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

All-Island Animal Disease Surveillance Report

2021

In collaboration with the Agri-Food and Biosciences Institute and Animal Health Ireland

ALL-ISLAND ANIMAL DISEASE SURVEILLANCE REPORT

2021

15 of March, 2023

This document has been compiled in collaboration with:

- Department of Agriculture, Food and the Marine of Ireland
- Agri-Food & Biosciences Institute, Northern Ireland
- Animal Health Ireland

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INTRODUCTION

The delivery of the 2021 All-Island Surveillance Report is later than normal this year, and this is regretted. It is however a timely reminder of how this report is produced each year. It is, the work of vets and scientists across nine veterinary laboratories in two jurisdictions, with two different laboratory information management systems, neither of them optimised for data extraction and visualisation. It is both a constraint we have to work within, and a matter of some pride, that the entire report is written, compiled and produced by these same veterinarians and scientists, and particularly from its inception, the Editor Cosme Sánchez-Miguel, assisted by others. The publication is compiled in the spaces and breaks between *post mortems*, phone advice and all of the other tasks AFBI & DAFM deliver to stakeholders of our busy veterinary diagnostic laboratories. There are no administrative, graphic design or other inputs. It is a heroic achievement, if we say so ourselves.

We are pleased to be able to say, for the first time, that we have been able to assign some additional resources in Cork to the production of the next (2022) All-Island Disease Surveillance Report, and we hope to be able to bring forward the publication date of the 2022 report to a date within the following calendar year as heretofore.

We thank all who worked to produce the report, especially Cosme, and wish all our readers the best for the coming year.

Mícheál Casey, Head of Regional Veterinary Laboratories

Barry McInerney, Head of Disease Surveillance and Investigation Branch

PREFACE

This All-Island Animal Disease Surveillance Report (AIADSR) is the sixteenth Animal Disease Surveillance Report and the eleventh report in collaboration with our colleagues from the Agri-Food and Bioscience Institute (AFBI), Northern Ireland, and Animal Health Ireland (AHI).

As in the previous three years, most of the data has been almost entirely analysed and compiled with the programming languages R and LaTeX respectively. Both languages provide an excellent environment for data analysis, visualisation and typesetting, and we hope that this edition reflects the surveillance work carried out in the different institutions contributing to this report.

Although the AIADSR is intended for Private Veterinary Practitioners, it has always been conceived and constructed to provide valuable animal health surveillance information to other stakeholders. An effort has been made to present and visualise the data by including numerous tables, colourful charts and photos throughout its pages to transmit the information gathered from submissions to the Veterinary Laboratory Service (VLS) of the Department of Agriculture, 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.

Cosme Sánchez-Miguel (Editor)

Cork Regional Veterinary Laboratory

Acknowledgements

The 2021 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 2021 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), Lawrence Gavey (AHI) and Siobhan Corry (AFBI) and their colleagues for their collaboration in the 2021 All-Island Animal Disease Surveillance Report.

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

Cosme Sánchez-Miguel (Editor)

Cork Regional Veterinary Laboratory, DAFM.

BEASTINGS

(the colostrum of a cow)

Thick, strong yellow gold,
slow and heavy, teaming
with immunoglobulins,
its belly taut and tender,
Christmas afternoon full, of good.

Scum forms, a wax sealing.
Minded in buckets safe behind gates,
in corners behind hay bales,
in washed milk cartons, zip locked
bags in freezers for emergencies.

Any chance of a drop of beastings,
I've a cow down here with no milk.
Consignments passed with good wishes,
collected in cars in the dark of mornings
or nights,*I'll stay going and feed this calf, thanks.*

Cajoled to glug intently down
stomach tubes to clot
in abomasums, antibodies seeping
into capillaries. Or sucked through
pulsing calf tongue funnels.

A litre of beastings would make you up
old farmer, lining your raw stomach and guts,
heating you, putting the life back into you.
But your cow house is quiet, your neighbours'
freezers empty, the time for beastings passed.

— **MARESA SHEEHAN**, Kilkenny RVL

Part I

Cattle Diseases

CHAPTER 1

OVERVIEW OF CATTLE DISEASES

Rebecca Froehlich-Kelly, *Research Officer*
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The central veterinary laboratory and five regional veterinary laboratories (RVLs) received approximately 770 bovine carcass submissions for necropsy in 2021. For better analysis, submissions have been categorised below into age groups with an analysis of most frequent diagnoses.

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

1.1 Neonatal Calves (birth to one month of age)

In 2021, 692 neonatal calves were submitted to the RVL network for *post mortem* examination. Similar to previous years, gastrointestinal infections were diagnosed most frequently as the cause of death, affecting 258 (37.3 *per cent*) of submitted neonatal calves (Table 1.1 and Figure 1.1). Pathogens involved are discussed in detail in the chapter *Neonatal Enteritis*. Gastrointestinal infections, especially those caused by bacteria, e.g. coliforms, are also often associated with hypogammaglobulinaemia as they can affect passive immune transfer in the first hours after birth. The resulting hypogammaglobulinaemia commonly leads to a higher incidence of associated conditions like systemic infection, the navel ill-joint ill-complex, and respiratory disease. This emphasises the need for good quality colostrum with as little contamination as possible for the neonatal calf, as well as good calving pen hygiene and clean equipment like stomach tubes.

