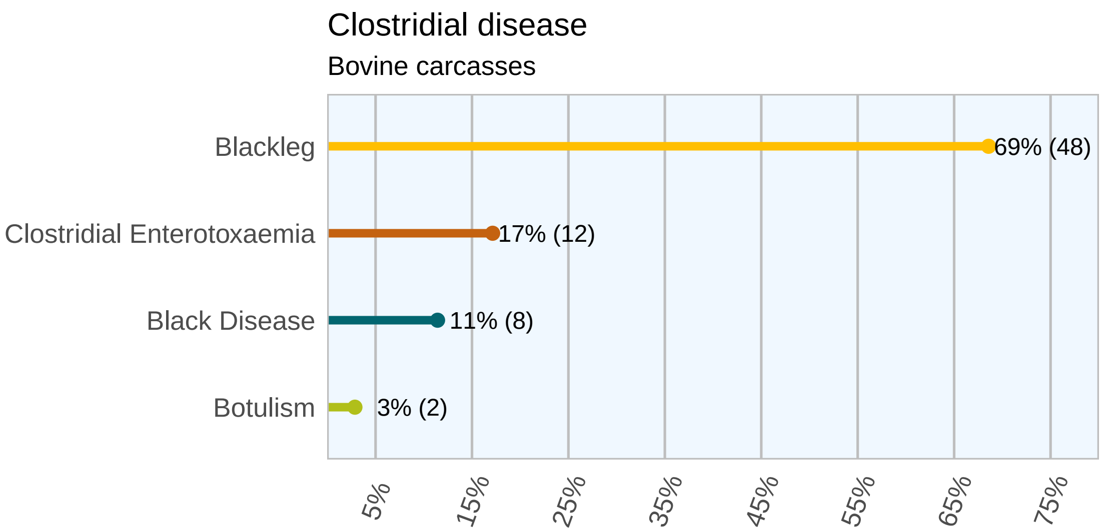


Figure 7.2.: Clostridial disease diagnosed in bovine carcases in 2022 (n=70).

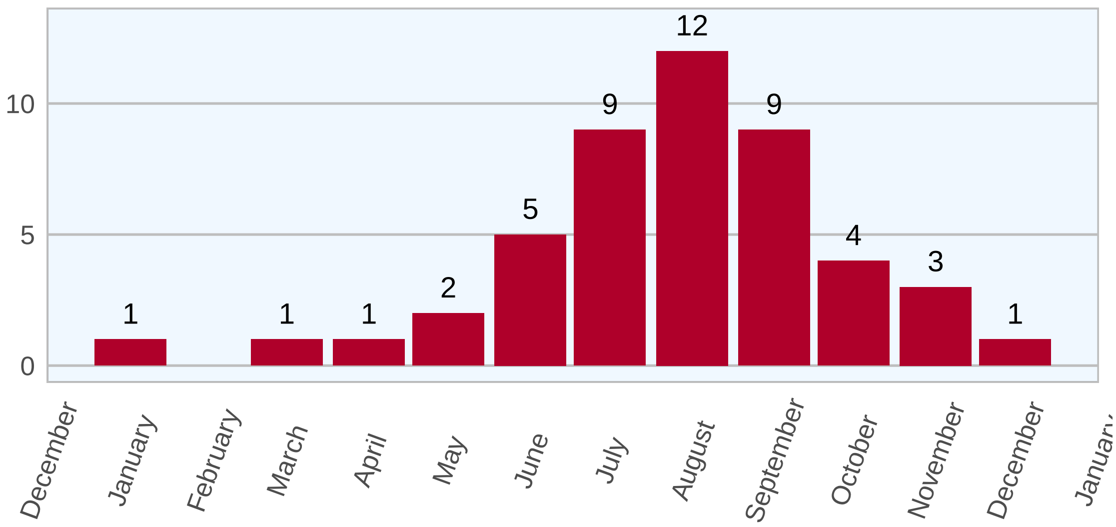


Figure 7.3.: Occurrence of blackleg diagnoses in RVLs in 2022, by calendar month (n=48).

Treatment options for blackleg disease are limited once clinical signs appear, and the success rates are generally low due to the rapidly progressive nature of the disease. Vaccination and good management practices are also essential in preventing blackleg, including maintaining clean and hygienic grazing environments, minimising trauma or injuries that could facilitate bacterial entry, and avoiding overcrowding of young animals.

It is worth noting that while blackleg is most commonly associated with cattle, other ruminant species, such as sheep, goats, and deer, can also be affected. Two cases of blackleg were recorded in sheep in 2022 (Figure 7.7).

> Vaccination and good management practices are essential in preventing clostridial diseases.

Clostridial enterotoxemia

Clostridial enterotoxemia (*Clostridium perfringens*) was the second most commonly diagnosed clostridial disease in cattle (12 cases) and the second most common clostridial infection in sheep (91 cases).

Clostridium perfringens forms part of the gastrointestinal tracts of animals; however, different strains of *Clostridium perfringens* can produce potent toxins that, once absorbed into the general circulation, have devastating effects on the host. Enterotoxaemia primarily affects young ruminant animals and is typically characterised by sudden death, often occurring after an abrupt change in diet or overconsumption of highly fermentable carbohydrates. Diagnosis of enterotoxemia is based on the information gathered by clinical history and signs, and *post mortem* findings, along with the laboratory analysis of small intestinal contents (identification of the presence of *Clostridium perfringens* and its toxins) and, when possible, the support of histological examination. Preventive vaccination and management practices are crucial in reducing the risk of enterotoxemia. These include gradual diet transitions, avoiding sudden access to rich or high-carbohydrate feeds, maintaining proper sanitation and hygiene in feeding areas, and minimising stress factors predisposing animals to the disease.

Black disease

Eight cases of black disease (*Clostridium novyi* Type B), also known as infectious necrotic hepatitis, were diagnosed in 2022 (Figure 7.2). Usually, a low prevalence clostridial disease is caused by severe liver damage frequently associated with the migrating of immature liver fluke (*Fasciola hepatica*), damage that is thought to facilitate the anaerobic conditions that initiate the proliferation of *C. novyi*. Diagnosis of black disease is typically based on clinical signs, history, *post mortem* examination and supported by the detection of toxins (α and β toxins). The carcasses of affected animals are highly congested and autolyse rapidly, which gives them a grossly dark appearance (hence the name *black disease*) and characteristic irregular necrotic areas with a pale yellow-white core surrounded by a dark red rim of congestion within the hepatic parenchyma (Figure 7.4).

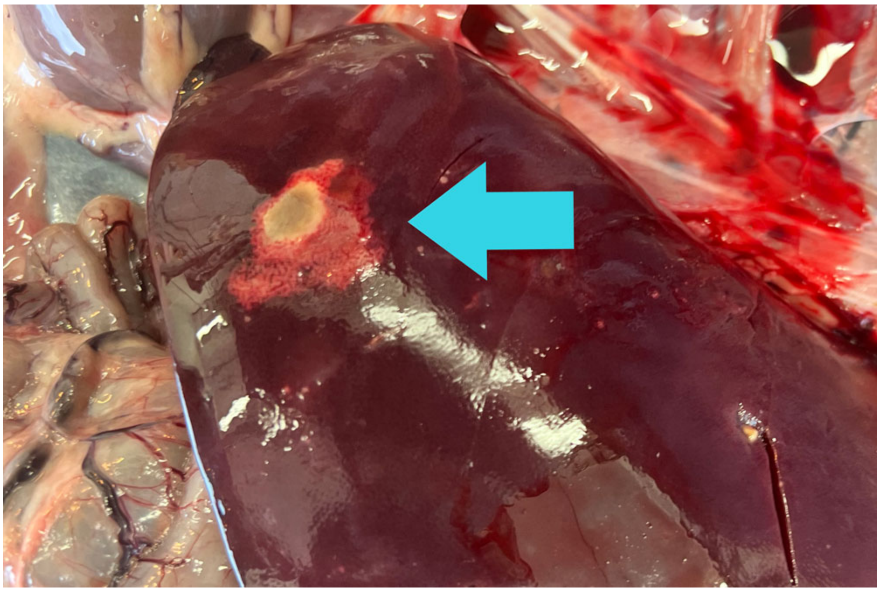


Figure 7.4.: Liver showing irregular pale foci of necrosis surrounded by mild congestion in a sheep with infectious necrotising hepatitis, (black disease) caused by *Clostridium novyi* type B infection. Photo: Shane McGettrick.

Prevention of black disease primarily revolves around vaccination, as with most other clostridial disease. Liver fluke infestation can create an environment favourable to *Clostridium novyi* infection. Therefore, controlling liver fluke infestations through appropriate flukicide and grazing management practices to avoid areas inhabited by the fluke's intermediated host (*Galba truncatula*) are advisable preventive measures.

Botulism

Finally, Bovine Botulism (*Clostridium botulinum*), generally caused by consuming material contaminated by botulinum toxin, was recorded in two cases. Botulism is a paralytic disease (flaccid paralysis), and though there are seven different botulinic toxins, botulism in cattle and sheep (less common in this species) is mainly due to toxin types C and D.

Poultry litter and material associated with poultry litter is a significant risk factor in most botulism outbreaks. Occasionally, an association can be found to access food or water with a decomposing birth or animal carcasses. The diagnosis of botulism is challenging due to the lack of gross lesions and the low sensitivity of the tests available. The diagnosis of Botulism is broadly based on the typical clinical features (flaccid paralysis, hind limb ataxia, recumbency, etc.), the history of exposure to broiler manure or animal or bird carcases, and excluding other potential causes of recumbency and death (milk fever,

Figure 7.5.: The decomposed remains of a dead cat found in a bale of silage, on a farm where Botulism was subsequently diagnosed in silage-fed cows. Photo: Limerick RVL.

lead poisoning, encephalopathies, trauma, etc.). Testing for the toxins of *C. botulinum* is carried out by mouse bioassay in suspect feed or gastrointestinal content; however, the toxins are very heat labile, and the sensitivity of the mouse bioassay ranges from moderate to low.

Two cases were diagnosed in 2022, one in Co. Clare. Four cows died of five affected in a thirty-suckler cows herd. The animals were housed at the time of the outbreak. The remains of a mummified cat were subsequently found in round bale silage (Figure 7.5). C/D toxins were identified; all affected animals demonstrated classical signs of Botulism.

The second suspected case was diagnosed in a Co. Kerry herd. The animals were at pasture at the time of the outbreak and showed classical progressive paralysis causing ataxia, followed by sternal and progressing to lateral recumbency. Five shorthorn replacement heifers died in this outbreak; however, a potential source of botulism neurotoxin was not identified, and the samples failed to produce the botulinic toxins.

7.2. Clostridal disease in sheep

Enterotoxemia is the most common clostridial disease diagnosed in sheep, with 91 cases in 2022. Table 7.2 and Figure 7.7 show **pulpy kidney disease** enterotoxaemia as a separate category to indicate the high incidence of this clostridial disease among other types of enterotoxaemia in sheep.

The generic category of **Clostridial enterotoxaemia** includes other clostridial enterotoxaemia, such as lamb dysentery (*C. perfringes* type B), hemorrhagic enteritis (*C. perfringes* type C)(Figure 7.6) and yellow lamb disease (*C. perfringes* type A) or any enterotoxaemia in which a classification based on the detection of the toxin and gross findings was not reached.

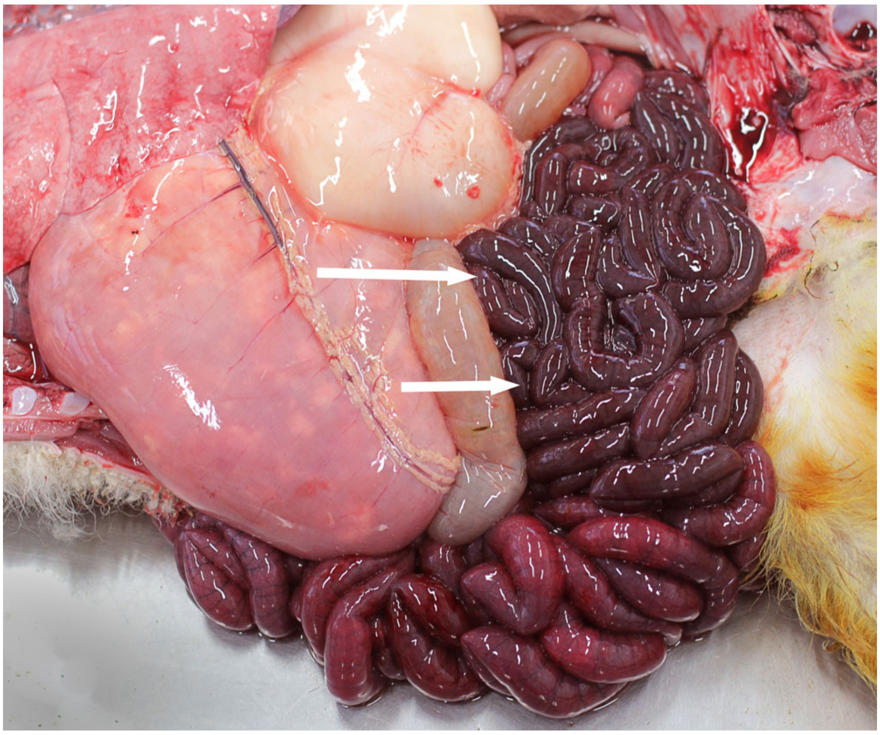


Figure 7.6.: Haemorrhagic enteritis in a lamb with C. perfringes type C enterotoxaemia. Photo: Cosme Sánchez-Miguel.

Table 7.2.: Clostridial disease diagnosed in ovine carcasses in 2022 (n=96).

Disease	No. of Cases	Percentage
Pulpy Kidney Disease	47	**49.0**
Clostridial Enterotoxaemia	44	**45.8**
Black Disease	3	**3.1**
Blackleg	2	**2.1**

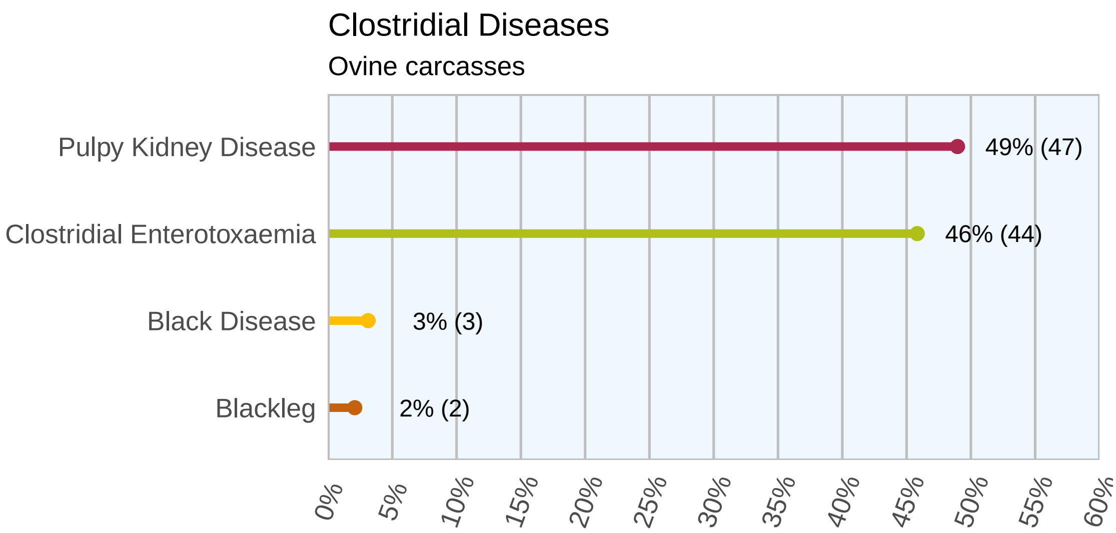


Figure 7.7.: Clostridial disease diagnosed in ovine carcases in 2022 (n=96).

Pulpy kidney enterotoxemia is a critical and often fatal characterised by a sudden onset and rapid progression that predominantly affects lambs. It is caused by the bacterium *Clostridium perfringens* Type D. The animals affected commonly display fibrinous pericardial effusion (Figure 7.8), oedema of the cerebral hemispheres, and focal symmetric encephalomalacia and the detection of α and ϵ toxins. The former is responsible for the destruction of vascular endothelium, capillary permeability and cerebral oedema observed in this disease.

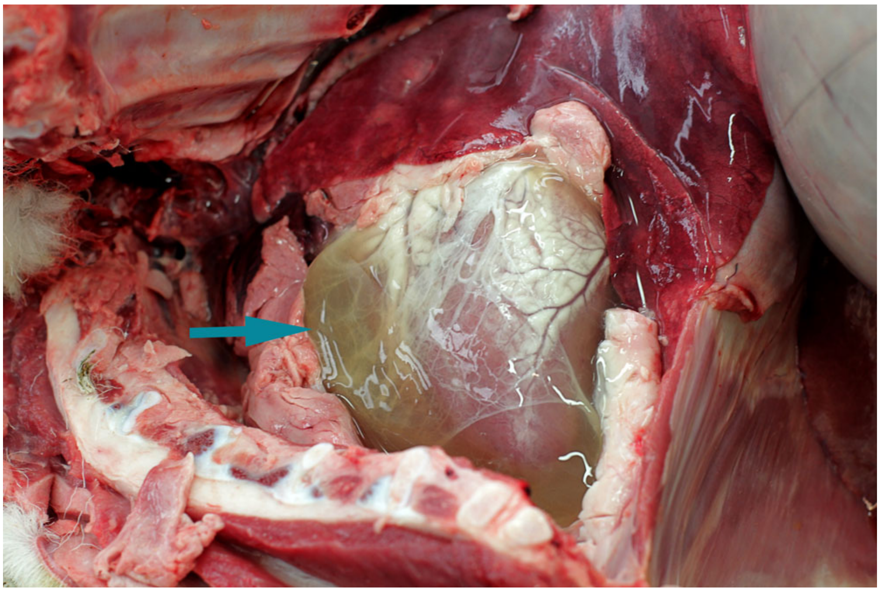


Figure 7.8.: Pericardial effusion (arrow) with gelatinous fibrin in a lamb with *C. perfringes* type D enterotoxaemia. Photo: Cosme Sánchez-Miguel.

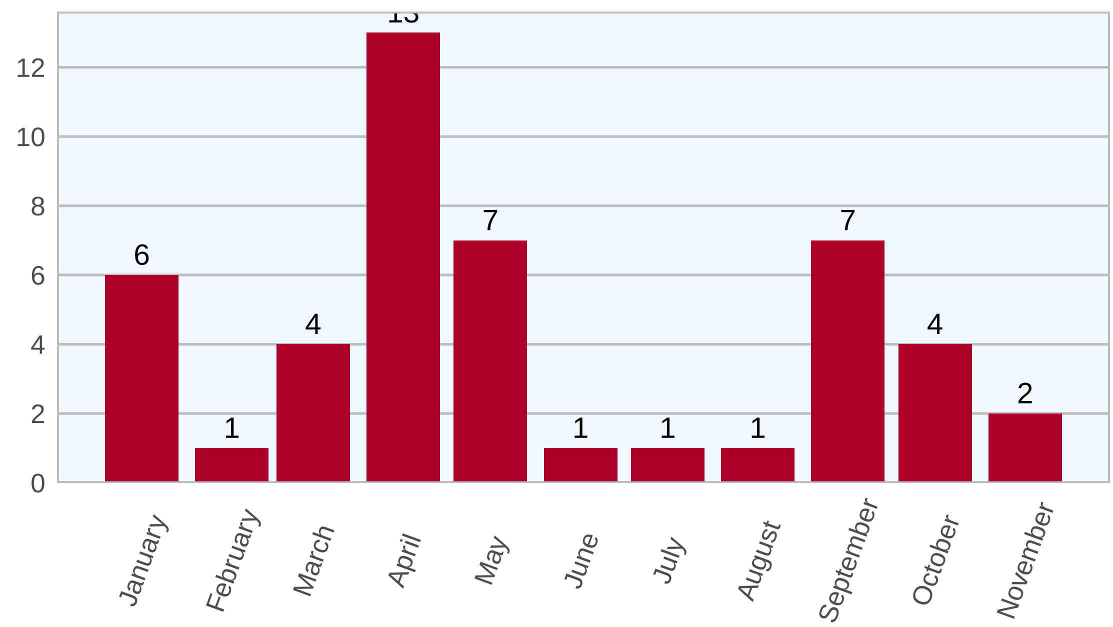


Figure 7.9.: Occurrence of diagnosis of pulpy kidney disease in RVLs in 2022, by calendar month (n=47).

Black disease and blackleg were diagnosed in three and two sheep, respectively (Table 7.2). The annual distribution of all the cases of clostridial diseases diagnosed in sheep is plotted in Figure 7.9

8. Bovine Parasites

Rebecca Froehlich-Kelly, *Research Officer*
Sligo Regional Veterinary Laboratory,
Doonally, Sligo, Ireland

8.1. Overview

This chapter will focus on internal parasites only, particularly those affecting the digestive tract. The main groups of gastro-intestinal parasites important in cattle belong to the groups of trichostrongylidae, trematodes and protozoa (Figure 8.1).

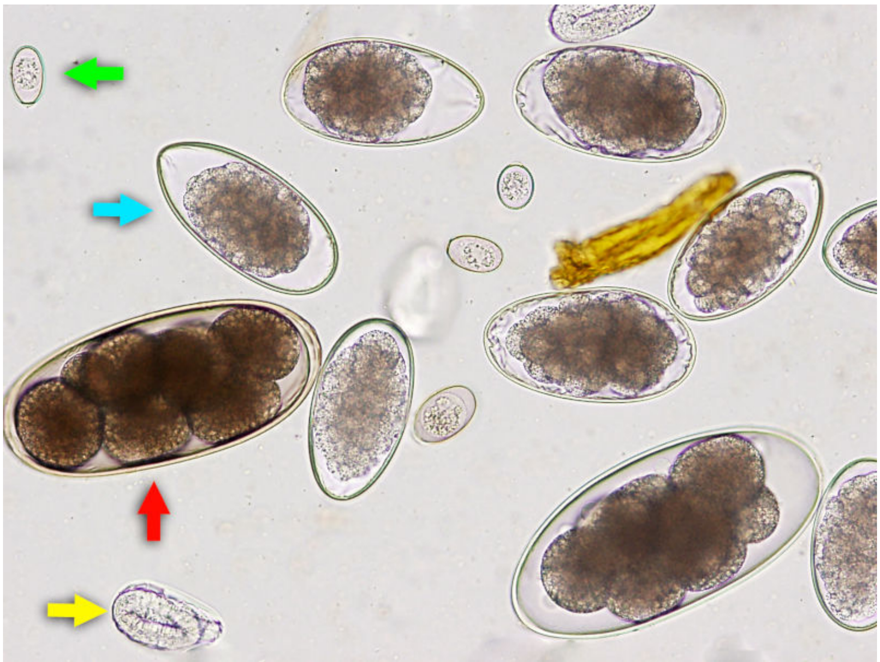


Figure 8.1.: Modified McMaster fecal egg counting. Microscopic appearance of parasitic eggs and oocysts in a faecal smear: *Trichostrongyles* (blue arrow), *Nematodirus* (red arrow), Larvated strongyloid egg (yellow arrow) and coccidial oocysts (green arrow). Photo: Cosme Sánchez-Miguel.

8.2. *Trichostrongylidae*

The members of the trichostrongylidae family affecting cattle belong to the genera *Cooperia*, *Ostertagia*, *Haemonchus* and *Trichostrongylus*; of those *Ostertagia* and *Cooperia* are the two main pathogenic species for bovines in Europe.

Table 8.1.: Number of bovine faecal samples tested for Trichostrongylidae eggs in 2022 and results by percentage (n=5628).

Result	No. of samples	Percentage
Negative	4282	**76.1**
Low (50-200 epg)	688	**12.2**
Medium (200-700 epg)	375	**6.7**
High (>700 epg)	283	**5.0**

Parasitic gastro-enteritis causes a range of clinical signs including diarrhoea, weight loss and anorexia with variation in severity and even death. The development of clinical disease due to parasitic infection depends on several factors. Due to the lack of a developed immunity, animals in their first grazing season especially can be affected with significant morbidity and even mortality when encountering a significant pasture challenge.

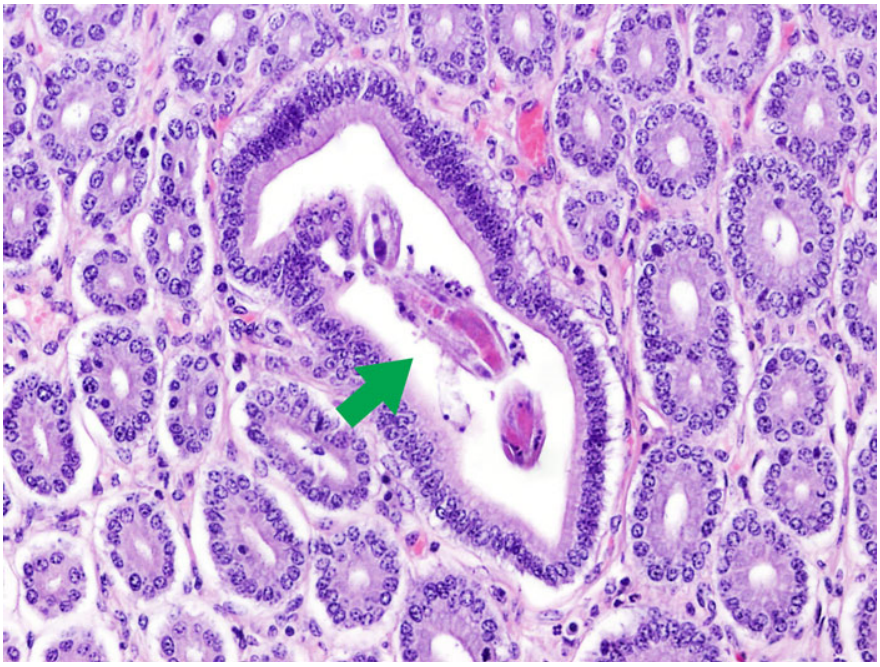


Figure 8.2.: Fragments of Ostertagia spp. (arrow) in the abomasal gastric glands. Photo: Cosme Sánchez-Miguel.

Subclinical disease in older animals can impact performance, with weight gain and potentially milk yield affected. Routinely, faecal samples are examined using the McMaster method (limit of detection 50 eggs per gram of faeces) to assess the parasite burden in an animal. Table 8.1 and Figure 8.3 present the percentage of positive samples in submitted samples throughout the year. The rise of positive samples from July through to November can be explained by a build up of pasture challenge over the course of the grazing season.

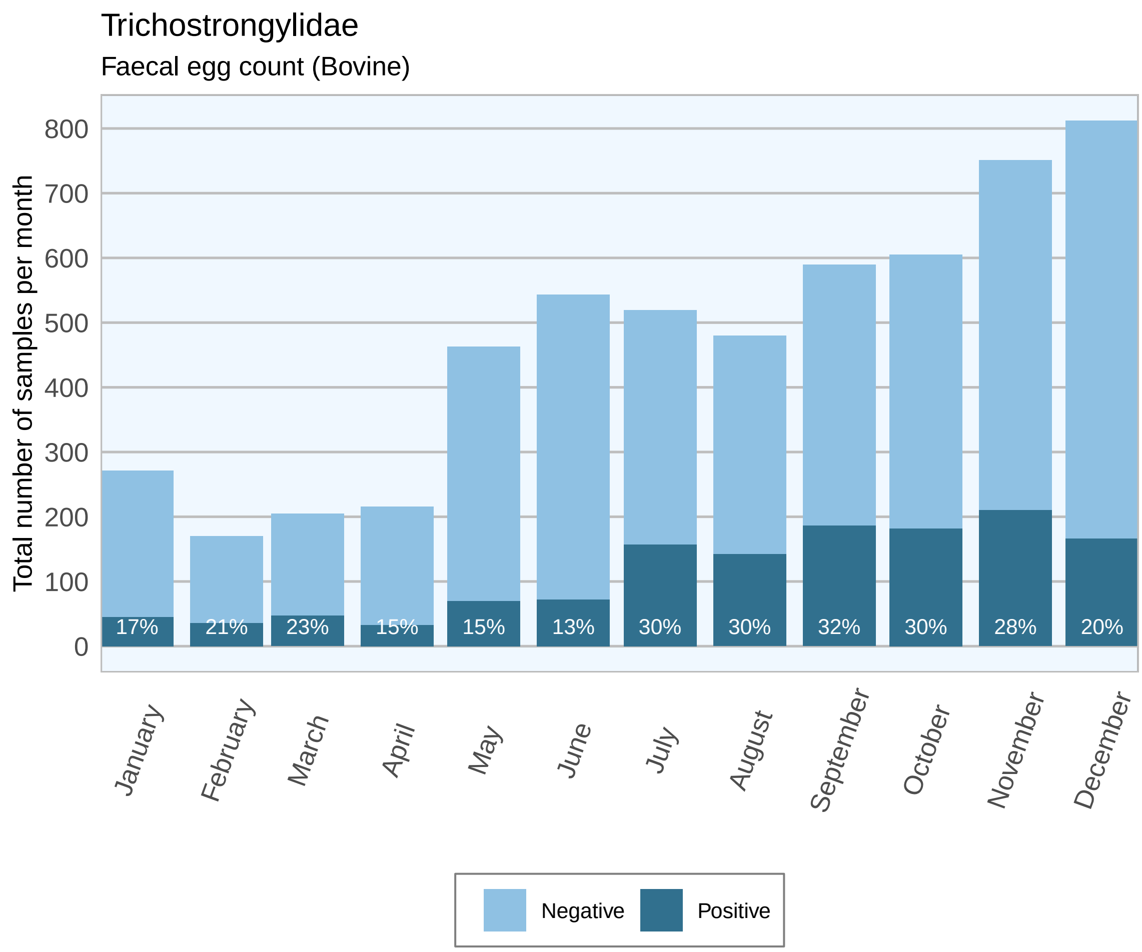


Figure 8.3.: Stacked count of bovine faecal samples (all ages) tested per month for Trichostrongylidae during 2022. The percentage in each bar represents positive samples (n=5628).

8.3. *Nematodirus spp.*

Nematodirus spp. is considered a parasite mainly significant to sheep. However, in certain circumstances and with high pasture burdens it has been described to cause clinical disease in calves. However, similar to previous years the number of positive samples for *Nematodirus spp.* in bovine samples was low in 2022 (Table 8.2).

Table 8.2.: Number of bovine faecal samples tested for Nematodirus eggs in 2022 and results by percentage (n=5628).

Result	No. of samples	Percentage
Negative	5555	**98.7**
Low (50-200 epg)	50	**0.9**
Moderate (200-700 epg)	21	**0.4**
High (>700 epg)	2	**0.0**

8.4. *Coccidia spp*

Coccidia spp. are protozoan parasites. The three most important species affecting bovines are *Eimeria alabamensis*, *Eimeria bovis* and *Eimeria zuernii*, with the latter two being the main species in calves/weanlings. Clinical signs of coccidiosis include diarrhoea, tenesmus, and acute weight loss as well as poor growth rates in subclinical disease. The main risk factors are the age of the animal and high stocking density. Stress inducing events as well as concurrent disease can predispose animals further. When submitting samples for coccidiosis, it is important to consider that oocyst production declines in later stages of the disease, or that disease can occur in the prepatent period. It is always advised to sample multiple samples from an affected group (Table 8.3 and Figure 8.4).

Table 8.3.: Number of bovine faecal samples submitted in 2022 (all ages) for detection of coccidial oocysts and results by percentage, (n=6023).

Result	No. of samples	Percentage
Not Detected	4476	**74**
Light Infection	1210	**20**
Moderate Infection	185	**3**
Heavy Infection	76	**1**
Severe Infection	76	**1**

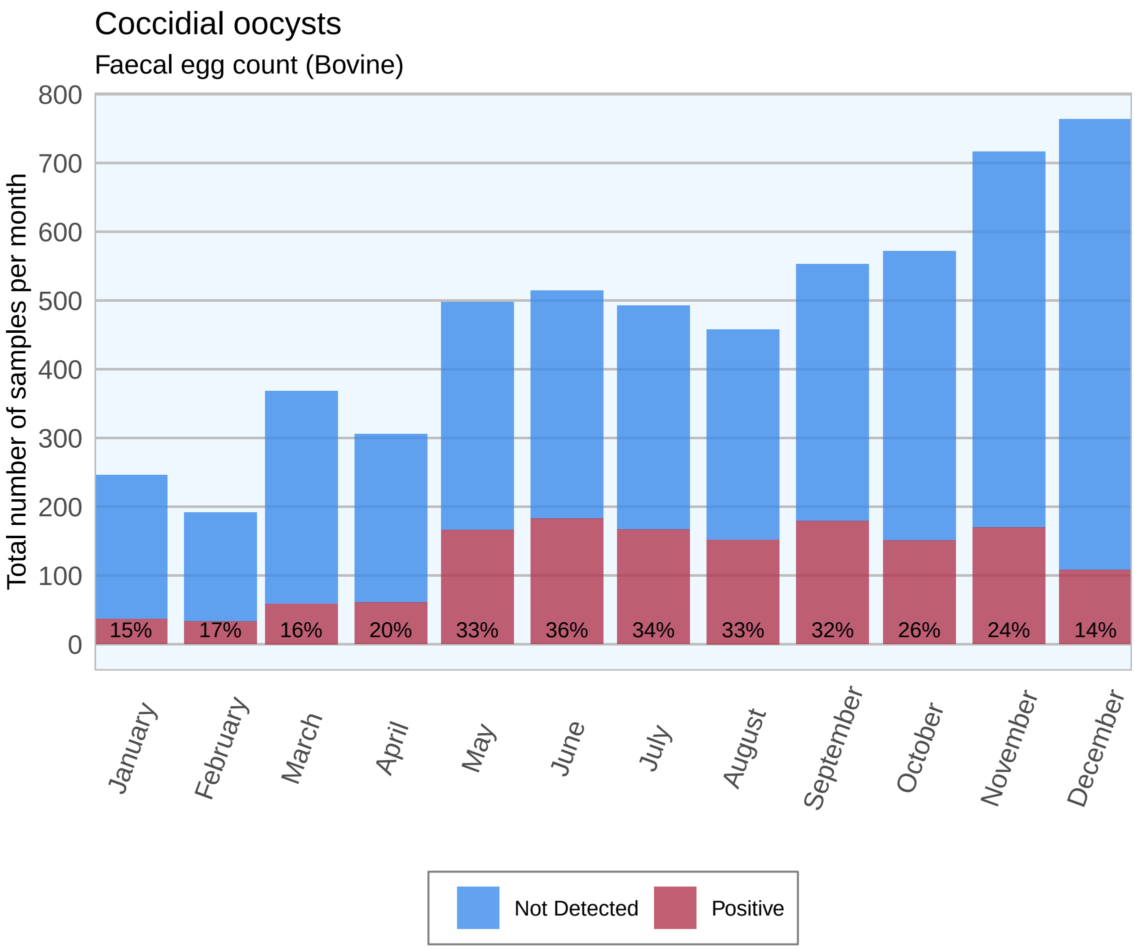


Figure 8.4.: Stacked number of bovine faecal samples (all ages) tested for coccidial oocysts in 2022. The percentage in each bar represents the number of positives (n=6023).

8.5. Liver Fluke

Two species of trematodes are prevalent on the island of Ireland, the liver fluke *Fasciola hepatica* and the rumen fluke *Calicophoron daubneyi*.

Eggs of both parasites can be detected in faecal samples by sedimentation technique. They can both be distinguished by their appearance. When sampling for liver fluke, it needs to be considered that egg shedding can be intermittent and is typically low in numbers. Hence, multiple samples of cohort animals are advised.

Table 8.4.: Number of bovine faecal samples submitted in 2022 (all ages) for detection of liver fluke eggs and breakdown of positive and negative results (n=4520).

Result	No. of samples	Percentage
Liver fluke eggs not detected	4439	**98**
Positive liver fluke eggs	81	**2**

In contrast to sheep, *Fasciola hepatica* causes pre-dominantly chronic disease in cattle. Typical signs of fasciolosis in cattle are ill thrift and poor performance. Moreover, sequelae to the parasitic hepatitis, e.g. secondary photosensitisation or oedema (*bottle jaw*), can occur (Table 8.4 and Figure 8.5).

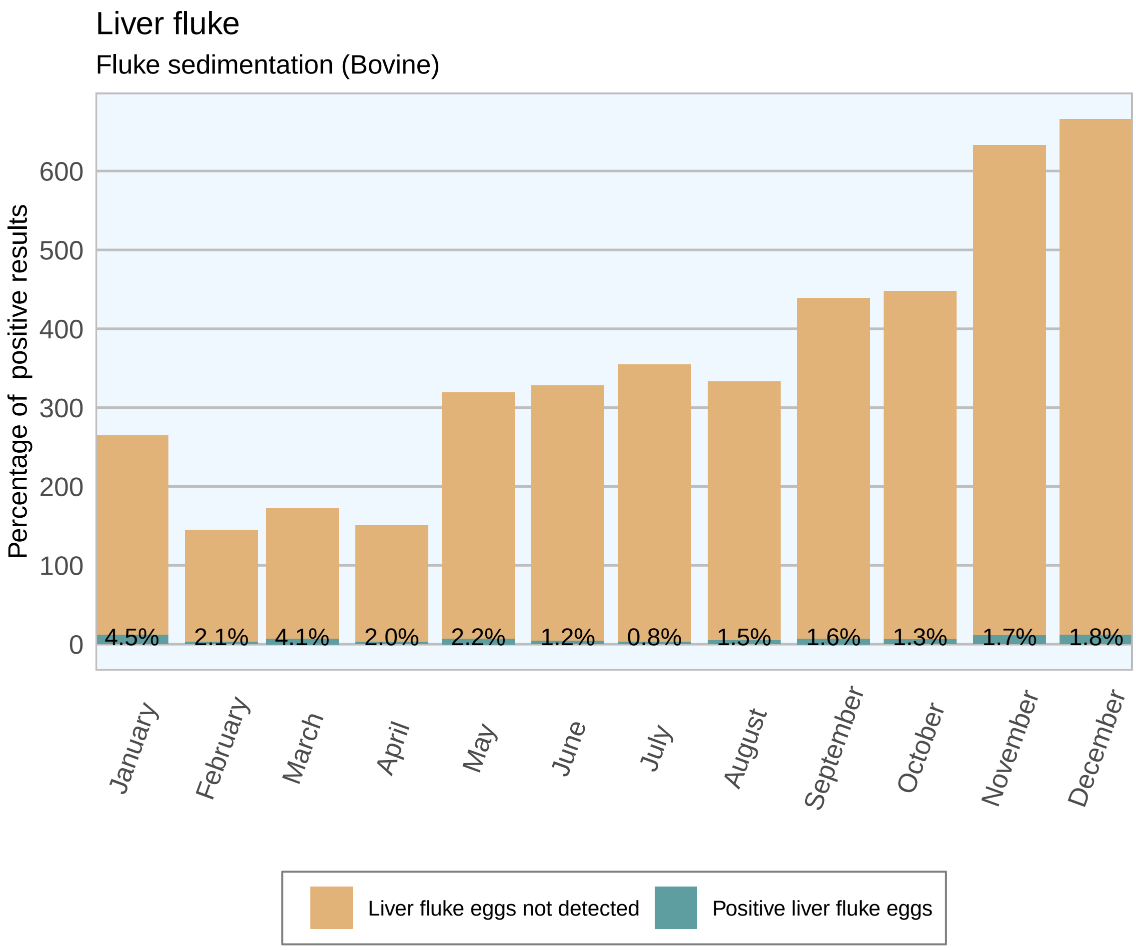


Figure 8.5.: Stacked number of bovine faecal samples (all ages) tested for liver fluke in 2022. The percentage in each bar represents the number of positive samples per month (n=4520).

8.6. Rumen fluke

The prevalent rumen fluke species in Ireland is *Calicophoron daubneyi* which has been widely detected in the last decade in submitted faecal samples as well as carcases. Previously, it was reported as a significant parasite in subtropical and tropical areas. The reason to this relatively new expansion or occurrence of the parasite is not fully elucidated yet. Many factors including climate change, introduction of a new species or the (over)use of narrow spectrum flukicides has been discussed. To date there are no reports of clinical disease caused by adults present in the rumen.

Table 8.5.: Number of bovine faecal samples submitted in 2022 (all ages) for detection of rumen fluke eggs and breakdown of positive and negative results (n=4520).

Result	No. of samples	Percentage
Rumen fluke eggs not detected	2946	**65**
Positive rumen fluke eggs	1574	**35**

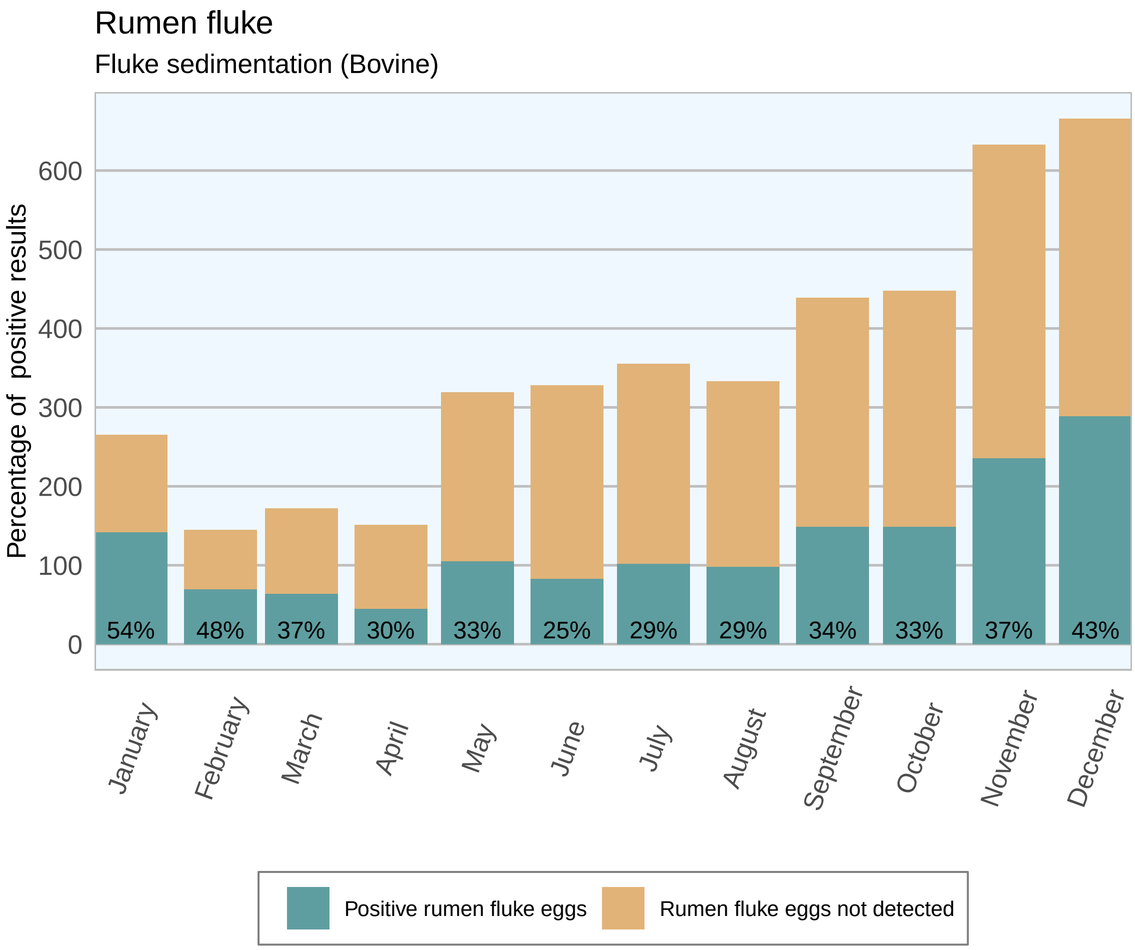


Figure 8.6.: Stacked count of bovine faecal samples (all ages) tested for rumen fluke in 2022. The percentage in each bar represents positive samples (n=4520).

However, severe clinical disease, larval paramphistomosis, has been well described caused by its migrating larvae. While the occurrence of larval paramphistomosis is rare, severity and even mortality can be significant. Clinical signs include ill-thrift, diarrhoea, weight loss and anorexia. Hence, rumen fluke should always be considered as a possible cause of disease in sheep, goats or younger cattle both on pasture and shortly after removal from pasture. Similar to liver fluke, rumen fluke eggs are detected in faecal samples by sedimentation technique. As can be seen in Table 8.5 and Figure 11.6, rumen fluke eggs were detected in 35 *per cent* of submitted samples. However, detection of rumen fluke eggs in healthy animals does not indicate the need for treatment.

Part II.

Sheep

9. Ovine Diseases

***Marie-Claire McCarthy**, Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

In 2022, the national sheep population stood at 4.01 million, distributed across 35,555 flocks. This represents a slight decline of 0.35% on 2021 national sheep population estimates. The population was made up of 2.66 million breeding ewes (over 12 months old) and almost 86,000 breeding rams, with the remaining sheep categorized as lambs, wethers and cull ewes (1.26 million). While the average flock size was 113, 69 *per cent* of flocks were smaller than this, with the majority of flocks (40 *per cent*) being made up of 50 sheep or less.

In 2022, 1254 ovine carcases were submitted to the Regional Veterinary Laboratory service for *post mortem* examination. This comprised of 481 adult sheep (older than one year) and 773 lambs (under 12 months old). This represents a decrease in total ovine carcase submissions compared to 2021 (n=1442). As the range of diagnoses is age dependent, the post-mortem results in this section are presented by age category. Conditions have been grouped into broader diagnostic categories according to the affected system to facilitate presentation and comparison with previous reports.

9.1. Lambs

Gastrointestinal infection was the most frequently identified cause of mortality in lambs in 2022 (29.1 *per cent*). Within this category, parasitic gastro-enteritis (PGE) represented the most frequently diagnosed condition, with 141 cases recorded (62 *per cent* of GIT infections) (Table 9.1 and Figure 9.2). Most commonly, PGE diagnoses were associated with strongyle infections (83 *per cent* of PGE cases), with *Haemonchus contortus* found in a small number of lambs (4 *per cent* of cases). Enteritis associated with *Coccidia* species and *E.coli* was the next most frequent diagnosis.

Systemic infections were recorded as the cause of mortality in 14.1 *per cent* of lamb submissions. This includes conditions such as bacteraemia, septicaemia and toxaemia. The agents most commonly identified in such cases were *Bibersteinia trehalosi* (58 *per cent*), *E. coli* (10 *per cent*) and *Mannheimia haemolytica* (5.5 *per cent*).

Respiratory infections were diagnosed in approximately 11.9 *per cent* of lamb carcase submissions in 2022. The pathogens most frequently isolated in pneumonia cases were *Mannheimia haemolytica* (32 *per cent*) and *Bibersteinia trehalosi* (30 *per cent*).

Clostridial disease was diagnosed in approximately 10.2 *per cent* of lamb carcase submissions in 2022. Pulpy kidney disease and clostridial enterotoxaemia were the most frequently diagnosed conditions, accounting for 53 and 37 *per cent* of cases respectively. Further detail relating to ovine clostridial disease is available in section of *Bovine and Ovine Clostrial Diseases.*

Figure 9.1.: Haemorrhagic parasitic tracts in a sheep with severe acute liver fluke infection. Photo: Cosme Sánchez-Miguel

Table 9.1.: Conditions most frequently diagnosed on *post mortem* examinations of lambs in 2022 (n=773).

Disease	No. of Cases	Percentage
GIT Infections	225	**29.1**
Systemic Infections	109	**14.1**
Respiratory Infections	92	**11.9**
Clostridial disease	79	**10.2**
Nutritional/metabolic conditions	46	**6.0**
GIT torsion/obstruction	36	**4.7**
CNS	27	**3.5**
Liver disease	26	**3.4**
Other	18	**2.3**
Trauma	17	**2.2**
Urinary Tract conditions	17	**2.2**
Tick Borne Fever	15	**1.9**
Diagnosis not reached	14	**1.8**
Poisoning	10	**1.3**
GIT ulcer/perforation/foreign body	9	**1.2**
Autolysis	8	**1.0**
Reproductive Tract Conditions	7	**0.9**
Cardiac/circulatory conditions	6	**0.8**
Integument/Musculoskeletal	6	**0.8**
Navel Ill/Joint Ill	6	**0.8**

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

Nutritional or metabolic conditions were identified in 6 *per cent* of lamb submissions. Within this diagnostic category, ruminal acidosis was the most frequently recorded diagnosis, accounting for 57 *per cent* of deaths. Cobalt deficiency was diagnosed in 9 *per cent* of cases.

Neurological conditions were identified as the cause of death in 3.5 *per cent* of lambs submitted for postmortem examination. Encephalitis was the most common neurological disorder, accounting for almost 50 *per cent* of cases within this diagnostic category. *Listeria monocytogenes* was the aetiological agent most frequently identified in cases of encephalitis. Tick borne fever was diagnosed in 15 lamb carcases.

Surveillance for *Anaplasma phagocytophilum* (the causative agent of tick borne fever) increased in 2022, resulting in increased detection rates of this pathogen in adult sheep and lambs this year.

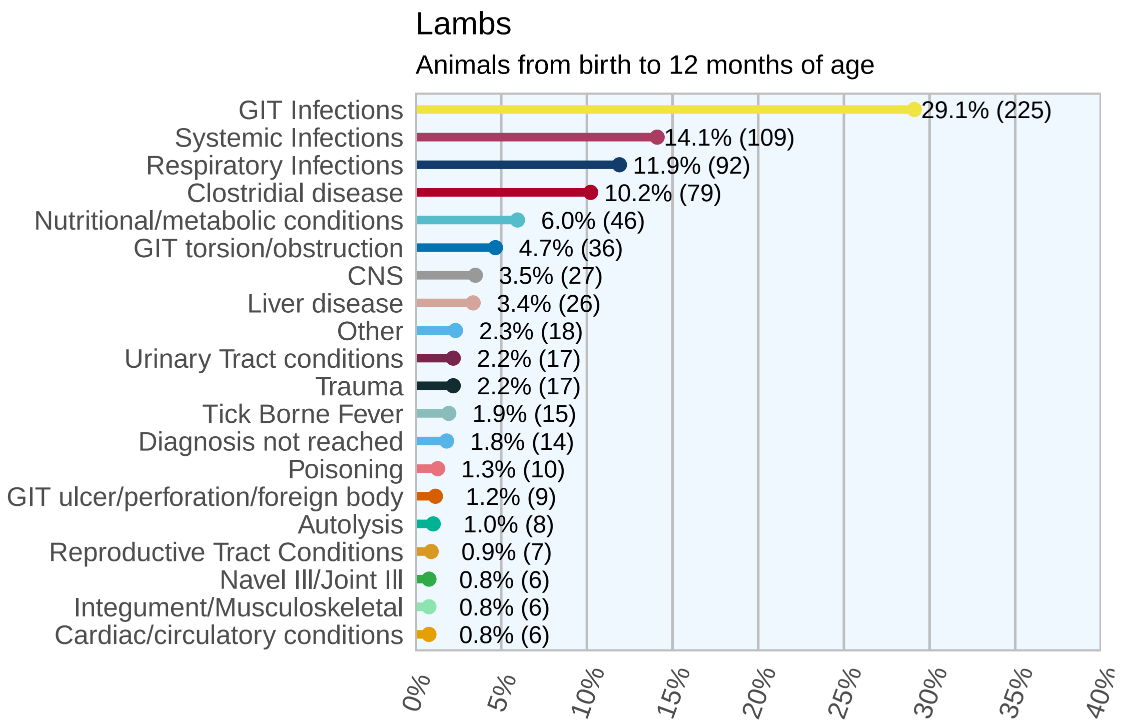


Figure 9.2.: Conditions most frequently diagnosed on *post mortem* examinations of lambs in 2022 (n=773). Only categories with n greater than 8 are shown. Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Information Note

It should be noted that the examining veterinarian can only assign one cause of death to each animal submission. 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 end enteritis. If the lesions are not considered to be linked, as they might be in the case of a systemic infection (sepsis), then the pathologist 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 pathologists differ to a small extent. A detailed description of involved pathogens is provided in the chapters discussing the respective organ systems.)

Table 9.2.: Conditions most frequently diagnosed on *post mortem* examinations of adult sheep (over one year of age) in 2022 (n=481). Note: the Other grouping is a combination of multiple minor categories that have less than five cases.

Disease	No. of Cases	Percentage
Respiratory Infections	83	**17.3**
GIT Infections	63	**13.1**
Nutritional/metabolic conditions	44	**9.2**
Systemic Infections	40	**8.3**
CNS	33	**6.9**
Liver disease	32	**6.7**
Other	23	**4.8**
Autolysis	22	**4.6**
Reproductive Tract Conditions	21	**4.4**
Cardiac/circulatory conditions	19	**4.0**
Diagnosis not reached	18	**3.7**
Clostridial disease	17	**3.5**
GIT torsion/obstruction	16	**3.3**
Trauma	11	**2.3**
GIT ulcer/perforation/foreign body	9	**1.9**
Peritonitis	9	**1.9**
Poisoning	8	**1.7**
Tumour	7	**1.5**
Tick Borne Fever	6	**1.2**

9.2. Adult sheep

Respiratory disease was the most frequently recorded diagnosis in adult sheep in 2022, accounting for 17 *per cent* of deaths. The pathogens most frequently isolated in pneumonia cases were *Bibersteinia trehalosi* and *Mannheimia haemolytica* (Table 9.2 and Figure 9.4,).

Tick pyemia

Tick pyaemia is a condition of young lambs where the tick inoculates *Staphylococcus aureus* into affected lambs. This gives rise to septicaemia (bacteria and toxins in the blood), resulting in dullness, depression, inappetence, etc. The bacteria can then seed out in internal organs such as the kidneys and liver and joints and can also cause spinal abscesses. Control of tick-borne diseases necessitates controlling tick populations through the removal of vegetation suitable for tick survival. External long-acting parasiticides specifically aimed at ticks can be used to kill ticks during periods of greatest risk. Specific treatment of tick pyaemia involves antibiotic treatment of the *Staphylococcus aureus* bacterial infection.

Gastrointestinal infections accounted for 13.1 *per cent* of diagnoses in adult sheep. Parasitic gastroenteritis accounted for 65 *per cent* of diagnoses within this category, with strongyles detected in the majority of these cases.

Nutritional and metabolic conditions were diagnosed in approximately 9.2 *per cent* of submissions. Within this category, ruminal acidosis represented the most frequent diagnosis (36 *per cent*), followed by hypocalcaemia (23 *per cent*) and pregnancy toxaemia (18 *per cent*).

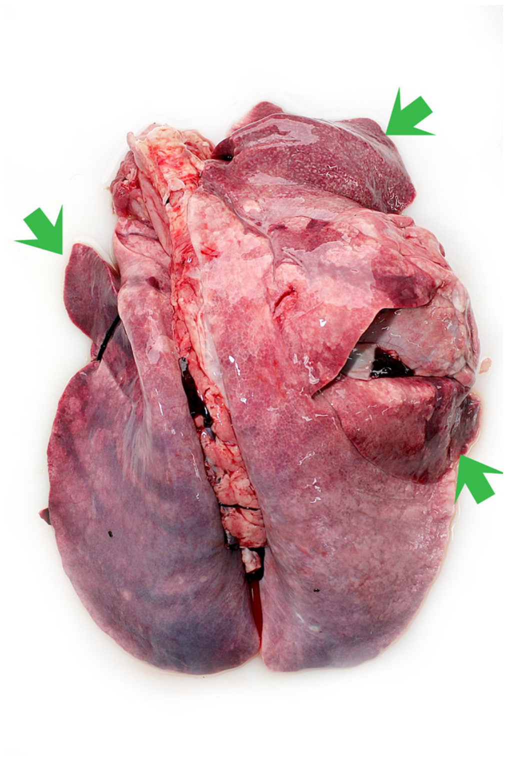


Figure 9.3.: Pneumonia in a ewe with Mannheimia heamolytica. Photo: Cosme Sánchez-Miguel.

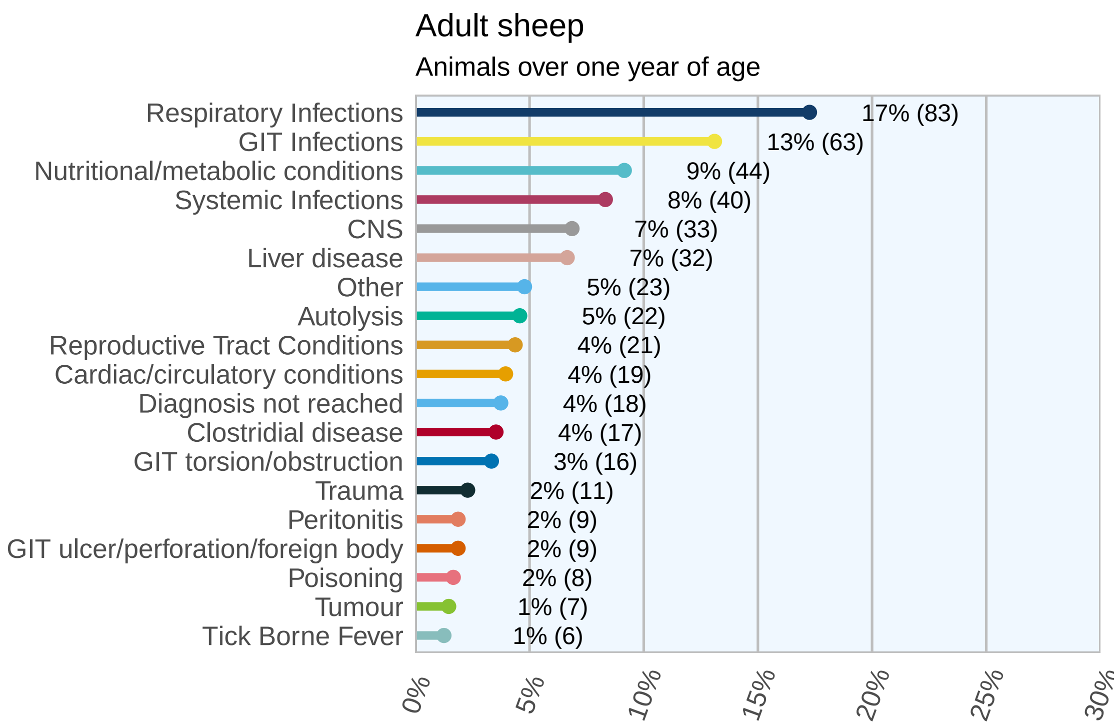


Figure 9.4.: Conditions most frequently diagnosed on *post mortem* examinations of adult sheep (over one year of age) in 2022 (n=481). Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Systemic infections accounted for 8.3 *per cent*of adult sheep diagnoses. *Bibersteinia trehalosi* was the pathogen most frequently isolated in cases of bacteriaemia, septicaemia and toxaemia.

Neurological conditions were diagnosed in almost 7 *per cent*of adult sheep examined during 2022.

Within this category, encephalitis represents the largest diagnostic subcategory, accounting for 64 *per cent*of cases. *Listeria monocytogenes* was detected in the majority (66 *per cent*) of these cases. Cerebrocortical necrosis (CCN) was the second most frequently diagnosed neurological condition, accounting for 21 *per cent* of cases.

Autolysis (*post mortem* decomposition) was evident in 4.6 *per cent* of adult sheep carcases, making it difficult obtain a definitive cause of death in these animals. To ensure the best chance of obtaining an accurate post-mortem diagnosis, carcases should be submitted to the RVL as soon as possible after death.

Results from 2022 ovine *post mortem* examinations are consistent with previous years, with gastrointestinal, systemic and respiratory infections representing the three most common causes of mortality in lambs under 12 months of age. Similarly in adult sheep, the most common diagnoses in 2022 are congruous with those of previous years.

Figure 9.5.: Corrugation and yellow pigmentation of the small intestinal mucosa of a sheep with Johne's disease caused by a sporadic pigmented strains of *Mycobacterium avium* subsp. *paratuberculosis*. Photo: Cosme Sánchez-Miguel.

9.3. Thin Ewe Study

The Regional Veterinary Laboratories in conjunction with Teagasc launched a *Thin Ewe Study* in 2022. It aims to provide information on causes of chronic ill thrift in ewes in Irish sheep flocks.

In particular, the study aims to investigate if *Iceberg diseases* are playing a significant role or if more common issues such as broken mouths/poor teeth and parasites that are the major contributors to lack of thrive in ewes. It is believed that the impact of these *Iceberg diseases* is low, but this study aims to establish their role (if any) on ill-thrift in sheep. The five main *Iceberg diseases* in Sheep are Maedi-Visna (MVV), Caseous Lymphadenitis (CLA), Border Disease (BD), Ovine Pulmonary Adenocarcinoma/Jaagsiekte (OPA) and Johnes Disease (JD)(Figure 9.5).

While these diseases can cause severe clinical illness, they also frequently cause sub-clinical disease, where the only signs you may see are poor performance and ill-thrift. Farmers with these diseases in their flocks can frequently describe disappointment in the performance of their flocks despite good husbandry and breeding and good nutrition. They describe a "long tail" to their flock i.e. a large number of slow/poor doers in their flock. These diseases are largely refractory to treatments and culling affected animals is advisable. A recent study of 75 flocks in the UK found over half had at least one *Iceberg disease*. This study highlights the need for more research here. Flock recruitment is coordinated through the Teagasc advisory service and flock owners are encouraged to submit three thin ewes for euthanasia and *post mortem* examination. Farmers interested in participating should in the first instance contact their Teagasc advisor, who will ask you to contact your local RVL to book in your sheep.

The RVLs are carrying out this testing free of charge to encourage participation. All results from this study will be sent back to the flock owner's vet.

Positive outcomes for individual sheep flock owners include providing them with information on possible causes of ill-thrift on their farms. This should enable them to put measures in place to reduce the impact of the causes of ill thrift resulting in better sheep health and welfare and improved productivity. For the National Sheep Flock this study aims to provide information on the possible causes of ill thrift in the national flock and particularly on any possible role for *Iceberg diseases*. This may inform future decisions impacting flock health.

This study should also prove very useful for flock owners if parasitism or poor teeth are identified as likely causes of ill-thrift in their flocks. Husbandry and control programmes dealing with these problems should have a very positive effect on sheep health and productivity.

10. Ovine Abortion

Marie-Claire McCarthy, *Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

10.1. Overview

In 2022, 432 *post abortion* specimens (foetuses and/or foetal membranes) were submitted to the Regional Veterinary Laboratory service for examination. As with previous years, toxoplasmosis and enzootic abortion of ewes (EAE) represented the most frequently diagnosed pathogens in cases of ovine abortion in 2022. The remaining diagnoses were largely attributed to bacterial pathogens.

10.2. *Toxoplasma gondii*

Of the 262 *post abortion* specimens tested for *T. gondii* using PCR (n=262), 42 were positive (16 *per cent*) (Table 10.1). When combined with results from foetal serum agglutination tests (n=318) the percentage of positive cases rose to 20 *per cent* (Table 10.2 and Figure 10.2). Samples were considered positive if either or both tests were positive. Serology titers of 1/32 or greater were deemed positive. Detection rates of *T. gondii* in 2022 were broadly consistent with those of previous years (Benavides et al. 2017).

The most prominent source of *T. gondii* infection is ingestion of oocysts shed by infected cats. The outcome of *T. gondii* infection is dependent on the stage of gestation when infection occurs. In early gestation (0–50 days), foetal death and resorption is typical, with ewes returning to the ram or scanning empty. Between approximately 50 and 100 days of gestation, *T. gondii* infection is characterised by foetal death and abortion. In most cases, there are no gross lesions, but in some cases distinctive white focal lesions are visible in the cotyledons of the placenta and brain (protozoal encephalitis, Figure 10.1). Beyond 110 days of gestation, infection is usually associated with the birth of weak and stillbirth lambs. Infection during late gestation can also result in the birth of live, clinically normal lambs. The reason for this variation in the pathogenesis of abortion is not fully elucidated, but it is thought to be related to variation in maternal and foetal immune responses throughout pregnancy.

Table 10.1.: Ovine foetuses examined by Toxoplasma PCR in 2022, (n=262).

PCR Result	No of Cases	Percentage
No Pathogen detected	214	81.7
Positive	42	16.0
Inconclusive	6	2.3

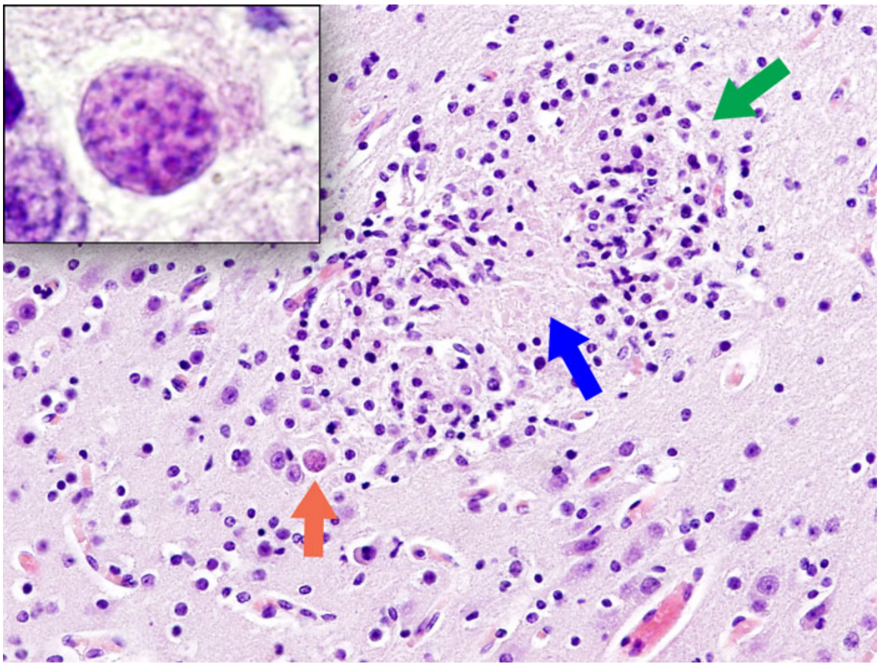


Figure 10.1.: *T. gondii* encephalitis in the brain of an ovine foetus: focal necrosis (blue arrow) with peripheral glositis. A *T. gondii* tachyzoite (orange arrow and inset) can be observed adjacent to the area of inflammation (green arrow). Photo: Cosme Sánchez-Miguel.

Table 10.2.: Toxoplasma PCR and Toxoplasma serology (Agglutination Test) test results in 2022 (n=318).

Result	No of Cases	Percentage
Negative	256	80
Positive	62	20

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

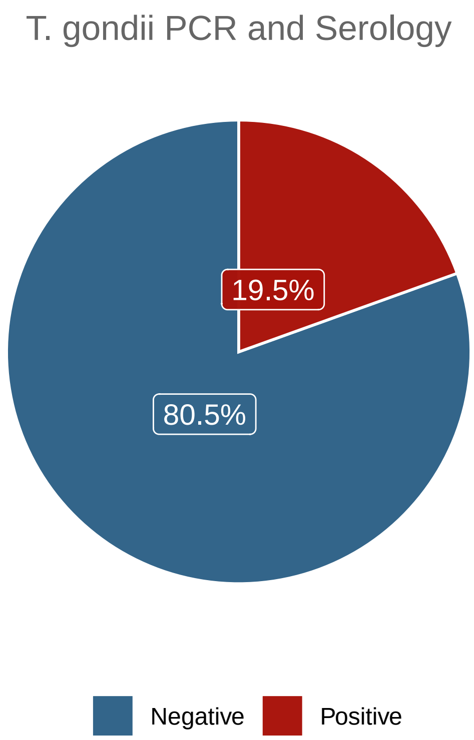


Figure 10.2.: Pie charts showing the *Toxoplasma gondii* PCR and serology (Agglutination Test) test results in ovine foetuses in 2022.

10.3. *Chlamydophila abortus* (EAE)

Chlamydophila abortus PCR testing was conducted on 264 ovine *post abortion* submissions in 2022 (Table 10.3 and Figure 10.3). Of these samples, 73 (28 *per cent*) were positive with a further 31 cases (12 *per cent*) returning an inconclusive result. These results are consistent with those reported in 2021 and continues the trend of increased EAE detection rates in recent years.

Table 10.3.: Percentage of *Chlamydophila abortus* PCR results in ovine foetuses in 2022 (n=264).

PCR Result	No of Cases	Percentage
Positive	73	**28**
No Pathogen detected	160	**61**
Inconclusive	31	**12**

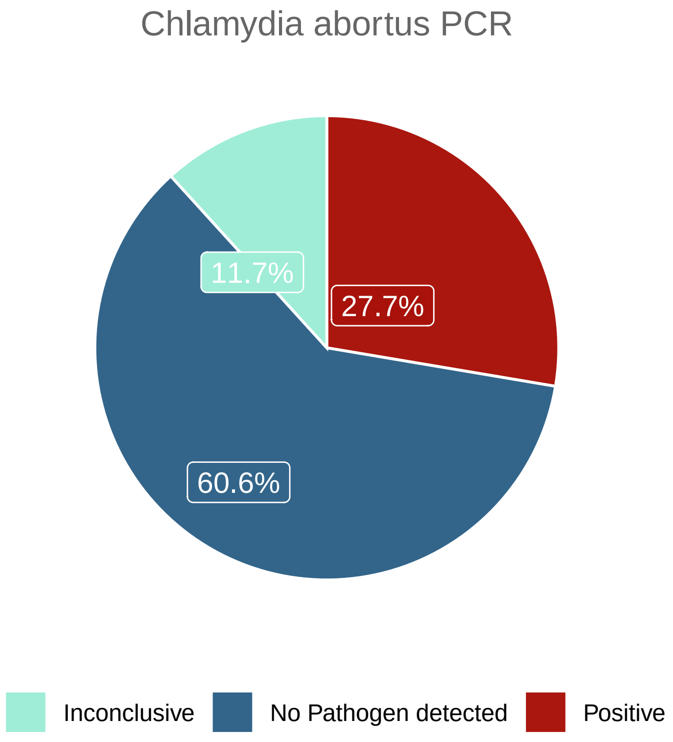


Figure 10.3.: Pie chart showing the *Chlamydophila abortus* PCR test results in ovine foetuses in 2022.)

Enzootic abortion of ewes is an economically important disease primarily affecting intensively managed flocks. The initial source of infection in EAE free flocks is usually through introduction of latently infected replacement ewes. When infected animals abort, large numbers of chlamydiae are shed in the placenta and uterine fluids resulting in environmental contamination of lambing areas. Ewes become infected through ingestion of contaminated feed or bedding. As with *T. gondii*, the clinical consequences of infection are dependent on the timing of infection and the infectious dose. Infection in non-pregnant sheep is usually latent. Recrudescence of infection in these ewes occurs in the next pregnancy, resulting in suppurative necrotising placentitis and subsequent abortion. Ewes infected in late pregnancy do not typically abort as there is a lag period between infection and manifestation of reproductive failure. These ewes are likely to abort in the following pregnancy. Ewes infected during early pregnancy typically abort later in that pregnancy. Infection is generally asymptomatic, with no apparent clinical signs associated with impending abortion (Entrican et al. 2010).

Abortion generally occurs 2–3 weeks prior to expected lambing. Aborted lambs can appear fully developed and normal, but some may have a 'pot-bellied 'appearance due to subcutaneous oedema. Premature, live lambs are usually weak and fail to survive beyond 1–2 days. Infected ewes may have a char-

Table 10.4.: Combined frequency of detection of selected secondary abortion agents on routine foetal culture of ovine foetuses (n=432).

Organism	No of Isolates	Percentage
No Significant Growth	291	**67.4**
Coliforms	111	**25.7**
Listeria spp	17	**3.9**
Streptococcus spp	11	**2.5**
Campylobacter fetus	10	**2.3**
Aspergillus spp	8	**1.9**
Bibersteinia trehalosi	8	**1.9**
Staph. spp	8	**1.9**
Bacillus licheniformis	7	**1.6**
Unclassified	7	**1.6**
Salmonella spp	6	**1.4**
Trueperella pyogenes	6	**1.4**
Campylobacter spp	1	**0.2**
Mannheimia haemolytica	1	**0.2**
Yeasts and Fungi	1	**0.2**

acteristic dirty, pink uterine exudate for a number of days *post abortion*, which is highly infectious. Ewes that have aborted because of EAE are considered immune to further abortions from the same cause, but these ewes may be persistently infected, excreting large quantities of infectious materials capable of infecting naïve ewes.

With EAE, the typical pattern of infection in a naïve flock is a small number of abortions in the first year following introduction of infected ewes. In year two, abortion storms are common, affecting up to 30 *per cent* of the flock. In year three, abortion events are generally restricted to young ewes who acquired infection in the previous season (enzootic phase). This pattern is influenced by the transmission rate of the disease and the number of infected animals introduced to a naïve flock.

Control and prevention of EAE are based on implementation of robust bioexclusion and biocontainment procedures. Aborting ewes should be promptly isolated from the remainder of the flock for 2–3 weeks. Areas where abortions occurred should be thoroughly cleaned and disinfected. Maintaining a closed flock is desirable, however where this is not practical, stock should be sourced from flocks of known EAE free status. Vaccination is an effective preventative measure for EAE, with vaccination of ewes recommended at least four weeks before breeding.

10.4. Other Organisms

Routine foetal culture was performed on 432 *post-abortion* submissions during 2022 (Table 10.4). In the majority of cases, no significant bacterial growth was reported (68 *per cent*). Coliforms were detected in approximately 26 *per cent* of cases, but the clinical significance of these organisms is uncertain. *Listeria spp.* were detected in almost 4 *per cent* of samples.

10.5. Investigations of Ovine Abortions

While most flocks will experience some abortion cases each year, rates of abortion exceeding 2–3 *per cent* should be investigated. In the event of multiple abortion cases, a detailed history should be gathered relating to flock health and management, along with specific detail on abortion cases. Aborted material should be bagged and placed in a sealed container for transport to the RVL. Ideally, the whole foetus and placenta should be submitted for *post mortem* examination, but where this is not possible, the placenta and foetal stomach contents (collected aseptically) should be submitted for testing.

Zoonotic implications

Many of the ovine abortifacient pathogens are zoonotic, and thus can cause infection in humans. As a result, pregnant women should avoid contact with ewes during the lambing season.

11. Ovine Parasites

Maresa Sheehan, *Senior Research Officer*
Kilkenny Regional Veterinary Laboratory, DAFM
Leggatsrath, Hebron Road, Kilkenny, Ireland

Parasites in sheep, including roundworms, coccidia and external parasites (sheep scab and ticks), likely represent the greatest challenge to sheep health, welfare and productivity. There is documented widespread evidence of resistance of worms to the three main classes of anthelmintics, benzimadazoles (white), macroclylic lactones (clear) and levamisole (yellow). Prompted by this widespread resistance stakeholders in Ireland, Teagasc, UCD, DAFM and pharmaceutical companies have issued key action points to limit the development of resistance and advice on dosing and drench efficacy testing. The four key actions are:

1. Don't treat adult ewes for stomach worms unless there is a demonstrated need,
2. Use only white wormers to treat Nematodirus disease in lambs,
3. Quarantine and drench bought-in sheep with a new active (orange-Zolvix or purple-Startect) to prevent bringing in resistant worms,
4. Use faecal egg counts to know when treatment is needed, and to check the treatment has worked.

11.1. *Trichostrongyles*

A number of different roundworms, such as *Haemonchus contortus*, *Nematodirus battus*, *Teladorsagia circumcincta*, *Trichostrongylus spp.* and *Cooperia spp.* can give rise to parasitic gastroenteritis in lambs. In contrast to *T. circumcincta* which appears to be the main species found in the abomasum of lambs in Ireland (Good et al. 2006). *Haemonchus spp.* infections were not commonly reported here (Rinaldi et al. 2015). Nonetheless, with potential climate changes, *Haemonchus* has become more prevalent.

Table 11.1.: Number of ovine faecal samples tested for Trichostrongylidae eggs in 2022 and results by percentage (n=2402). The ranges assume the absence of H. contortus in the faecal sample.

Result	No. of samples	Percentage
Negative	814	**34**
Low (50-250 epg)	443	**18**
Medium (250-750 epg)	415	**17**
High (>750 epg)	730	**30**

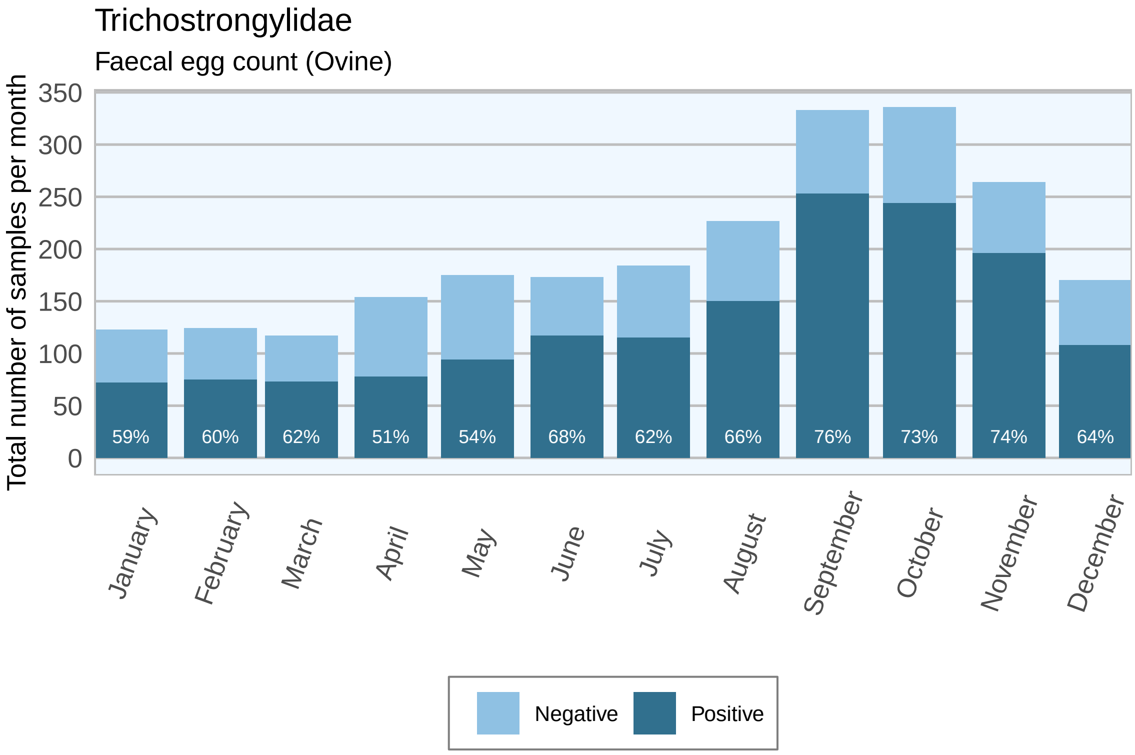


Figure 11.1.: Stacked count of ovine faecal samples (all ages) tested per month for Trichostrongylidae during 2022. The percentage in each bar represents positive samples (n=2402).

11.2. *Haemonchus contortus*

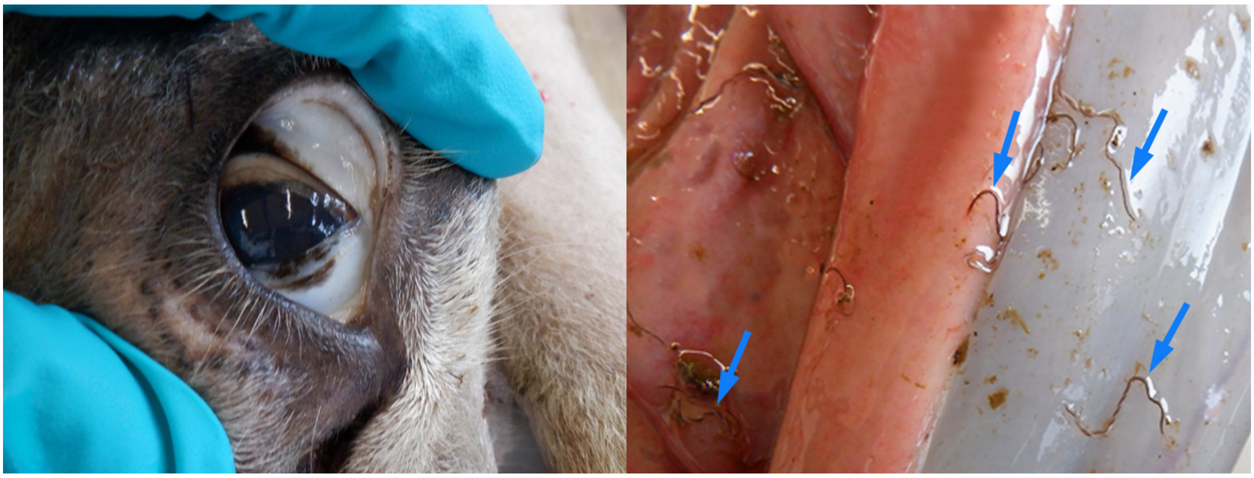
This *barber pole* worm (Figure 11.2b) has caused disease and losses on Irish sheep farms throughout Ireland in 2022, with the South and South East of Ireland seeing most cases. The adult female worm can release between 5,000 and 10,000 eggs, per day. Diarrhoea is not a typical clinical sign associated with haemonchus infection. Clinical signs include anaemia, with pale mucous membranes (Figure 11.2a), sub-mandibular oedema (*bottle-jaw*), hyperpnoea and tachycardia. The pathogenesis is associated with the blood feeding activities of the adult and developing larvae.

There is little immunity to this parasite in lambs and immunity in adults can be overwhelmed by large infections. In addition to the broad spectrum wormers, closantel and nitroxynil, narrow spectrum products, are also effective against *H. contortus*, and these are the products of choice where this is the target predominant parasite. This is particularly important with regard to ewes where we are trying to minimise unnecessary treatment of other worm species.

> 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.

11.3. *Nematodirus*

Nematodirosis is a severe parasitic disease of lambs 6 to 12 weeks of age which become infected by ingesting large numbers of infective larvae from grazing on contaminated pasture. The life cycle of *Nematodirus battus* is unlike that of other roundworms in that eggs deposited on pasture do not hatch until



(a) H. contortus anemia

(b) *Barber pole* worms, (*H.contortus*)

Figure 11.2.: *Barber pole* worms (a) (*Haemonchus contortus*) in the mucosa of the abomasum (arrows). (b) Anaemia in a ewe with heavy burden of *Haemonchus contortus* worms, Kilkenny RVL. Photos: Maresa Sheehan.

the following year to release the infective larvae. This happens during a mass hatching event in spring when soil temperatures increase after a period of cold weather. Disease typically occurs in April, May and June.

Table 11.2.: Number of ovine faecal samples tested for Nematodirus eggs in 2022 and results by percentage (n=2401).

Result	No. of samples	Percentage
Negative	2109	**87.8**
Low (50-150 epg)	137	**5.7**
High (>300 epg)	78	**3.2**
Moderate (>150-300 epg)	77	**3.2**

After ingestion by lambs, *Nematodirus* larvae invade the wall of the intestine. Disease is characterised by profuse diarrhoea, dehydration and weight loss. Calves may also be similarly affected. In outbreak scenarios, lambs can be seen congregating around water troughs due to the severe thirst that develops. Adult sheep are unaffected by the parasite.

This disease is best prevented by keeping the current year's lambs off any pasture that was grazed by lambs or young calves (which can be carriers of infection) in the previous year. Enterprises with high stocking rates are particularly vulnerable. Twin lambs, or single lambs born to ewes of poor milking ability may be at a greater risk of developing the disease as they begin consuming greater amounts of grass earlier in life.

The *Nematodirus* forecast is a useful tool published yearly on the gov.ie webpage[1] this predicts the timing of egg hatching in different parts of the country, it is advised that at-risk lambs should be treated approximately two weeks after the peak of *Nematodirus* egg hatching. However, consideration should be given to dosing lambs earlier on individual farms where clinical signs consistent with Nematodirus are observed.

[1]https://www.gov.ie/en/press-release/0e52f-nematodirus-forecast-2023/

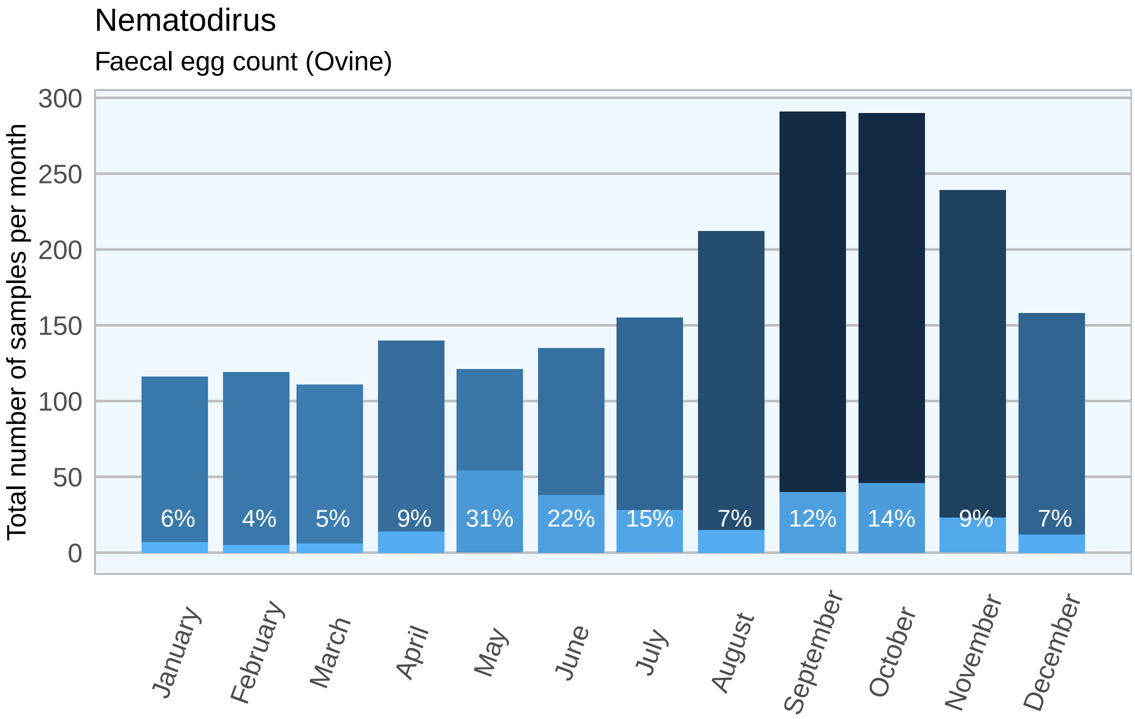


Figure 11.3.: Count of ovine faecal samples exmined for Nematodirus eggs in 2022. The percentage in each bar represents the number of positive samples per month n=(2401).

11.4. Coccidiosis

This protozoan parasite can cause clinical signs varying from loss of pellet formation to weight loss, anorexia and diarrhoea (with or without blood). Disease is most severe in animals less than 1 year of age. Diagnosis of the disease should be made on clinical signs and laboratory diagnostics as oocysts are prevalent in faeces of sheep of all ages, and only some species (*Eimeria crandallis* and *E. ovindalis*) are known to be highly pathogenic.

Result	No. of samples	Percentage
Not Detected	1272	**54**
Light Infection	659	**28**
Moderate Infection	217	**9**
Heavy Infection	133	**6**
Severe Infection	74	**3**

As the clinical signs can be similar it is important to differentiate disease caused by Nematodirus and that caused by *Eimeria spp*. Co-infection is possible in susceptible lambs.

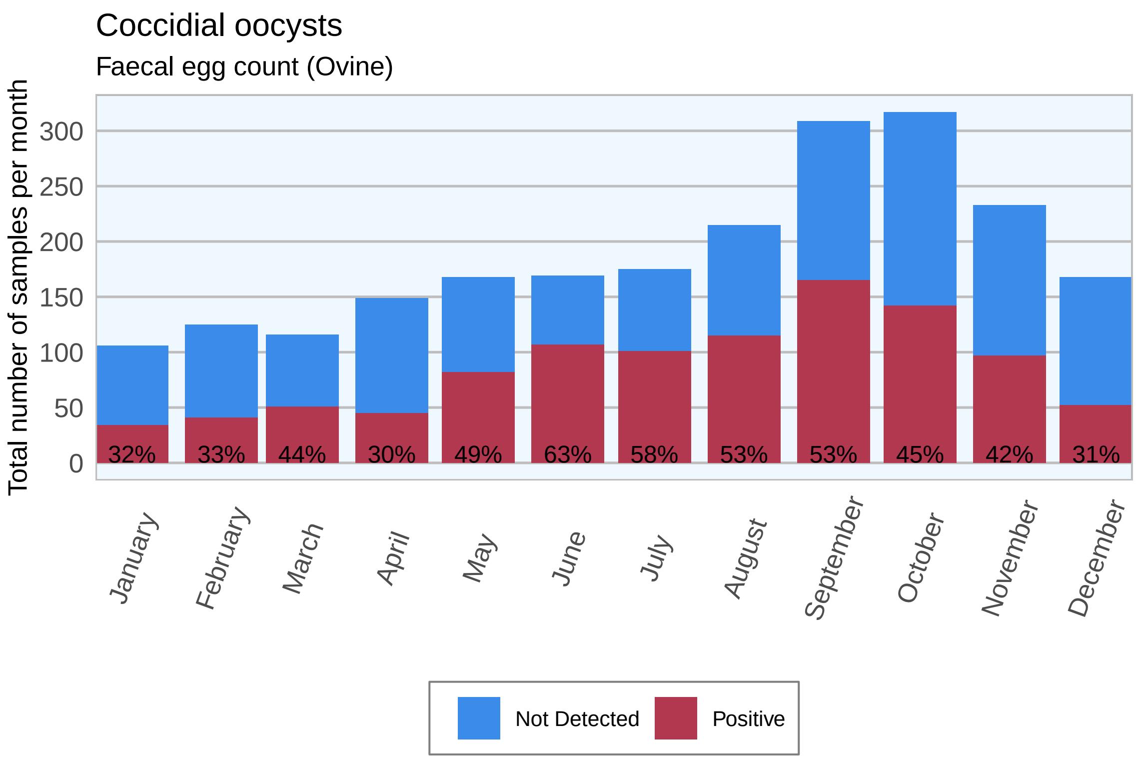


Figure 11.4.: Stacked number of ovine faecal samples (all ages) tested for coccidial oocysts in 2022. The percentage in each bar represents the number of positives (n=2355).