Table 1.1: Conditions most frequently diagnosed on *post mortem* examinations of bovine neonatal calves in 2021 (n=692).

Category	No. of Cases	Percentage
GIT Infections	258	**37.3**
Systemic Infections	101	**14.6**
Respiratory Infections	63	**9.1**
Navel Ill/Joint Ill	53	**7.7**
GIT ulcer/perforation/foreign body	51	**7.4**
Other	38	**5.5**
GIT torsion/obstruction	36	**5.2**
Hereditary and developmental abnormality	34	**4.9**
Peritonitis	15	**2.2**
Diagnosis not reached	14	**2.0**
Nutritional/metabolic conditions	11	**1.6**
Trauma	10	**1.4**
Cardiac/circulatory conditions	8	**1.2**

Note:
The ’Other’ grouping combines
multiple minor categories that have less than five cases.

The second most common cause of death was attributed to systemic infections. Those were diagnosed as the cause of death in 101 cases (14.6 *per cent*). Systemic infections are defined as affecting many organs instead of just one organ, with haematogenous spread common. While there are many entry points for pathogens, the gastrointestinal tract, navel and respiratory system are the most common ports of entry in newborn calves.

Accordingly, respiratory infections and navel ill/joint ill were diagnosed in 63 (9.1 *per cent*) and 53 (7.7 *per cent*) cases, respectively, bringing them to the third and fourth most common diagnoses. As highlighted above, these four most common diagnoses can all be related to poor colostral immunity as well as hygiene/management issues.

Gastric ulceration (Figure 1.2) with or without perforation/foreign bodies was assigned as

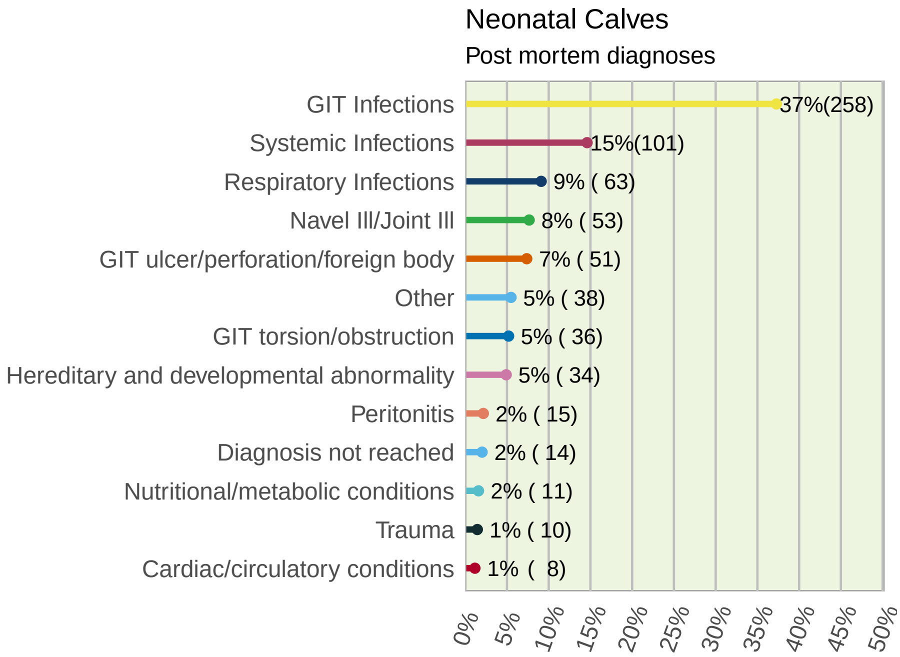

Figure 1.1: Conditions most frequently diagnosed on *post mortem* examinations of bovine neonatal calves in 2021 (n=692). Note: the 'Other' grouping combines multiple minor categories with less than five cases. The absolute number of cases is between brackets.

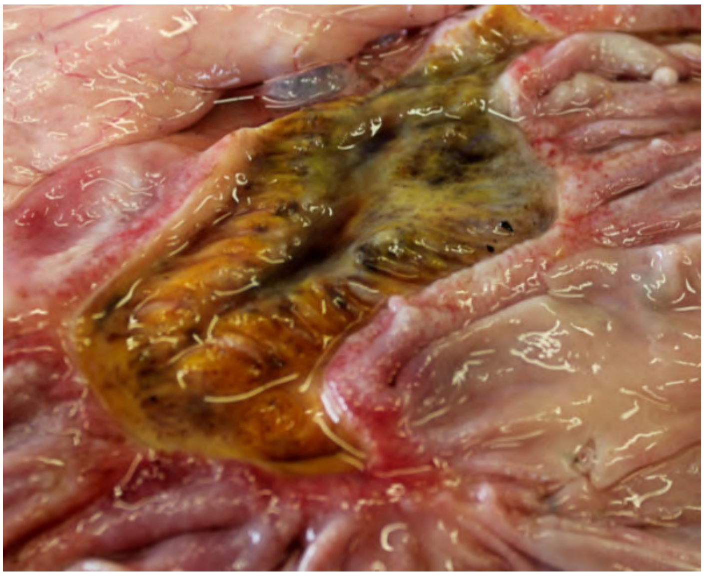

Figure 1.2: Abomasal ulceration in a calf. Photo: Rebecca Froehlich-Kelly

the cause of death for 51 cases (7.4 *per cent*). In recent years, this number seemed to rise slightly. The pathogenesis of abomasal ulceration in cattle is not fully elucidated but has been associated with other concurrent diseases. Recently, there seems to be a rise in the number of cases of abomasal bloat in milk-fed calves. Management and hygiene appear to be critical factors in preventing the condition. Gastrointestinal issues included cases of intestinal torsion or obstruction, which accounted for 36 cases (5.2 *per cent*). In 34 cases (4.9 *per cent*), a hereditary defect leading to death was diagnosed. Most commonly, these