11.5. Liver fluke and rumen fluke

Geographical location and individual farm habitats will determine the prevalence of liver and rumen fluke in sheep on individual farms. Laboratories in the Northern half of the country and in the West report highest numbers of faecal samples positive for liver and rumen fluke eggs in samples submitted. Diagnosis of liver and rumen fluke infection is complicated by the prolonged pre-patent period. The use of faecal coproantigen testing or fluke antibody testing may aid diagnosis in the pre-patent period.

Table 11.3.: Number of bovine faecal samples submitted in 2022 (all ages) for detection of liver fluke eggs and breakdown of positive and negative results (n=2032).

Result	No. of samples	Percentage
Liver fluke eggs not detected	1902	**94**
Positive liver fluke eggs	130	**6**

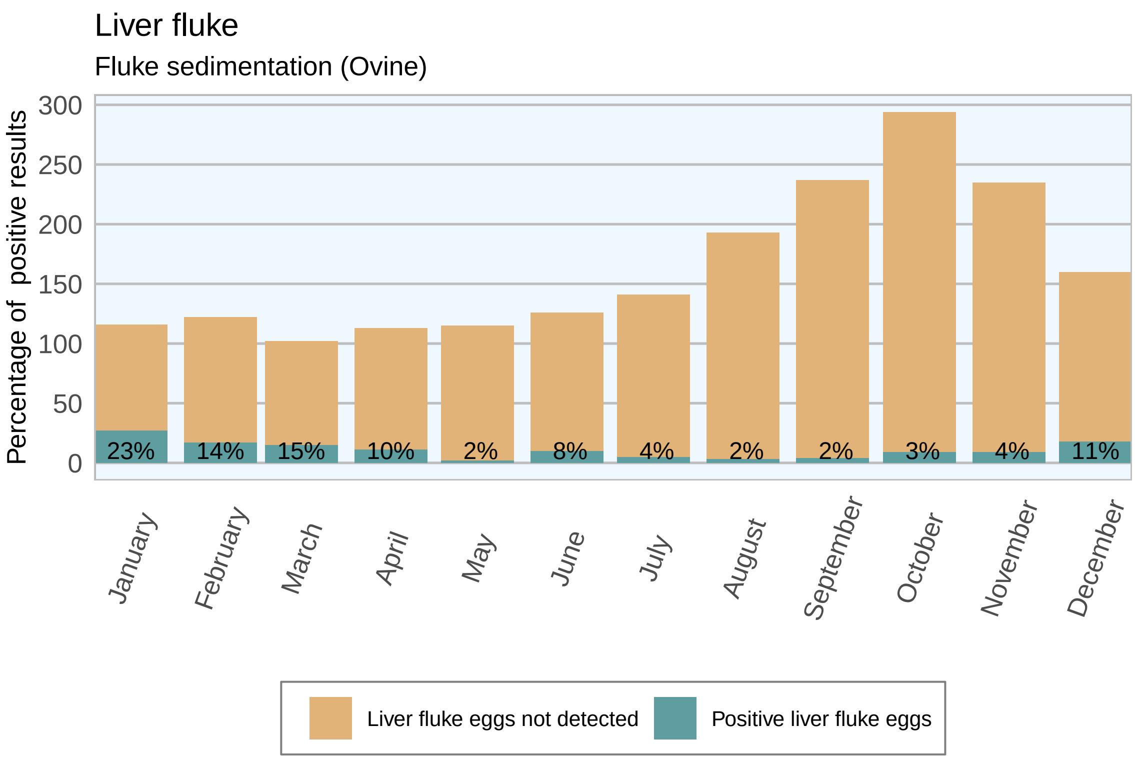


Figure 11.5.: Stacked number of ovine faecal samples (all ages) tested for liver fluke in 2022. The percentage in each bar represents the number of positive samples per month (n=2032).

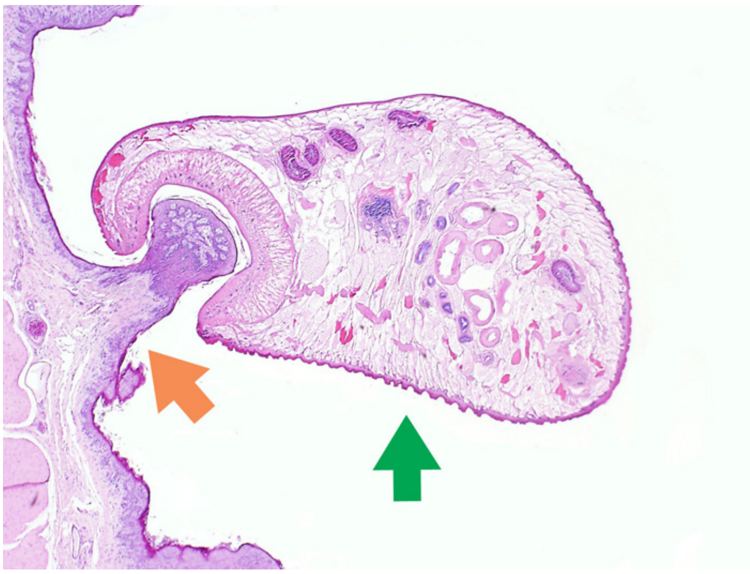


Figure 11.6.: Rumen fluke (green arrow) latched to the epithelium of the rumen (orange arrow). Photo: Cosme Sánchez-Miguel.

Table 11.4.: Number of ovine faecal samples submitted in 2022 (all ages) for detection of rumen fluke eggs and breakdown of positive and negative results (n=2032).

Result	No. of samples	Percentage
Rumen fluke eggs not detected	1655	**81**
Positive rumen fluke eggs	377	**19**

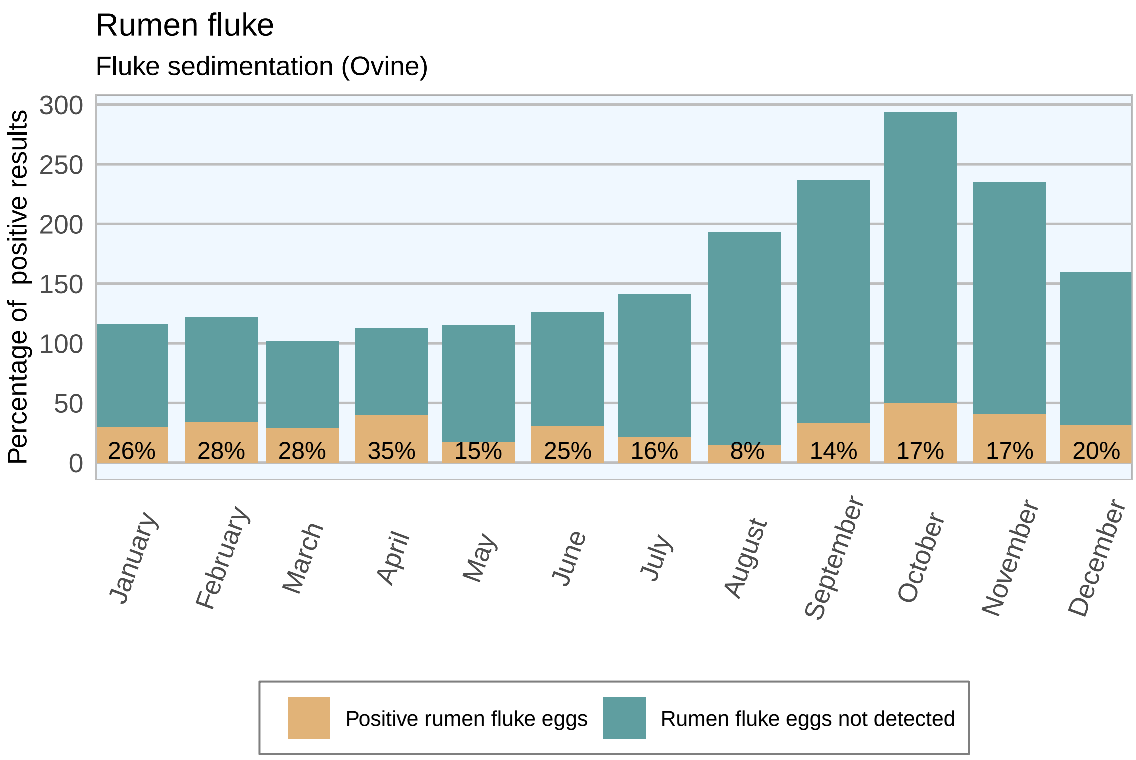


Figure 11.7.: Stacked count of ovine faecal samples (all ages) tested for rumen fluke. The percentage in each bar represents positive samples (n=2032).

Clinical disease associated with rumen fluke larvae is due to intestinal damage caused by massive numbers of larvae in the intestine. The adult worms in the rumen are not usually considered to cause disease. Diagnosis of larval paramphistomosis requires post mortem examination and the use of modified laboratory techniques.

> Please note that control of liver fluke must always be given precedence as detection of its presence is always significant

Figure 11.8.: *Psoroptes ovis*, the sheep scab mite. Photo: Cosme Sánchez-Miguel.

11.6. Sheep scab

Sheep scab caused by *Psoroptes ovis* Figure 11.8 is diagnosed in skin scrapings and wool plucks submitted from pruritic sheep to the laboratory service sporadically. This notifiable disease can cause serious welfare issues and production losses. Cases of resistance to injectable macrocyclic lactones in sheep scab mites have been reported in the UK since 2018 (Doherty et al. 2018).

Part III.

Miscellaneous

12. Zoonotic Diseases

Jim O'Donovan *, Research Officer*
Cork Regional Veterinary Laboratory,
Model Farm Road, Bishopstown, Cork

Zoonotic diseases, or zoonoses, are defined by the World Health Organisation (WHO) as any disease or infection that is naturally transmissible from vertebrate animals to humans. 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". 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 2022, DAFM Regional Veterinary Laboratories (RVLs) isolated and identified or otherwise detected a number of zoonotic agents, some of which are discussed below.

12.1. Campylobacteriosis

During 2022, DAFM RVLs isolated *Campylobacter jejuni* from 96 bovine faeces samples and 19 ovine faeces samples.

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 subsp. Fetus*).

Campylobacteriosis is recognised as the most commonly reported cause of gastrointestinal disease in humans in the European Union (EU) since 2005. In 2022, there were 3617 confirmed cases of human campylobacteriosis reported in Ireland HSPC, 2023[1]. 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. Guillaume-Barré syndrome is also reported as a rare sequel to *Campylobacter spp.* infection.

[1] https://www.hpsc.ie/notifiablediseases/annualidstatistics/Annual_ID_Summary_Report_for_HPSC_Web_v8.0-2018-2022-21032023.pdf

12.2. Coxiellosis (Q fever)

During 2022, DAFM tested 969 bovine and ovine sera for antibodies to *Coxiella burnetii*, the causative agent of Q fever, of which 57 tested positive (5.9 *per cent*). *C. burnetii* DNA was detected by PCR test in 20 of 814 samples tested (2.5 *per cent*), typically swab samples taken from foetuses or foetal membranes.

C. burnetti 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. burnettii* 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.

There have been no confirmed cases of Q fever in humans in Ireland since 2020 when 2 cases were reported (HSPC, 2023[2]).

12.3. Listeriosis

During 2022, *Listeria spp.* were isolated from 37 bovine, 15 ovine and one caprine sample, mainly from cultures of foetal stomach contents. *L. monocytogenes* was the species most frequently isolated.

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 or immersion in *L.monocytogenes* contaminated puddles/mud runs. 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, and infections among the elderly, the immunocompromised and pregnant women have higher mortality rates. In 2022, there were 18

[2] https://www.hpsc.ie/notifiablediseases/annualidstatistics/Annual_ID_Summary_Report_for_HPSC_Web_v8.0-2018-2022-21032023.pdf

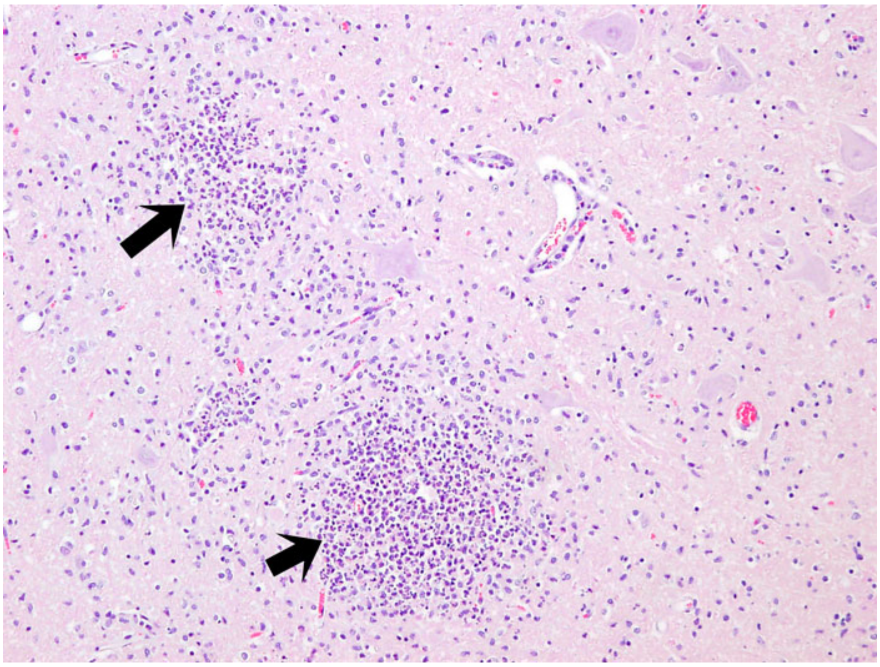


Figure 12.1.: Two microabscesses (arrows) infiltrated by neutrophiles and gitter cells in the midbrain of a ruminant with listeriosis. Photo: Cosme Sánchez-Miguel.

confirmed human cases of listeriosis in Ireland (HSPC 2023), 15 of which were in people aged 65 and older.

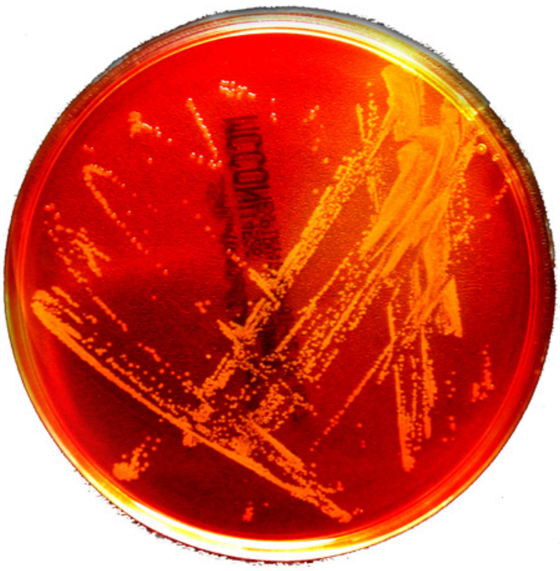


Figure 12.2.: Non-lactose fermenting colonies (Salmonella spp.) on MacConkey agar. Photo: Pat Sheehan.

12.4. Salmonellosis

During 2022, DAFM RVLs isolated *Salmonella spp.* from 31 foetuses submitted to the regional veterinary laboratory network; the most common serotype was *Salmonella enterica* Dublin, isolated from 21 of these foetuses. In samples other than foetuses submitted during 2022, DAFM RVLs isolated *S.* Dublin from twelve carcasses. Overall, Salmonella spp. were isolated from 2.3 *per cent* of 5627 samples cultured (n=128).

Salmonellosis is caused by several species of Salmonella, but the majority of animal and human disease are associated with serovars of *S. 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 spp.* presents a serious public health risk because food products of animal origin are considered a significant source of human infection.

In 2022 in Ireland there were 340 confirmed human cases of salmonellosis (HSPC, 2023[3]). Transmission of salmonellosis to humans occurs via direct contact with infected animals, indirect contact (e.g., with animal housing/equipment), or the consumption of contaminated water and foodstuffs. Symptoms tend to be more severe in the very young, the elderly and those who are immunocompromised. Symptoms of salmonellosis in humans include diarrhoea, vomiting, pyrexia and inappetence, and in more severe cases it can cause septicaemia.

12.5. Yersiniosis

Yersinia pseudotuberculosis was isolated from three animal specimens in 2022. *Y. pseudotuberculosis* causes enteric infections (Figure 12.3) which are often subclinical in wild and domestic animals, and humans.

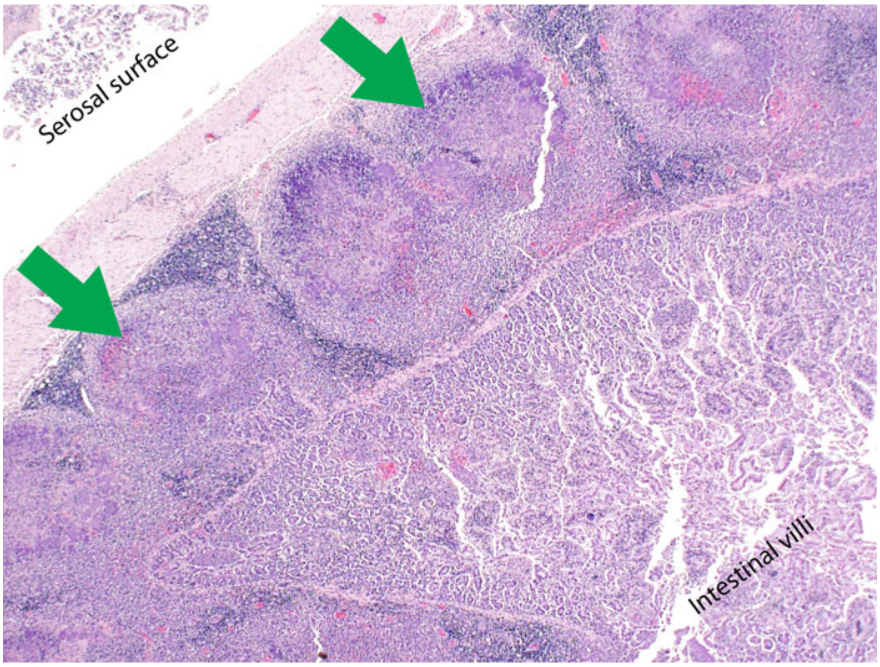


Figure 12.3.: Necrotizing enteritis in yersiniosis showing microabscesses oveer the Peyer's patches with characteristic microcolonies of coccobacilli. Photo: Cosme Sánchez-Miguel.

Three species of Yersinia are pathogenic for animals and humans; *Y. pestis* (the aetiological agent of the bubonic plague), *Y. enterocolitica* and *Y. pseudotuberculosis*. Most human infections are caused by *Y.*

[3] https://www.hpsc.ie/notifiablediseases/annualidstatistics/Annual_ID_Summary_Report_for_HPSC_Web_v8.0-2018-2022-21032023.pdf

enterocolitica; *Y. pseudotuberculosis* infection 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. Human cases of yersiniosis present as gastrointestinal disease and mesenteric lymphadenitis, with complications such as reactive arthritis, erythema nodosum, bacteraemia and sepsis. Provisionally, there were seventeen confirmed cases of yersiniosis in Ireland in human patients in 2022 (HSPC, 2023[4]). These cases occurred in several age groups, seven of the seventeen were reported in patients aged 65 and older.

[4]https://www.hpsc.ie/notifiablediseases/annualidstatistics/Annual_ID_Summary_Report_for_HPSC_Web_v8.0-2018-2022-21032023.pdf

13. Toxicology

***Celine Mannion**, Senior Research Officer*
Veterinary Biochemistry & Toxicology Laboratory,
Pathology Division
Central Veterinary Research Laboratory, DAFM,
Backweston Campus, Celbridge, Co. Kildare, Ireland

13.1. Lead poisoning

As part of DAFM's disease surveillance role the Veterinary Laboratory Service provides diagnostic support for suspect toxicities and investigates incidents. Lead incidents, involving poisoning or excessive exposure, are important animal health and food safety concerns, especially where milking cows or animals close to finishing weight are involved. Risk management measures such as removing animals from the source of lead, further blood sampling as a marker of carcase lead residues and bulk tank milk monitoring where there is evidence of exposure of milking cows etc. may be required.

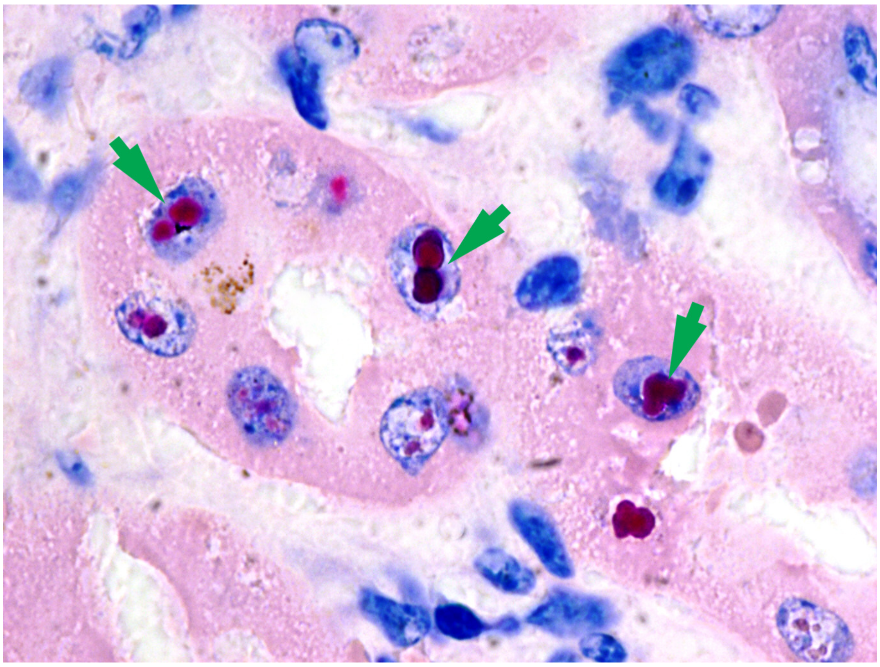


Figure 13.1.: Eosinophilic intranuclear inclusion bodies (arrows) in the cortical renal tubular epithelium of a weanling with lead nephrotoxicity (Ziehl Neelsen stain). Photo: Cosme Sánchez-Miguel.

In 2022 13 separate incidents of lead toxicity were confirmed and investigated following the submission of carcases or receipt of clinical samples for investigation. This represents a decrease compared to the previous year where 32 confirmed cases were recorded. All 13 cases in 2022 were diagnosed in cattle, mostly during spring and summer after turn out to pasture (Figure 13.2). Three of these cases involved milking cows and most cases were reported in cattle older than one year. Discarded batteries were the most common source of lead although lead-based paints were occasionally implicated. Animals usually presented with symptoms of acute lead poisoning i.e., sudden death or blindness, staggering and convulsions with death occurring shortly afterwards, or subacute lead poisoning i.e., blindness, teeth grinding, dullness with death or survival after several days.

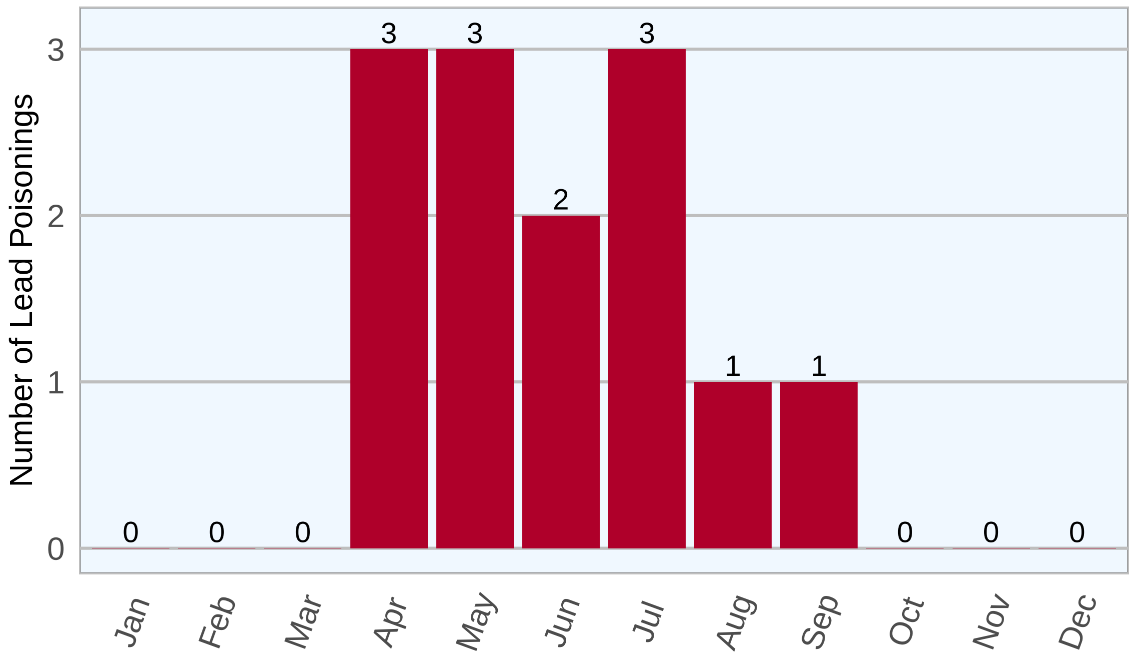


Figure 13.2.: Number of fatal lead toxicity cases in cattle by month in 2022 (n = 13)

14. Wildlife Surveillance

Denise Murphy , *Research Officer*
Athlone Regional Veterinary Laboratory, DAFM
Coosan, Athlone, Westmeath, Ireland

Throughout 2022, DAFM's Veterinary Laboratories examine several wildlife species both as part of DAFM's wildlife disease surveillance exercises and to also to assist the National Parks and Wildlife Service (NPWS) in investigating suspected wildlife crimes.

14.1. RAPTOR Programme

The RAPTOR (Recording and Addressing Persecution and Threats to Our Raptors) Programme, a collaboration between the National Parks and Wildlife Service (NPWS), the State Laboratory and the Regional Veterinary Laboratories, has been running since 2011. It is a mechanism for managing suspected wildlife crimes and disease surveillance. There are several components to this programme including x-rays, *post mortem* examination and toxicology testing. The RAPTOR protocol is currently being revised to better segregate and resource submissions likely to result in prosecution from those of surveillance value and this revision should be completed by the end of 2023. In 2022, 17 birds were examined in the DAFM veterinary laboratories under the RAPTOR programme, including buzzards (n=8), barn owls (n=4), kestrels (n=2) and white-tailed eagles (n=3). Where preservation allowed, samples were collected at *post mortem* and were submitted to the State Laboratory for toxicology testing. Tests carried out on these samples in the State Laboratory include alpha chloralose, beta chloralose, brodifacoum, bromadiolone, carbofuran, chlorophacinone, coumatetralyl, diclofenac, dicumarol, difenacoum, difethialone, diphacinone, flocoumafen, flunixin, meloxicam, methiocarb, methiocarb sulfoxide, nitroxinil, strychnine and warfarin. The sample for testing is extracted from the matrix and subjected to liquid chromatography tandem mass spectrometry, which is a common analytical technique used for confirmatory analysis for the presence of analytes in biological matrices. Bromadiolone was detected in a buzzard found dead at a farmyard in Co. Tipperary.

Bromadiolone is a potent anticoagulant rodenticide. Poisoning does not show effects for 24 to 36 hours after it is eaten and can take up to 2–5 days to cause death. Due to the state of decomposition in that case and with no visible evidence of bleeding, the significance of the elevated levels could not be determined with certainty. X-rays taken of a buzzard that had been found dead in Co. Westmeath revealed multiple lead pellets in the right thigh from gunshots. Liver samples submitted to the state lab for toxicology detected Brodifacoum and Flocoumafen (both anticoagulant rodenticides) but again, there was no gross evidence of internal haemorrhage in the carcase usually associated with rodenticide poisoning. Two barn owls examined had liver residues of bromifacoum and flocoumafen. Because these chemicals have a similar anticoagulant effect, combined, even at lower concentrations, they could potentially result in secondary poisoning with sub lethal effect due to prolonged clotting times affecting survivability. Samples from a young male white-tailed eagle found dead in Co Mayo tested positive for Nitroxynil, Brodifacoum and Flocoumafen. X-rays taken of a white-tailed eagle found dead in Co. Tipperary revealed approx. 10 lead pellets in the body and wings and a number of lead pellets were recovered

Figure 14.1.: Peregrine falcon (*Falco peregrinus*) presented for *post mortem* examination. Photo: Cosme Sánchez-Miguel.

from the wings and legs. Bromadiolone was detected in samples collected at *post mortem* also.

14.2. Rabbit Heamorrhagic Disease Type 2

DAFM veterinary laboratories examined 5 rabbits and 9 hares in 2022. The rabbits examined were domesticated pets and two were from a pet farm. Two pet rabbits and one rabbit from the pet farm tested positive for Rabbit Viral Haemorrhagic disease type 2 (RHD2), a strain of calicivirus that is highly contagious and rapidly fatal. 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. RHD2 was not detected in any of the 9 hares examined. Coccidiosis was identified as the cause of death in the other pet rabbit and in 3 hares. Bacterial pneumonia was diagnosed in one hare and bacterial sepsis in another.

14.3. *Echinococcus multilocularis* Survey

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. Alveolar echinococcosis, frequently caused by *E. multilocularis* is a potentially fatal, serious parasitic zoonotic condition. People affected show symptoms of fatigue, weight loss, abdominal pain, general malaise and signs of hepatitis or hepatomegaly. In untreated patients, the disease can develop to a severe form resulting in liver failure.

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. 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 2022, 400 foxes were sampled and tested using PCR and all were negative for *Echinococcus multilocularis.*

15. Mycobacterial Disease: TB

Colm Brady, *Research Officer*
Bacteriology Division, DAFM Laboratories,
Central Veterinary Research Laboratory, DAFM,
Backweston Campus, Co. Kildare, Ireland

Tuberculosis (TB) and Johne's disease (JD) are mycobacterial diseases which continue to pose a significant challenge to the health of livestock in Ireland. Furthermore, the zoonotic potential of TB in animals is well established. Therefore, the Department of Agriculture, Food, and the Marine's (DAFM) role in monitoring and control of mycobacterial disease not only protects public health but acts as an important support to Irish agri-food activity, not least, trade.

15.1. Introduction

From its inception to the present, the bovine TB eradication scheme has succeeded in drastically reducing the level of TB in the national herd. However, DAFM, in its efforts to achieve full eradication, is continuously investigating new scientific research and new methods which can be adopted by the scheme. The latest method to be embraced by DAFM is whole genome sequencing (WGS). WGS is the process of determining the DNA sequence of an organism's genome at a single point in time.

15.2. National Reference laboratory

The National Reference Laboratory (NRL) for bovine TB is situated in the DAFM laboratory complex in Backweston. One of the functions of the NRL is to carry out testing on suspect TB tissue samples (tissue samples taken from animals suspected of having TB). Approximately 6,000 such samples are submitted to the NRL each year. They mainly comprise abattoir slaughter check samples (suspect TB lesions detected at post-mortem (PM) abattoir inspection submitted as part of DAFM's surveillance programme), PM samples from singleton or inconclusive tuberculin skin test animals or PM samples from special TB investigations. The laboratory also tests suspect TB lesions submitted from the Regional Veterinary Laboratory service.

All samples with gross lesions are examined histopathologically. On histopathology, where a TB granuloma is detected, a diagnosis of TB is made; on the other hand, where an alternative diagnosis is ascertained, TB can be ruled out, for example, actinobacillosis, neoplasia or parasitism. There is no requirement to then carry out bacterial culture on samples with a histological diagnosis, however tissues from these samples are stored for a period in the freezer and can be retrieved later if necessary. All samples inconclusive on histopathology and additionally other submitted samples undergo mycobacterial culture. While there are a number of mycobacterial agents in the *Mycobacterium tuberculosis* complex which may potentially cause TB, the NRL consistently isolates *Mycobacterium bovis*.

Table 15.1.: Use of WGS, currently, in the Veterinary Laboratory Service, DAFM.

Laboratory area involved	Work carried out
AMR NRL	Resistance gene determination
Salmonella NRL	Serotyping and outbreak analysis
Listeria NRL	Outbreak analysis/Investigations
Staphylococcus NRL	Toxin gene detection and outbreak analysis
VTEC NRL	Toxin gene detection and outbreak analysis
Campylobacter NRL	AMR outbreak analysis
Cronobacter	Outbreak analysis
Mycobacterium bovis	**Database building, spoligotyping and outbreak analysis**
Research Projects	Five separate projects at the time of writing

Whole Genome Sequencing (WGS)

WGS is a laboratory process which determines the DNA sequence of an individual organism's genome. Six years ago, a centralised WGS unit was established in the Food Microbiology division. Over those six years, demand for WGS has been continually expanding. Table 15.1 below illustrates the great breadth of its current utility. In November 2020, the national reference laboratory (NRL) for TB introduced WGS for routine use. Currently the NRL is working towards accreditation of the WGS technique for *M bovis* by mid-2023, something which has already been achieved for several of the other areas listed in Table 15.1.

15.3. Whole Genome Sequencing (WGS)

The technique itself requires the extraction of DNA material from a *M. bovis* isolate, and this extracted DNA must then be prepared for sequencing, a process called library preparation. After sequencing itself, and with the aid of specialised computer software, the raw sequencing data is assembled into the almost complete genome which in the case of *M. bovis* is almost 4.4 million base pairs long. The assembled genome then has its alleles called (This refers to the process of identifying alleles from the sequence data at 4,701 loci on the genome in the case of *M. bovis*). It is the difference between these allele calls that allows us to determine the relatedness from one sample to another in a process called whole genome multilocus sequence typing (wgMLST). The laboratory regards a finding of less than seven allelic differences between samples as representing a close relationship, while a less than 16 allelic difference could still be considered a relatedness of significance.

This data then needs to be interpreted in order for it to be of use in epidemiological investigations of TB breakdowns. The target sample/herd is compared to all the samples in the database to determine relatedness. If one or more related samples are detected, metadata such as species, location, age of samples, contiguous herds, movement history and any other available epidemiological data, is examined to determine if there are any epidemiological links to related samples which might provide an insight into the potential cause of the breakdown(s) under investigation. This process is done manually and is particularly labour intensive. Overall, because of the many time-consuming layers of work required, not least bacterial culture, the interval from field request for WGS to result & interpretation would be measurable in months.

The advantage of WGS over earlier molecular typing techniques such as spoligotyping is that it

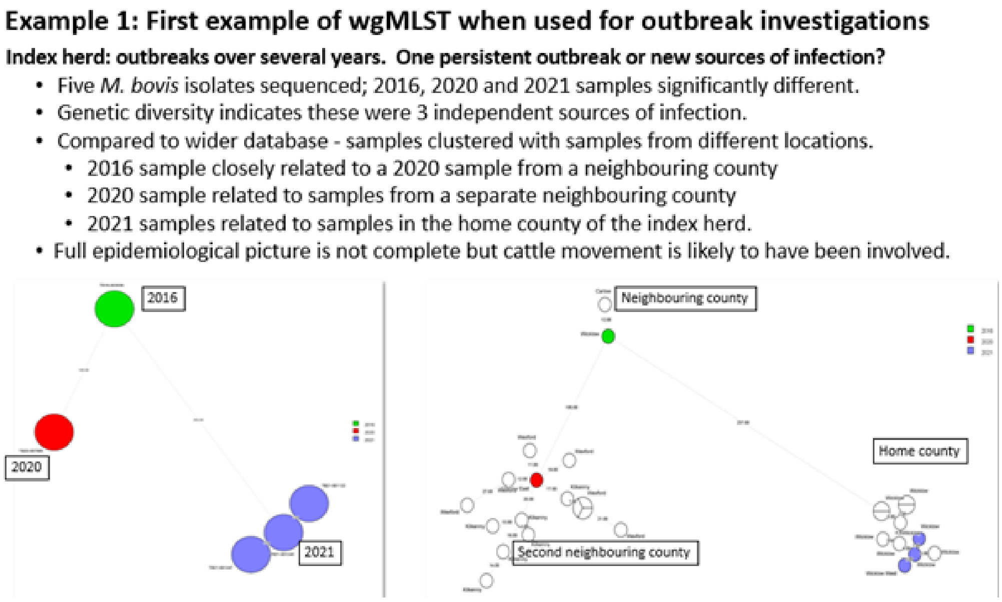


Figure 15.1.: First example of wgMLST when used for outbreak investigations.

provides a far higher degree of resolution to differentiate between isolates of *M. bovis* which can be a very useful epidemiological tool to help in outbreak investigations. To date, WGS has been applied to 3,129 isolates of *M. bovis*. The isolates which have been sequenced are representative of all counties in Ireland and multiple species: bovine (2,554), badger (384), deer (31), alpaca (22), pigs (13), and other (125). The following are just three examples where WGS has recently been put to practical use.

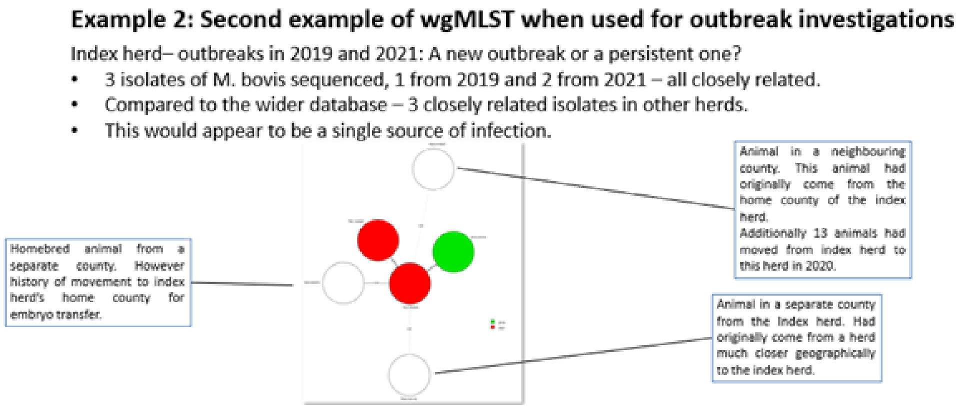


Figure 15.2.: Second example of wgMST when used for outbereak investigations.

WGS offers a uniquely high degree of resolution for discriminating between different lineages of *M. bovis*. To maximise its usefulness, it is necessary to create a database of *M. bovis* sequences in Ireland and this work is ongoing. As the three examples illustrate, WGS is already being used at farm level to assist in identifying potential sources of infection. These investigations are underlining the importance of cattle to cattle transmission in the spread of bovine tuberculosis. Further study into transmission dynamics will be facilitated as both geographical and temporal coverage of sequences in the database are increased.

16. Mycobacterial Disease: Johne's Disease

Colm Brady, *Research Officer*
Bacteriology Division, DAFM Laboratories,
Central Veterinary Research Laboratory, DAFM,
Backweston Campus, Co. Kildare, Ireland

16.1. Introduction

Mycobacterium avium subspecies *paratuberculosis* (MAP), is the causative agent of JD, a slowly progressive, chronic granulomatous enterocolitis of ruminants.

16.2. Pathology

Gross pathological change is characterised by thickening and corrugation of intestinal mucosa, most prominent in the ileum (Figure 16.1). Pathological change also occurs in other parts of the small intestine and in many though not all cases the large intestine is also affected by lesions. On histopathological examination, intestinal change is characterised by granulomatous infiltration of the intestinal lining with distortion and effacement of intestinal structures (Figure 16.2a). The presence of acid-fast bacilli may be seen on Ziehl-Nielsen staining of the lesions particularly in the more advanced stages of the disease (Figure 16.2b).

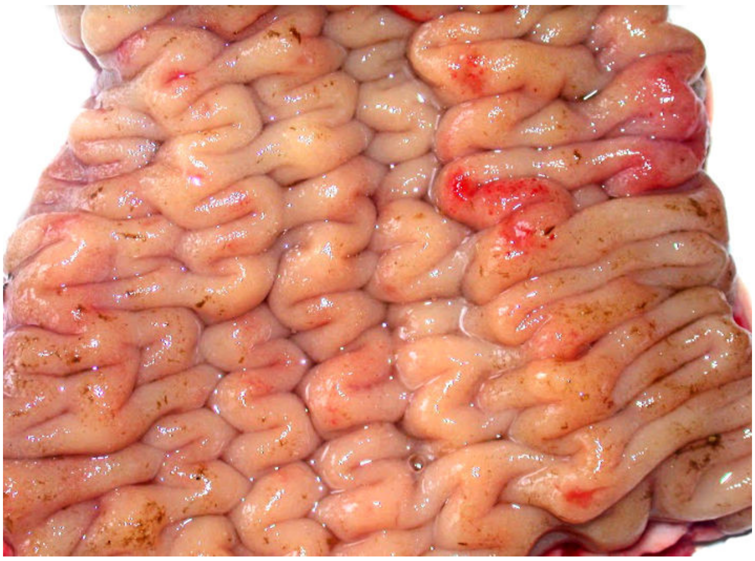


Figure 16.1.: Thickening and corrugation on the mucosal surface of the ileum in a cow which had Johne's disease manifested by ill thrift and diarrhoea. Photo: Colm Brady.

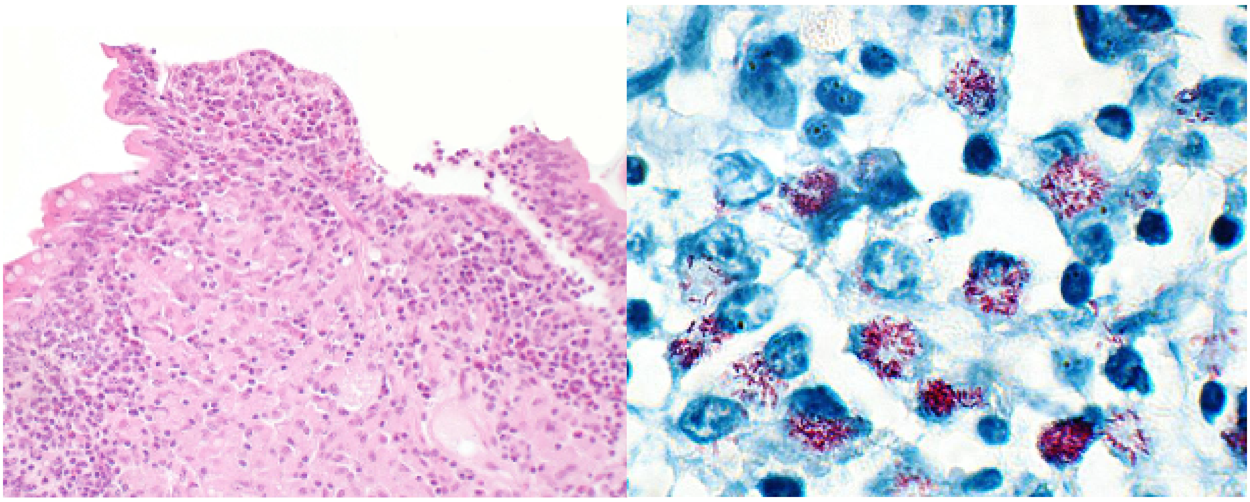
16.3. Clinical signs

Clinical signs include weight loss despite maintenance of appetite, diarrhoea, submandibular oedema, emaciation, lethargy, and death. Johne's disease is refractory to treatment.

Like other mycobacterial diseases, latency is a common feature of JD; animals can remain sub- clinically infected for years. While cattle are most vulnerable to infection in early life where calves might be exposed to MAP infected milk/colostrum or faeces from a MAP shedder, clinical disease occurs most frequently in cattle aged 2 to 5 years of age. This latency provides a very significant challenge for both epidemiological investigations and control of JD on Irish farms, not least because diagnosis can be difficult.

16.4. Diagnosis

Ante mortem diagnostic tests can be divided into two categories, direct tests that detect the presence of the causative agent itself – MAP. The direct tests identify the presence of MAP itself, either by bacterial culture or alternatively by polymerase chain reaction (PCR). The indirect tests detect the immune response to JD, the enzyme linked immunosorbent assay (ELISA) is the test in common use.



(a) H-E staining

(b) Ziehl-Nielsen staining

Figure 16.2.: Granulomatous inflammation in the terminal ileum of a cow which had Johne's disease manifested by ill thrift and diarrhoea, (a) H-E staining and (b) Acid fast bacilli (in red) in a granulomatous lesion of the terminal ileum of a cow with Johne's disease, Ziehl-Nielsen staining. Photos: Colm Brady.

16.5. Bacterial culture

Bacterial culture which can take several weeks is highly specific, isolation of MAP on culture from faecal or tissue samples can be regarded as confirmatory for JD. However, since shedding of MAP may be intermittent or entirely absent in the early stages of JD, the sensitivity of bacterial culture is low.

16.6. Polymerase Chain Reaction (PCR)

The PCR technique which has been developed to detect MAP from faecal and tissue samples works by finding DNA which belongs to the MAP genome. This technique is relatively fast in that turnaround time for the test is just a few days, however low shedding of MAP until later in the course of the disease offers the same challenges for PCR as has already been described for culture.