Table 1.2: Conditions most frequently diagnosed on *post mortem* examinations of calves (1-5 months old) in 2021 (n=699).

Category	No. of Cases	Percentage
Respiratory Infections	213	**30.5**
GIT torsion/obstruction	96	**13.7**
GIT Infections	84	**12.0**
Systemic Infections	49	**7.0**
GIT ulcer/perforation/foreign body	47	**6.7**
Clostridial disease	35	**5.0**
Diagnosis not reached	29	**4.2**
Cardiac/circulatory conditions	21	**3.0**
Nutritional/metabolic conditions	21	**3.0**
Other	16	**2.3**
CNS	16	**2.3**
Peritonitis	14	**2.0**
Urinary Tract conditions	11	**1.6**
Hereditary and developmental abnormality	10	**1.4**
Integument/Musculoskeletal	10	**1.4**
Liver disease	9	**1.3**
Navel Ill/Joint Ill	9	**1.3**
Poisoning	9	**1.3**

Note:
The 'Other' grouping combines
multiple minor categories that have less than five cases.

include various atresias of the intestines or malformations of the heart. Cause of death could not be established in 14 cases (4 *per cent*).

1.2 Calves (one to five months of age)

In total 699 carcases of calves aged one-to-five months were submitted to DAFM RVLs in 2021. As in previous years, respiratory disease was the most common cause of death reported, involving 213 (30.5 *per cent*) cases. A breakdown of involved pathogens is presented in greater in detail in the chapter 2 of *Bovine Respiratory Disease*. Gastric torsion, obstructions and gastrointestinal infections were the second (96 cases, 13.7 *per cent*) and the third most common causes of death (84 cases, 12 *per cent*). In particular, intestinal torsions or volvulus are common in calves of this age group; a history of submissions typically describes sudden death or sometimes colic symptoms and *post mortem* abdominal bloat. Death in these cases is caused by severe vascular compromise and intestinal ischaemia, as well as the rapid multiplication of anaerobic bacteria and their toxins which can lead to circulatory shock and death within a short time.

Similar to the younger calves, systemic infections were also prevalent and accounted for 49

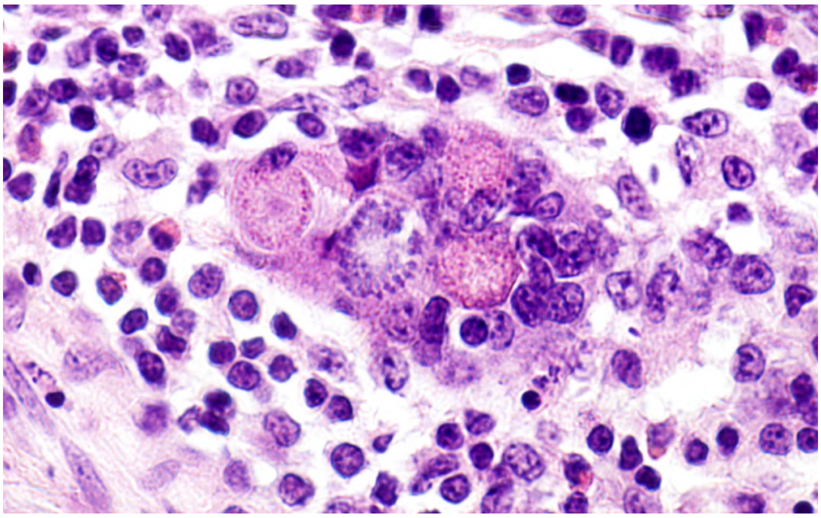

Figure 1.3: Coccidial development stages in the intestinal mucosa of a calf. Photo: Rebecca Froehlich-Kelly

(7 *per cent*) of the 699 cases. Clostridial disease was diagnosed in 35 cases (5 *per cent*). In 29 (4.2 *per cent*) cases a final cause of death could not be determined.

1.3 Weanlings (six months to one year of age)

In 2021, 442 weanlings, cattle aged six months to one year, were submitted to the RVL network for necropsy, a slight rise in cases compared with 2020 and 2019, in which 377 and 367 carcases, respectively, were submitted.

Similar to the previous category of calves, respiratory disease was most commonly associated with death, affecting 152 cases (34.4 *per cent*). This represents a slight decline compared with 2020 when 39.8 *per cent* of deaths were related to respiratory disease, but still slightly more than in 2019, when 30.6 *per cent* of cases were diagnosed with primary respiratory disease. As mentioned above, involved pathogens are discussed in more detail in the chapter 2 of *Bovine Respiratory Disease*.