16.7. ELISA

ELISA detects the host's immune response to MAP and is used extensively for routine diagnosis. ELISA is favoured as a screening test due to its relatively low cost compared to direct testing. The ELISA also provides relatively fast results. However, the specificity of MAP ELISA tests can be influenced by tuberculin testing and by exposure to other mycobacteria, giving rise potentially to false positive results. In short, a positive ELISA reaction is not confirmation of JD. The sensitivity of ELISA is also influenced by stage of infection, higher in animals with clinical disease and marked shedding of MAP. However, sensitivity is lower in infected animals which are subclinical and either not shedding or shedding lower numbers of MAP making false negative results more likely.

16.8. National Reference Laboratory for JD

The National Reference Laboratory (NRL) for JD is situated in the DAFM laboratory complex in Backweston. The NRL works to support the Animal Health Ireland (AHI)-led Johne's Disease Control Programme. Most of the Johne's Disease diagnostic work in Ireland is now carried out in commercial AHI-designated laboratories. However, the NRL carries out bacterial cultures to isolate MAP from submissions from DAFM's Regional Veterinary Laboratory service or from herds under specific investigation. The NRL confirmed the presence of MAP in 35 samples in 2022. Thirty-three samples were submitted from a bovine animal, one of the samples was submitted from a goat, while in the case of the remaining sample, MAP infection was confirmed in a sheep.

16.9. Control Programme

The Irish Johne's Control Programme is managed by Animal Health Ireland. The programme provides a package of disease prevention and containment practices to control the spread of Johne's disease. These practices provide a pathway for test negative herds to guard against entry of infection and to demonstrate an improved test assurance against Johne's disease. In the case of test positive herds, the programme provides a pathway for test positive herds towards reducing the spread and effects of MAP Infection. The programme is voluntary, and herds in Ireland are encouraged to join. More information on the programme and how to register can be found on the Animal Health Ireland[1] webpage.

[1] http//animalhealthireland.ie

Part IV.

Pigs

17. Porcine Diseases

***Sara Salgado**, Research Officer*
Dublin Regional Veterinary Laboratory, DAFM Laboratories,
Central Veterinary Research Laboratory, DAFM,
Backweston Campus, Co. Kildare, Ireland

In 2022, DAFM laboratories carried out necropsy examinations on 317 pig carcasses and 50 aborted foetuses while 2401 non-carcass diagnostic samples were submitted from pigs for a range of diagnostic tests to assist veterinarians with disease investigation and for surveillance on Irish pig farms. These figures are similar to 2021 submission rates.

Diagnosis	Total Number	Percentage
Pneumonia	49	**15.3**
Abortion	44	**13.7**
Enteritis	44	**13.7**
Other	40	**12.5**
Bacteraemia/septicaemia/toxaemia	22	**6.9**
Colitis	21	**6.5**
Meningitis	14	**4.4**
No Diagnosis	11	**3.4**
Abscessation	10	**3.1**
Pleuropneumonia	8	**2.5**
Polyserositis	8	**2.5**
Arthritis	7	**2.2**
Cellulitis	6	**1.9**
Hepatitis	6	**1.9**
Trauma	6	**1.9**
Navel ill/Joint ill Complex	5	**1.6**
PMWS	5	**1.6**
Endocarditis	4	**1.2**
Haemorrhagic Bowel Syndrome	4	**1.2**
Hepatopathy	3	**0.9**
Oedema Disease	2	**0.6**
Pneumonia and Septicaemia	2	**0.6**

Note:
Categories that have less than two cases have been included in the 'Other' category

17.1. *Post Mortem* Diagnoses.

The most frequent diagnoses in pig necropsy submissions during 2022 are detailed below. This dataset only 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.

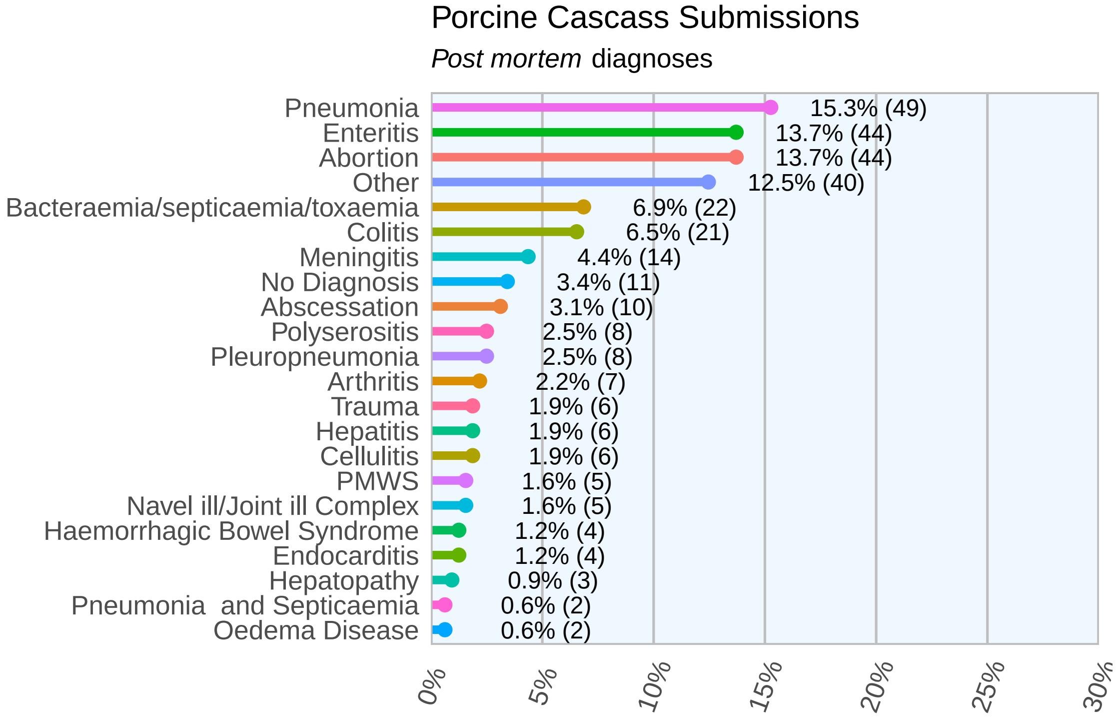


Figure 17.1.: Conditions most frequently diagnosed on *post mortem* examinations of pigs in 2022 (n=321). Note: Categories that have less than two cases have been included in the 'Other' category. The absolute number of cases is between brackets.

As with previous years, Enteritis and Pneumonia/Pleuropneumonia remained the most commonly diagnosed diseases in pig carcasses submitted for examination. This is consistent with previous years' submissions to DAFM laboratories and with pig production diseases prevalence worldwide, where both enteritis and pneumonia representing the most common disease categories impacting large scale pig production. These diseases often require antibiotic intervention. Disease control by vaccination and improved biosecurity can reduce disease occurrence.

Enteritis

Enteritis is most common disease category diagnosed in pig carcasses submitted to DAFM labs in 2022, representing 24.72 *per cent* of cases diagnosed, more commonly in neonates. DAFM laboratories operate a proactive porcine neonatal enteritis investigation service for pig farms and veterinarians on account of the significant morbidity and economic loss on 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 laboratories were Rotavirus, *Salmonella* spp, *E. coli* , *E. coli* 0149 and *Clostridium difficile*.

Pneumonia/Pleuropneumonia

Pneumonia and pleuropneumonia were among the second most frequent diagnoses reached in DAFM labs pig *post mortem* investigations in 2022 accounting for 21.45 *per cent* of all diagnoses reached. All porcine respiratory disease investigations at DAFM laboratories undergo bacterial, viral, and histopathological examinations to determine aetiology.

As pneumonia in pigs is rarely exclusively due to infection with a single pathogen, the term Porcine Respiratory Disease Complex (PRDC) is used to describe this syndrome. PRDC is a significant cause of morbidity and mortality. Poor growth rates and condemnations at slaughter also contribute to economic loss for the herdowner (*pleurisy* is the most common cause of pig carcasses being detained or condemned at slaughter in Ireland).

The common bacteria identified from pneumonia cases were *Actinobacillus pleuropneumonia*, *Pasteurella multocida* and *Mycoplasma hyopneumoniae*. Viral agents such as Influenza Virus, Porcine Reproductive and Respiratory Syndrome Virus (PRRS) and Porcine Circovirus 2 (PCV2) are also detected as part of this multifactorial disease.

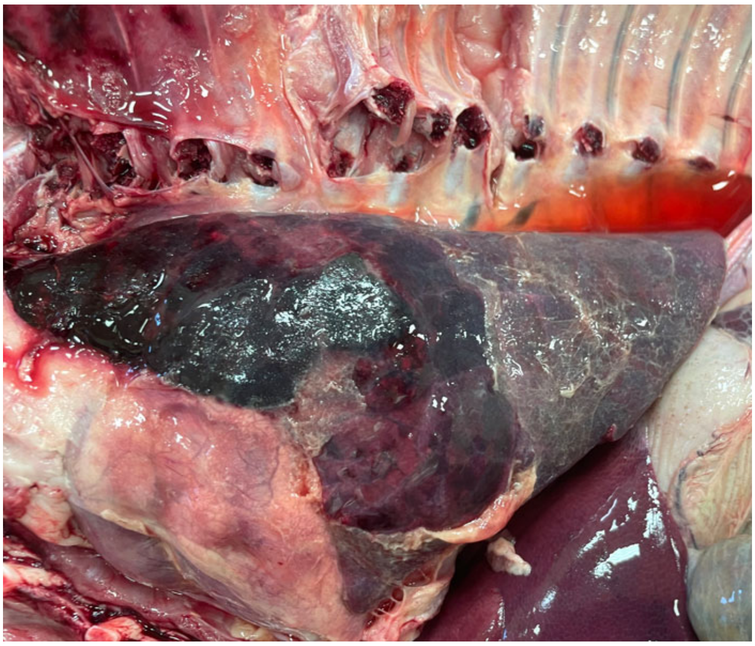


Figure 17.2.: Severe diffuse pleuropneumonia and pericarditis, characteristic of *Actinobacillus* pleuropneumonia. Photo: Sara Salgado

A porcine bacterial respiratory pathogen multiplex PCR test is performed in the Cork Blood Testing Laboratory. In 2022 of 149 samples tested (for *Actinobacillus pleuropneumonia*, *Haemophilus parasuis* and *Mycoplasma hyopneumoniae*), 10 detections of *Actinobacillus pleuropneumonia*, 18 detections for *Haemophilus parasuis* and 23 detections for *Mycoplasma hyopneumoniae* were made. In tandem testing of *post mortem* pneumonia submissions for bacterial pathogens using routine culture and PCR methods, provides the best opportunity for detection of bacterial respiratory pathogens. The fastidious nature of some pathogens does not favor their growth in artificial media while for others the presence of systemic antibiotics impedes bacterial growth in culture. Nonetheless bacterial culture isolated are necessary for antimicrobial sensitivity testing.

Abortions

Abortion was the third most common diagnostic category accounting for 16 *per cent* of diagnoses. Any increase in the rate of abortions or stillbirths within a pig unit can have serious impact on the productivity and economic viability of the enterprise. Samples from aborted or stillborn pigs will typically be tested for a variety of both bacterial and viral pathogens, such as Parvovirus, PRRS, Swine Influenza Virus and PCV2. An aetiological agent was identified in 10 of the 44 abortion investigations. *E. coli* was isolated in five cases, *Klebsiella spp.* in four and *Actinobacillus rossi* in one case.

Figure 17.3.: Porcine foetuses for post portem examination. Photo: Margaret Wilson

17.2. Exotic Disease Monitoring

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.

National Disease Emergency Hotlines

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

An ASF factsheet for vets detailing the clinical signs of ASF is available on the African swine fever page on the DAFM website African Swine Fever[1] DAFM also produced a biosecurity leaflet specifically aimed at non-intensive pig farms and an ASF factsheet for farmers, both are available to download from the African swine fever webpage (linked above).

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 establish a diagnosis. Practitioners are also advised to encourage clients with small pig herds to submit any dead or fallen carcasses 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.

17.3. Exotic Disease Surveillance Data

During 2022, 276 pigs were sampled for *Brucella suis*. Additionally 1595 samples were collected as part of the Cull Sow abattoir surveillance scheme. These were screened for Aujeszky's, African Swine Fever and Classical Swine Fever.

[1] https://www.gov.ie/en/publication/249e9-african-swine-fever/.

Part V.

Poultry

18. Poultry Diseases and Surveillance

Laura Garza Cuartero , *Research Officer, Virology Division,*
William Byrne , *Senior Research Officer, Food Microbiology Division*
Sebastian Mignacca , *Research Officer, Sebastian Mignacca*
Central Veterinary Research Laboratory, DAFM,
Backweston Campus, Co. Kildare, Ireland

18.1. 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 wild mammals, 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. On the other hand, 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 with no other 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 (WOAH) 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.

a) Avian influenza serology testing in poultry through 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*, *Regulation (EU) 2035* of 2019 and Commission Delegated *Regulation (EU) 2020/688*. The PHP includes testing for *Mycoplasma spp.* and *Salmonella spp.*, and , to increase Avian Influenza surveillance, samples are also tested for AI by AGID/ELISA. In 2022, 11.913 poultry samples were tested by this method through the PHP (Table 18.1).

b) 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 2022, 6747 samples were tested for H5 and H7 HAI. The categories sampled for the EU Poultry Surveillance Scheme include:

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

Passive surveillance:

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[1], 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: gov.ie - List of Target Species for Avian Influenza Surveillance[2]

In 2022, 184 wild birds were tested by passive surveillance; from those the majority of Avian Influenza detections were in Gannets (62), Barnacle geese (10), common buzzards (3), Mute swans (2) ,Peregrine Falcons (2) and followed by detections in a Barn owl, a Cormorant, a Grey heron, a Guillemot, a Kestrel, wild pheasants, and a Raven. All positives were of the H5N1 Avian Influenza subtype.

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 through the Regional Veterinary Office, an official investigation will be carried out by DAFM, directed by the competent authority (National Disease Control Center) 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.

[1] https://aviancheck.apps.rhos.agriculture.gov.ie/report
[2] https://www.gov.ie/en/publication/50ce4-avian-influenza-bird-flu/

Table 18.1.: Avian influenza surveillance testing during 2022 in Ireland.

2022	No Animals tested	Non- notifiable AI subtypes	Notifiable H5 and H7 subtypes
Poultry- Poultry Health Programme (AGID test) (a)	11913	0	0
Poultry –H5 and H7-EU Surveillance (HI test) (b)	6747	0	0
Poultry - AI ELISA (diagnostics)	973	0	0
Wild birds - PCR	184	0	88 x H5N1 (77 x HPAI , 11 x Pathogenicity not determined), 2 x H5Nx (pathogenicity not determined)
Poultry - PCR (c)	931	0	2 x backyard flocks H5N1 HPAI, 2 x Turkey Fattening Flocks H5N1 HPAI.
Captive birds (PCR)***	55	0	0

[a] AGID: Agar Gel Immunodiffusion test;

[b] HI: Haemagglutination Inhibition test for H5 and H7;

[c] Poultry-PCR: includes individual animals and pooled swabs from different animals

In 2022, two backyard flocks and two turkey fattening flocks were affected by the H5N1 HPAI strain (Table 18.1).

18.2. Avian *Mycoplasma spp.* 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* and-or *Mycoplasma Meleagridis.*

Mycoplasma gallisepticum (MG): 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 sp.* can infect chickens, turkeys and game birds. Ducks and geese can also become infected particularly when associated with infected chickens.

Table 18.2.: Official Sampling for Poultry Health Programme and EU AI surveillance during 2022 in Ireland

Type of submissions	Test	No. Tests	Positive
National-Poultry Health Programme	M. gallisepticum SPAT	29484	0
National-Poultry Health Programme	Avian Influenza AGID	11913	0
National-Poultry Health Programme	M. meleagridis SPAT	1685	0
National-Poultry Health Programme	Salmonella arizonae 'H' SAT	1260	0
EU-H5 H7 HI -Surveillance	Avian Influenza H5	6747	0
EU-H5 H7 HI -Surveillance	Avian Influenza H7	6747	0

Mycoplasma meleagridis (MM): With this *Mycoplasma sp.* 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.

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 MG or MM (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 2022, 29484 and 1685 serum samples were screened for *M. gallisepticum* and *M. meleagridis*, respectively, at the CVRL as part of DAFM PHP programme (Table 18.2).

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.

Table 18.3.: Number of Salmonella culture Tests from on-farm samples during 2022 in Ireland.

Avian Production Type	No. Samples	No. Positive Flocks
Boiler	99	1 (a)
Broiler Breeder	841	0
Layer and Layer breeder	415	2 (b)
Turkey	23	5 ©
Turkey Breeder	8	0

[a] S. Enteritidis
[b] S. Typhimurium, two samples from one layer flock
[c] S. Typhimurium, five from a turkey farm

18.3. Avian Salmonella Surveillance

As part of the national Poultry Health Programme, serological testing for screening of *Salmonella arizonae* is carried out in turkey flocks in addition to Avian influenza and *M. meleagridis* (Table 18.3). Last year, 1260 serum samples were screened for *S. arizonae*.

In parallel, every year, DAFM carries out the EU Salmonella Surveillance by collecting samples on-farm and confirming detected serotypes by culture (Table 18.3). The programme operates as follows:

- In at least one flock of broilers on 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 2022, 1380 samples collected from farms by DAFM were analysed; of these, *Salmonella spp.* were detected in 1 broiler farm (*S. Enteriditis*) and in a registered turkey finishing holding (*S. Typhimurium*) (Table 18.3).

18.4. Newcastle Disease and pigeon PMV1

Newcastle Disease (ND) is a notifiable disease that affects poultry and it is caused by virulent strains of Avian Avulavirus 1 -AAvV-1- (also called Avian Paramxyovirus type 1 -APMV1- or PMV1). A similar variant, Pigeon AvV-1 (PPMV1) infects pigeons and other wild birds. AAvV-1 infections may be presented as a wide range of clinical signs depending on the strain virulence from lethargy and mild respiratory signs to egg drop production, neurological signs, and sudden death.

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

Table 18.4.: Paramyxovirus- 1 (PMV-1) testing during 2022 in Ireland.

PMV1 PCR	No birds	positive events/cases	Strain virulence
wild birds	28	2 (a)	not determined
captive/racing	45	1 (b)	Virulent
poultry	54	0	0

[a] Inconclusive

[b] One captive pigeon

Table 18.5.: PCR testing of submitted samples (PVP and RVL submissions) in 2022. This table does not include the pathogens detected as part of surveillance programs or farm investigations fro Class A diseases.

Pathogen	Animals tested	Positive
Infectious laryngotracheitis *	66	19
Infectious Bronchitis	135	31
Mycoplasma gallisepticum *	176	29
Marek's Disease	108	50
Mycoplasma synoviae *	200	39
Avian pneumovirus	24	0
Chlamydia psittaci *	85	3

* Notifiable diseases. This table does not include the pathogens detected as part of surveillance programmes or farm investigations for Class A diseases.

passive surveillance. In 2022, 28 wild birds, 45 captive/racing birds, and 54 poultry were tested for PMV1 PCR. 1 captive pigeon was positive for Pigeon PMV-1 and confirmed as the Virulent strain. Two Kittiwakes were inconclusive and therefore strain virulence was not determined (Table 18.4).

18.5. Other 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 in this case- from backyards and commercial flocks are tested. PVPs submit swabs directly to the CVRL and carcasses of animals are submitted to the RVLs where they are sampled.

Last year, the pathogens most detected in poultry backyards were Marek's Disease Virus (50), *M. synoviae* (39), *M. gallisepticum* (29), Infectious Bronchitis (31), followed by Infectious Laryngotracheitis (19) (Table 18.5).

18.6. Case reports in poultry (Dublin RVL)

Diseases Identified in poultry/avian submissions : *E coli*, *Enterococcus sp.*, Marek's (MD), *Brachyspira sp.*, Fowl cholera, Cannibalism, Pododermatitis, Spironucelous, avian TB, carbofuran poisoning in a raptor, and miscellaneous (coccidiosis (Figure 18.1), intestinal nematodiasis, aspergillosis, amyloidosis, mycoplasmosis, adenovirus infection, lymphoid leukosis, Gumboro disease, trichomoniasis, breast myopathy, and ovarian tumours).

Colisepticaemia

Colisepticaemia is a cause of significant economic loss worldwide. This disease complex (also referred as salpingitis/peritonitis/salpingoperitonitis syndrome, and egg peritonitis syndrome) was the most common cause of death in poultry submissions and was diagnosed in a large variety of enterprises such as layer hens, broiler breeders, broilers chickens, and in chicks affected with yolk sacculitis. Lesions were usually expressed with mild to severe fibrinous coelomitis involving often liver, pericardium and heart, and, sometimes, also spleen, oviduct, intestine, lung and kidneys, associated with heterophils infiltration, intravascular thrombi and intralesional bacteria aggregates. Sero-fibrinous cellulitis and ingluvitis were also observed in severe infection.

Figure 18.1.: Intestinal tract with enteritis caused by *Eimeria spp.* (coccidiosis). Photo: Sebastian Mignacca

Several factors such as intercurrent disease (i.e., concurrent histomonosis, intestinal worms, red mite, pasteurellosis, MD and Infectious Bronchitis(BI)) as well as non-infectious factors (i.e. adverse environmental conditions) are often linked with *E. coli* infection, suggesting that salpingitis/peritonitis are often a result of opportunist infection. Live vaccines (e.g. Newcastle disease or IB), and nutritional deficiencies may increase susceptibility. Outbreaks in some flocks could be the consequence of cannibalism or vent pecking. Disease is generally the result of ascending infection via the cloaca, and *E. coli* is typically isolated in pure growth from the reproductive tract. Pathogenic strains may also invade from the respiratory tract following infection with other respiratory pathogens. Moreover, sequestered colonies in sites such as the intestine, nasal passages, air sacs or reproductive tract may be a latent source of infection. Birds are continuously exposed through contaminated faeces, water, dust and environment, and yolk sacculitis is usually related to egg contamination in the hatchery or infection during the hatching. On farm control measures include a vigorous sanitation program, good litter management, dust and ammonia levels control, and minimising sources of stress and parasitism.

Enterococcus spp. infection

During 2022, broiler chicks in good or moderate condition but affected with lameness and increased mortality were also submitted. On *post mortem* examination, they exhibited fibrinous or fibrous pericarditis and necrosis of the head of femur. Culture from liver and bone marrow yielded *Enterococci spp.*.

Diseases associated with enterococci in poultry, although worldwide in distribution, are relatively uncommon and the growth of the causative bacteria in the laboratories is difficult. However, it has recently been shown that early mortalities in flocks, which are likely to be attributed to *poor chick quality*, are in some cases due to this infection. *Enterococci* can be recovered from the environment, including hatcheries, and can be associated with septicaemia. *E. faecium* has been recovered from endocarditis in chickens and *E. cecorum* has been obtained from bacterial chondronecrosis and osteomyelitis in broilers. Clinically, lameness and swellings affecting primarily tarsometatarsal joints and feet are observed, and differential diagnosis include joint infection due to *S. aureus*, *Mycoplasma synoviae*, avian reovirus, and mineral imbalance in the diet, especially in growing animals and layer hens.

Marek's disease

Poultry submissions showing gross lesions indicative of Marek's disease (enlarged spleen, thickened sciatic nerve, multifocal pale firm masses within muscle and internal organs) and confirmed by histological examination and PCR, were received during the year. In the majority of confirmed cases, the history was non-specific such as depression, weight loss, anorexia and diarrhoea, and almost always *concomitant* disease (bacterial or parasitic) was also present, confirming the immunosuppressing role of the virus.

Marek's disease is caused by alpha herpesvirus and usually affects birds older than 4 weeks of age. In the infected flocks, it can express in different presentation. In the acute form, its incidence is frequently between 10–30 *per cent* or higher. Mortality can increase rapidly over few weeks and then cease or can continue at a steady or falling rate over several months and predisposes to secondary infections. Affected birds are often paralysed, whilst grossly, the bursa may be enlarged or atrophied. Histologically the lesions consist of T-cell neoplasms and there may be infiltration in a number of organs such as skin, muscle, proventriculus, eye, brain, and peripheral nerve. Due to its highly contagious nature and ability to survive for long periods, both within the host and in the environmental, its eradication is difficult. Affected animals shed the virus constantly and some birds may be latently infected. Control is based mainly on preventive vaccination and improved management methods. However, depopulation when other measures are ineffective must be considered.

Brachyspira spp infection

Brachyspira spp as primary cause of disease was detected in a commercial table layer flock and in a peacock.

The genus *Brachyspira* includes nine officially recognised species, several of which are pathogenic to mammals and birds. Avian intestinal spirochaetosis (AIS) is a gastrointestinal disease in poultry caused by the colonisation of the caeca and/or colon-rectum by *B. pilosicoli*, *B. intermedia*, and *B. alvinipulli*. AIS primarily affects layer hens and broiler breeders over the age of 15 weeks.

Clinical signs (mainly induced by *B. pilosicoli*) can range from asymptomatic to severe disease, leading to increased mortality rates. Mild to moderate disease could result in 6–10 *per cent* reduction in egg production, delayed onset of lay, reduced growth rates and decreasing egg quality (smaller, less numerous, poor-quality shells, and less coloured yolk), faecal stained eggs, and changes of the animal dropping (diarrhoea, increased fat content, foamy consistence due to increased gas production, and presence of mucus and blood). Systemic infection results in increased flock mortality and it is infrequently observed. Wild birds are typically asymptomatic.

Fowl cholera

Fowl cholera is a highly contagious disease affecting several avian species including chickens, turkeys, and waterfowl and it is caused by *Pasteurella multocida*. The acute form of fowl cholera was diagnosed in 2 different layer sites ranging 80–40 weeks of age, reporting sudden high mortality. At *post mortem* examination they showed good to poor body condition, mild faecal staining of the vent, mild pallor of comb, moderate abdominal distension, often enlarged and mottled spleen, diffuse mild to moderate fibrinous coelomitis, pericarditis and hepatitis, with multifocal to coalescing small friable yellow-grey foci within the hepatic parenchyma, intestinal content more liquid/mucous, and moderate gassy coecum. Acute and multifocal to coalescing lesions consisting of necrosis, fibrin thrombi and heterophilic infiltration with intralesional bacteria aggregates were observed in a number of tissues were seen microscopically.

The active ovary and the good condition observed in several birds supported the diagnosis of acute form of the disease. In one case, fowl cholera coexisted with colisepticaemia.

The disease can range from acute septicaemia to chronic and localised infections, whilst 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. Lesions of *P. multocida* infection in poultry vary in type, extent, and severity, depending on the species of bird, immune status and stage of the disease, and older birds are more susceptible than younger. Biosecurity plays an important role in its control, and depopulation for a few weeks should be considered when other measures are ineffective.

Cannibalism and vent pecking, and pododermatitis

From an animal welfare aspect, vent pecking, cannibalism and pododermatitis were observed in some submissions.

Lesions ranged in moderate vent pecking or fatal cannibalism with faecal and blood staining of the feathers around the vent, wounds, scars and necrotic debris on the cloaca, and intestinal segments protruding out of the orifice. Carcasses showed also generalized severe pallor of comb, muscles and viscera, large fresh blood clots in the coelomic cavity, and large intestine and part of the small intestine missed. Cohorts often had large amount of feather fragments within the gastrointestinal tract.

Cannibalism has been reported in all the enterprises, stress and overstocking is usually associated with this issue, but outbreaks are often more severe in large flocks of free-range or aviary birds. It may be reduced by selecting less cannibalistic strains of poultry, avoiding early onset of lay, providing high perches from an early age, providing nest that minimize visibility of the cloaca during laying, ensuring an adequate diet, reducing stress, provision of attractive foraging material, and removal of affected or ill thrifty birds.

On the other hand, pododermatitis (Figure 18.2) appears to be triggered by litter conditions, could

Figure 18.2.: Coalescing foci of hyperkeratosis and fissures on the plantar surface of the foot in a finished broiler (pododermatitis). Photo: Sebastian Mignacca

be influenced by dietary factors (methionine and biotin deficiency, altered protein digestibility, high unsaturated fats), and enteric health. Wet litter, high or low litter pH, and high ammonia can also contribute to its pathogenesis, especially in housed animals or during winter. Pododermatitis is usually painful and can lead to bacterial infection, and a weekly inspection is recommended to detect early lesions. Applying fresh litter, switching bedding from straw to wood shavings, installing slats under the drinkers, providing smooth surfaces to walk on, and managing the litter and ventilation, could be beneficial.

Sprironucleousis

Lesions consistent with spironucleous infection were seen in a flock of young pheasant during the summer 2022. The history reported around 400 overstocked birds from two different sources with increasing death (up to 30 dead in a single day). Clinically, the birds were inappetent, severely emaciated, dehydrated and lacked of plumage. On *post mortem*, there was a slight to moderate amount ingesta in the digestive tract, and diarrhoea was not evident. A multifocal moderate to severe lymphoplasmactic and histiocytic enteritis associated with high numbers of *Spironucleus spp* within the intestinal crypts was evident microscopically. Clinical signs are more severe in stressed birds (i.e. during periods of inclement weather), and outbreaks tend to occur where bedding is wet and/or animals overstocked.

Avian TB in a back yard hen

An avian tuberculosis (Figure 18.3) cases was observed in a back yard hen reared as pet. The recumbent bird exhibited pain on palpation and on welfare grounds was euthanised. Multifocal to coalescing miliary nodules were observed grossly, whilst typical tubercular granuloma associated with acid fast bacteria were observed microscopically. Non-tuberculosis mycobacteria (NTM) was detected on PCR from spleen, NTM includes a number of species, in this case NTM is most likely *M. avium*. *Mycobacterium avium* subsp. *avium* (*M. avium*) is considered most predominant cause of tuberculosis in birds

Figure 18.3.: Multifocal granulomatous lesions in the liver of a hen with avian tuberculosis. Photo: Cosme Sánchez-Miguel

Tuberculosis in poultry is occasionally seen in small poultry flock as a chronic disease. *M. avium* infection is transmitted through contact with contaminated environments, and the bacteria is typically ingested, although infection may occur by aerosol. *M. avium* may persist in soil for many years.

Carbofuran poisoning in a bird of prey

As part of the protected raptor surveillance, a white-tailed eagle in good body condition was sent to Backweston Labs for *post mortem* examination and toxicological testing. Chemical testing identified stomach and liver carbofuran concentrations of 16600*ng/g* (16.6*mg/kg*) and 275*ng/g* (0.275*mg/kg*), respectively.

Like other carbamate insecticides, carbofuran is a potent and direct cholinesterase inhibitor that is toxic from the moment of exposure. It is classified by the World Health Organisation (WHO) as extremely hazardous to humans based on acute oral rat *LD50* values as low as 8 *mg/kg*. This same concentration is potentially lethal to a mammal of average sensitivity. Bird deaths have occurred where carbofuran granules resembling grain seeds or grit are ingested, ingestion of carbofuran baited material, or through relay toxicity by ingestion of small birds or mammals that have eaten carbofuran pellets. One granule of carbofuran is sufficient to kill a small bird. Carbofuran poisoning is primarily an acute event, and is readily absorbed causing death by anoxia within 9–18 minutes of consumption. In this case, the raptor submitted had a stomach concentration of carbofuran of 16.6mg/kg which is a diagnostically significant exposure in birds. The low liver concentration of 0.275*mg/kg* is likely a result of acute death rather than residue.

Other diagnoses observed throughout the 2022 included mainly, coccidiosis, intestinal nematodiasis, aspergillosis, amyloidosis, mycoplasmosis, adenovirus infection, lymphoid leukosis, Gumboro disease, trichomoniasis, breast myopathy, and ovarian tumours.

Case selection for diagnosis, in particular from large poultry units is important. Birds submitted should be typical of the disease observed on farm, rather than submitting randomly selected birds. All the above cases, emphasise the value of sampling skills of the PVPs, the continuous and active interaction and feedback from them, and the good compliance with farmers in order to reach a reliable diagnosis.

18.7. Appendix: H5N1 HPAI Epizootic in Ireland in 2022

On the 12th of November 2022, a fattening turkey flock was reported to have increased mortalities with some diarrhea. After carrying out a farm investigation and testing, H5N1 HPAI was confirmed.

At *post mortem* examination, the gross findings were hemorrhagic lungs, Hemorrhagic enteritis and excess pericardial and coelomic fluid. In histopathology multifocal necrotizing splenitis and encephalitis was reported. On November 22nd the same strain H5N1 HPAI was confirmed in another fattening turkey flock. Deaths were reported, as well as cyanosis in head and neck, diarrhea, depression, wing dropping and gasping.

Histopathological findings were acute necrotizing splenitis, enteritis, encephalitis, pneumonia, and pancreatitis. For each of the outbreaks the following official samples were collected:

- 20 Oropharyngeal swabs
- 20 Cloacal swabs
- Blood from 20 birds
- 5 carcases for tissue sampling (brain, lung and intestine)
- Next, oropharyngeal & cloacal swabs and tissues were tested using molecular methods, and the blood serum by serological methods .

Once the strain was confirmed as H5N1, sequencing of the cleavage site in the HA unit of the virus determined that the strain was highly pathogenic (HPAI).

Restriction measures

- Once H5N1 HPAI was confirmed in a flock, they were depopulated as per *Statutory Instrument No. 130 of 2016 (Notification and Control of Diseases affecting Terrestrial Animals (No. 2) Regulations 2016).*

- Restriction zones for sampling and monitoring were established for each of the positive premises:

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- 3km radius as a Protection zone

- 10km radius as a Surveillance Zone.
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- All flocks monitored and sampled in those areas tested negative for Avian Influenza PCR.

Ireland's self-declaration of disease freedom

No further poultry outbreaks were detected after this, and the OIE published Ireland's self-declaration of disease freedom from Avian Influenza in poultry on 21st January of 2022:[3]

[3] https://www.woah.org/app/uploads/2022/01/2022-01-ireland-hpai.pdf

Other detections in wild birds and mammals

In addition to the first case of a fox positive for H5N1 HPAI which was found at the same location than other dead geese in Co. Donegal, another fox in Co. Cork was confirmed H5N1 positive.

Further laboratory analysis

H5N1 positive samples from wild birds, poultry and the fox were sent to the European Reference Laboratory for Avian Influenza in Italy (IZSVe) for further genome sequencing.

Whole genome sequencing showed that the viruses from Ireland belong to clade 2.3.4.4b and cluster with HPAI H5N1 viruses identified in Europe in 2022. Phylogenetic analysis of the 8 segments indicated the presence of four different genotypes belonging to other viruses spread across Europe.

The fox virus presented the mutation PB2-E627K in the PB2 protein, which is one of the most important mammalian adaptive markers, related to increased replication and virulence in mammals, which was also detected in the first positive fox from Ireland and mammals in Europe. Other mutations have been identified in AI viruses across all bird species from Ireland which are associated with different degrees of increased virulence in mammalian cells. Investigations and collaborations with the EURL are on-going.

Early notification of AI suspect cases, AI surveillance and high biosecurity standards are of critical importance to limit the spread of the disease. For more information on Avian Influenza see the DAFM webpage.[4]

[4] https://www.gov.ie/en/press-release/75a80-important-safety-information-for-the-public-about-avian-influenza-bird-flu/

Part VI.

Antimicrobial Resistance

19. Antimicrobial Resistance

Rosemarie Slowey , *Senior Research Officer, Bacteriology Division*
Amalia Naranjo Lucena , *Research Officer, Bacteriology Division*
Central Veterinary Research Laboratory, DAFM,
Backweston Campus, Co. Kildare, Ireland

Antimicrobial resistance (AMR) has been recognised as one of the greatest potential risks to human health with the World Health Organisation (WHO) listing AMR among the top 10 threats for global health (Dadgostar 2019). Overuse or misuse of antimicrobials in livestock is considered the main risk factor for AMR in food-producing animals, which are in turn a source of resistant bacteria that can affect humans (Hoelzer et al. 2017; Vanderhaeghen and Dewulf 2017).

The Irish National Action Plan (iNAP2) on AMR is Ireland's roadmap for tackling AMR at a national level. It recognizes the importance of antimicrobial susceptibility testing (AST) of bacteria from animals as a key tool in combatting AMR. The Department of Agriculture Food and the Marine (DAFM) Regional Veterinary Laboratories process every year a large number of samples from sick animals, from which bacteria are isolated. A selection of these is tested immediately using the disc diffusion method, which employs paper discs containing antimicrobials of veterinary significance on a layer of bacteria on the surface of a solid agar plate. For surveillance reasons (i.e. using epidemiological cut-offs, or additional antimicrobials relevant to human medicine), a representative sample of these bacteria are also tested by the National Reference Laboratory for AMR using the broth micro-dilution method.

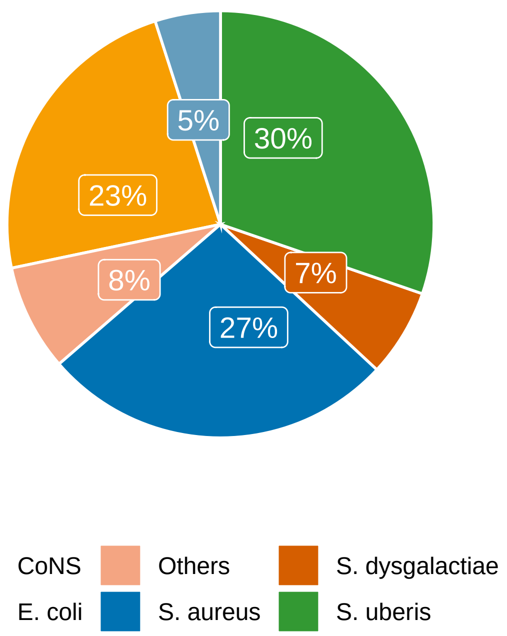


Figure 19.1.: Proportion of mastitis isolates tested for antimicrobial susceptibility test (AST) in 2022 (One isolate per bacterial species and farm was selected).

Table 19.1.: Antimicrobials used for antibiotic susceptibility testing (AST) of mastitis and enteric bacteria.

Antimicrobial	S. aureus	CoNS	Streptococcus spp.	E. coli / Salmonella
Beta Lactam				
Penicillin	DD	DD	DD	.
Ampicillin	.	.	DD	DD
Cefoxitin	DD	DD	.	.
Cefpodoxime	.	.	.	DD
Ceftiofur	DD	.	DD	DD
Cetotaxime	.	.	.	BM
Ceftazidime	.	.	.	BM
With B lactamase inhibidor				
Amoxicilin-clavulanate	DD	.	.	DD
Macrolide				
Erytromycin	DD	DD	DD	.
Tetracyclines				
Tetracycline	DD	DD	DD	DD
Lincosamide				
Pirimycin	DD	.	DD	.
Lincomycin				
Clindamycin	.	BM	.	.
Folate pathway inhibidor				
Sulphamethoxazole-Trimethoprim	DD	DD	.	DD
Phenicol				
Chloramphenicol	BM	.	.	BM
Glycopeptide				
Vancomycin	BM	BM	.	.
Pleuromutilin				
Tiamulin	BM	.	.	.
Streptogramin				
Quinupristin / Dalfopristin	BM	.	.	.
Fluoroquinolone				
Enrofloxacin	.	.	.	DD
Ciprofloxacin	BM	.	.	.
Polymixin				
Colistin	.	.	.	BM
Aminoglycosides				
Streptomycin	.	.	.	DD
Kanamycin	BM	.	.	.
Gentamycin	BM	.	.	BM
Carbapenem				
Meropenen	.	.	.	BM
Oxazolidone				
Linezolid	BM	BM	.	.
Glycylcycline				
Tigecycline	.	.	.	BM

Note:
DD: Disc Diffusion; BM: Broth microdilution;
[1] Cefoxitin is used to screen for MRSA;
[2] Cefpodoxime, Cefotaxime and Ceftazidime are used to screen for ESBL production;
[3] Pirlimycin result predicts lincosamide susceptibility in Streptococcus and Staphylococcus;
[4] Penicillin result predicts amoxicillin susceptibility in Staphylococcus, Amoxicillin, Amoxicillin clavulanate and cephalosporin result in Streptococcus.

19.1. Mastitis Pathogens

Mastitis is an inflammation of the mammary gland resulting from bacterial infection (Blowey and Edmondson 2010). Mastitis-causing bacteria comprise the majority of samples which undergo AST in the Regional Veterinary Laboratories. Mastitis can be caused by several different bacterial species and the most common ones in Ireland in 2022 were *Staphylococcus aureus* (*S. aureus*), Coagulase Negative Staphylococcus (CoNS), *Streptococcus uberis* (*S. uberis*), *Streptococcus dysgalactiae* (*S. dysgalactiae*) and *Eschericha coli* (*E. coli*) (Figure 19.1).

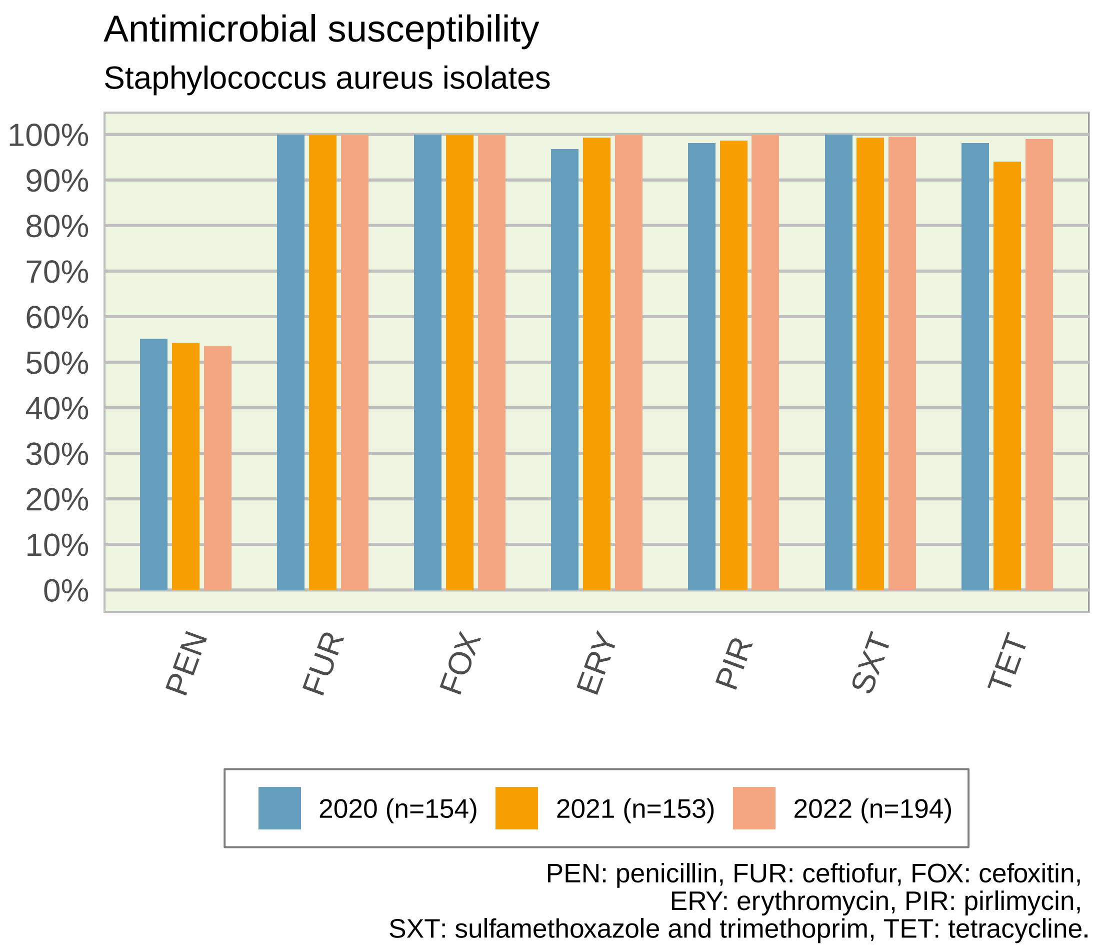


Figure 19.2.: Percentage of antimicrobial susceptibility among Staphylococcus aureus isolates from bovine mastitis samples in 2020, 2021 and 2022.

S. aureus isolates from 194 individual farms were tested. More than half of the isolates (53.6 *per cent*) were susceptible to all antimicrobials tested. The lowest level of susceptibility was detected against penicillin (53.6 *per cent*), which is lower than that found in the United Kingdom in 2021 or Sweden in 2022 (UK-VARSS 2022; Swedres-Svarm 2022). Susceptibility to all other antimicrobials tested was higher than 98 *per cent* (see Figure 19.2).

No resistance was found against any of the High Priority Critically Important Antimicrobials (HP-CIA) tested, including erythromycin (macrolide) and ceftiofur (third-generation cephalosporin). In addition, 100 *per cent* of isolates were susceptible to cefoxitin, which is used to screen for the presence of Methicillin Resistant Staphylococcus aureus (MRSA). This was also the case in clinical mastitis isolates from the UK in 2021 (UK-VARSS 2022), whereas in France less than 5 *per cent* were MRSA (Anses 2022).

Overall, 125 isolates were also tested by broth micro-dilution, which allows to test additional antimicrobials. Susceptibility to fusidate and chloramphenicol was 92 *per cent* and 99.2 *per cent* respectively.