Gastrointestinal infections affected 92 cases (20.8 *per cent*) and were the second most commonly diagnosed cause of death; clostridial disease was the third most common and affected 56 cases (12.7 *per cent*). Blackleg, an emphysematous myonecrosis, is one of the most commonly found clostridial diseases in cattle and is caused mainly by *Clostridium chauvoei*. Clostridial disease is discussed in more detail in its dedicated chapter. There is a multi-valent vaccine available for the control of clostridial diseases.

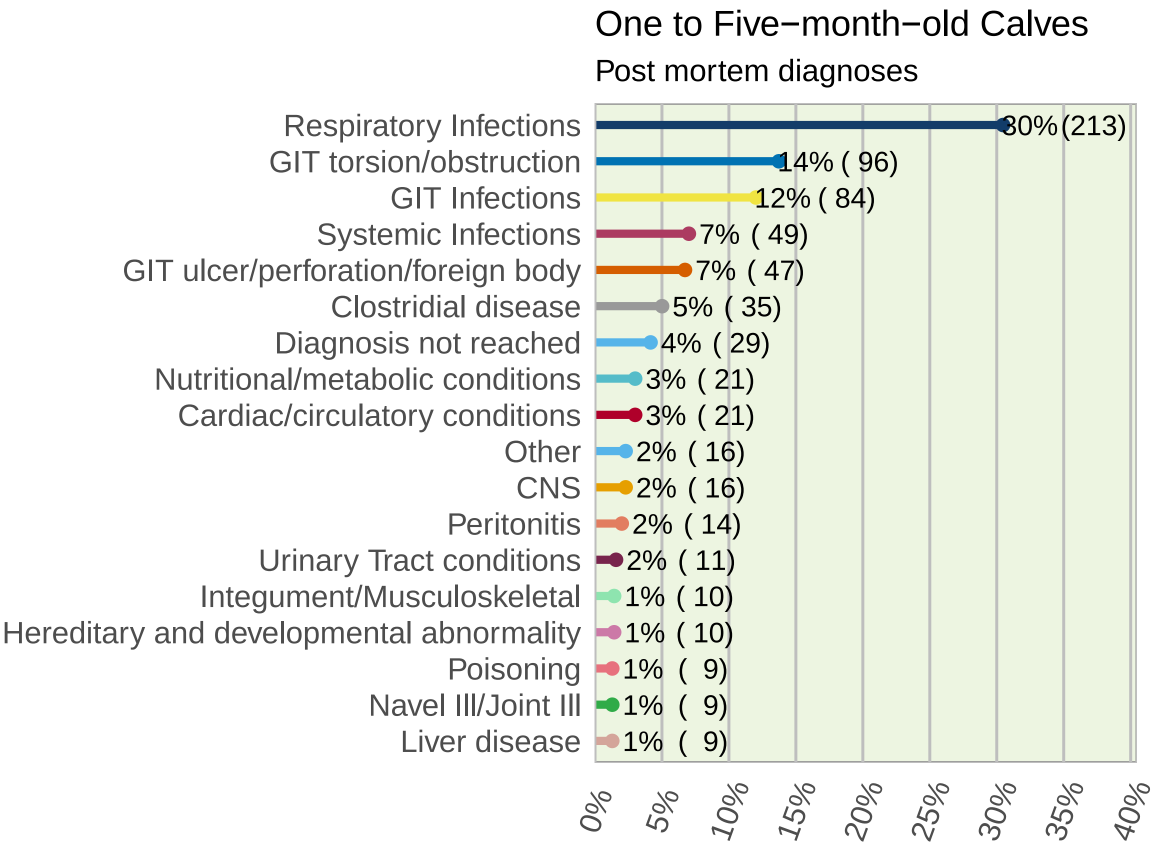

Figure 1.4: Conditions most frequently diagnosed on *post mortem* examinations of calves (1–5 months old) in 2021 (n=699). Note: the 'Other' grouping combines multiple minor categories with less than five cases. The absolute number of cases is between brackets.

1.4 Adult Cattle (over 12 months of age)

Similar to the calf and weanling age categories, respiratory disease emerged as the most common cause of death in adult cattle submitted to DAFM's RVL network. 86 (16.6 *per cent*) cases of the 519 submitted carcasses were diagnosed with respiratory disease as the leading cause of death, a similar proportion as in previous years. Causes of respiratory disease in adult cattle are primarily of infectious nature of parasitic, viral or bacterial origin.

These are in further detail discussed in the chapter 2 of *Bovine Respiratory Disease*. Poisonings were the second most common cause of death and affected 48 cases (9.2 *per cent*). In Ireland, poisonings tend to occur mainly during the grazing season and can be either caused by metals, like lead or copper, or plants in which ragwort or yew tree are the most common. Lead poisoning is the most commonly recorded poisoning. The cases are usually accidental, and discarded car or machinery batteries are the most common source.

Lead poisoning can have more considerable implications for the farm, particularly in dairy, as the entry of excessive lead into the food chain needs to be avoided for public health reasons.

Table 1.3: Conditions most frequently diagnosed on *post mortem* examinations of weanlings (6–12 months old) in 2021 (n=442).

Category	No. of Cases	Percentage
Respiratory Infections	152	**34.4**
GIT Infections	92	**20.8**
Clostridial disease	56	**12.7**
Diagnosis not reached	26	**5.9**
Other	23	**5.2**
Systemic Infections	21	**4.8**
CNS	20	**4.5**
Nutritional/metabolic conditions	14	**3.2**
GIT torsion/obstruction	10	**2.3**
GIT ulcer/perforation/foreign body	10	**2.3**
Cardiac/circulatory conditions	6	**1.4**
Liver disease	6	**1.4**
Peritonitis	6	**1.4**

Note:
The 'Other' grouping combines
multiple minor categories that have less than five cases.

A final diagnosis as a cause of death could not be reached in 37 cases (7.3 *per cent*). Many metabolic conditions, e.g. hypomagnesaemia or hypocalcaemia, are not easily diagnosed on *post mortem* examination, particularly if the carcase is not fresh. Often further investigation, which can include blood samples of cohort animals, is needed to investigate further.

Cardiac and circulatory system conditions were identified as the cause of death in 35 cases (6.7 *per cent*). This category includes endocarditis, pericarditis, caudal vena cava thrombosis, haemorrhage and haemolytic disorders.

Similar to weanlings and calves, clostridial disease was one of the most commonly diagnosed causes of death. In cows, usually Blackleg, which is predominantly but not exclusively caused by *C chauvoei*, and Black's disease (Figure 1.8), caused by *C novyi*, are the mainly diagnosed conditions and are in greater detail discussed in the chapter 9 of *Clostridial diseases*.

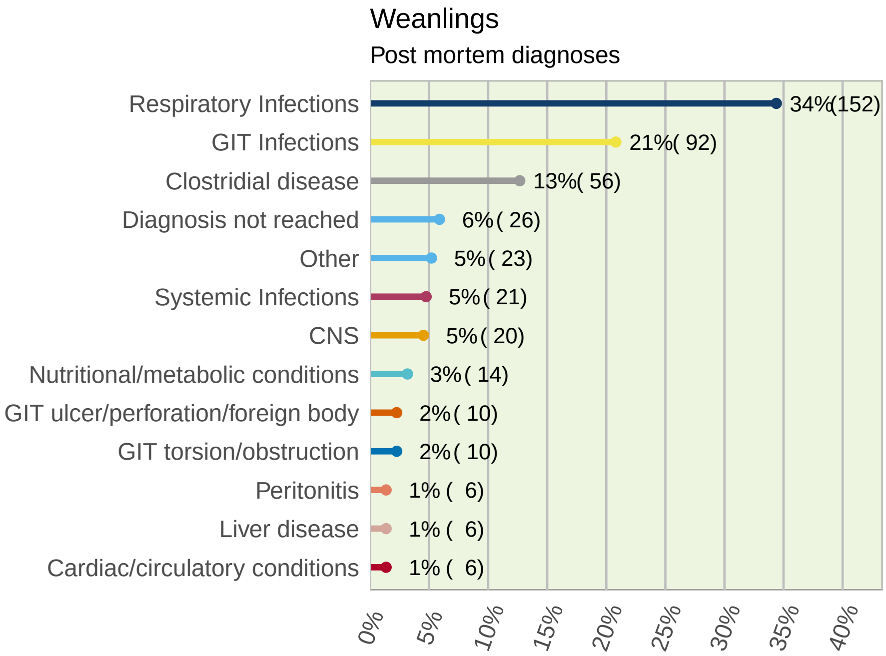

Figure 1.5: Conditions most frequently diagnosed on *post mortem* examinations of weanlings (6–12 months old) in 2021 (n=442).Note: the 'Other' grouping combines multiple minor categories with less than five cases. The absolute number of cases is between brackets.

Figure 1.6: Pulmonal abscessation and pneumonia. Photo: Rebecca Froehlich-Kelly

Table 1.4: Conditions most frequently diagnosed on *post mortem* examinations of adult cattle (over 12 months old) in 2021 (n=519).

Category	No. of Cases	Percentage
Respiratory Infections	86	**16.6**
Poisoning	48	**9.2**
Diagnosis not reached	38	**7.3**
Cardiac/circulatory conditions	35	**6.7**
Clostridial disease	31	**6.0**
Systemic Infections	29	**5.6**
Nutritional/metabolic conditions	27	**5.2**
Other	26	**5.0**
GIT Infections	26	**5.0**
CNS	25	**4.8**
GIT ulcer/perforation/foreign body	21	**4.0**
Peritonitis	20	**3.8**
Liver disease	16	**3.1**
Integument/Musculoskeletal	14	**2.7**
Tumour	13	**2.5**
GIT torsion/obstruction	12	**2.3**
Mastitis	11	**2.1**
Reproductive Tract Conditions	11	**2.1**
Trauma	9	**1.7**
Johne’s Disease	8	**1.5**
Abscessation	7	**1.4**
Babesiosis	6	**1.2**

Note:
The ’Other’ grouping combines
multiple minor categories that have less than five cases.