Coagulase-negative *Staphylococci*

Coagulase negative staphylococci are frequently isolated from bovine milk and are a cause of subclinical mastitis Pyörälä and Taponen (2009). Thirty-four CoNS were tested in 2022. The bacterial species were as follows: 10 *S. haemolyticus*, 9 *S. chromogenes*, 6 *S. equorum*, 2 *S. epidermidis*, 1 *S. intermedius*, 1 *S. simulans*, 1 *S. succinus*, 1 *S. warneri* and 1 *S. xylosus*.

Ten isolates were susceptible to all antimicrobials tested, while four isolates were MDR (resistant to three or more antimicrobial classes). All isolates except for two were tested by micro-dilution in addition to disc diffusion.

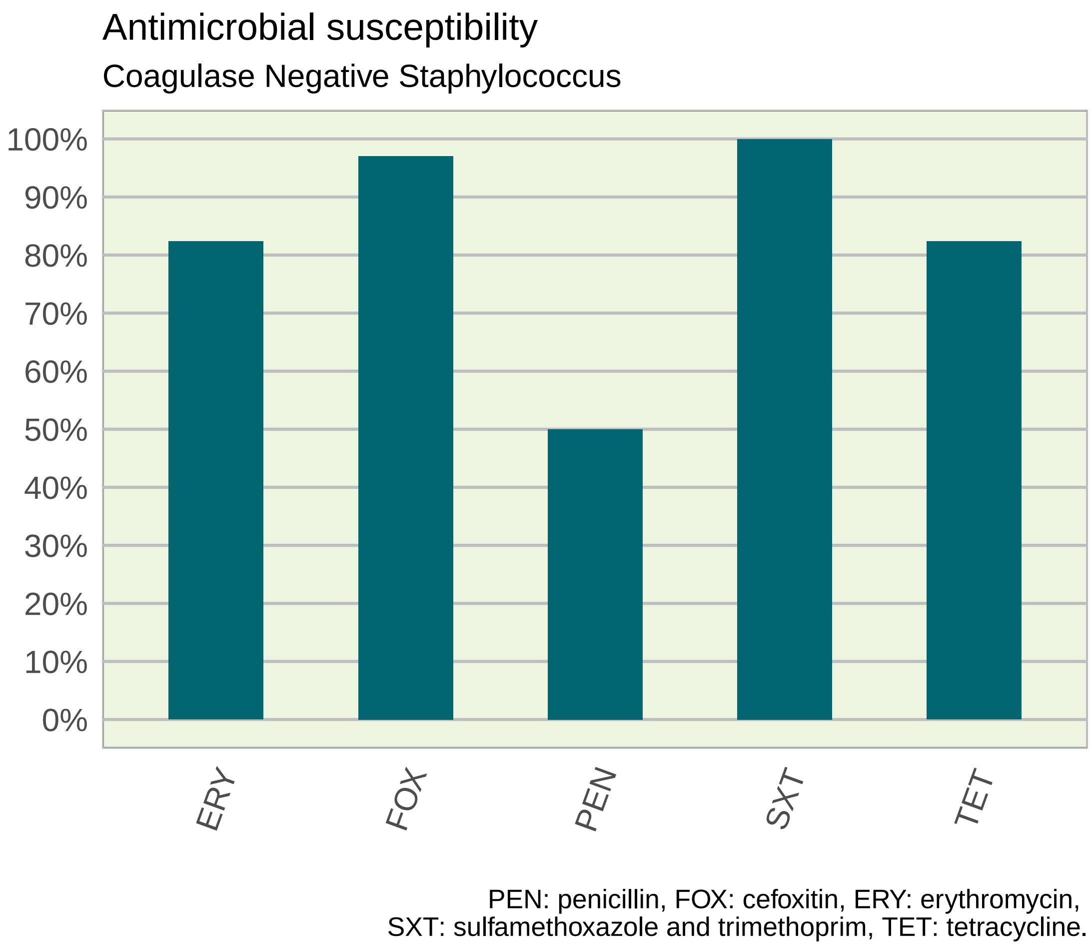


Figure 19.3.: Percentage of antimicrobial susceptibility among Coagulase Negative Staphylococci isolates from bovine mastitis samples in 2022.

Resistance levels were slightly higher in CoNS (Figure 19.3) than those detected for *S. aureus*. In particular, we found five isolates were resistant to erythromycin, an antimicrobial included in the 'caution' group by the Antimicrobial Advice Ad Hoc Expert Group (AMEG) to the European Medicine's Agency (EMA).

In addition, one *S. epidermidis* was resistant to cefoxitin. Sequencing of this isolate revealed the presence of the mecA gene, confirming the phenotypic result. This is of particular concern, as S. epidermidis can cause skin infections in humans. The isolate was also resistant to chlorampheni-

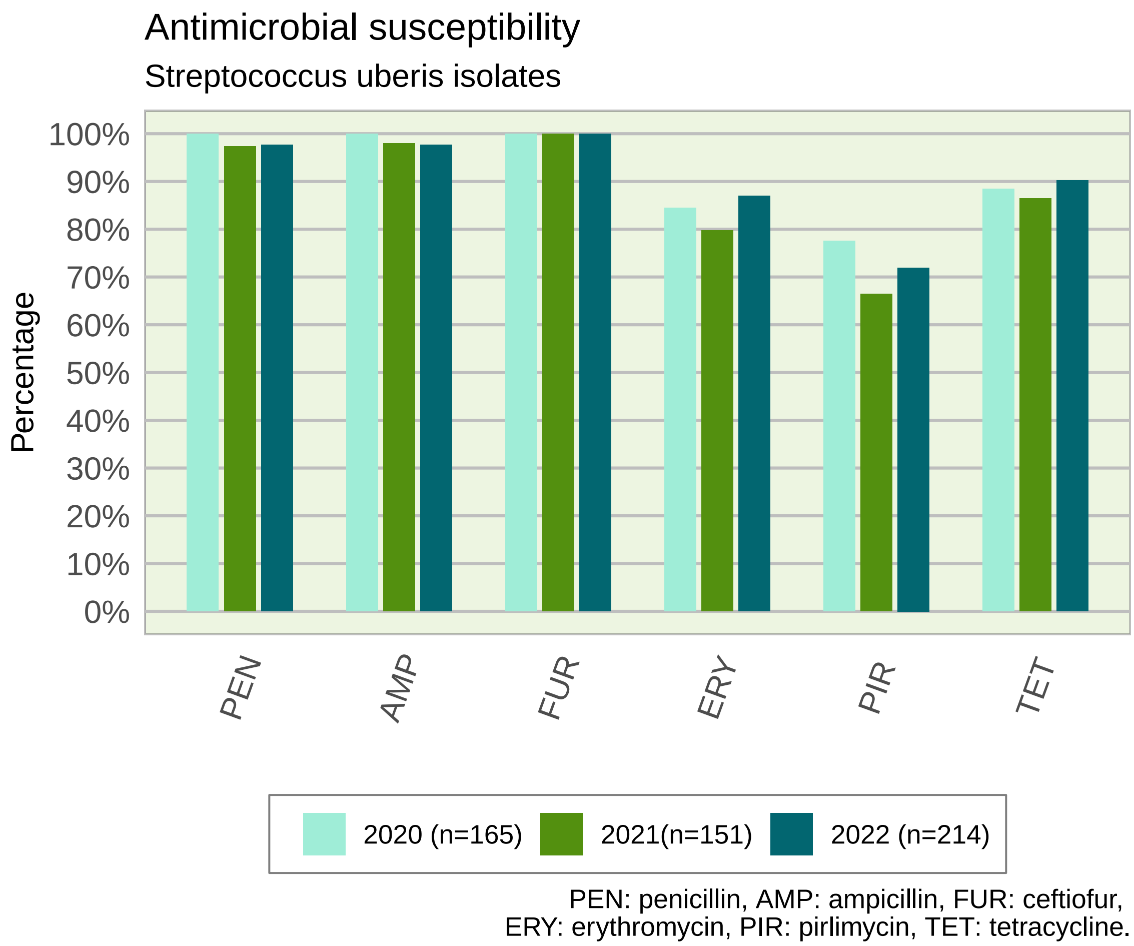


Figure 19.4.: Percentage of antimicrobial susceptibility among Streptococcus uberis isolates from bovine mastitis samples in 2020, 2022 and 2022.

col, ciprofloxacin, clindamycin, erythromycin, fusidate, gentamycin, penicillin, sulphametoxazole, tetracycline and trimethoprim.

Streptococcus uberis

Streptococcus uberis is an opportunistic invader of the mammary gland that can cause mastitis (Bradley 2002). These are bacteria not adapted to the mammary gland but that can be present in the environment and in certain circumstance become pathogenic. In 2022, *S. uberis* isolates from 214 individual farm were tested for AST using disc diffusion. One-hundred and sixty-two were additionally screened using micro-dilution.

Resistance of streptococci to β -lactam antimicrobials is usually low, as acquisition of resistance genes is generally not successful. However, more studies are reporting a higher prevalence of resistance to penicillin and ampicillin, and the presence of resistance genes (Tenhagen et al. 2006; Kaczorek et al. 2017; Haenni, Lupo, and Madec 2018; Reyes et al. 2019). All strains were susceptible to ceftiofur, and very high susceptibility to penicillin and ampicillin (97.7 *per cent*) was detected (Figure 19.4).

Susceptibility of *S. uberis* isolates to erythromycin and pirlimycin was 87 *per cent* and 72 *per cent* respectively. Resistance to macrolides and lincosamides in streptococci are connected as they can share the same resistance mechanism., Twenty-six isolates (12.1 *per cent*) displayed erythromycin and pirlimycin resistance, which is slightly lower than that observed in France in 2021 (Anses 2022).

Streptococcus dysgalactiae

Forty-seven *S. dysgalactiae* isolates from individual farms were tested. Twenty-six isolates were fully susceptible and no MDR isolates were found.

Overall, extremely high levels of susceptibility were recorded, except for tetracycline (61.7 *per cent* of isolates susceptible) (see Figure 19.5). Susceptibility to erythromycin was 97.9 *per cent*, while susceptibility to all other antimicrobials tested, including β-lactams, was 100 *per cent*.

Susceptibility to erythromycin was higher than in France in 2021 (Anses 2022). However, tetracycline susceptibility was lower than in the UK (UK-VARSS 2022), where 100 *per cent* of isolates were susceptible.

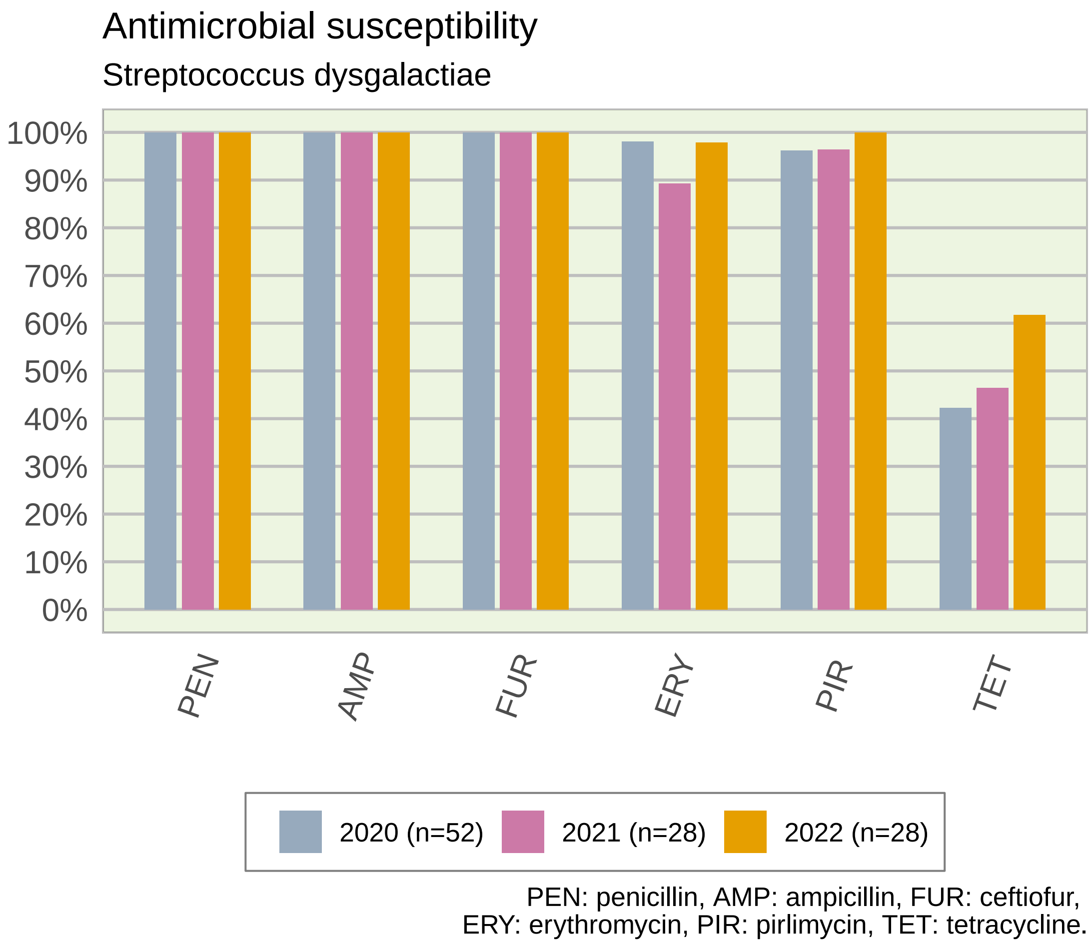


Figure 19.5.: Percentage of antimicrobial susceptibility among Streptococcus dysgalactiae isolates from bovine mastitis samples in 2020,2021 and 2022.

19.2. *Escherichia coli*

Escherichia coli is comprised by a heterogeneous group of bacteria. While *E. coli* is a commensal inhabitant of the gut, some strains have developed the ability to invade the mammary gland causing mastitis (Goulart and Mellata 2022). *E. coli* is therefore considered as one of the bacteria causing environmental mastitis.

In 2022, 165 *E. coli* isolates from individual farms were tested for AMR. One-hundred and nine were fully susceptible (66 *per cent*), while seventeen (10.3 *per cent*) were MDR. As shown in Figure 19.6, susceptibility levels were lowest to ampicillin (75.2 *per cent*), streptomycin (84.3 *per cent*) and tetracycline (87.3 *per cent*).

There was an average increase in susceptibility of 3.2 *per cent* since 2021 for most antimicrobials except for cefpodoxime and ceftiofur. Susceptibility to enrofloxacin, a fluoroquinolone included in the HPCIA list was 95.7 *per cent*. A single isolate was resistant to cefpodoxime and ceftiofur and confirmed as an Extended-spectrum Beta-lactamase (ESBL) producer by WGS. No ESBLs were recovered from milk in 2020 or 2021 and they are in fact rarely found in beef samples from healthy animals tested for the official surveillance as stated in EC legislation. One additional isolate was resistant to cefpodoxime and amoxicillin-clavulanic acid.

In the UK, no isolates were found to be resistant to cefpodoxime in 2021 and susceptibility to enrofloxacin was found to be slightly higher (resistance of 2.4 *per cent*)(UK-VARSS 2022).

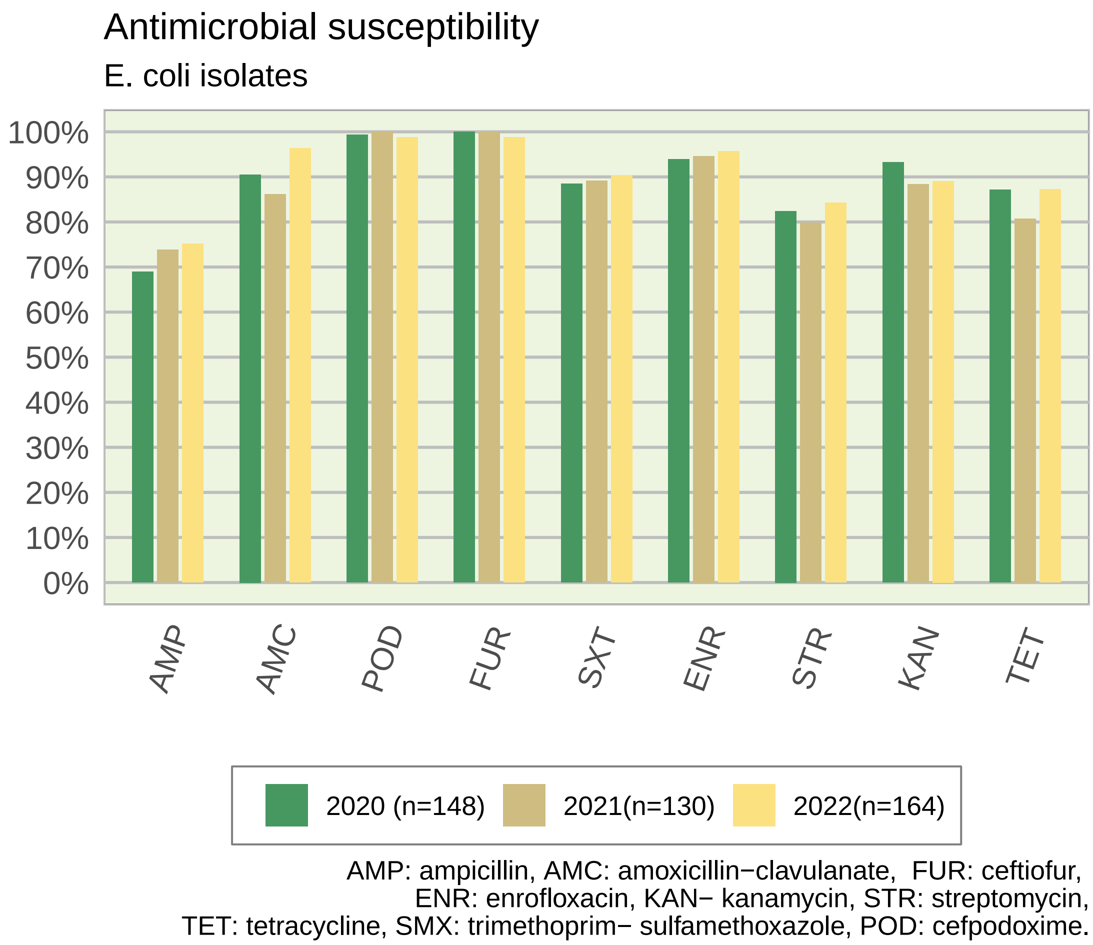


Figure 19.6.: Percentage of antimicrobial susceptibility among E. coli isolates from bovine mastitis samples in 2020,2021 and 2022.

19.3. Enteric bacteria

As mentioned above, *Escherichia coli* is a normal constituent of the gut flora of animals, but virulent strains can cause serious disease in multiple animal species and humans.

E. coli from joint fluids, yolk sacs, internal organs and faeces of birds (broilers, turkeys, hens and exotic species) were isolated and AST performed (n=33). Additionally, sixteen porcine isolates, mainly from intestinal origin, and twelve bovine isolates, most of them from young animals with septicaemia were also tested.

Overall, resistance levels were lower in poultry isolates, where highest levels of resistance were found against ampicillin (23.5 *per cent*), tetracycline (20.6 *per cent*) and trimethoprim-sulphamethoxazole (11.8 *per cent*). In addition, susceptibility to fluoroquinolones increased in 2022 (91.8 *per cent*) as compared to 2021 (82.1 *per cent*).

In contrast, pig isolates showed 77 *per cent*, 68.8 *per cent* and 61.6 *per cent* resistance to trimethoprim-sulphamethoxazole, tetracycline and streptomycin respectively. In fact, resistance to trimethoprim-sulphamethoxazole and streptomycin increased by an average of 13 *per cent* since 2021. Although the number of isolates tested was low (n=16) and may not be representative.

Five out of twelve bovine isolates were resistant to streptomycin, trimethoprim-sulphamethoxazole and tetracycline. Two isolates were resistant to enrofloxacin (16.6 *per cent*), a fluoroquinolone present in the HPCIA list. In the UK in 2021, 1.2 *per cent*, 31.4 *per cent* and 2.6 *per cent* of bovine isolates were found to be resistant to enrofloxacin in England and Wales, Northern Ireland and Scotland respectively (UK-VARSS 2022).

All poultry, pig and bovine isolates were susceptible to extended spectrum cephalosporins. Similar results were obtained in the UK for poultry isolates, although resistance was found in clinical E. coli from pigs and bovines (UK-VARSS 2022).

Salmonella spp.

Salmonellosis is the third leading cause of death among the food transmitted diseases. It can produce acute abdominal pain, diarrhoea, fever and nausea in humans.

Salmonella spp are widely distributed in livestock. In many cases, cattle and pigs can be asymptomatic carriers of the bacteria, although Salmonella in animals can cause reproductive problems, septicaemia or enteric disease. DAFM performs active surveillance in healthy poultry and pigs as mandated by the EU Commission, and passive surveillance from clinical cases submitted to the Regional Veterinary Laboratories.

Forty-seven bovine Salmonella isolates were tested for AMR using disc diffusion, and 41 of these were confirmed by micro-dilution. From these, only one was a monophasic variant of *S.* typhimurium. Seventeen isolates originated from abortion cases, eight from calves a few days old, and the remaining were from animals older than 1 month. The predominant serovar from the abortion cases was *S.* Dublin (n=14), two were *S.* newport and 1 was *S.* typhimurium. Please see Figure 19.7 for an overall view of serotypes.

Overall, 85.1 *per cent* were susceptible to all antimicrobials tested, and only two isolates were MDR. Low levels of resistance to tetracycline (6.4 *per cent*, n=3), ampicillin (4.3 *per cent*, n=2) or sulphamethoxazole-trimethoprim (2.4 *per cent*, n=1) were detected. One isolate was resistant to chloramphenicol and 3 isolates to ciprofloxacin, a HPCIA.

Eight Salmonella isolates were obtained from ovine samples. In seven cases Salmonella enterica subsp diarizonae was isolated but the death had a multifactorial origin or Salmonella was an incidental finding. In the remaining case, *S.* Dublin caused a severe metritis. As reported in 2021, no resistance was recorded in ovine isolates.

Thirty-one porcine Salmonella isolates were tested by disc diffusion, and 28 were confirmed by

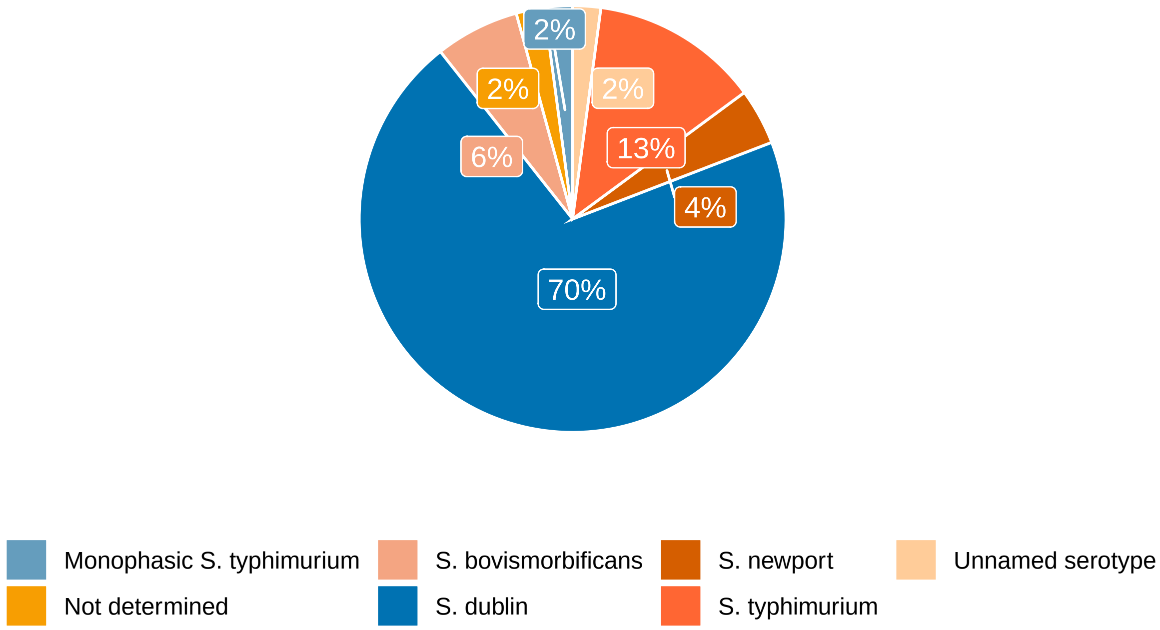


Figure 19.7.: Salmonella serotypes obtained from bovine clinical samples in 2022.

micro-dilution in 2022. From these, only two were fully susceptible, and seventeen (54.8 *per cent*) were MDR. Most isolates were monophasic *S.* typhimurium (n=11) and *S.* typhimurium (n=9), see Figure 19.8.

Resistance levels were considerably higher than in bovine and ovine species. Streptomycin and tetracycline resistance was the highest (both at 71 *per cent*), followed by ampicillin (64.5 *per cent*) and sulphamethoxazole-trimethoprim (41.9 *per cent*), see Figure 19.9. The levels of ampicillin and sulphamethoxazole-trimethoprim resistance were lower than in 2021, whereas they have increased with respect to tetracycline All Island Animal Disease Surveillance Report 2021[1]

Resistance to ciprofloxacin and chloramphenicol was tested using micro-dilution, with 21.4 *per cent* and 32.1 *per cent* respectively showing resistance. Resistance to tetracycline and chloramphenicol has increased as compared to 2021 results. All isolates were susceptible to extended spectrum cephalosporins.

19.4. Respiratory pathogens

Respiratory bacteria in animals can cause disease, particularly pneumonia, when the animal is affected by viral infections, sub- optimal environmental conditions or immunosuppression caused by the stress or weaning or transport.

Mannheimia haemolytica

Seventy-three cultures of *M. haemolytica* from cattle were analysed. Eight displayed resistance to tetracycline and one of these was also resistant to penicillin. Five strains were intermediate to the latter. Ten isolates had intermediate readings for enrofloxacin, an increase from 2021 in Ireland and similar to UK

[1] http://www.animalhealthsurveillance.agriculture.gov.ie/media/animalhealthsurveillance/content/labreports/2021_All_Island_Animal_Disease_Surveillance_compressed_FINAL.pdf

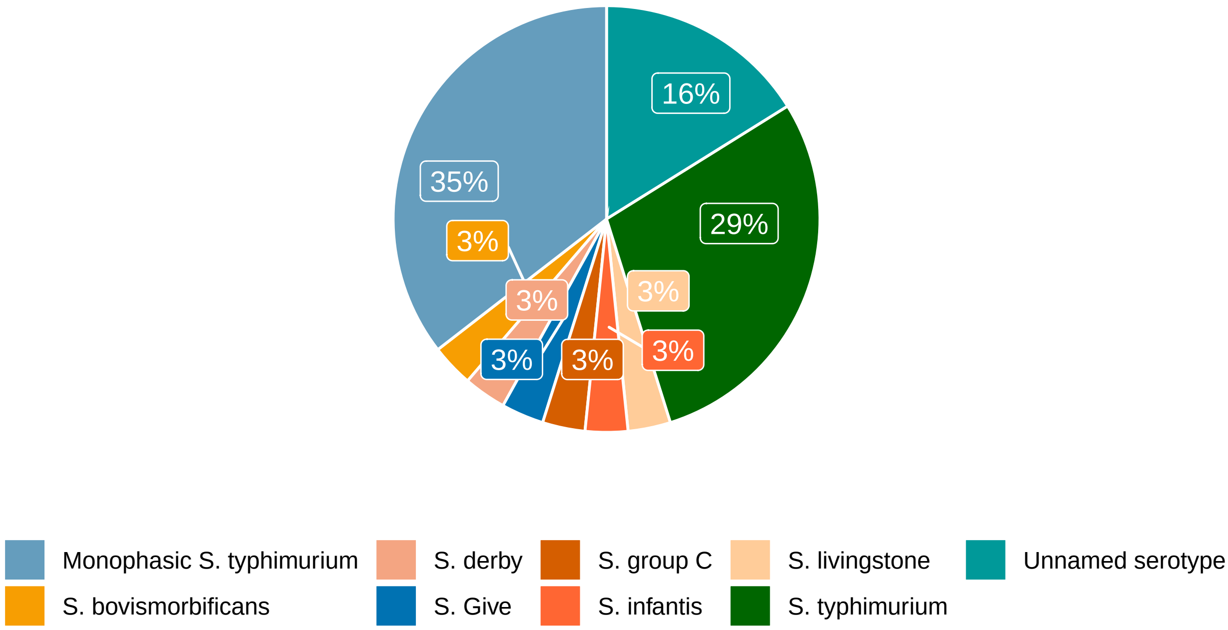


Figure 19.8.: Salmonella serotypes obtained from porcine clinical samples in 2022.

[UK 2022]. A single isolate was intermediate to both tulathromycin and tilmicosin. The remainder were fully susceptible.

Resistance to tetracycline was recorded in 12 *per cent* of the 33 ovine isolates tested and over 96 *per cent* were susceptible to tilmicosin, tulathromycin and penicillin. In 2021, three isolates out of 35 from sheep had intermediate readings for tulathromycin but all were susceptible to tilmicosin, while 20 *per cent* had intermediate readings to penicillin.

Pasteurella multocida

P. multocida is also part of the normal flora of the oropharynx of cattle and can from part of the bovine respiratory disease complex. *P. multocida* from 149 animals (mainly of calves or weanlings) were included in the dataset. Most were recovered from the respiratory tract of animals with evidence of pneumonia, which was frequently caused by multiple pathogens.

The majority (137) were susceptible to all antimicrobials and all were susceptible to penicillin, ampicillin and ceftiofur. Resistance was most frequently recorded to tetracycline (8 *per cent*) and spectinomycin (6.9 *per cent*). There were low levels of resistance to florfenicol (2.7 *per cent*), tiamulin (1.1 *per cent*) and the macrolides tulathromycin (2 *per cent*) and tilmicosin (1.1 *per cent*). In contrast, in the UK, resistance to all macrolides tested and tetracycline was considerably higher in 2021 (more than 20 *per cent* and 53.6 *per cent* respectively) (UK-VARSS 2022). All but one isolate (classified as intermediate), were susceptible to enrofloxacin. This is a reduction compared to 2021 results in Ireland, where three isolates were found to be resistant. In Sweden, no resistance was found against enrofloxacin, while in the UK 5.3 *per cent* of isolates showed a reduced susceptibility (Swedres-Svarm 2022).

Much of the resistance was present in 5 MDR strains. Four of the MDR strains were resistant to florfenicol, tetracycline and spectinomycin; 2 were also resistant to tulathromycin. The other exhibited resistance to tetracycline, spectinomycin, tiamulin and both tulathromycin and tilmicosin. These results are similar to those obtained in Ireland in 2021, when 3 MDR strains were found. The resistance profiles of these strains are especially concerning because the treatment options for infected animals are greatly limited.

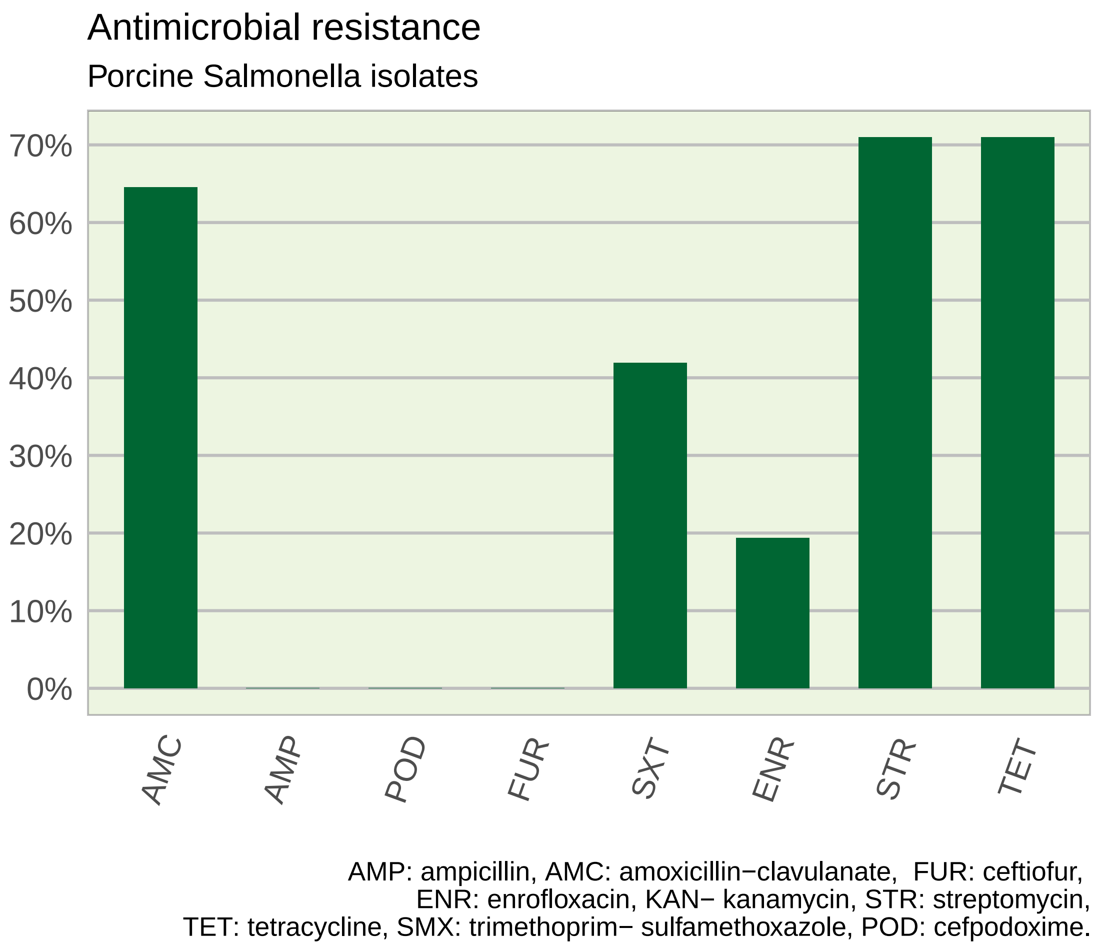


Figure 19.9.: Percentage of antimicrobial resistance among porcine Salmonella isolates samples in 2022.

Pasteurella may also be involved in pneumonia of sheep and pigs. All 7 ovine and 14 porcine P. multocida from 2022 were fully susceptible. In the UK, only 48.1 *per cent* of pig's isolates were fully susceptible in 2021 (UK-VARSS 2022).

Streptococcus suis

The upper respiratory tracts of healthy pigs are frequently colonised by *S. suis*. However, this bacterium has zoonotic potential and some serotypes in particular can cause serious disease in pigs, leading to significant economic losses.

Twenty-two isolates of *S. suis* from pigs underwent susceptibility testing. In 18 of these cases, the bacterium was associated with disease (pneumonia, often in association with other bacteria or viruses, meningitis, polyserositis, septicaemia). Most were recovered from the respiratory tract, meninges or pericardium.

Only 2 strains were susceptible to all antimicrobials. All were susceptible to the beta lactam antimicrobials, ampicillin and ceftiofur. In 2021, the same results were observed in Ireland, whereas in the UK 2.8 *per cent* of isolates were resistant to penicillin (UK-VARSS 2022). Half (n=11) were resistant to tetracycline, a reduction of 12 *per cent* since 2021 in Ireland. Resistance to the macrolide- lincosamide-streptogramin B antimicrobial classes can be encoded by a single gene; this resistance type was identified in 10 isolates (45 *per cent*), which were resistant to erythromycin and clindamycin. Four of these expressed resistance to quinupristin- dalfopristin, an antimicrobial used to treat Gram positive infec-

Table 19.2.: Antimicrobials used for antibiotic susceptibility testing (AST) of respiratory bacteria

Antimicrobial	P. multocida	M. haemolytica	S. suis	A. pleuropneumoniae
Beta Lactam				
Penicillin	BM	BM	DD	BM
Ampicillin	BM	BM	DD	BM
Ceftiofur	DD	DD	DD	DD
Fluoroquinolone				
Enrofloxacin	DD	DD	BM	DD
Tetracyclines				
Tetracycline	BM	BM	DD	BM
Phenicol				
Forfenicol	DD	DD	BM	DD
Macrolide				
Tulathromycin	DD	DD	.	DD
Tilmicosin	BM	DD	.	.
Erytromycin	.	.	DD	.
Aminoglycoside / aminocyclitols				
Spectinomycin	BM	BM	.	BM
Pleuromutilin				
Tiamulin	BM	.	.	.
Lincosamide				
Clindamycin	.	.	BM	.

Note:
DD: Disc Diffusion; BM: Broth microdilution;

tions in humans. Resistance to erythromycin and clindamycin in Sweden in 2022 was much lower, 8 *per cent* and 11 *per cent* respectively (Swedres-Svarm 2022),. In the UK, 32.4 *per cent* of 2021 *S. suis* isolates were resistant to erythromycin and lincomycin, and 33-37 *per cent* in France (UK-VARSS 2022; Anses 2022).

No *S. suis* were resistant to enrofloxacin, but 6 (27 *per cent*) were classified as intermediate. No resistance was recorded to vancomycin or linezolid, 2 other critically important antimicrobials in human medicine.

Histophils somni

Histophilus somni is normally found in the respiratory and genital tract of healthy ruminants, but in can cause several disease syndromes, including respiratory disease, thrombotic meningioencephalitis, septicaemia and abortion.

In 2022, 24 isolates (22 bovine, 2 ovine), recovered from the lungs or brains or sick animals, underwent antimicrobial susceptibility testing. All were fully susceptible, except for one from a calf with pneumonia, which harboured genes for resistance to multiple antimicrobial classes(tetracyclines, macrolides, phenicols, sulphonamides and aminoglyocsides).

Part VII.

Agri-Food and Biosciences Institute

20. Agri-Food and Biosciences Institute, AFBI

The Agri-Food and BioSciences Institute (AFBI)[1] is a leading provider of scientific research and services to government, non-governmental organisations and commercial organisations. We are sponsored by our key stakeholder, the Department of Agriculture Environment and Rural Affairs (DAERA).

Our customers include a range of local, national and international commercial companies, Northern Ireland and UK Departments, Agencies and associated bodies in the European Union.

AFBI was created on 1st April 2006 by joining the Science Service of the then Department of Agriculture and Rural Development with the Agricultural Research Institute of Northern Ireland (ARINI).

AFBI has 7 sites across Northern Ireland;

- Newforge Lane (Headquarters),
- Stormont,
- Hillsborough,
- Crossnacreevy,
- Loughgall,
- Omagh
- Bushmills,

https://youtu.be/s1gGj2rTnKo?si=XbdLLPikV6MliABy

Our Veterinary Sciences Division (VSD) undertakes an integrated programme of scientific and research work, which has the aims of maintaining and improving the health and welfare of production animals and protecting public health by ensuring the safety of food of animal origin. VSD has four scientific branches:

- Bacteriology;
- Disease Surveillance & Investigation;
- Chemical & Immunodiagnostic Sciences; and
- Virology.

The major work themes of the division include statutory testing in support of DAERA and other government departments; maintenance of an emergency response capability for known and emerging disease threats; animal disease surveillance and investigation; research and development; and commercial services and industry support. An important feature, and strength, of the work of the division is the

[1] https://www.afbini.gov.uk

interdependency and linkage between these work themes.

The division has multidisciplinary scientific capability in the areas of:

- Microbiology
- Molecular biology
- Genetics
- Immunology
- Serology
- Parasitology
- Pathology and histopathology
- Chemical surveillance
- Epidemiology
- Ecology
- Veterinary investigation and advice

While traditional diagnostic and microbiological skills remain fundamental to the work of VSD, advances in molecular diagnostics and genomics and associated data and epidemiological modelling are becoming increasingly important to our epizootic, statutory and R&D functions. AFBI is continuing to expand its capability and capacity in these areas, including investing in next generation sequencing technology, which position us well to contribute to cutting-edge research and to deliver scientific advances in the area.

21. Bovine Diseases, AFBI

Seán Fee, *Veterinary Research Officer*
Omagh Veterinary Laboratory,
43 Beltany road, Omagh BT78 5NF, Northern Ireland

21.1. 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 32 *per cent* of cases (Figure 21.2 and Table 21.1). Common infectious causes of diarrhoea recorded 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.

Figure 21.1.: Umbilical haemorrhage and fractured ribs in a one-day old calf. Photo: Seán Fee.

Twenty cases of diarrhoea due to *E. coli* were recorded with eight of these presenting with the *E. coli K99* antigen. 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. Rotavirus was detected in 27 cases (19 *per cent* of the enteric infections). Coronavirus may produce an enteritis similar to that caused by rotavirus. Nine cases of enteritis due to coronavirus were recorded in 2021. Transit of calves through markets increases the likelihood of exposure to Salmonella. Two cases of BVDV infection were recorded in neonatal calves less than one month old in 2022, a reduction from the seven cases recorded in 2021. Thirty-six cases of enteritis due to the protozoan parasite *Cryptosporidium* were diagnosed in 2022, similar to the 39 cases which were recorded in 2021.

Table 21.1.: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for *post mortem* in 2022 (n= 445).

Category	No. of cases	Percentage
Enteric infections	141	**31.7**
Nutritional / metabolic conditions	73	**16.4**
Septicaemia / toxaemia	71	**16.0**
Respiratory infections	64	**14.4**
Navel ill / Joint ill	29	**6.5**
Other diagnoses	25	**5.6**
GIT torsion /obstruction	12	**2.7**
Heart / circulatory system	9	**2.0**
GIT ulcer / perforation	5	**1.1**
Peritonitis	5	**1.1**
Diagnosis not reached	4	**0.9**
Central nervous system	4	**0.9**
Skeletal conditions	3	**0.7**

Nutritional and metabolic conditions were the next most frequently diagnosed group of conditions. Hypogammaglobulinaemia due to inadequate absorption of colostral antibody was recorded in 52 cases and was the most frequently recorded nutritional/metabolic condition (accounting for 71 *per cent* of the diagnoses in this category) followed by 10 cases of ruminal feeders (14 *per cent* of the 59 cases in this category) and there were five cases of ruminal acidosis recorded. 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 regime, 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. Two cases of nutritional myopathy (white muscle disease) due to deficiency of selenium/vitamin E were diagnosed at *post mortem* examination in 2022 affecting a one-week-old calf and a three-day-old calf from different herds. Nutritional myopathy may develop in-utero and affect foetuses, calves may be born with nutritional myopathy, or it may develop in growing calves and is common in calves up to six months of age, occurring more sporadically thereafter.

Death due to septicaemic or toxaemic conditions represented 16 *per cent* (71 cases) of deaths in neonatal to one-month-old calves. Colisepticaemia was the major cause of death in this group accounting for 45 cases (63 *per cent* of the septicaemic / toxaemic conditions) and emphasising 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. Ten cases of salmonellosis due to *Salmonella* Dublin were diagnosed in neonatal calves in 2022 and two cases of *Salmonella* Typhimurium were recorded. Young calves less than three months old are in one of the highest risk groups for acquiring *Salmonella* infections.

To reduce the risk of infection good calving pen management and hygiene is of critical importance. Regular disinfection of the calving pen is important, bedding should be clean, the number of cows present in the calving pen should be minimised and importantly the calving pen should not be used as a sick bay. Calves should receive adequate colostrum, colostrum should not be pooled, and calves should be reared in a clean hygienic environment at an appropriate stocking density and away from

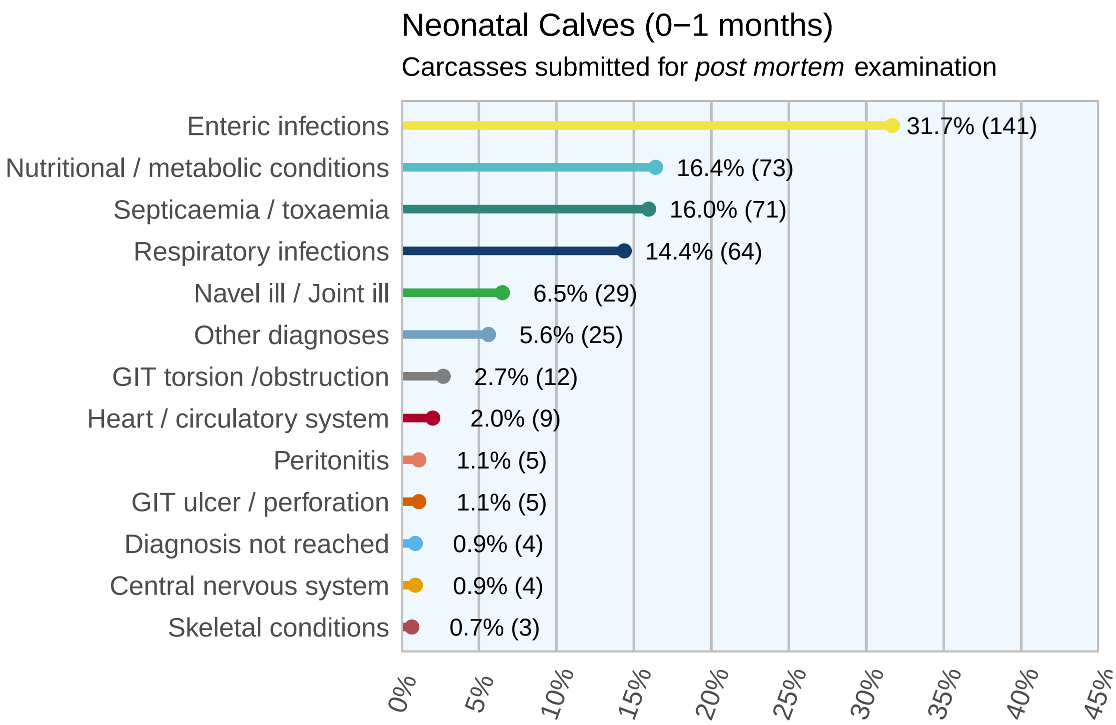


Figure 21.2.: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for *post mortem* in 2022 (n=445). The absolute number of cases is between brackets.

adult animals and older calf groups. Five cases of systemic pasteurellosis were recorded in neonatal calves in 2022.