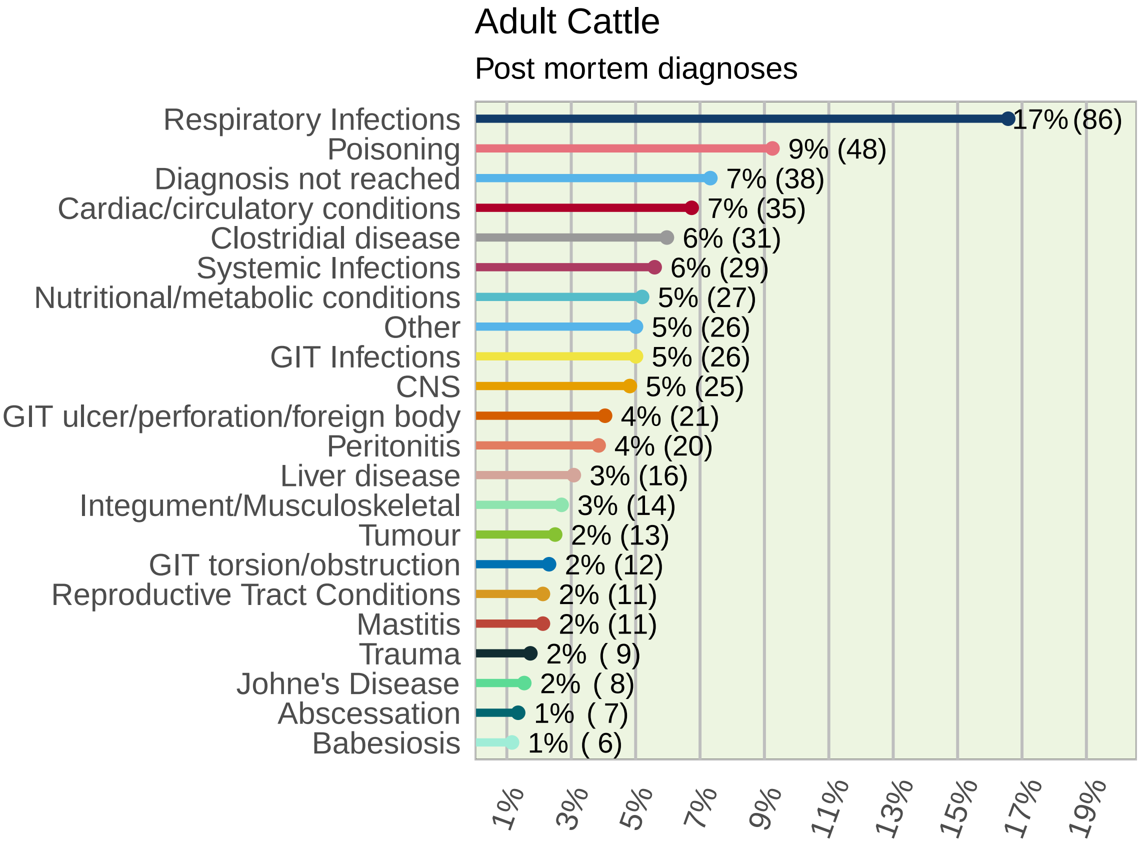

Figure 1.7: Conditions most frequently diagnosed on *post mortem* examinations of adult cattle (over 12 months old) in 2021 (n=519). Note: the 'Other' grouping combines multiple minor categories with less than five cases. The absolute number of cases is between brackets.

Figure 1.8: Typical ischaemic liver lesion in a cow with Black's disease. Photo: Rebecca Froehlich-Kelly

CHAPTER 2

Bovine Respiratory Disease

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Leggatsrath, Hebron Road, Kilkenny, Ireland

Bovine respiratory disease (BDR) remained one of the leading causes of mortality in cattle in 2021. Clinical signs consistent with BRD include pyrexia, depression, anorexia, serous to muco-prurulent ocular and/or nasal discharges, increased respiratory rate with a variable abdominal component, the presence of a cough, abnormal lung sounds ranging from an absence to the presence of crackles/ wheezes and increased heart rate. In many cases, the disease can be very acute with several animals in the group affected.

Table 2.1: Number of cases and percentage (%) by age of the general pathogenic groups detected in the BRD cases diagnosed on *post mortem* examination (n=507).

Aetiology	Neonatal (0-1 month old)	Calves (1-5 months old)	Weanling (6-12 months old)	Adult Cattle (over 12 months old)	Total
Bacterial	47 (74.6)	146 (68.5)	84 (55.3)	40 (50.6)	**317 (62.5)**
Parasitic	0 (0.0)	32 (15.0)	37 (24.3)	24 (30.4)	**93 (18.3)**
Viral	5 (7.9)	13 (6.1)	21 (13.8)	10 (12.7)	**49 (9.7)**
No agent identified	9 (14.3)	21 (9.9)	8 (5.3)	4 (5.1)	**42 (8.3)**
Fungal	2 (3.2)	0 (0.0)	1 (0.7)	1 (1.3)	**4 (0.8)**
Other	0 (0.0)	1 (0.5)	1 (0.7)	0 (0.0)	**2 (0.4)**

Table 2.2: Number of cases and relative frequency of the top ten pathogenic agents detected in BRD cases diagnosed on *post-mortem* examination (n=507).

Organism	**No. of cases**	**Percentage**
Mannheimia haemolytica	102	**20.1**
Dictyocaulus spp	93	**18.3**
Pasteurella multocida	84	**16.6**
Histophilus somni	43	**8.5**
No agent identified	42	**8.3**
Mycoplasma bovis	40	**7.9**
RSV	26	**5.1**
Other minor organisms	25	**4.9**
Trueperella pyogenes	18	**3.6**
IBR virus	15	**3.0**
Bibersteinia trehalosi	7	**1.4**
PI3	5	**1.0**
Fungal	4	**0.8**
Mycobacterium bovis	3	**0.6**

The portals of entry into the respiratory system include haematogenous spread, direct extension (e.g. hardware disease) and most commonly, aerogenous entry, where pathogens gain access via inspired air. The respiratory tract has several host defence mechanisms, including warming and moistening air in the nasal cavity, the mucociliary escalator, resident microflora, and innate and adaptive immune responses. BRD typically has a multifactorial aetiology that results from complex interactions between pathogens and environmental and host factors. Stressors such as transportation, overcrowding, weaning, mixing and inadequate ventilation can negatively affect the host's defence mechanisms. Numerous infectious agents are associated with BRD. Often an initial pathogen (e.g. viral agents) will alter the animal's defence mechanisms, allowing the colonisation of the lower respiratory tract by additional agents, e.g. bacteria. The animal's immune status is essential in developing pneumonia; failure of passive transfer is a risk for increased severity of respiratory disease in young calves.

BRD cases are often caused by infection with more than one agent. However, there are limitations to identifying the agents involved by *post mortem* examination. Confounding factors include longer disease duration, antimicrobial treatment and the laboratory techniques employed in individual cases. As examples, viral pathogens that initiated BRD may no longer be detectable in the respiratory tracts of animals that have died or were euthanised following a chronic clinical course, or antibiotic treatment *ante mortem* may confound attempts to isolate bacteria.

> 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 with the pathologist acknowledging the possibility that an undetected primary viral infection could have preceded to the development of the bacterial infection (see the section of pathogen interactions).

(a) Fibrinous bronchopneumonia **(b)** lung cut surface

Figure 2.1: (a) Firm and swollen lung with pleura covered with a thick layer of fibrin. Fibrinous bronchopneumonia/pneumonic mannheimiosis (*Manneimia haemolytica*), (b) cut surface of a lung with pneumonic mannheimiosis showing distended interlobular septa by fibrin, and irregular areas of coagulative necrosis. Photos: Aideen Kennedy.

The most frequently identified bacterial agents were ***Mannheimia haemolytica*** and ***Pasteurella multocida***. Both agents are commensals of the nasopharynx, as is *Biberstinia trehalosi* (identified in 1.4 *per cent* of cases). 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.

Histophilus somni was detected in 8.5 *per cent* of cases of BRD. *H. somni* a gram-negative member of the *Pasteurellaceae* family. It causes septicemic infection with clinical presentations, including pneumonia, polyarthritis, myocarditis, abortion and meningoencephalitis. The respiratory system is usually the initial site of replication, followed by spread to the CNS via blood circulation. 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.

Mycoplasma bovis was identified in almost 8 *per cent* of BRD cases in 2021 (Figure 2.3), and was most frequently identified in calves aged 1–5 months of age see (Table 2.2) . In addition to bronchopneumonia *M. bovis* can also cause arthritis, mastitis and otitis media. *M. bovis* has been associated with outbreaks of pneumonia in feedlot cattle and sometimes is followed by an outbreak of polyarthritis following the initial respiratory presentation. *M. bovis* is capable of causing pneumonia on its own or as part of the BRD complex (See pathogen interections in Section 2.3)

Trueperella pyogenes was identified in 3.6 *per cent* of cases; usually, it is a secondary pathogen in pneumonia where other pathogenic respiratory agents have previously acutely damaged tissues. ***Mycobacterium bovis*** (TB) was identified in three cases of respiratory disease.

2.1 Parasitic Bovine Respiratory Disease

Dictyocaulus spp. was the aetiological agent in 18.3 *per cent* of BRD cases in 2021 (Table 2.2). Warm and humid weather favours larval development. The highest number of lungworm cases was recorded in October of 2021 (Figure 2.2). Dictyocaulosis or hoose is typically associated with dairy calves in their first grazing season, as they have no previously acquired immunity (Table 2.3). Older animals can also show signs of the disease. This can occur in older animals with little immunity. 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. 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.