Figure 21.3.: Abomasal bloat in a one-day old calf. Photo: Seán Fee.

Respiratory tract infections were the next most frequently diagnosed cause of mortality in neonatal calves accounting for almost 15 *per cent* of cases. *Mycoplasma bovis* was the most frequently diagnosed bacterium causing respiratory disease being recovered in 19 of the 64 cases (30 *per cent*) of respiratory infections, followed by *Mannheimia haemolytica* which was detected in ten of the 64 cases (16 *per cent*) of neonatal respiratory infections and *Pasteurella multocida* was detected in nine cases. *Arcanobacterium pyogenes* was detected in eight cases and a single case of *Histophilus somni* was recorded. As was the case in previous years RSV was the most frequently diagnosed viral respiratory pathogen diagnosed (four cases). Aspiration pneumonia accounted for two cases (3 *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.

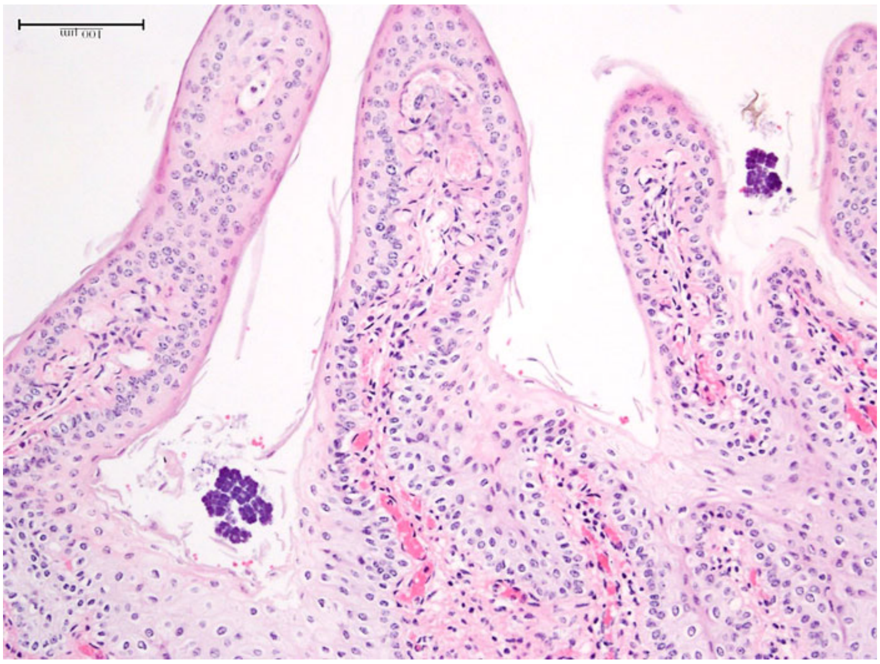


Figure 21.4.: Tetrads of *Sarcinia* bacteria on the abomasal mucosa in a case of abomasal bloat in a one-week old calf. Photo: Seán Fee.

Navel-ill accounted for 7 *per cent* of diagnoses at post-mortem examination of neonatal calves (29 cases) emphasising the need for good calving pen hygiene and the importance of dipping/spraying of the navel.

21.2. 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 50 *per cent* of the 364 cases in this age group (Figure 21.5 and Table 21.2). Bacterial respiratory infections were most frequently diagnosed. *Mycoplasma bovis* was detected in 67 cases of pneumonia. *Pasteurella multocida* was detected in 30 cases and there were ten cases of pneumonia due to *Mannheimia haemolytica*. There were seven cases of pneumonia due to *Histophilus somni* and to *Trueperella pyogenes*. Parasitic pneumonia due to lungworm was recorded more frequently in 2022 than in 2021 rising from nine cases in 2021 to 17 cases in 2022 (Figure 21.6). BRSV was the most commonly recorded viral respiratory infection (13 cases) followed by one case of PI3 and one case of BVDV. Two cases of aspiration pneumonia were recorded.

Table 21.2.: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for *post mortem* in 2022 (n= 364).

Category	No. of cases	Percentage
Respiratory infections	183	**50.3**
Enteric infections	35	**9.6**
Other diagnoses	25	**6.9**
Nutritional / metabolic conditions	23	**6.3**
GIT torsions /obstruction	19	**5.2**
GIT ulcer / perforation	18	**4.9**
Septicaemia / toxaemia	16	**4.4**
Peritonitis	13	**3.6**
Cardiovascular conditions	12	**3.3**
Clostridial disease	7	**1.9**
Nervous disease	6	**1.6**
Diagnosis not reached	5	**1.4**
Urinary tract conditions	2	**0.5**

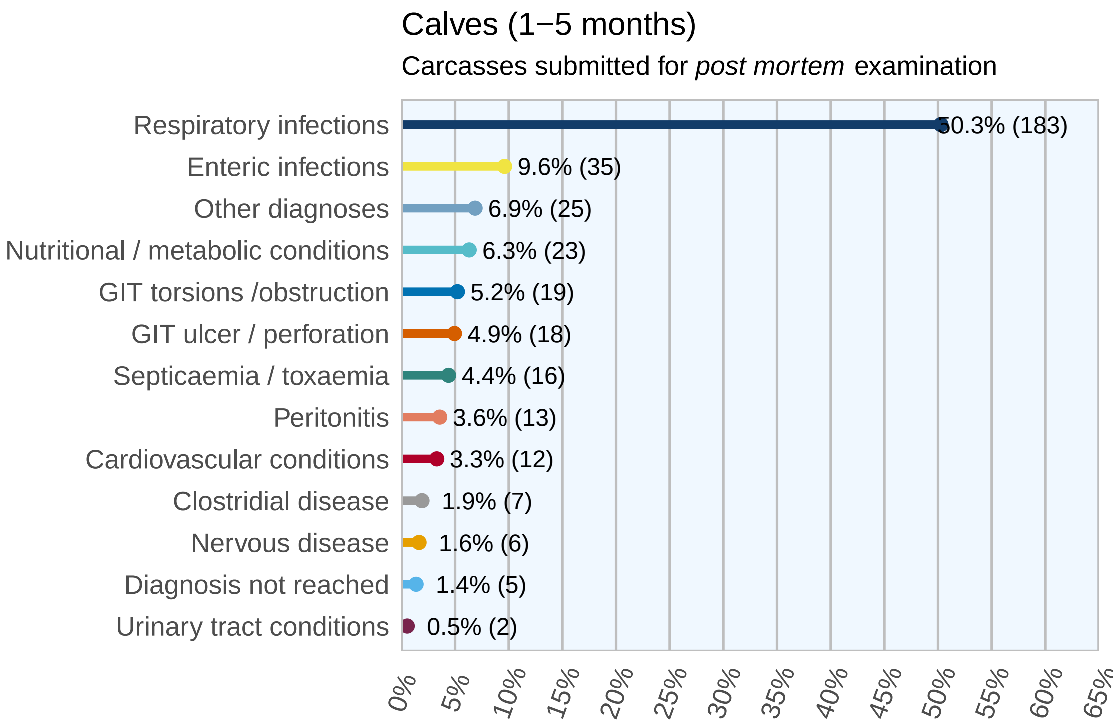


Figure 21.5.: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for *post mortem* in 2022 (n=364). The absolute number of cases is between brackets.

Infections of the gastrointestinal tract represented the second most important group of diagnoses after respiratory infections in this age group. There were 35 cases of enteric infections (or 10 *per cent* of the 364 cases overall in this age group). Coccidiosis was the most frequently recorded enteric infection (seven cases or 20 *per cent* of the enteric infections recorded) followed by five cases of fungal rumenitis and four cases of candidiasis. 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. Other gastrointestinal infections of note included three cases of BVD/Mucosal disease.

Significant non-infectious conditions of the gastrointestinal tract included ulcers, perforations, torsions and obstruction. There were 17 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. Twelve cases of perforation of the abomasum were recorded and a further six 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.

Twenty-three cases of nutritional or metabolic conditions were recorded with the most frequent being ruminal acidosis (14 cases) and there were six cases of bloat.

Septicaemic or toxaemic conditions accounted for four *per cent* of cases (16 cases) in one to five-month-old calves. Salmonellosis due to *Salmonella* Dublin was the most significant disease within this grouping (eight cases) followed by septicaemic pasteurellosis (four cases).

21.3. Weanlings 6–12 months old

Pneumonia was the main cause of death in older calves (from six to 12 months old) followed by deaths caused by clostridial infections and then neurologic conditions (Figure 21.7 and Table 21.3). Bacterial infections were again the most frequent recorded cause of respiratory infections. *Mycoplasma bovis* was detected in 26 cases representing 23 *per cent* of respiratory diagnoses, *Pasteurella multocida* was detected in 12 cases (11 *per cent* of respiratory diagnoses), and *Mannheimia haemolytica* in six cases. Three cases of pneumonia due to *Histophilus somni* were recorded and *Trueperella pyogenes* was isolated in two cases.

Figure 21.6.: Lungworm infestation in a three-month-old calf. Photo: Seán Fee.

Parasitic pneumonia due to lungworm infection was recorded in 19 cases which represented more than a threefold increase in the number of hoose cases in 2022 compared with the six cases detected in 2021. Respiratory infections caused by viruses were detected in ten cases (9 *per cent* of respiratory infections) with BRSV (six cases) and BVDV (two cases) the most frequently recorded, followed by IBRV and PI3 (one case each). Eighteen cases of clostridial disease were recorded (11 *per cent* of diagnoses in this age group) and with most of these being cases of blackleg (15 cases or 83 *per cent* of the clostridial infections recorded). The remaining clostridial infections detected in this age group were two cases of botulism and a single case of black disease.

Table 21.3.: Conditions most frequently diagnosed in weanlings calves six to twelve months old submitted to AFBI for post mortem in 2022 (n= 170).

Category	No. of cases	Percentage
Respiratory tract infections	113	**66.5**
Clostridial disease	18	**10.6**
Nervous system disease	10	**5.9**
Other diagnoses	7	**4.1**
Enteric infections	7	**4.1**
Gastrointestinal ulcers, torsion and obstruction	6	**3.5**
Diagnosis not reached	5	**2.9**
Nutritional / Metabolic conditions	4	**2.4**

There were ten cases of nervous system disease (representing 6 *per cent* of the 170 cases in this age group). Cerebrocortical necrosis was recorded most frequently (five cases), followed by three cases of neurologic listeriosis and one case of encephalitis due to *Histophilus somni*. Gastrointestinal conditions represented 8 *per cent* of cases (13 cases) recorded in weanlings. There were three cases of intestinal torsion (22 *per cent* of the gastrointestinal conditions, one case of abomasal ulceration and a single case of perforated abomasal ulcer). Of the more significant infectious causes of gastrointestinal disease there were three cases of coccidiosis, two cases of parasitic gastroenteritis and one case of BVDV/Mucosal disease.

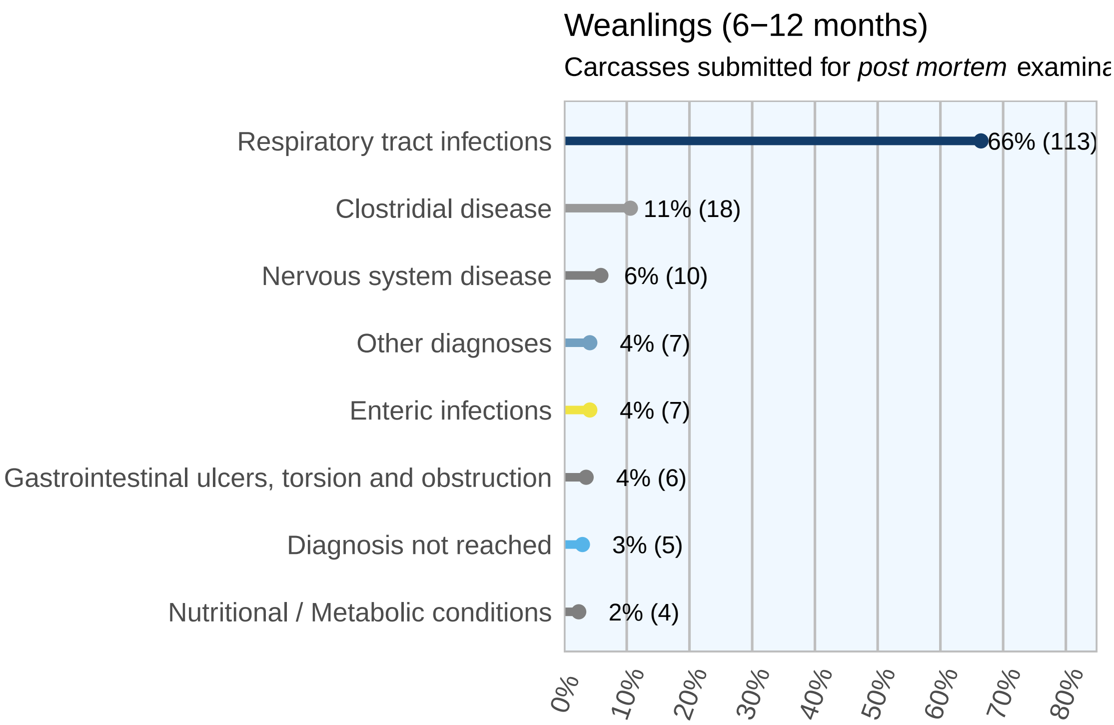


Figure 21.7.: Conditions most frequently diagnosed in weanlings calves six to twelve months old submitted to AFBI for *post mortem* in 2022 (n=170).The absolute number of cases is between brackets.

21.4. Adult Cattle (older than 12 months)

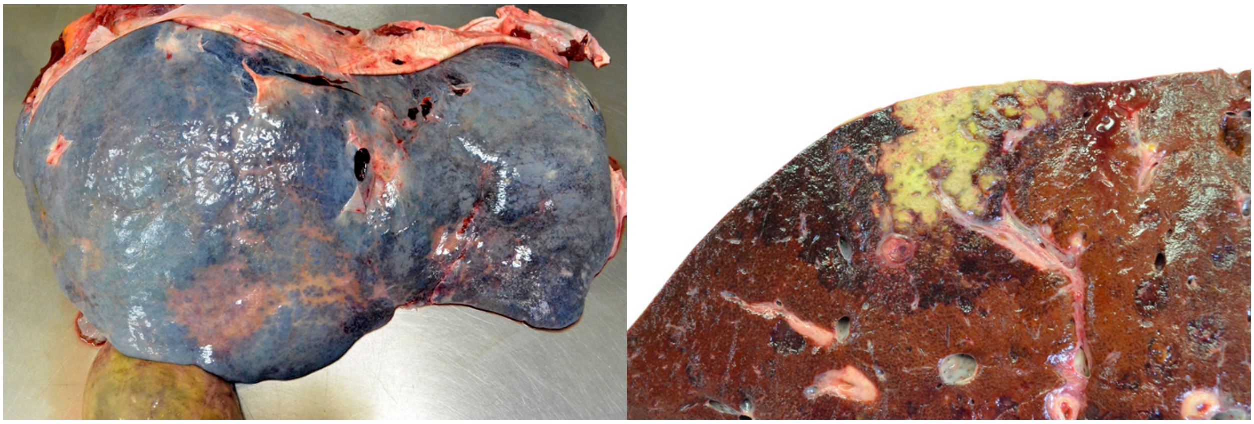
As has been the case in previous years respiratory infections were the most frequently diagnosed cause of death in adult cattle (greater than 12 months old) (Figure 21.9 and Table 21.4) . *Mycoplasma bovis* (18 cases) was the most frequently diagnosed pathogen. Ten cases of parasitic pneumonia (hoose) due to the nematode *Dictyocaulus viviparous* were recorded in 2022, rising from five cases of hoose which were recorded in 2021. 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. Nine cases of pneumonia due to *Trueperella pyogenes* were recorded in 2022 while *Mannheimia haemolytica*, an increasingly important cause of pneumonia particularly in adult cows was the next most frequently reported respiratory pathogen (seven cases of this infection were recorded representing 9 *per cent* of respiratory infections in adult bovines). *Pasteurella multocida* (six cases) were the next most frequently identified respiratory bacterial pathogen. Pneumonia due to tuberculosis was recorded in one submission.

Table 21.4.: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for *post mortem* in 2022 (n= 332).

Category	No. of cases	Percentage
Respiratory infections	80	**24.1**
Diagnosis not reached	46	**13.9**
Cardiac / circulatory system	26	**7.8**
Reproductive / mammary conditions	26	**7.8**
Other diagnoses	24	**7.2**
Nutritional / metabolic conditions	20	**6.0**
Clostridial disease	19	**5.7**
Liver disease	17	**5.1**
Enteric infections	17	**5.1**
GIT ulceration / perforation / foreign body	13	**3.9**
Peritonitis	12	**3.6**
Skeletal conditions	12	**3.6**
Intestinal or gastric torsion / obstruction	8	**2.4**
Poisoning	7	**2.1**
Nervous system conditions	3	**0.9**
Urinary tract conditions	2	**0.6**

Anteroventral lung was consolidated with histopathology typical of mycobacterial infection as well as concurrent histopathology suggestive of other bacterial causes. There were typical gross lesions of tuberculosis in bronchomediastinal lymph nodes and *Mycobacterium bovis* was cultured. Nine cases of viral respiratory infection were detected comprising six cases of IBRV infection and three cases of BRSV. Five cases of embolic pneumonia were recorded. Embolic pneumonia cases occur when bacteria or septic thrombi from a primary source of infection spread to the lungs via the blood stream. In three of the five cases recorded the initial site of pathology was liver abscessation and in one case infection spread from udder cleft dermatitis where a large unhealing skin defect was present between the left and right forequarters of the udder.

Diseases of the heart and circulatory system (26 cases) accounted for 8 *per cent* of the conditions recorded in cattle older than 12 months. The most frequently reported cardiovascular diagnoses were thrombosis of the caudal vena cava and also haemorrhages (both 9 cases or 35 *per cent* of cardiovascular diagnoses). 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. There were three cases of



(a) Hepatic fibrosis due to ragwort toxicity (b) Black disease

Figure 21.8.: Hepatic fibrosis (a) due to ragwort toxicity in a seven-year-old cow, (b) Black disease in twelve-year-old cow. Photos: Seán Fee.

vegetative endocarditis and three cases of cardiac abscessation.

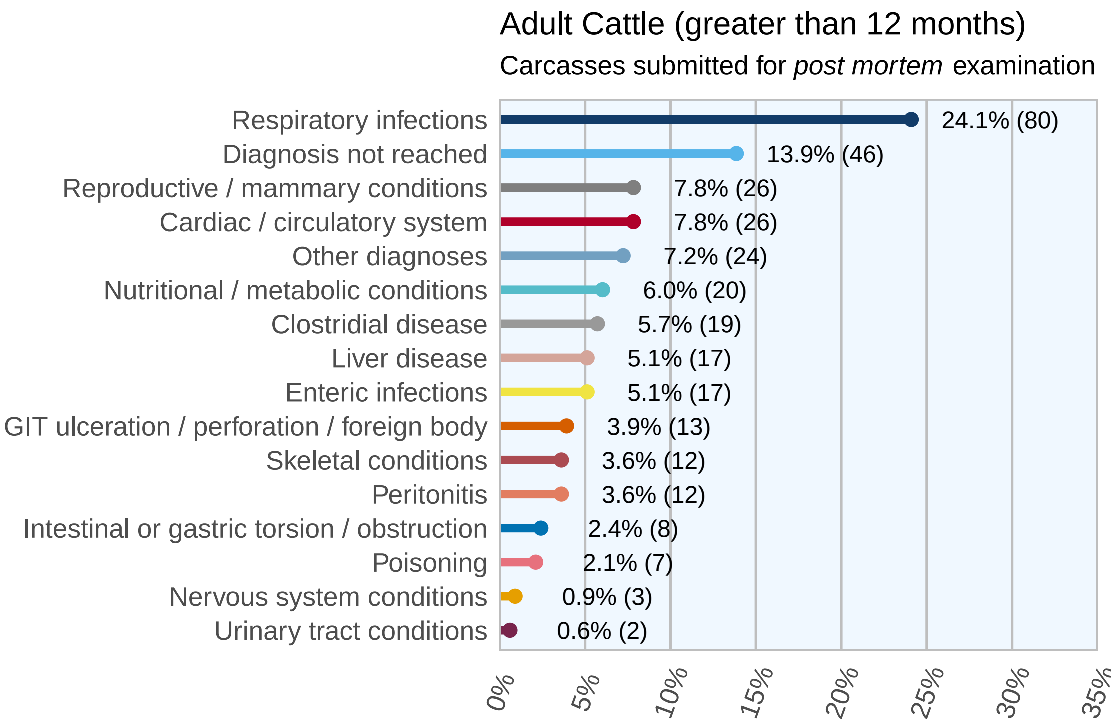


Figure 21.9.: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for *post mortem* in 2022 (n=332). The absolute number of cases is between brackets.

Reproductive and mammary conditions also accounted for 8 *per cent* of the conditions recorded in cattle older than 12 months (26 cases). Mastitis was the most frequently recorded condition (nine cases), and toxic coliform mastitis was the principal cause of fatal mastitis being diagnosed in four cases. There were five cases of fatal uterine torsion, three cases of a ruptured uterine artery and two cases of a ruptured uterus.

Nutritional and metabolic conditions accounted for 20 cases (6 *per cent* of the cases in adult cattle). The main conditions encountered included hypomagnesaemia (seven cases), hypocalcaemia (six cases), ruminal acidosis (five cases), and one case of hypophosphataemia.

Clostridial disease was responsible for 6 *per cent* (19 cases) of deaths in adult cattle in N Ireland. Blackleg was the most commonly diagnosed clostridial disease in adult cattle (10 cases), followed by

Figure 21.10.: Uterine torsion in a ten-year-old cow. Photo: Seán Fee.

botulism (seven cases) and black disease (two cases).

21.5. Bovine Respiratory Diseases

Siobhan Corry, *Veterinary Research Officer*
Omagh Veterinary Laboratory,
43 Beltany road, Omagh BT78 5NF, Northern Ireland

Bovine respiratory disease is one of the most significant causes of mortality in animals submitted for *post mortem* examination. As bovine respiratory disease has multiple aetiologies, *post mortem* examination remains an extremely important resource for diagnosis.

Table 21.5.: Relative frequency of the different aetiological agents identified in cases of pneumonia diagnosed during post mortem by AFBI in 2022 (n= 326).

Category	No. of cases	Percentage
Mycoplasma bovis	122	**37.4**
Pasteurella multocida	50	**15.3**
Dictyocaulus viviparus	44	**13.5**
Mannheimia haemolytica	34	**10.4**
Bovine Respiratory synthical virus BRSV	23	**7.1**
Trueperella pyogenes	22	**6.7**
Infectious Bovine Rhinotracheitis (IBR)	10	**3.1**
Histophilus somnus	9	**2.8**
Bovine Viral Diarrhoea (BVD)	5	**1.5**
Parainfluenza virus 3	3	**0.9**
Staphylococcus aureus	2	**0.6**
Fungal	1	**0.3**
Corynebacterium species	1	**0.3**

Nearly all bovine animals on farm will inevitably be carrying some infectious agents within the respiratory tract. Disease will manifest when natural defences are low, animals are under stress or when the burden of infection in the environment is overwhelming.

Mycoplasma bovis remains the leading aetiological agent identified in cases of bovine respiratory disease in cattle submitted for *post mortem* examination (Figure 21.11 and Table 21.5) . A positive *Mycoplasma* PCR result should always be interpretated with gross findings, histopathological picture, results of other diagnostic tests and the clinical picture on farm to determine its significance. Whilst other agents may also be playing a role in the diagnosed pneumonia the presence of *Mycoplasma bovis* is always significant from a herd point of view and its presence on farm can contribute to pneumonia, mastitis and joint problems.

Mannheimia haemolytica, of the *Pasteurellaceae* family can cause a severe necrotising fibrinous pleuropneumonia (Figure 21.12). The bacteria are a commensal of the upper respiratory tract in many animals and usually only causes adverse effects within the lung when the normal defences are impaired, say due to respiratory viral infection, poor ventilation or if animals are under stress. Preventions such as vaccination, adequate ventilation and husbandry practices which minimise stress should be considered.

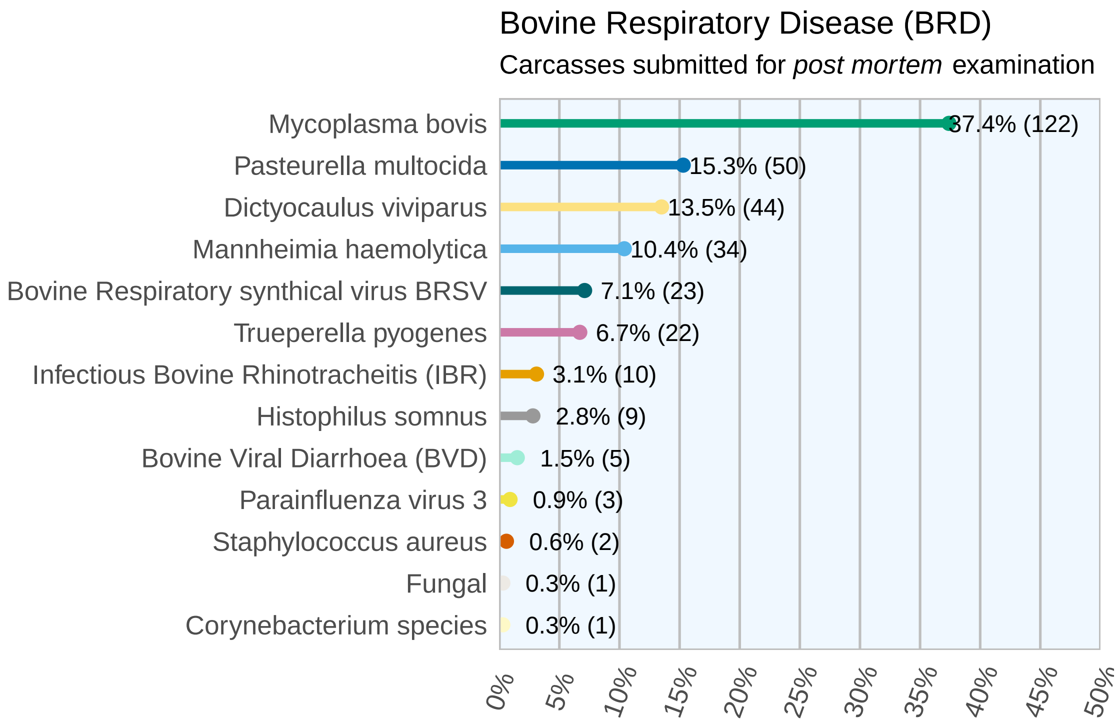


Figure 21.11.: Relative frequency of the different aetiological agents identified in cases of pneumonia diagnosed during *post mortem* by AFBI in 2022 (n=326). The absolute number of cases is between brackets.

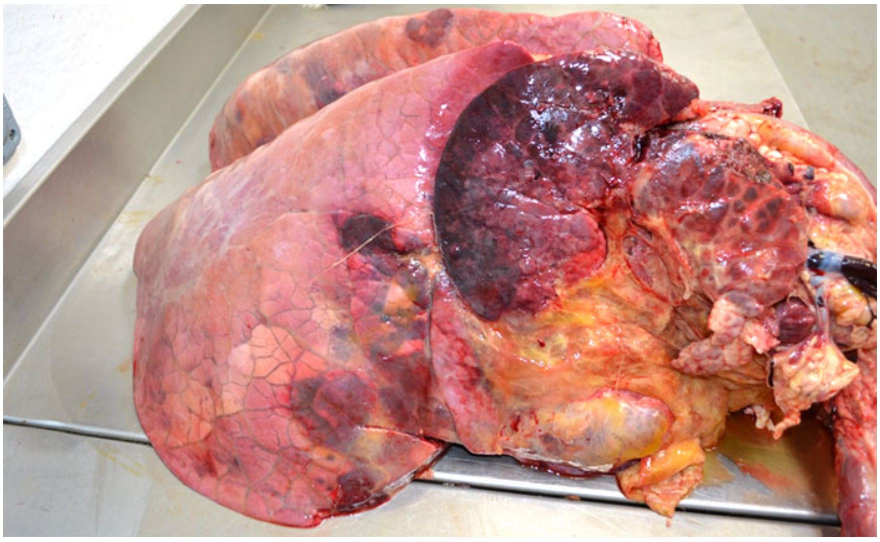


Figure 21.12.: Pleuropneumonia caused by Mannheimia haemolytica. Photo: Seán Fee.

21.6. Bovine Mastitis

Siobhan Corry, *Veterinary Research Officer* ✒
Omagh Veterinary Laboratory,
43 Beltany road, Omagh BT78 5NF, Northern Ireland

Mastitis is one of the most important production diseases of the dairy industry. 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.

Identification of a mastitis pathogen is important as different pathogens require different mastitis management strategies and targeted treatment. Aetiological agents causing mastitis can be categorized into contagious and environmental pathogens. 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.

Table 21.6.: Bacterial isolated in milk samples submitted to AFBI in 2022 (n= 620).

Category	No. of cases	Percentage
E.coli	223	**36.0**
Streptococcus uberis	181	**29.2**
Staphylococcus aureus	93	**15.0**
Streptococcus dysgalactiae	32	**5.2**
Bacillus licheniformis	22	**3.5**
Bacillus cereus	20	**3.2**
Trueperella pyogenes	18	**2.9**
Yeast	10	**1.6**
Fungi	10	**1.6**
Corynebacteria	9	**1.5**
Pasteurella multocida	2	**0.3**

Environmental pathogens are those whose primary reservoir is in the environment. They tend to cause clinical disease of a shorter duration. Of the samples of mastitic milk submitted for bacteriology, a bacterial agent associated with mastitis was isolated in 620 samples. 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. *E. coli*, an environmental cause of mastitis was the most frequently isolated organism in 2022 accounting for 36 *per cent* of isolates cultured (Figure 21.13 and Table 21.6). Risk factors include poor hygiene, suboptimal milking machine function and teat end damage.

Another frequently identified environmental organism, *Streptococcus uberis* was identified in 29.2 *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 15 *per cent* of samples submitted in 2022. This was the third most frequently cultured mastitis associated bacterium.

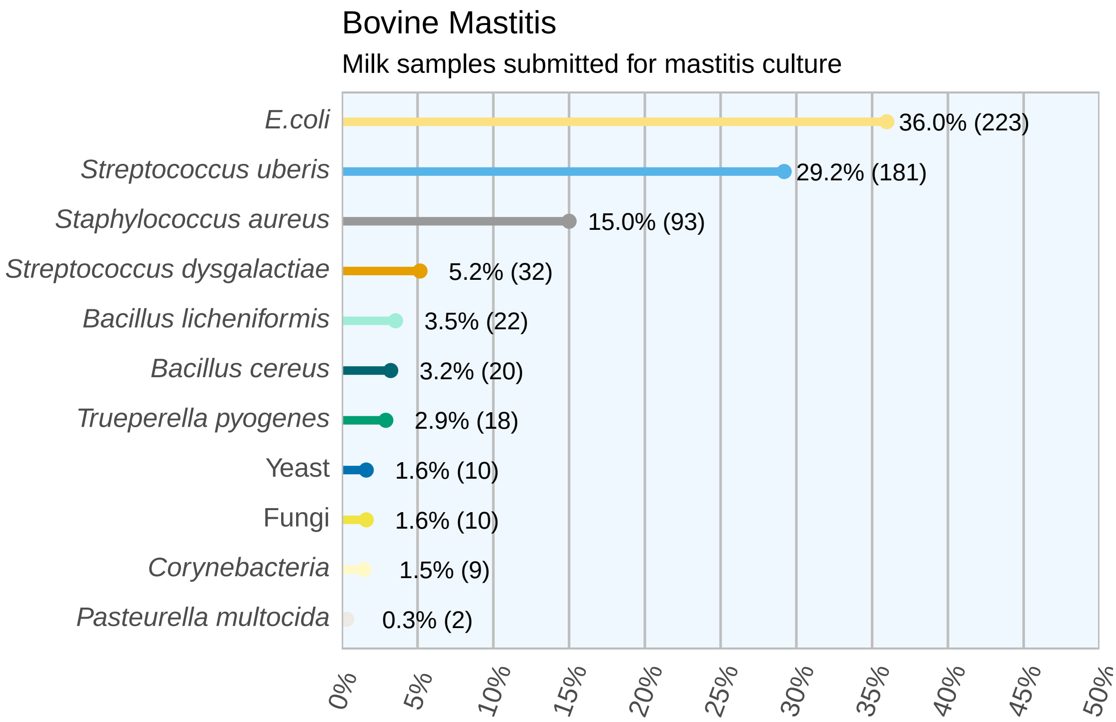


Figure 21.13.: Bacteria isolated in milk samples submitted to AFBI in 2022 (n=637). The absolute number of cases is between brackets.

21.7. Bovine Abortion

Pauline Sheridan, *Veterinary Research Officer*
Omagh Veterinary Laboratory,
43 Beltany road, Omagh BT78 5NF, Northern Ireland

Of the 302 bovine abortions AFBI examined in 2022, an infectious agent was identified in 43 *per cent* of submissions and this reflects that infections detectable in the foetus are not the only causes of abortions, and that non-infectious causes such as anomalies in the foetus or maternal factors such as fever or malnutrition, may also induce pregnancy loss (Figure 21.14 and Table 21.7). Examination of the dam, the placenta and the foetus with maternal serology provides the greatest opportunity to obtain a diagnosis.

Table 21.7.: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2022, (n= 302).

Category	No. of cases	Percentage
No infectious agent identified	160	**53.0**
Trueperella pyogenes	35	**11.6**
Bacillus licheniformis	19	**6.3**
Salmonella spp	15	**5.0**
Neospora caninum	13	**4.3**
E.coli	12	**4.0**
Streptoccocal spp	8	**2.6**
Other	7	**2.3**
Leptospirosis	6	**2.0**
Foetal dystocia	6	**2.0**
Pasteurella spp	5	**1.7**
Listeria monocytogenes	4	**1.3**
Foetal abnormality	4	**1.3**
Bovine Viral Diarrhoea	3	**1.0**
Staphylococcal spp	2	**0.7**
Thyroid hyperplasia	2	**0.7**
Aspergillus spp	1	**0.3**

Bacterial agents comprised 81.5 *per cent* of infectious diagnoses, with *Bacillus licheniformis*, *Trueperella pyogenes* and *Salmonella spp* the most frequently diagnosed infectious agents occurring in 22.8 *per cent* of all bovine abortion submissions. The proportion of bovine abortions associated with *Salmonella spp* was decreased in 2022, with 5 *per cent* of bovine abortions associated with *Salmonella sp* compared to 10.4 *per cent* in 2021. The cattle adapted serotype of *Salmonella enterica* subspecies *enterica*, *S* Dublin, was the predominant *Salmonella sp.* identified and unusually there were more diagnoses of *Salmonella* abortions during the summer months.

A range of bacterial agents were recovered from sporadic cases of bovine abortion, including *Streptococcus sp.*, *Staphylococcus sp.*, while *Escherichia coli* was cultured from 4 *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. Leptospira was detected in only 2 *per cent*of cases

Deformities were detected in occasional foetuses including cleft palate, and anomalies in heart

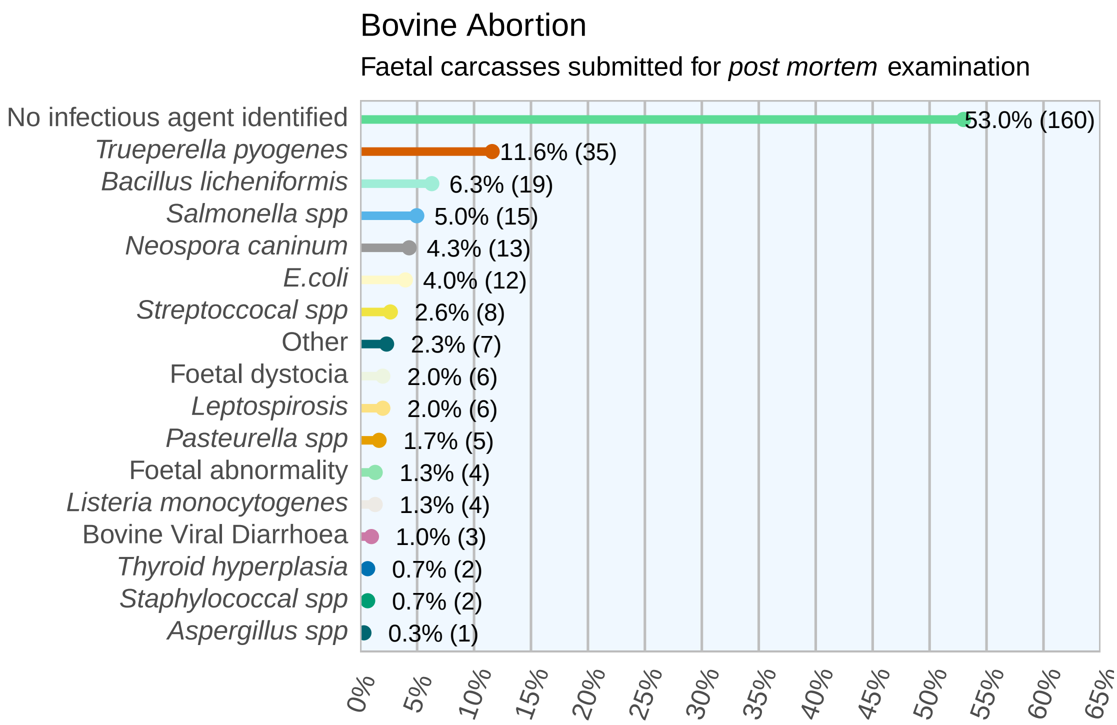


Figure 21.14.: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2022 (n=302).

structure. A number of mummified foetuses were examined, these foetuses died in the early stages of pregnancy but were not expelled from the uterus for a considerable period of time and any bacteria cultured from the carcases were typically secondary or opportunistic agents rather than primary causes of abortion.

21.8. Zinc Sulphate Turbidity Testing

Siobhan Corry, *Veterinary Research Officer*
Omagh Veterinary Laboratory,
43 Beltany road, Omagh BT78 5NF, Northern Ireland

AFBI carries out ZST tests on serum samples submitted by veterinary surgeons, and on samples collected at *post mortem* examination on calves and occasionally lambs 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.

These results indicate that failure of passive transfer of immunity to neonates continues to be a problem in herds, and so highlight the need to continue to reiterate the importance of good colostrum management. It is recommended that every calf receives 3 litres of good quality colostrum within the first 2 hours of life. 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.

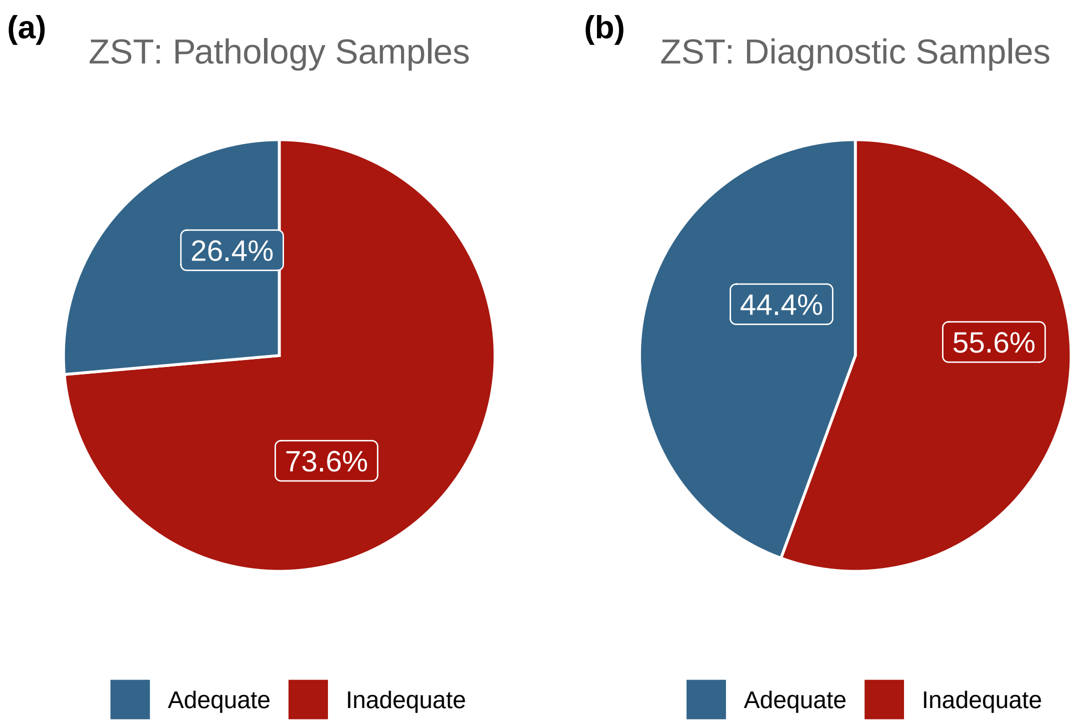


Figure 21.15.: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2022 from bovine calf serum samples taken (a) at *post mortem* (n=140) and (b) submitted as diagnostic samples (n=399). Adequate colostral immunity is defined as greater than or equal to 20 units.

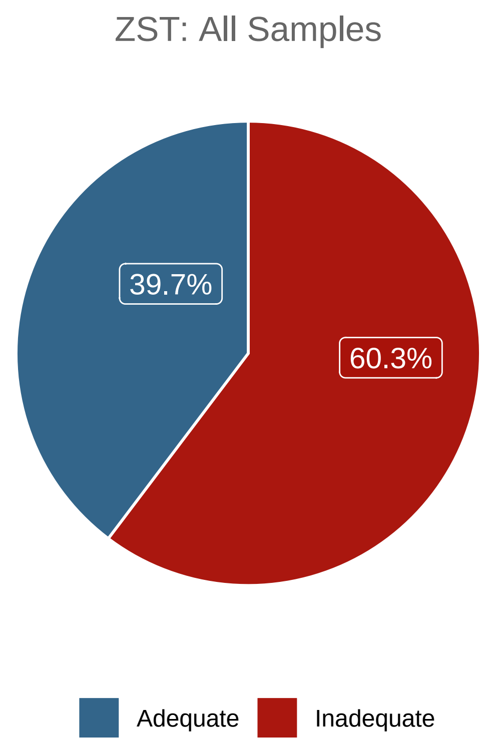


Figure 21.16.: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2022 from bovine calf serum samples (n=539). Adequate colostral immunity is defined as greater than or equal to 20 units.

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 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.

In 2022 a total of 539 serum samples were tested; of these 399 were diagnostic samples submitted from live calves, and 140 were obtained at *post mortem* examination (Figure 21.16). Of the diagnostic samples submitted from live calves, 55.6 *per cent* were considered inadequate while only 44.4 *per cent* were considered adequate (Figure 21.15 (b)). This is a reduction on previous years, in 2021, 57 *per cent* of diagnostic samples submitted from live calves were considered adequate. The results of those obtained at *post mortem* showed that only 26.4 *per cent* of samples were considered adequate while 73.6 *per cent* of samples tested less than 20 units and therefore indicated inadequate transfer of immunoglobulins (Figure 21.15 (a)). This is similar to the 2021 result where 72 *per cent* of samples taken from calves submitted for *post mortem* were considered 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 mortality. Additional information can be found in the following publications Todd et al. (2018); Ian Hogan et al. (2015); I. Hogan et al. (2016) ; Hudgens et al. (1996) and in the Colostrum Management tools webpage.[1]

[1] https://extension.psu.edu/colostrum-management-tools-hydrometers-and-refractometers

21.9. Bovine Neonatal Enteritis

Siobhan Corry, *Veterinary Research Officer*
Omagh Veterinary Laboratory,
43 Beltany road, Omagh BT78 5NF, Northern Ireland

Enteritis has for many consecutive years been the most diagnosed condition in calves up to one month of age submitted to AFBI for *post mortem* investigation (Figure 21.18 and Table 21.8). Often calves present with a clinical history of diarrhoea, however in some cases death can occur without significant diarrhoea.

Enteritis in neonatal calves is the leading cause of dairy calf morbidity and mortality worldwide, and beef calves are also frequently affected. Affected calves suffer dehydration, metabolic acidosis and electrolyte depletion which frequently results in death, but the long-term effects include reduced weight gain and development, increased time to first calving and reduced milk production in the first lactation in dairy heifers, resulting in significant economic consequences for individual farms and the national herd.

Table 21.8.: The frequency of common enteropathogenic agents identified in calf faecal samples tested by AFBI in 2022.

Organism	No. Tested	Positive	Percentage
Cryptosporidium species	511	157	**30.7**
Rotavirus	519	155	**29.9**
Coronavirus	543	42	**7.7**
Escherichia coli K99	329	26	**7.9**

A number of causative viral, bacterial, protozoal and parasitic organisms are responsible for disease, but differentiation of the specific cause cannot be made on clinical signs, or on gross *post mortem* findings alone and laboratory testing is necessary. Often in the case of a herd outbreak, mixed infections occur with multiple pathogens being present, so 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. Submissions are made up of both faecal samples submitted by veterinary practices and carcases of calves submitted for *post mortem* examination. 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. Investigations into outbreaks of neonatal enteritis should always include an assessment of adequacy of passive transfer of colostral immunoglobulins as failure of passive transfer is a main risk factor for neonatal enteritis.

Two pathogens have consistently been identified as the most commonly detected in submissions to AFBI, and 2022 followed this trend. *Cryptosporidium* was identified in 31 *per cent* of the samples tested and Rotavirus was identified in 30 *per cent* of the samples tested.

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. *Cryptosporidium parvum*, a single-celled parasite, produces a watery diarrhoea in neonatal calves The organism infects cells of the small intestine and heavy colonisation occurs quickly through rapid replication (Figure 21.17). Animals are infected through ingestion of oocysts which have been produced in large numbers by other infected calves. The oocysts can survive for long periods in the environment due to a tough outer shell which is also resistant to many commonly used disinfectants and extremes of temperature. 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.

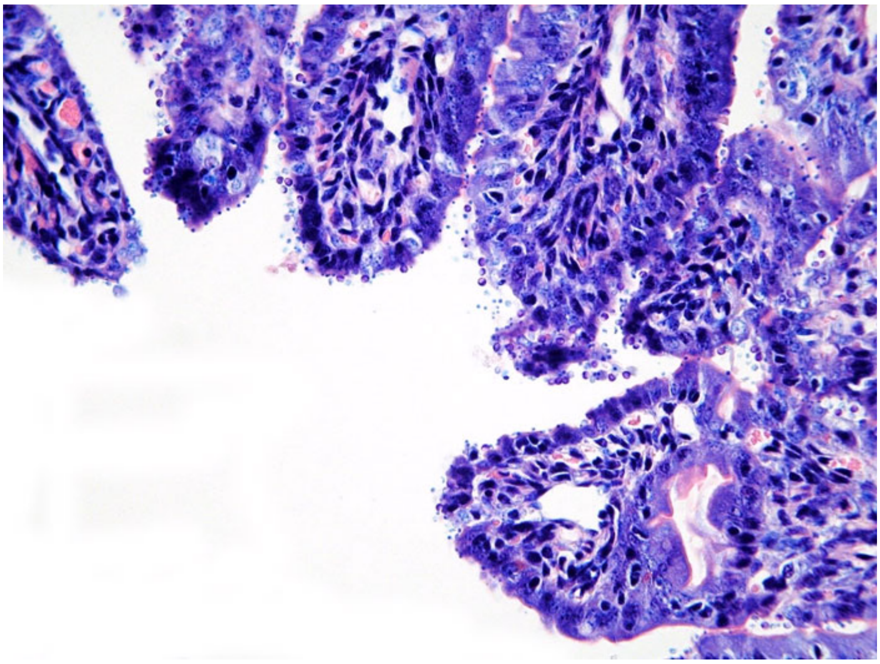


Figure 21.17.: Histopathology of the gut wall showing adhered cryptosporidial organisms. Photo: Bob Hanna.

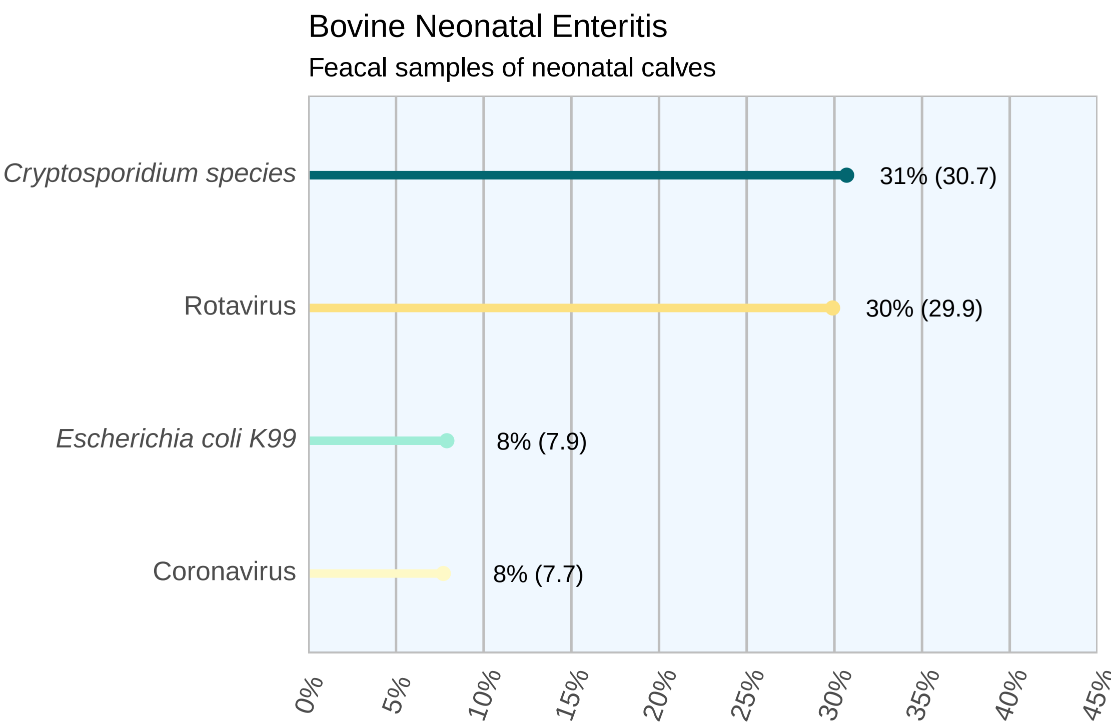


Figure 21.18.: Frequency of common enteropathogenic agents identified in calf faecal samples tested by AFBI in 2022.

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. Cryptosporidial species 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.

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 young calves. 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 possesses 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* by 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. For additional information see Shaw et al. (2020); Thomson et al. (2017); Blanchard (2012).

21.10. Bovine Parasites

***Bob Hanna**, Veterinary Research Officer*
Stormont Veterinary Laboratory,
12 Stoney Road, Belfast BT4 3SD, Northern Ireland

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.

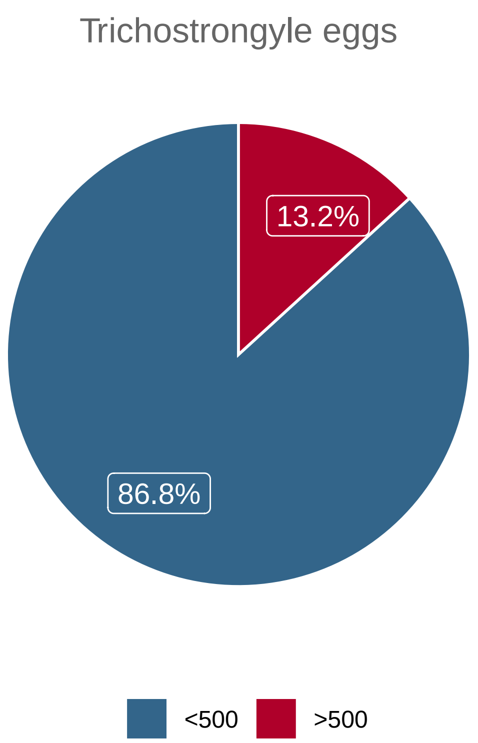


Figure 21.19.: Relative frequency of detection of trichostrongyle eggs in bovine faecal samples examined by AFBI in 2022 (n=2081).

Samples with a FEC of 500 eggs per gram (epg) and greater indicate clinically significant PGE. In 2022, 13.2 *per cent* (number of samples examined, n=2081) of bovine faeces samples submitted to AFBI for parasitological examination had a FEC ≥500epg (Figure 21.19), compared to 4.0 *per cent* of samples submitted in 2021, 5.1 *per cent* of samples submitted in 2020 and 3.9 *per cent* of samples submitted in

2019. The peak period for clinically significant gastrointestinal nematode infection was autumn (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). Sometimes a lower peak occurs earlier in the year (corresponding with Type 2 PGE in yearlings), but this was not evident in the record for 2022. Further, peak infections occurred slightly later than usual (August and September in 2020). The reasons for these differences are likely to be climatic differences between the years, and perhaps changing anthelmintic usage.

Samples with a FEC of 500 eggs per gram (epg) and greater indicate clinically significant PGE. In 2022, 13.2 *per cent* (number of samples examined, n=2081) of bovine faeces samples submitted to AFBI for parasitological examination had a FEC ≥500epg (Figure 21.19), compared to 4.0 *per cent* of samples submitted in 2021, 5.1 *per cent* of samples submitted in 2020 and 3.9 *per cent* of samples submitted in 2019. The peak period for clinically significant gastrointestinal nematode infection was autumn (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). Sometimes a lower peak occurs earlier in the year (corresponding with Type 2 PGE in yearlings), but this was not evident in the record for 2022. Further, peak infections occurred slightly later than usual (August and September in 2020). The reasons for these differences are likely to be climatic differences between the years, and perhaps changing anthelmintic usage.

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[2].

Liver fluke

In 2022, *Fasciola hepatica* incidence was 3.8 *per cent* (n=1700) of bovine faecal samples submitted to AFBI (Figure 21.22), compared to 7.0 *per cent* in 2021, 6.0 *per cent* in 2020 and 6.6 *per cent* in 2019. It is likely that this reflects the availability of the infective metacercarial cysts on pasture in the late autumn and early winter of 2021. 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 21.20), 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. 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 reside in the bile ducts, leading to characteristic calcification of ducts and the pipe-stem liver appearance visible on *post mortem* (Taylor, Coop, and Wall 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.

[2] https://www.cattleparasites.org.uk/

Figure 21.20.: *Galba truncatula*, the snail host of *Fasciola hepatica* and *Cotylophoron daubneyi*. Photo: Bob Hanna.

Liver fluke infection, fasciolosis, has major economic implications for livestock productivity due to the resulting morbidity and mortality (McCann, Baylis, and Williams 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 of 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)).

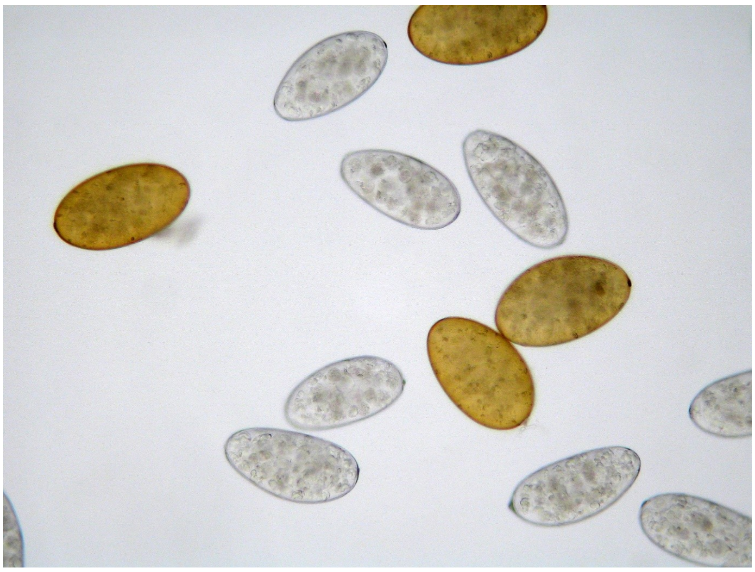


Figure 21.21.: Liver and rumen fluke eggs in a faecal sample. Photo: Bob Hanna.

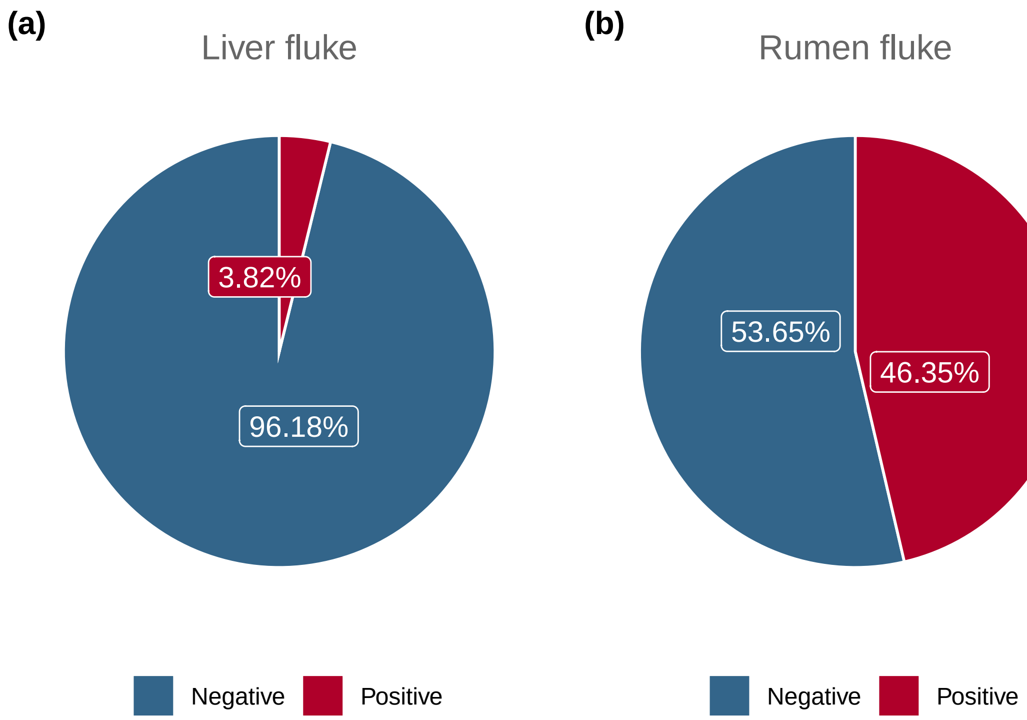


Figure 21.22.: Relative frequency of detection of (a) liver fluke eggs (n=1700) and (b) rumen fluke eggs (n=1700) in bovine faecal samples examined by AFBI in 2022.

Rumen fluke

Adult *Calicophoron daubneyi* flukes (also known as paramphistomes) (Figure 21.23) 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 in 2022, at 46.4 *per cent* (Figure 21.22 a) (n=1700), shows a slight increase compared with that in 2021 (43.0 *per cent*) but is slightly less than in previous years, 2020 (48.5 *per cent*) and 2019 (52.6 *per cent*). In faecal examinations, the eggs of *C. daubneyi* can be distinguished from those of *F. hepatica* by their characteristic clear appearance (Figure 21.21). 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.

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 2022, coccidian oocysts were seen in 21.5 *per cent* (n=1894) of bovine faecal samples examined in

Figure 21.23.: Adult *Cotylophoron duabneyi* in the rumen of the dairy cow . Photo: Bob Hanna.

AFBI (Figure 21.24). This level is similar to that recorded in 2021 (21.0 *per cent*), 2020 (21.6 *per cent*) and 2019 (21.3 *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 less than 5.0 *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.

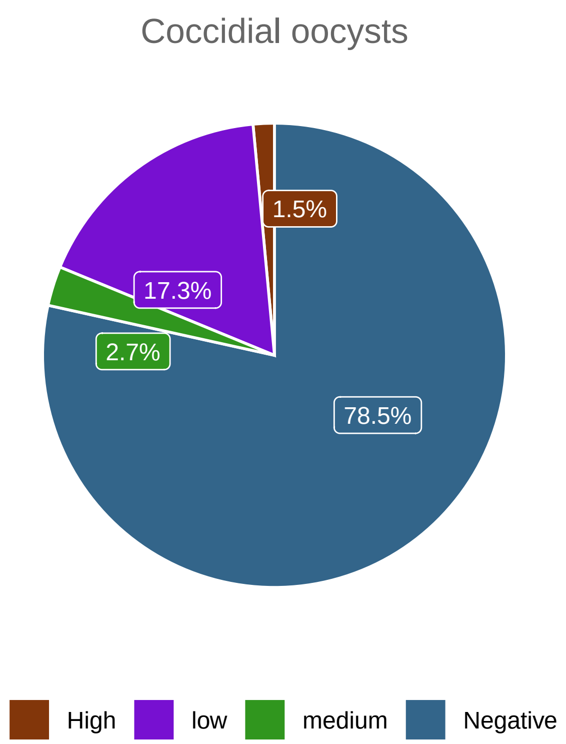


Figure 21.24.: Results for bovine faecal samples tested for coccidial oocysts during 2022 (n=1894).

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 1 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. The parasitic infection attacks the caecum and colon, producing 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.

Dictyocaulus viviparus (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. Amongst 338 *post mortem* diagnoses of pneumonia in 2022, where the aetiological cause was identified, 44 cases (13.0 *per cent*) involved *D. viviparus* infection.

The peak incidence of lungworm infection was in August to October (Figure 21.25). 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.

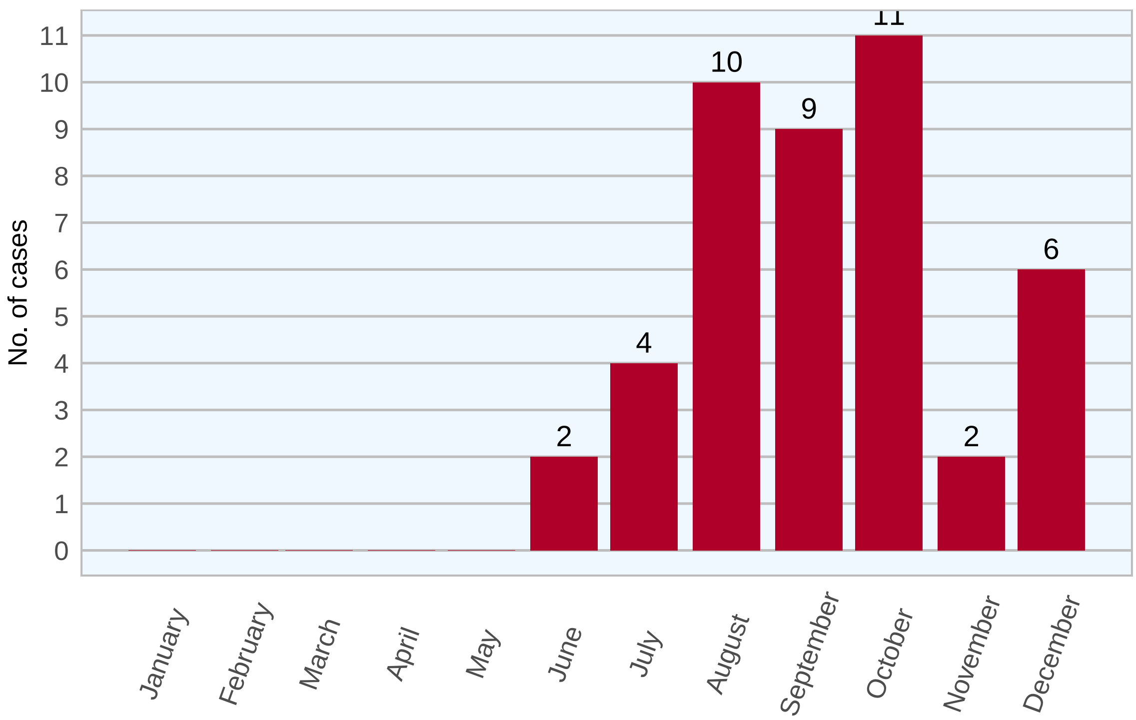
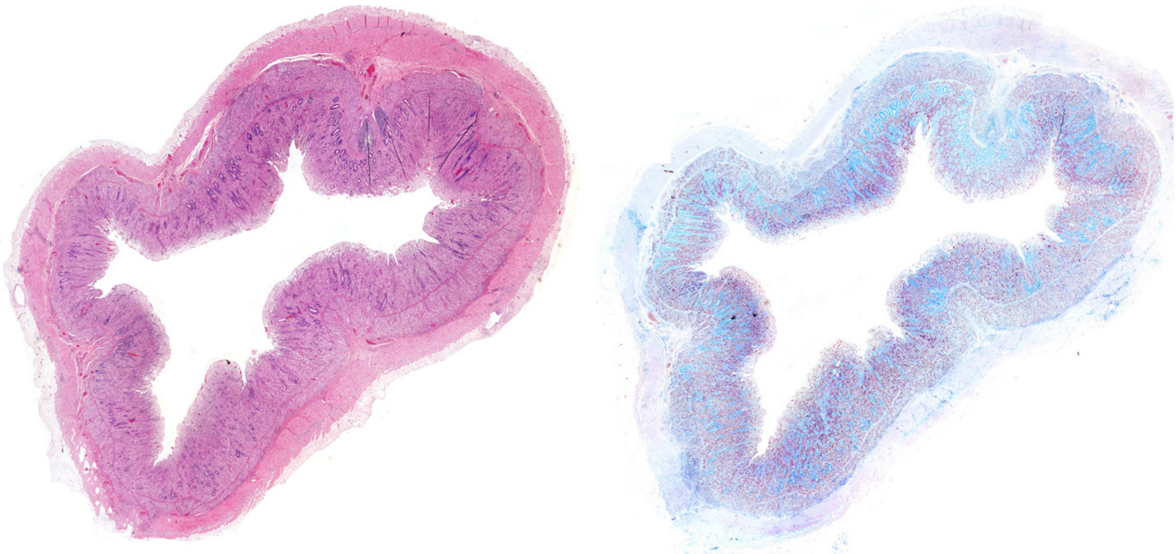


Figure 21.25.: Number of lungworm cases diagnosed during *post mortem* by AFBI per month in 2022, (n=44).

21.11. Johne's Disease

***Lindsey Drummond**, Veterinary Research Officer*
Stormont Veterinary Laboratory,
12 Stoney Road, Belfast BT4 3SD, Northern Ireland

Johne's disease (JD) or paratuberculosis is a disease of ruminants primarily, which occurs world-wide, commonly in cattle, and to a lesser extent in sheep and goats. Classically the clinical disease presents with chronic or recurrent progressive intractable diarrhoea with concomitant weight loss, while the appetite remains largely unaffected. Such clinical presentations represent the tip of the iceberg of economic losses due to JD in infected herds. Substantial insidious economic losses in JD infected herds result from decreased milk production, increased infertility, increased incidence of mastitis, increased incidence of lameness and decreased lifetime production caused by premature culling. The causative agent is *Mycobacterium avium subspecies paratuberculosis* (Map), a resilient, slow growing acid-fast bacterium. It is known to survive for longer than 1 year in the environment. Transmission is primarily by the faecal-oral route, and the ingestion of Map by susceptible animals via oral uptake of contaminated milk, water, feed products or from the environment. Vertical transmission in utero is also well established in cattle.



(a) Haematoxylin-Eosin stained section

(b) Ziehl-Neelsen stained section

Figure 21.26.: Intestinal sections with granulomatous (a) inflammation in the epithelium of an animal with Johne's disease (b) showing numerous *Mycobacterium avium sp. paratuberculosis* acid-fast bacilli (stained red). Photo: Cosme Sánchez-Miguel.

During 2022 11,134 bovine blood and milk samples were tested by AFBI for Map antibody (ELISA) and 1006 (9.04 *per cent*) were positive, with a further 157 (1.41 *per cent*) returning inconclusive results. 2138 faecal samples were submitted to AFBI for Map PCR screening. Map was identified in 337 of the 1953 (17.26 *per cent*) bovine samples tested, with a further 7 (0.36 *per cent*) recorded as inconclusive. Map infection was also confirmed in 2 of 29 caprine faecal samples tested, and 6 of 75 ovine faecal samples tested.

The Northern Ireland Johne's Disease Control Programme for Dairy Herds is a voluntary programme managed by Animal Health & Welfare NI (AHWNI). The programme complies with the requirements of the Red Tractor Farm Quality Assurance Scheme. It is compulsory for all participants in the programme to undertake a standardised Veterinary Risk Assessment and Management Plan

(V-RAMP). These are delivered by approved veterinary practitioners who have undergone AHWNI training. By the end of 2022, 219 veterinary practitioners had been trained to deliver V-RAMPs. In total 1373 V-RAMPs were carried out during 2022 and uploaded to the AHWNI online system.

22. Ovine Diseases, AFBI

22.1. Overview

Jason Barley, *Veterinary Research Officer*
Stormont Veterinary Laboratory,
12 Stoney Road, Belfast BT4 3SD, Northern Ireland

The number of sheep submissions in Northern Ireland increased in 2022 compared to 2021 with 654 submissions being received compared to 578. In 2022, parasitic disease and enteric disease were the most commonly diagnosed causes of death in sheep under 12 months of age in Northern Ireland. The relative importance of clostridial diseases and pasteurellosis remains high despite the availability of effective vaccines.

Figure 22.1 and Figure 22.2 show the diagnostic analyses for the most frequent causes of sheep mortality in Northern Ireland during 2022 for animals under 12 months and those over 12 months. The data are presented on a disease category basis and as a percentage of the total diagnoses excluding abortions.

Overall, there was little change to the patterns seen in 2021. In 2022 parasitic disease was very important in sheep in Northern Ireland with parasitic gastroenteritis being the most frequently diagnosed condition overall. It was noted that the trend for Nematodirosis to be present throughout the summer and autumn as well as the spring continued. The temperature adaptation of *N.battus* now appears to be much less apparent than before.

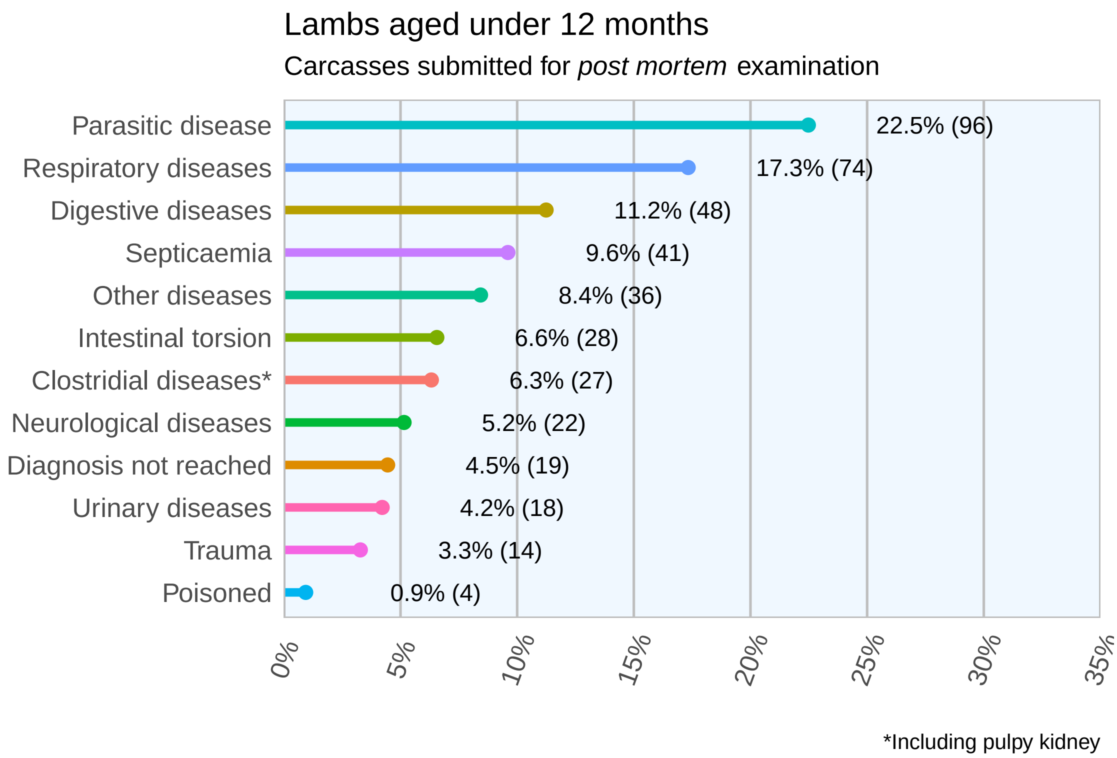


Figure 22.1.: Conditions most frequently diagnosed in small ruminants aged under 12 months submitted for *post mortem* by AFBI in 2022. (n=427). The absolute number of cases is between brackets.

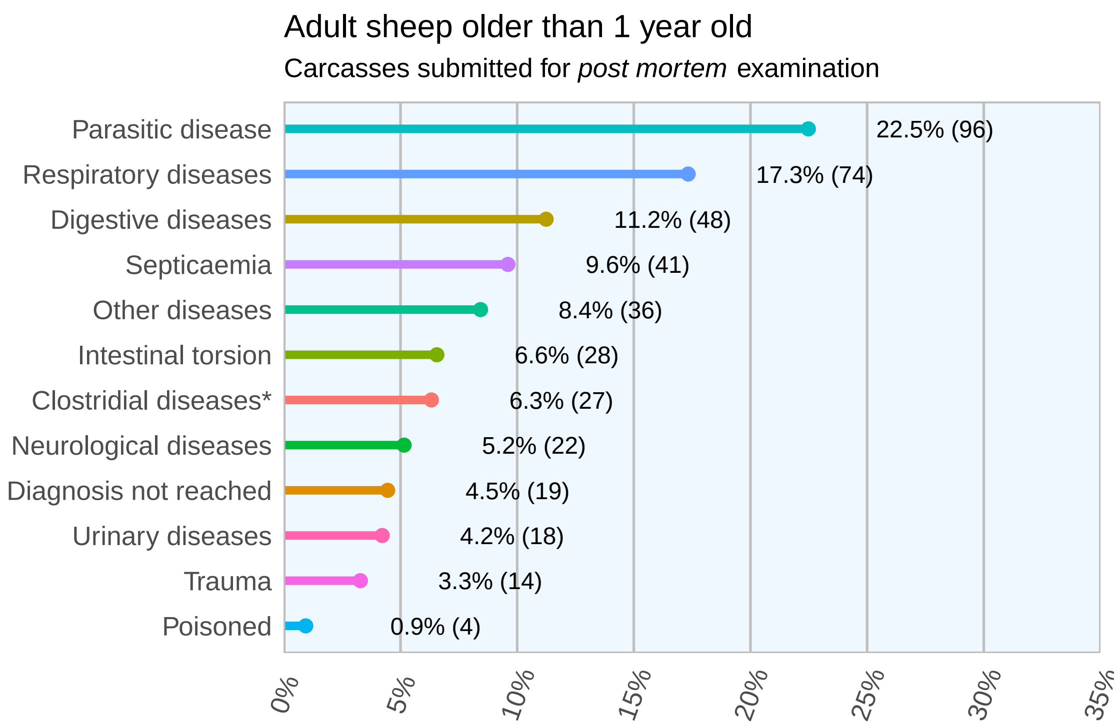


Figure 22.2.: Relative frequency of the different aetiological agents identified in cases of parasitic disease of small ruminants over 12 month of age diagnosed during *post mortem* by AFBI in 2022 (n=427). The absolute number of cases is between brackets.

22.2. Ovine Abortion

Specimens from 197 ovine abortions and stillbirths were examined during 2022 (Table 22.1 and Figure 22.3). Significant pathogens were detected in 117 cases (60.0 *per cent*). Pathogens identified included *C. abortus* (28 cases, 14.2 *per cent*), *T. gondii* (33 cases, 16.8 *per cent*), *Campylobacter spp.* (6 cases 3 *per cent*), *Listeria monocytogenes* (2 cases, 1 *per cent*), *T. pyogenes* (6 cases, 3 *per cent*), *Streptococcus spp.* (3 cases, 1.5 *per cent*) and *E. coli* (12 cases, 6.1 *per cent*).

Table 22.1.: Relative frequency of the identified infectious agents of ovine abortion from submitted foetal *post mortems* in 2022 (n= 117).

Diagnoses	No. of cases	Percentage
Toxoplamsa gondii	33	**28.2**
Chlamydia abortus	28	**23.9**
E.coli	12	**10.3**
Other	9	**7.7**
Trueperella pyogenes	6	**5.1**
Campylobacter spp	6	**5.1**
Mummified foetus	6	**5.1**
Salmonella species	5	**4.3**
Staphylococcus	4	**3.4**
Streptococcus	3	**2.6**
Leptospirosis	3	**2.6**
Listeria monocytogenes	2	**1.7**

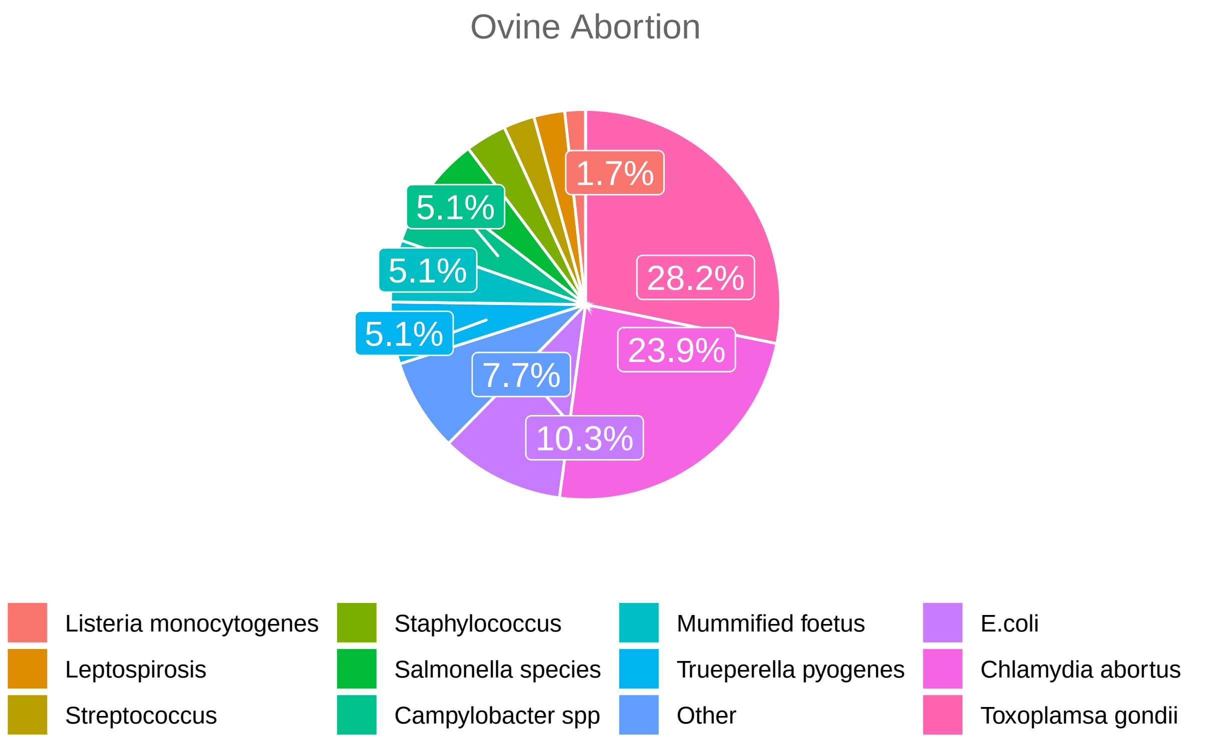


Figure 22.3.: Relative frequency of the identified infectious agents of ovine abortion from submitted foetal *post mortems* in 2022 (n= 117).

It was noted that enzootic abortion remains a very frequent cause of ovine abortion despite the availability of several vaccines. In some flocks control is attempted by the prophylactic use of long acting oxytetracycline during the pre-lambing period. Whilst useful in the face of an outbreak or abortion

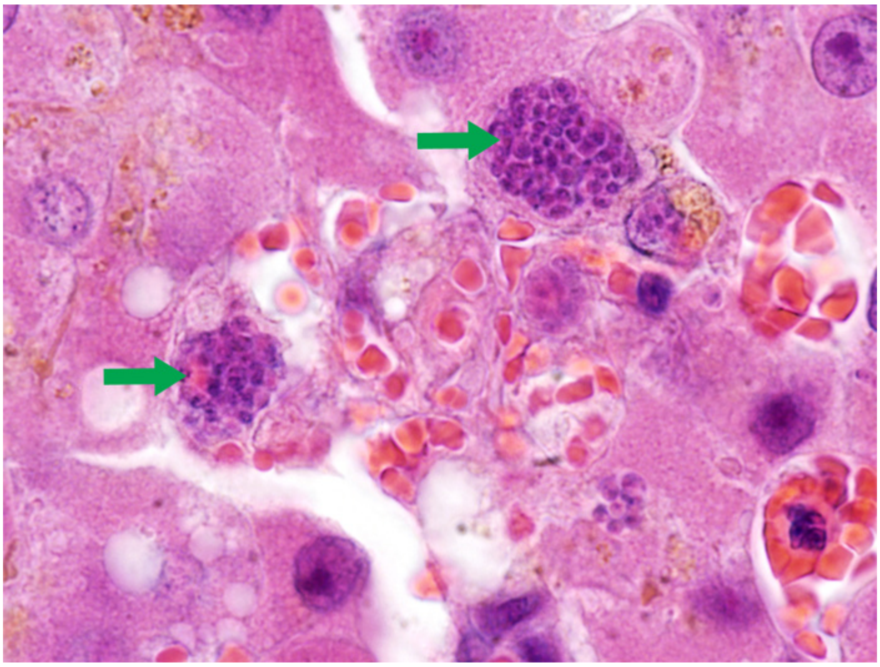


Figure 22.4.: *Toxoplasma gondii* tacyzoites (arrows) in a liver section. Photo: Cosme Sánchez-Miguel

storm, this method has limitations for routine control and serves to increase antibiotic usage in a way that is difficult to justify.

22.3. Ovine Parasites

Bob Hanna, *Veterinary Research Officer*
Stormont Veterinary Laboratory,
12 Stoney Road, Belfast BT4 3SD, Northern Ireland

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 22.5).

Figure 22.5.: Nematodirus eggs (A), trichostrongyle egg (B) and coccidian oocyst (C) in a faecal sample. Photo: Bob Hanna.

The number of trichostrongyle eggs detected is consistently higher in sheep when compared to cattle (Figure 22.6 and Figure 21.19 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. Further, 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 28 *per cent* in 2021 to 32.3 *per cent* in 2022 (number of samples examined, n=711; Figure 22.6), a higher figure than that recorded in recent years. Peak FECs occurred in autumn (corresponding to parasitic gastroenteritis in lambs at pasture). The small spring peak in FECs recorded in previous years (corresponding to increased egg shedding by periparturient ewes) was also noted in 2022. It has been found that the rates of diagnosis 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 (C. McMahon et al. 2012)

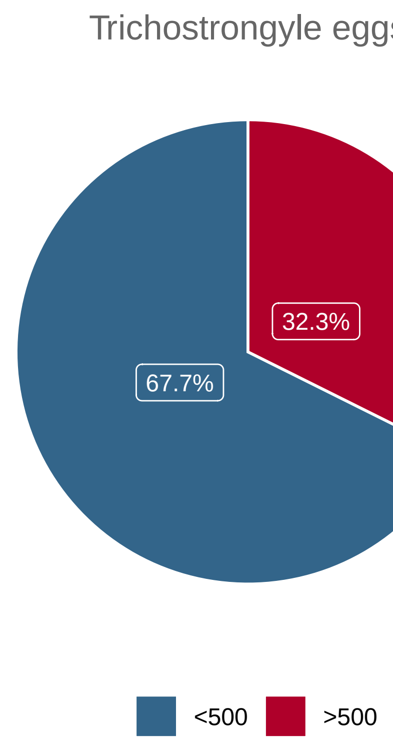


Figure 22.6.: Relative frequency of detection of trichostrongyle eggs in ovine faecal samples examined by AFBI in 2022 (n=711).

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 [Mcmahon2013a]. 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 [Mcmahon2013b]. The latest edition of the SCOPS (Sustainable Control of Parasites in Sheep) guidelines is accessible at https://www.scops.org.uk.

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 (Figure 22.7).

Figure 22.7.: *L3* larva of Nematodirus. Photo: Bob Hanna.

When lambs are weaned and are beginning to eat more grass, these *L3* larvae are ingested. If enough larvae are taken in, severe clinical disease can result. Faecal egg counts of more than 200 characteristic Nematodirus eggs per gram (Figure 22.8) 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 VSD 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 709 faecal samples examined for Nematodirus eggs in 2022, 8.7 *per cent* were found to contain ≥200 epg (Figure 22.8), a small decrease from the level recorded in 2021 (9.0 *per cent*), but still markedly higher than the level recorded in 2019 (4.6 *per cent*).

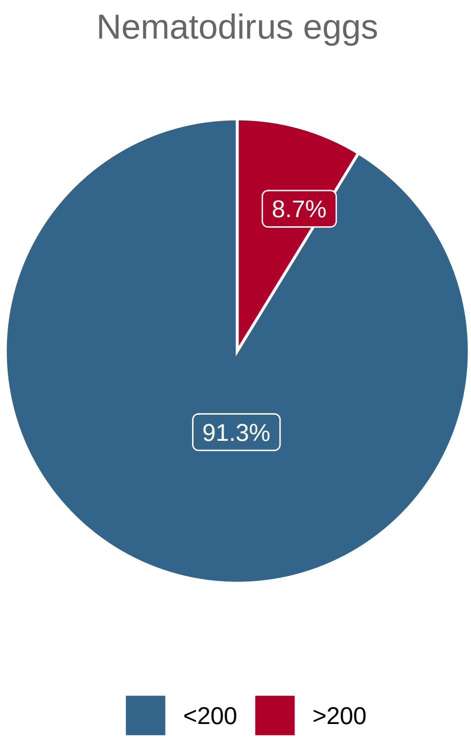


Figure 22.8.: Relative frequency of detection of Nematodirus eggs in ovine faecal samples examined by AFBI in 2022 (n=709).

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 (Connor 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 (Connor McMahon et al. 2017).

Coccidiosis

In 2022, as in previous years, coccidial oocysts were detected more frequently in sheep than in cattle faeces samples. Of the sheep samples examined in 2022, 68.8 *per cent* (n=710) were positive for oocysts (compared to 63.0 *per cent* in 2021, 69.2 *per cent* in 2020 and 69.4 *per cent* in 2019), but only 24.9 *per cent* exhibited moderate or high levels (Figure 22.9). 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.

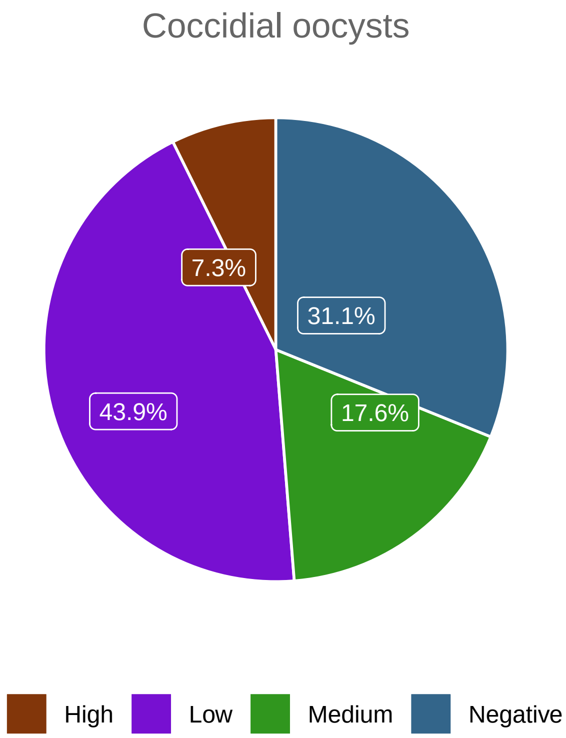


Figure 22.9.: Results for ovine faecal samples tested for coccidial oocysts during 2022 (n=710).

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 22.10), and deaths may result from septicaemia caused by ingress of bacteria through the damaged intestine wall.

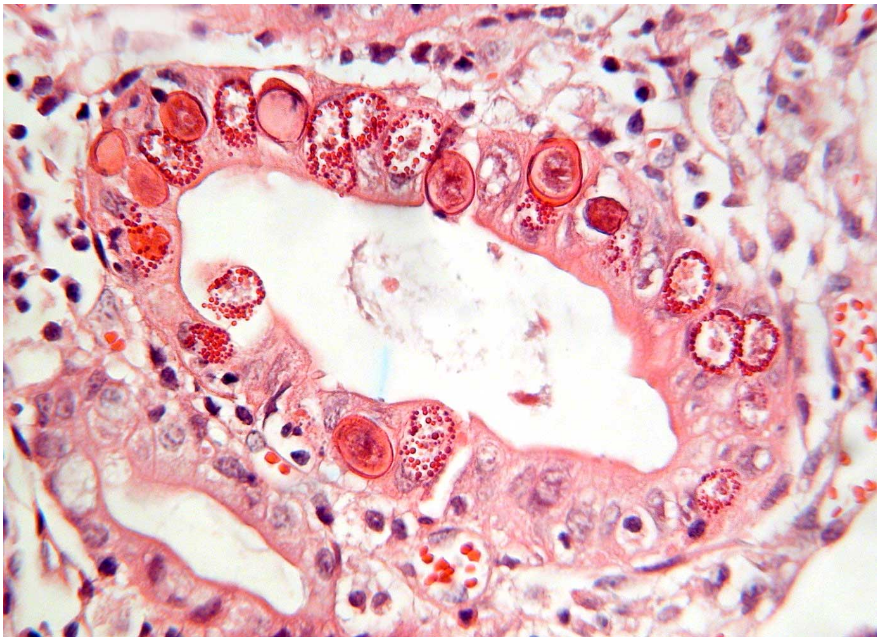


Figure 22.10.: Histopathology section of coccidiosis in the gut wall of a lamb. Photo: Bob Hanna.

Lambs are usually affected between 4 and 7 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 prevent overwhelming coccidial infection. Lambs with severe scouring 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 2022, rumen fluke eggs and liver fluke eggs were detected with similar frequency in faecal samples (positive FECs were recorded in 20.2 *per cent* and 19.5 *per cent* of 629 and 729 faecal samples respectively; fig-afbirumenflukeovpiefig and fig-afbiliverflukeeovpiefig). The percentage with liver fluke eggs detected has therefore shown an increase from 2021, when 11.0

per cent of samples examined yielded positive results, and is higher than the figures for 2020 (17.1 *per cent*) and 2019 (8.3 *per cent*). In 2022, 20.2 *per cent* of faecal samples tested were positive for rumen flukes (a reduction from 26.0 *per cent* in 2021, 24.1 *per cent* in 2020 and 25.0 *per cent* in 2019). Bearing in mind that the molluscan intermediate host (*Galba truncatula*) is the same for both types of fluke, the perceived decrease in rumen fluke incidence compared to liver fluke incidence is difficult to explain. It is likely that the findings may reflect local climatic differences or changes in stockholder behaviour in sample submission between 2019 and 2022. The possibility of intra-molluscan competitive effects between liver fluke and rumen fluke larval stages has yet to be researched fully. There is increased awareness of triclabendazole resistance in flukes in Northern Ireland, resulting in a shift towards control of *F. hepatica* by use of alternative products (containing for example closantel) to kill adult fluke in sheep and cattle in late winter and early spring [Hanna et al. (2015); Fairweather et al. (2020)). Of the available drugs, only oxyclozanide has proven efficacy against rumen fluke.

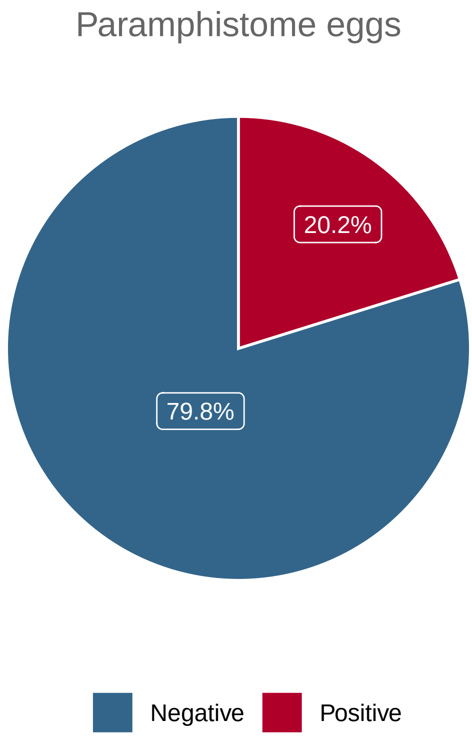


Figure 22.11.: Relative frequency of detection of Paramphistome eggs in ovine faecal samples examined by AFBI in 2022 (n=629).

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 22.13). 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 22.14). 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.

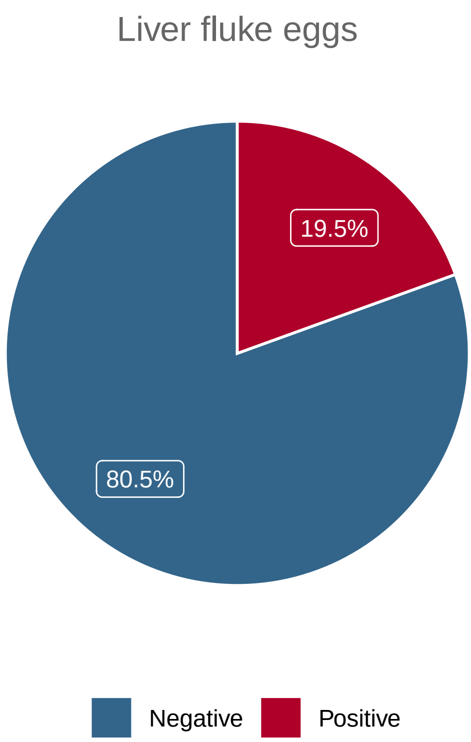


Figure 22.12.: Relative frequency of detection of liver fluke eggs in ovine faecal samples examined by AFBI in 2022 (n=729).

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 infective 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.

Figure 22.13.: Liver haemorrhage in acute fasciolosis. Photo: Bob Hanna.

Resistance to fluke treatments is an emerging problem and has been detected in Northern Ireland (Hanna et al. 2015). On some 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 dung 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 (Hanna et al. 2015; 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.

Figure 22.14.: Adult liver fluke in the main bile duct of a sheep. Photo: Bob Hanna.

Adult rumen flukes are less damaging to sheep and cattle than liver flukes, but heavy infections of immature worms may cause diarrhoea, ill-thrift and, exceptionally, death in young animals. Heavy burdens of adult rumen flukes have been reported to result in poor productivity in dairy or meat-producing animals, but few scientific studies have been completed. Liver flukes, particularly in acute infections, are potentially a much more serious risk to the welfare and productivity of sheep than stomach flukes, and the choice of which flukicides 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 with liver fluke in mind and only then, if need be, for rumen fluke. Further information on fluke disease in cattle and sheep may be found on the AFBI website https://www.afbini.gov.uk/.

23. Porcine and Avian Diseases, AFBI

Siobhan Corry, *Veterinary Research Officer*
Omagh Veterinary Laboratory,
43 Beltany road, Omagh BT78 5NF, Northern Ireland

23.1. Porcine disease

The pig industry in Northern Ireland continues to grow with the total pig numbers recorded in the June 2022 Agricultural census at 738,540 up 3 *per cent* from June 2021. A small number of highly productive businesses make up a large proportion of the Northern Ireland pig industry with most pigs concentrated on few farms. Units of more than 200 sows hold almost 80 percent of total breeding sows (DAERA Agricultural Census of Northern Ireland 2022). Whilst the majority of pig medicine is carried out by a few specialist pig veterinarians there are also many pigs kept on smaller holdings as farm pigs or even as pets and these animals may be seen by any veterinary practice. As in previous years, respiratory diseases and neurological diseases made up the majority of conditions diagnosed in pig submissions for *post mortem*.

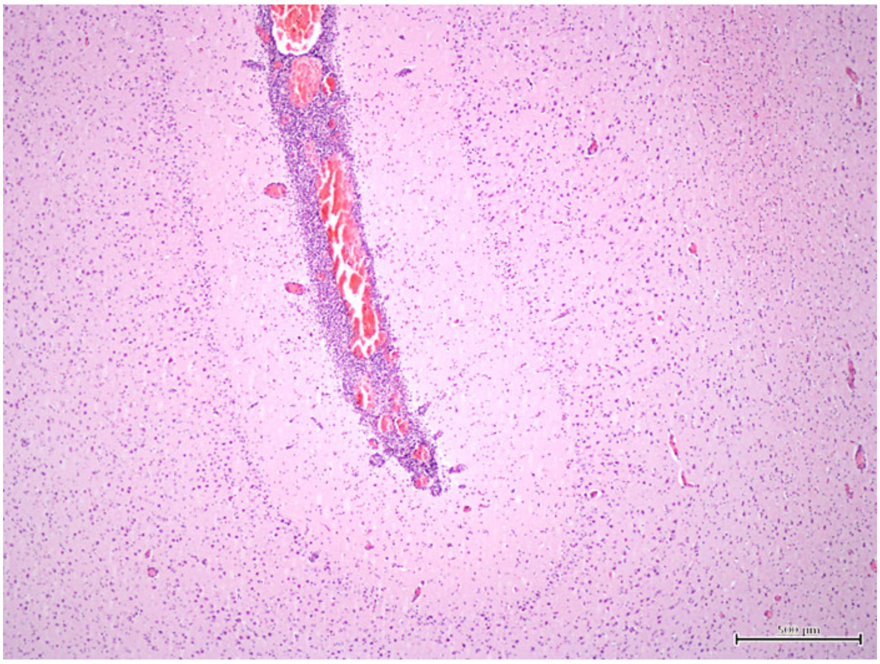


Figure 23.1.: A photograph of a case of bacterial meningitis from which *Streptococcus suis* was isolated. The sulcus is filled with neutrophils, other mononuclear cells, cell debris,fibrin and oedema fluid. Photo: Siobhan Corry.

Bacterial infections due to *Streptococcus spp.*, *E.coli* and *Salmonella* species were predominant diagnoses. Neurological conditions were predominantly due to suppurative meningitis, particularly of young pigs. Neonatal bacterial suppurative meningitis (NBSM) is an important clinical entity in pigs with *Steptococcus suis* commonly isolated. Most pigs carry *Streptococus suis* in their upper respiratory tract and development of bacteraemia will depend on a number of factors including the virulence of the strain present, stress factors such as high stocking density and mixing of groups and concurrent infections and diseases.

African Swine Fever Alert

African Swine Fever (ASF) is a highly contagious viral disease of pigs which can cause a high mortality rate. It is a notifiable epizootic disease. African Swine Fever is spreading in Europe and all those involved in pig production should be aware of the disease and their role in preventing its spread. Anyone who suspects ASF must immediately alert DAERA. Further information on ASF is available on the DAERA website. DAERA also has an epizootic hotline available: 0300 200 7852 (office hours) 028 9052 5596 (out of office hours)

23.2. Avian Disease

AFBI receives avian submissions every year not only from commercial and backyard farms for disease diagnosis, but also from the PSNI for the investigation of wildlife crime as well as submissions from the Department of Agriculture, Environment and Rural Affairs (DAERA) for the investigation of notifiable and epizootic disease in domestic and wild birds. Submissions consist of either single carcases, groups of up to six birds from a flock or diagnostic samples such as faeces or swabs taken on farm by private practitioners or DAERA vets. The number of birds kept on commercial poultry farms in Northern Ireland in 2022 totalled approximately 20.6 million birds. A small number of highly productive poultry farms make up a large proportion of the Northern Ireland poultry industry with just over 100 flocks containing over 50, 000 birds, (DAERA Agricultural census of Northern Ireland 2022).

Figure 23.2.: Pathology associated with *Histomonas meleagridis* in the liver of a turkey submitted for *post mortem* examination. Photo: Seán Fee.

Whilst the majority of commercial poultry medicine is carried out by a few specialist poultry veterinarians there are also many birds kept in backyard flocks and these animals may be seen by any veterinary practice. The following case reports are examples of diagnoses made on avian submission to AFBI Omagh and Stormont *post mortem* rooms.

Multiple superficial mucosal erosions were present on the duodenal epithelium of layers aged 35 weeks submitted for *post mortem* examination. Focal duodenal necrosis is a disease of egg laying chicken associated with decreased egg size and drop in production. The cause of the disease is unknown, but *Clostridium perfringens* type A has been implicated in the disease and alpha toxin, the significant toxin of *Clostridium perfringens* type A was detected in the intestinal contents taken from this case.

A turkey was submitted for *post mortem* examination following sudden death. There had been an increased mortality in the flock. *Histomonas meleagridis* organisms were detected on the liver histopathology. Histomoniasis (Figure 23.2), also known as Blackhead, is a protozoan parasitic infection of gallinaceous birds- heavy, ground feeding birds such as chickens and turkeys. Whilst chickens tend to be asymptomatic carriers, mortality rates in turkeys can be as high as 80 to 100 *per cent*. The protozoa are transmitted in the egg of the nematode *Heterakis gallinarum* and these eggs can remain infective in the environment for many years. Earthworms also play a role by acting as a host for the infective *H. gallinarum*.

Bird Flu Alert

Avian Influenza is a notifiable disease. Poultry keepers (including backyard poultry, game birds and pets) should remain vigilant for any signs of the disease in their animals. If a notifiable disease is suspected in a domestic or wild bird contact the DAERA Helpline on **0300 200 7840** or your local DAERA Direct Regional Office. Failure to do so is an offence. More information can be found here Avian Influenza (AI) | Department of Agriculture, Environment and Rural Affairs (daera-ni.gov.uk)

Part VIII.

Animal Health Ireland

24. Animal Health Ireland

Animal Health Ireland[1] provides benefits to livestock producers and processors by providing the knowledge, education and coordination required to establish effective control programmes for non-regulated diseases of livestock.

Constituted as a Company Limited by Guarantee, AHI functions as a partnership between private sector organisations and businesses in the agri-food sector and the Department of Agriculture, Food and the Marine. It is a not-for-profit organisation which receives no guaranteed income from the State; government funding is provided on the basis of strict matching with private sector contributions up to an agreed limit, meaning that the organisation depends entirely on its ability to attract investment from the private sector. The fact that Animal Health Ireland has continued to attract and grow such support over the period since its establishment bears testimony to the organisation's ability to deliver real outcomes on behalf of its stakeholders.

Animal Health Ireland provides benefits to livestock producers and processors by providing the knowledge, education and coordination required to establish effective control programmes for non-regulated diseases of livestock. The advice provided by AHI is developed by a number of Technical Working Groups, whose major outputs and policy advice, wherever possible, are published in international peer-reviewed journals.

Vision

Animal Health Ireland will be recognised as a world-class resource enabling Irish farmers and the agri-food industry to achieve and maintain the highest international standards of animal health, to improve the profitability and sustainability of their enterprises and to enhance the value and competitiveness of Irish products in the marketplace.

Mission

To contribute to an economically, socially and environmentally sustainable farming and agrifood sector through improved animal health and welfare.

[1] https://animalhealthireland.ie

Remit

Animal Health Ireland is tasked with pursuing effective control strategies for economically important diseases of livestock which are not subject to international regulation.

Values

The following values are strongly held and underpin our work with, and on behalf of, our stakeholders:

Service – we are committed to delivering outcomes of real and quantifiable value to our stakeholders. Objective – we base our practices, including the design and development of our programmes, on research, robust analysis, technical expertise and international best practice. *Collaborative – we recognise that our objectives can only be achieved through collaboration, and we continually engage with our stakeholders to maximise their contributions to all aspects of our work programmes and to ensure that these are aligned with their requirements.* Innovative – we constantly review the delivery of work programmes on behalf of our stakeholders, seeking better ways in which to add value to their businesses. *Accountable – we are committed to complete transparency in accounting to our stakeholders for the use of the resources with which they provide us to achieve shared objectives.

25. Bovine viral diarrhoea (BVD) Eradication Programme

María Guelbenzu Gonzalo
BVD & IBR Programme Manager
Animal Health Ireland (AHI)

25.1. Overview

A series of enhancements to the BVD eradication programme were introduced in 2021 in order to progress to eradication and to align the programme with the new European Animal Health Law (AHL). The AHL sets out the requirements for approval of national BVD eradication programmes at EU level for the first time, and the conditions that must be met for recognition of freedom under an approved programme. In July 2022 the Irish BVD programme was approved by the EU Commission. This approval is a key milestone for the programme and a prerequisite for applying for recognition for freedom.

25.2. Results

Since the beginning of 2021, animals with an initial positive or inconclusive BVD virus result that are not subject to re-test, or are negative on re-test at least 21 days later, are considered suspect. A confirmed case is considered persistently infected (PI) with BVD virus as defined by the OIE (OIE, 2021), having an initial positive or inconclusive result by RT-PCR or antigen capture ELISA which is again positive or inconclusive on a subsequent test at least 21 days later and without a subsequent negative result. Over 2.44 million calves were born in 2022. 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 99.6 *per cent* of these calves. Only 0.029 *per cent* of calves tested in the year had positive or inconclusive results, which when put in the context of all the animals in Ireland, the animal level prevalence is 0.01 *per cent*. The prevalence of herds with a suspect or confirmed BVD case continued to decrease to only 0.45 *per cent* of 83,000 breeding herds. We can now see the distribution of these herds in Figure 25.1. A highlight of the year is that Co Carlow was free from BVD during 2022. When all herds are taking into account (circa 109k), the herd-level prevalence is 0.28 *per cent*. Updated programme results are available on a weekly basis here[1].

For herds where a positive/inconclusive result is disclosed, an immediate restriction of animal movements for both moves in and out to reduce the risk of infected animals leaving the herd and spreading the virus. A series of requirements must be completed before the restriction may be lifted and these include an initial three-week period of herd restriction, beginning on the date of removal

[1] https://animalhealthireland.ie/programmes/bvd/programme-results/

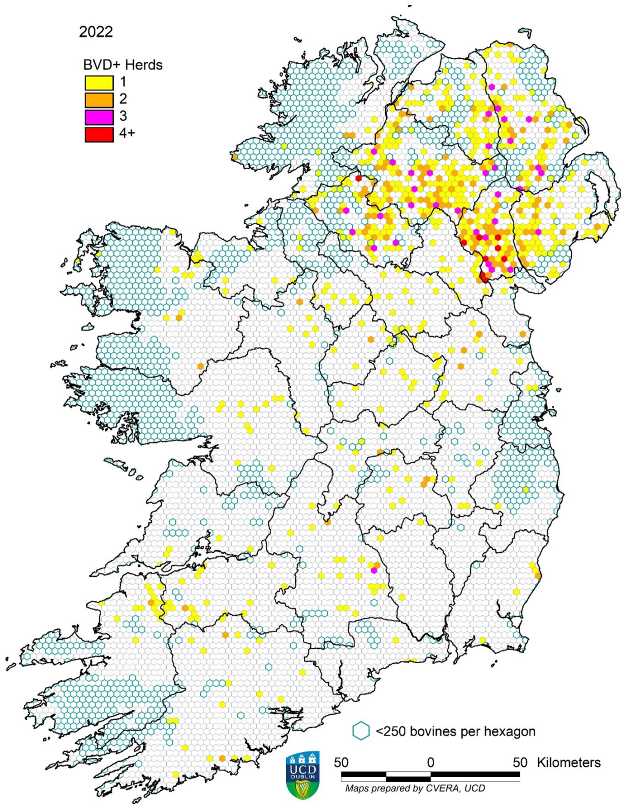


Figure 25.1.: Map showing distribution of herds with a suspect or confirmed BVD suspect animals born in 2022 up to the 31st December. Each hexagon represents an area of approximately 10km2.

of the suspect animal, which serves as a *circuit-breaker* to allow circulation of any additional transient infections established by the suspect or confirmed animal(s) to diminish or cease. After this period, the restrictions are lifted following completion of each of the following three measures by a trained private veterinary practitioner (PVP) nominated by the herd owner: an epidemiological investigation, carrying out a full herd test, and vaccinating all female breeding animals. By the end of 2022, over 48k animals had been blood tested and close to 61k had been vaccinated.

The measures have had an impact in reducing the period from test to removal of positive calves when compared to previous years. Analysis of the time in days showed that in 2019 this took a median of 7 days whilst in 2020 it reduced to 6 days and in 2021 and 2022 it was further reduced to a median of 3 days. While this further improvement is encouraging, it is critical that calves are tested as soon as possible and that suspect or confirmed cases are removed without delay in order to deliver further progress in the programme.

25.3. Negative herd status

By the end of 2022, close to 96 *per cent* of breeding herds had acquired NHS, with a further 3,000 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 RT-PCR test method offering testing at reduced costs to herds with NHS.

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

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 suspect or confirmed animal(s) from the herd in the 18 months preceding the acquisition of NHS.

The status of almost all animals (99.6 *per cent*) in the 83,000 breeding herds in Ireland is now known, including 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 2022, after a number of phone calls by the BVD Helpdesk, the number of these animals was reduced to 152. The majority of these animals are in beef herds. 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 12,778 at the end of 2022. 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 2022-born (88 *per cent*), with smaller numbers from preceding years. During the last year DAFM has issued letters to these herds and the BVD Helpdesk has also made contact, informing them of the need to test these animals.

26. Infectious Bovine Rhinotrachetis (IBR) Eradication Programme

María Guelbenzu Gonzalo
BVD & IBR Programme Manager
Animal Health Ireland (AHI)

26.1. Overview

During 2022, the IBR Technical Working Group finalised a proposal for a national IBR programme, supported by the Irish IBR model. A series of questions and options were explored and the impact on the time that would take to achieve eradication, the overall costs and other considerations were assessed. The model, which is a regional model based on County Kerry, can reproduce the herd structure, management practices and transport patterns of the entire cattle population without being dependent on continuous livestock registry data. One of the innovations of this model is that it incorporates the new classification system for Irish herds which brings a detailed understanding of herd types and subtypes, extending these beyond the those of dairy, beef and mixed herds that are commonly considered (Brock et al. 2022) . In total, seventeen herd classes were identified in Ireland. This proposal would align with the requirements of the new Animal Health Law (AHL) which came 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.

During the last quarter of 2022, the national IBR programme proposal was presented to the Department of Agriculture, Food and the Marine in advance of a meeting of the IBR Implementation Group (IBRIG), which is scheduled for February 2023. Also, sectoral costs and associated assumptions in terms of herd prevalence and cow numbers that are included in the Irish IBR model have been reviewed. In addition, costs associated with IBR status on Irish dairy farms included in the 'Analysis of the economics of BoHV-1 infection in Ireland' (available in AHI's website), have been updated. Based on a herd-level prevalence of 80 *per cent* and a dairy cow population of 1.55 million, annual losses in the dairy sector at the current milk price are estimated at €106 million.

26.2. IBR control and sustainability

During 2022, IBR control has been highlighted to the Food Vision Dairy and Beef Groups, as a measure that can contribute to environmental sustainability (GHG) through increased efficiency of production. It can also contribute to economic sustainability through increased financial returns and social sustainability through reduced antimicrobial use and improved animal welfare.

Reducing the prevalence of IBR nationally is one of the animal health measures under Action 5 of the AgClimatise Roadmap (Further enhance animal health strategies to support climate ambitions and environmental sustainability through promotion of sustainable animal health and welfare practices and enhancing food safety and authenticity). The role of IBR control in the sustainability of the Irish farming sector has also been explored and recognised by a range of roadmaps, strategies and plans brought forward by DAFM, including iNAP2 and the Climate Action Plan (2021). It is now recognised that animal health plays a role with improving economic, environmental and social and sustainability through improved efficiency and welfare, reduced antibiotic usage and reduced greenhouse gas emissions per unit of output.

26.3. Vaccination

A key tool for control that will be included as part of an IBR programme proposal is vaccination. When implemented appropriately on farm, it contributes to reducing the number of infected animals over time. Currently in Ireland there is a continued high level of expenditure on IBR vaccination. During 2021, over 3.15 million IBR vaccine doses were sold (Figure 26.1). This is an increase from the previous 12 months and reflects a continuing trend seen over the past 5 years. However, while this increased use of vaccination should be contributing to a reduction in the proportion of carrier animals in infected herds, it has not yet resulted in a consistent change in the proportion of herds with positive bulk tank results.

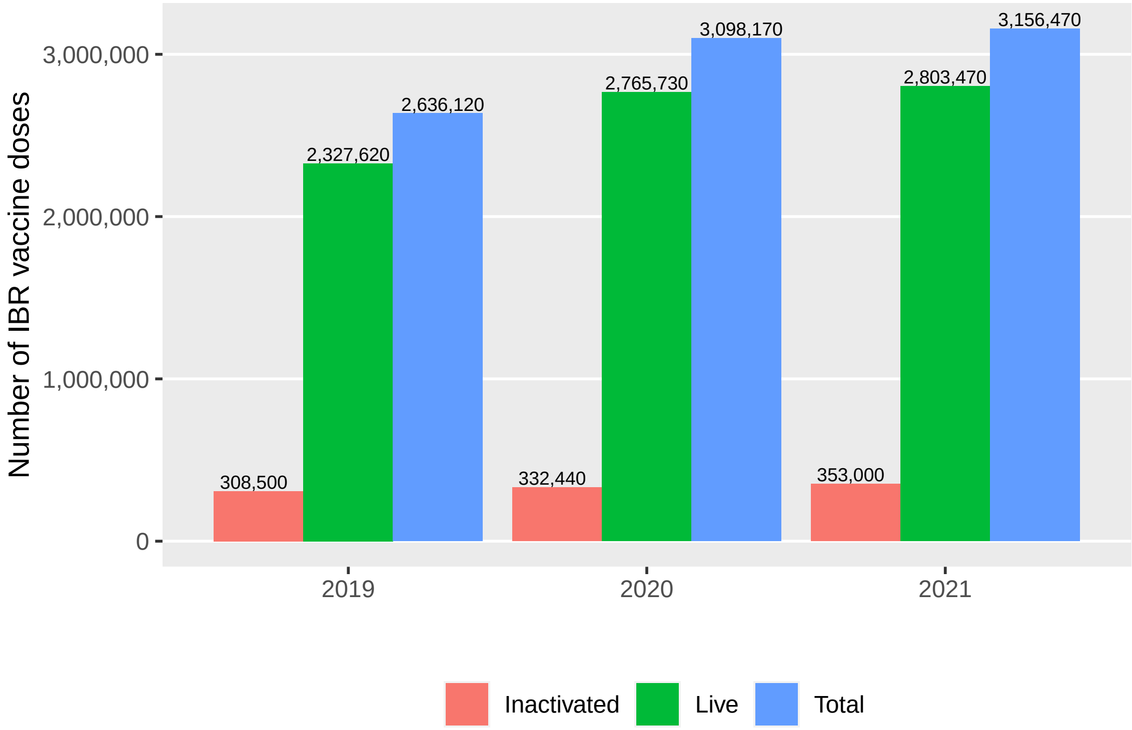


Figure 26.1.: Number of doses of IBR vaccine sold by year and vaccine type (inactivated, live) and total.

26.4. Bulk tank milk testing

The detection of antibodies is a useful and cost-effective tool for the monitoring and control of diseases. The application of bulk tank milk (BTM) as a herd level diagnostic tool has been used extensively in IBR disease control programmes around Europe. This collection of samples is cheap and easy, helping to reduce the cost of surveillance programmes. Since 2019, DAFM has undertaken national surveillance of dairy herds for IBR *gE* antibodies using bulk tank milk samples, with two rounds of testing per year being carried out each spring and autumn. The latest set of results show that 79 *per cent* of the bulk tank milks were positive to IBR *gE*.

A positive IBR gE BTM test result is obtained in herds with moderate to high prevalence of latently infected carrier animals, with ongoing circulation of the virus. Despite IBR vaccine sales increasing during the past few years (to over 3.1 million doses sold in 2021), which should be contributing to a reduction in the proportion of seropositive (carrier) animals in infected herds, it has not yet resulted in a reduction in the proportion of herds with positive bulk tank results. The results from this testing and a proposed plan for communicating these to herd owners will shortly be discussed both by the IBR Technical working group (TWG) and the IBR implementation group (IG). When agreed, results will be made available to herd owners by ICBF on behalf of DAFM.

It is proposed that the communication of the IBR BTM results will be accompanied by targeted messaging to encourage measures to reduce IBR prevalence. This is consistent with one of the Animal Health Actions contained within the AgClimatise Roadmap and the Annex to the Climate Action Plan (CAP) published in 2021 (CAP: https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/ and AgClimatise: https://www.gov.ie/en/publication/07fbe-ag-climatise-a-roadmap-towards-climate-neutrality/).

27. Irish Johne's Control Programme (IJCP)

Liam Doyle
Johne's disease (JD) Programme Manager
Animal Health Ireland (AHI)

Phase 2 of the IJCP finished at the end of 2022, having been implemented for a four year period (2019 to 2022 inclusive). Currently AHI have completed a comprehensive review of the 2019 to 2022 programme activities which in collaboration with the JD Technical Working Group (TWG), JD Implementation Group (IG) and stakeholders is being used to formulate a Phase 3 of the IJCP.

The essential components of the IJCP which members implemented during Phase 2 were as follows:

1. Nomination of an Approved Veterinary Practitioner (AVP), these being private veterinary practitioners who had undertaken JD training delivered by AHI.
2. Regular completion of a Veterinary Risk Assessment and Management Plan (VRAMP) by a nominated AVP.
3. An annual Whole Herd Test (WHT) of eligible animals (those aged 2 years and above) in years one to four of the programme using either a milk or serum sample from each animal.
4. Ancillary testing of faecal samples (by PCR) of all animals following ELISA test-positive or inconclusive results in herds where infection has not already been confirmed (i.e., absence of previous faecal-positive result).
5. Veterinary investigation, funded through the Targeted Advisory Service on Animal Health (TASAH) under the Rural Development Programme, following positive ancillary test results.
6. Members undertake not to move any animal that is inconclusive, positive or suspect based on testing for JD, except directly to a knackery, licensed slaughter premises, feedlot or herd from which animals are exclusively sent to slaughter.

27.1. Programme delivery

Approved Veterianry Practices (AVPs)

There are currently 531 AVPs trained and active in the programme carrying out VRAMPs and 477 AVPs trained to complete TASAH investigations. VRAMP

Figure 27.1 below shows VRAMP completions for the years 2019 to 2022 inclusive. According to a herd's test results which are initially assessed in the first year of IJCP membership (Year 1) it is allocated to a particular pathway at the start of its second year; test negative pathway (TNP) or test positive pathway (TPP). Along with the pathway a herd is also allocated number of years in that pathway, starting at two. During the four years of Phase 2 of the IJCP all herds, no matter what their pathway or number of years all required completion of an annual WHT. In terms of VRAMPs all herds except for those in Year 4 TNP required annual VRAMP completion, shown in Figure 1 as the 370 herds which did not complete a VRAMP in 2022. In 2022 1183 VRAMPS were completed which along with the 370 TNP year 4 herds not requiring a VRAMP meant that 1553 of the total registered herds (n=2109) fulfilled programme requirements. 556 herds registered in the programme did not complete a VRAMP in 2022.

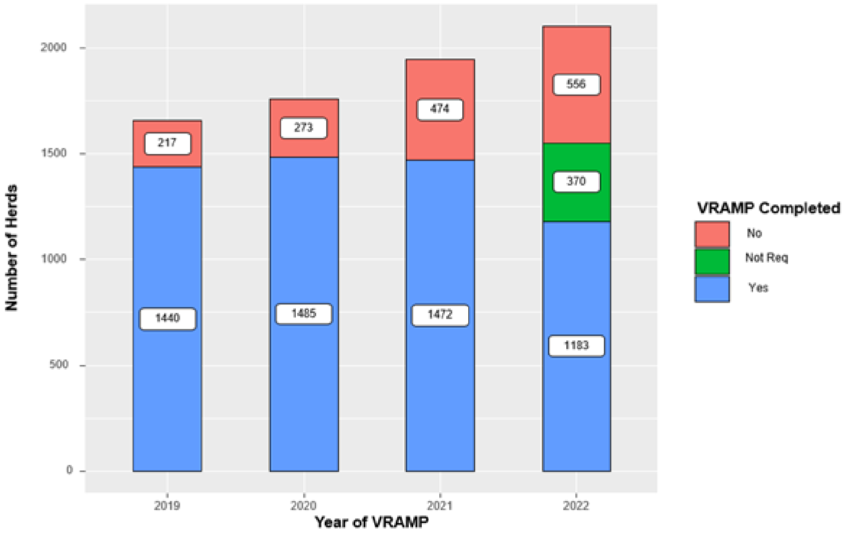


Figure 27.1.: Number of herds per year categorised by VRAMP completion status.

Figure 27.2 below shows the pattern of VRAMP completions in years 2019 to 2022. Line graphs for each year recording monthly totals of VRAMPs completed show a similar pattern of completion in each, with most completions towards the end of the programme year. 2022 was different from previous years, as already described in that a cohort of herds (n=370) in year 4 TNP were not required to complete a VRAMP. This is the reason why the line graph for year 4 TNP does not start at zero in January 2022.

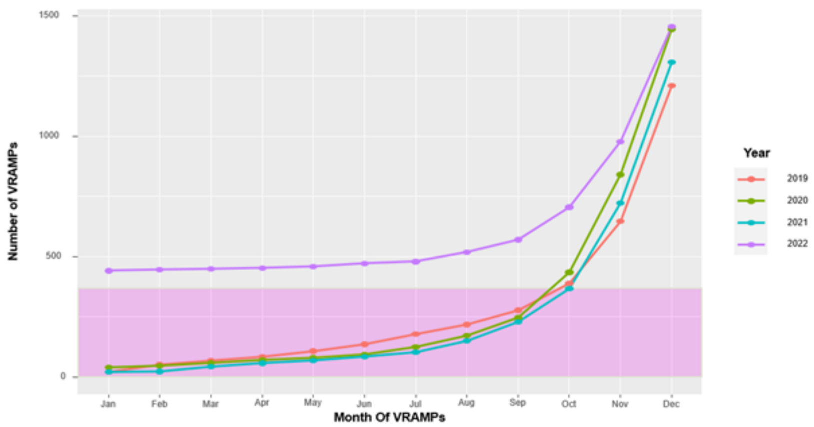


Figure 27.2.: VRAMP completions per month 2019 to 2022.

Table 27.1.: IJCP ELISA testing conducted during 2022.

Test	Sample	No. of tests	Negative	Positive	Inconclusive
ELISA	Blood	88310 (40%)	84472	**2834 (3.2%)**	1004 (1.1%)
ELISA	Milk	131737 (60%)	125698	**3393 (2.6%)**	2646 (2.0%)
Total ELISA	Milk + Blood	220047	210170	**6227**	3650

Whole Herd Test (WHT)

At the end of the programme year for 2022 (31st of January2023) 1,263 whole herd tests (WHT) have been completed in both beef and dairy herds (60 *per cent*) with 239 herds having started a WHT but not completing it (11 *per cent*) (Figure 27.3). The median number of cattle not tested in these 239 partially completed WHTs was seven (IQR: 4–15). 607 herds did not start a WHT in 2022 (29 *per cent*). The number of herds not starting a WHT in 2022 is greater than 2021 (607 vs. 457; Figure 27.2), partially explained by the larger membership in 2022 vs. 2021.

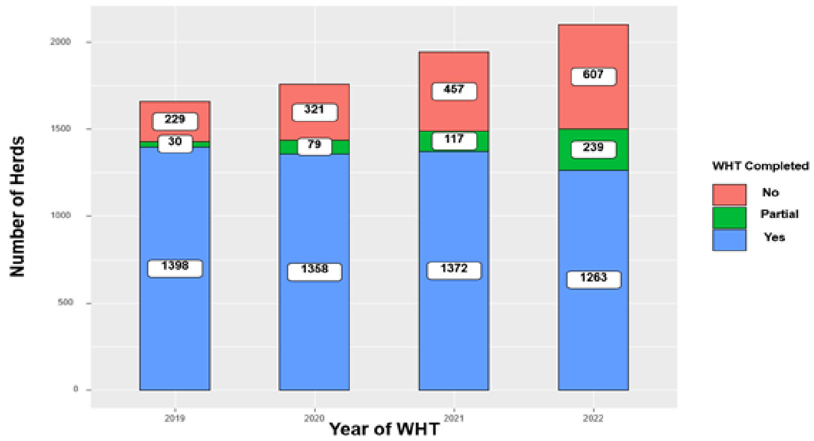


Figure 27.3.: Number of herds per year categorised by WHT completion status. % figures relate to the overall total number of herds (2,109).

WHTs are carried out using either milk or blood ELISA tests. The proportion of testing using milk ELISA has increased due to the increase in herdowners utilizing milk recording in their herds. The total number of ELISA tests (milk and blood) carried out in 2022 was 220,047 (2021 – 224,610) made up of 88,310 (40 *per cent*) blood ELISA tests and 131,737 (60 *per cent*) milk ELISA tests. With blood ELISA tests there was 2,834 positive results (3.2 *per cent*)) and 3,393 positive milk ELISA tests (2.6 *per cent*)). With blood ELISA tests there was disclosure of 1,004 inconclusive results (1.1 *per cent*)) and 2,646 inconclusive milk ELISA tests (2.0 *per cent*)) (Table 27.1).

Figure 27.4 below shows the combined total of blood and milk ELISA tests per month carried out each year from 2020 to 2022. The pattern of testing is similar in 2022 to both 2021 and 2020 with most of the testing being carried out between June and October.

Ancillary testing of faecal samples (by PCR)

Ancillary testing of all animals is carried out following ELISA test-positive or inconclusive results in herds where infection has not already been confirmed (i.e., absence of previous faecal-positive result).

In 2022 there was a total of 4,941 ancillary PCR tests carried out of which 302 (6.1 *per cent*)) were

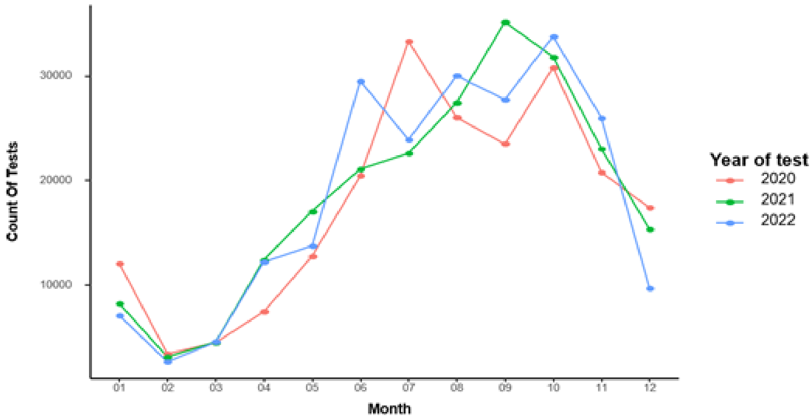


Figure 27.4.: Line chart showing combined total of blood and milk ELISA tests per month 2020 to 2022.

Table 27.2.: IJCP ancillary testing conducted during 2022.

Year	Test	Sample	No. of tests	Negative	Positive	Inconclusive
2022	PCR	Faeces	4941	4619	**302 (6.1%)**	20

positive (Table 27.2). This positivity rate is increased relative to 2021 when it was 3.5 *per cent*). Figure 27.5 shows the monthly count of ancillary PCR tests carried out for each of the years 2019 to 2022. The pattern across the years is consistent, with a marked increase in the number of tests conducted in the last 3 months of each year.

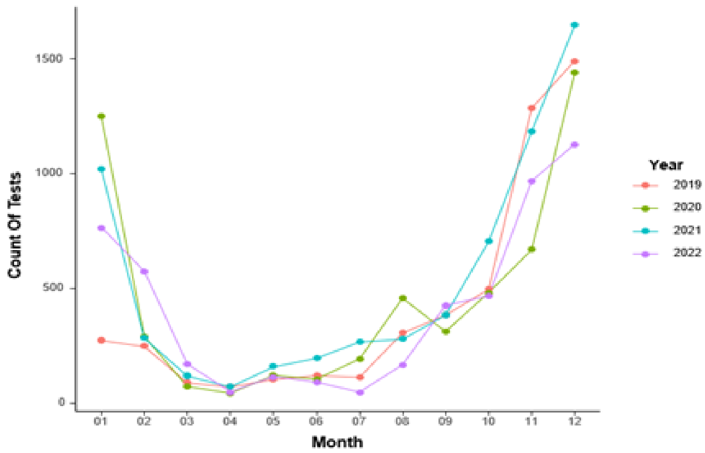


Figure 27.5.: Monthly count of ancillary PCR tests per year 2019 to 2022.

27.2. Targeted Advisory Service on Animal Health (TASAH)

The number of JD TASAH investigations completed per year, up to 2022 (The TASAH is an epidemiological investigation conducted by a trained vet to assess source, prevalence and impact of infection post the disclosure of a positive ancillary (Faecal PCR Test positive) (Table 27.3).

Table 27.3.: The number of JD TASAH investigations completed per year.

Year	Number of PCR test positives
2019	**68**
2020	**88**
2021	**84**
2022	**97**

MAP Bulk Tank Milk (BTM) testing summary

The use of BTM testing is a valuable and cost-effective method for monitoring and controlling diseases. For Johnes disease, since 2019, national surveillance of dairy herds has been conducted by the Department of Agriculture, Food and Marine (DAFM) to detect MAP antibodies using BTM samples. Two rounds of testing are performed each year, during spring and autumn. Results are shown up to 2022 (8 rounds of testing) and have been analysed (Figure 27.6).

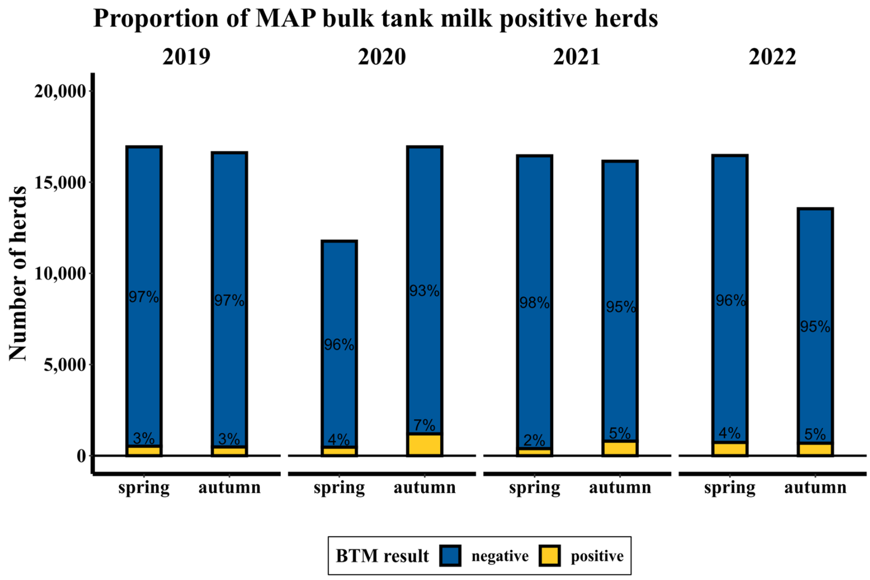


Figure 27.6.: MAP BMT testing each Spring and Autumn 2019 to 2022 inclusive.

The findings reveal a limited occurrence of antibody detection (2–7 *per cent*) per testing round), which is considerably lower than the estimated overall infection prevalence in the population (30 *per cent*)). This disparity arises due to the fact that the proportion of cows with antibodies in positive herds falls below the threshold necessary to consistently yield a positive result in bulk tank testing. As a result, a negative outcome offers little assurance that a herd is infection-free. However, a positive result is useful for case detection, suggesting that the level of infection present is at the upper end of the national profile.

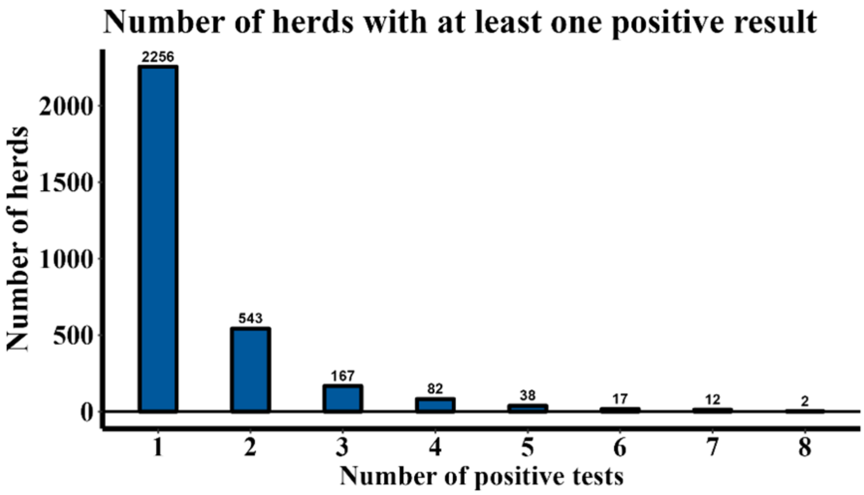


Figure 27.7.: Number of herds with at least one positive result

Of the 17,182 herds tested across any of the 8 sampling points, 3,117 tested positive at least once. These herds are informed by a letter from the Department of Agriculture, Food and the Marine (DAFM) of their positive results and encouraged to join the IJCP. Testing of samples will continue with a round each Spring and Autumn.

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A. R packages

The analysis, construction of graphics and visualisation of data for this 2022 *All-Island Animal Disease Surveillance* report have been conducted by using the R programming language, R version 4.2.2 (2023-02-21) (R Core Team 2021), and Quarto[1] integrated development environment of Poxit](https://posit.co/).

Extensive use of the collection packages of the tidyverse universe[2] (Wickham et al. 2019,) and the LaTeX[3] systems were utilised in this report for formatting and typesetting the final HTML and LaTeX documents.

Most of the data analysis was carried out with the packages included in *tidyverse* (Wickham 2022b); the charts were plotted using the package *ggplot2* (Wickham 2016) and the tables constructed with *kableExtra* (Zhu 2021) and *finalfit* (Harrison, Drake, and Ots 2021).

Many other R packages and LaTeX packages were also used in the preparation and compilation of this report, for further information see the references below.

[1] https://quarto.org/
[2] https://joss.theoj.org/papers/10.21105/joss.01686
[3] https://www.latex-project.org/