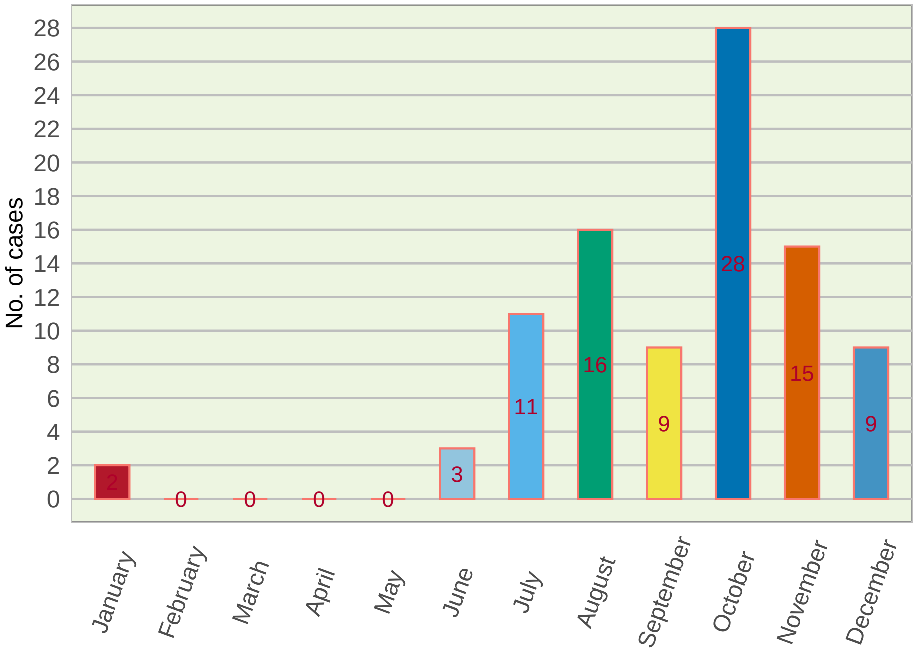


Figure 2.2: Number of diagnoses of parasitic bronchopneumonia by month during 2021 (n=93).

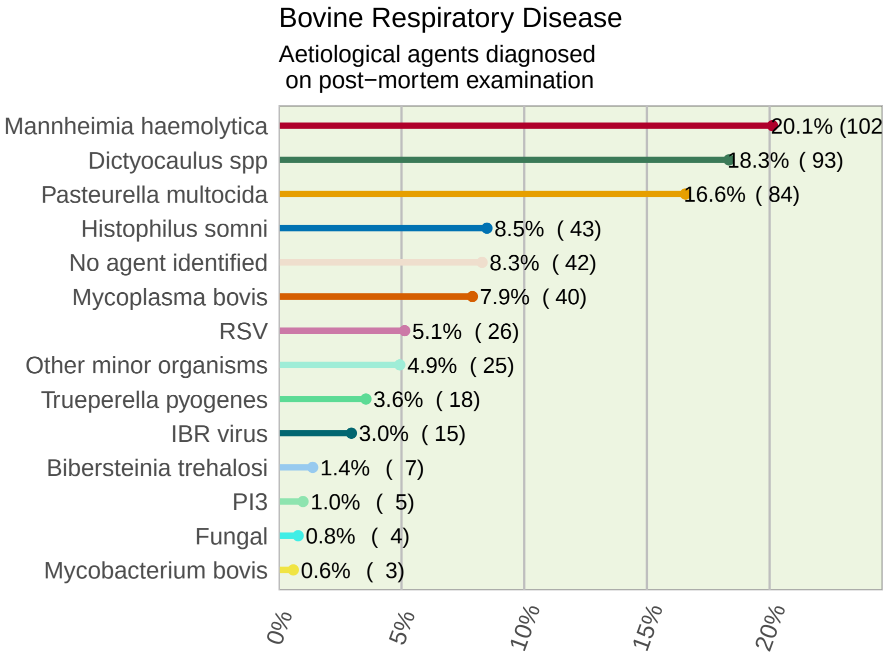


Figure 2.3: Relative frequency of the top ten pathogenic agents detected in BRD cases diagnosed on *post-mortem* examination, (n=507).

Table 2.3: Count and percentage by age goup of the general specific organisms detected in BRD on *post mortem* examination, (n=507).

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	1 (1.6)	3 (1.4)	3 (2.0)	0 (0.0)	7 (1.4)
Dictyocaulus spp	0 (0.0)	32 (15.0)	37 (24.3)	24 (30.4)	93 (18.3)
Fungal	2 (3.2)	0 (0.0)	1 (0.7)	1 (1.3)	4 (0.8)
Histophilus somni	7 (11.1)	21 (9.9)	13 (8.6)	2 (2.5)	43 (8.5)
IBR virus	3 (4.8)	0 (0.0)	7 (4.6)	5 (6.3)	15 (3.0)
Mannheimia haemolytica	21 (33.3)	38 (17.8)	25 (16.4)	18 (22.8)	102 (20.1)
Mycobacterium bovis	0 (0.0)	2 (0.9)	0 (0.0)	1 (1.3)	3 (0.6)
Mycoplasma bovis	3 (4.8)	23 (10.8)	10 (6.6)	4 (5.1)	40 (7.9)
No agent identified	9 (14.3)	21 (9.9)	8 (5.3)	4 (5.1)	42 (8.3)
Other minor organisms	4 (6.3)	12 (5.6)	6 (3.9)	3 (3.8)	25 (4.9)
Pasteurella multocida	5 (7.9)	43 (20.2)	28 (18.4)	8 (10.1)	84 (16.6)
PI3	0 (0.0)	3 (1.4)	2 (1.3)	0 (0.0)	5 (1.0)
RSV	2 (3.2)	9 (4.2)	10 (6.6)	5 (6.3)	26 (5.1)
Trueperella pyogenes	6 (9.5)	6 (2.8)	2 (1.3)	4 (5.1)	18 (3.6)

2.2 Viral Bovine Respiratory Disease

Viral agents were implicated as the primary cause of almost 10 *per cent* of BRD cases diagnosed on *post mortem* examination during 2021, with the highest frequency reported in weanlings (6–12 months of age) (Table 2.1 and Figure 2.3). 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 *per cent* of all BRD cases diagnosed, respectively (Table 2.3).

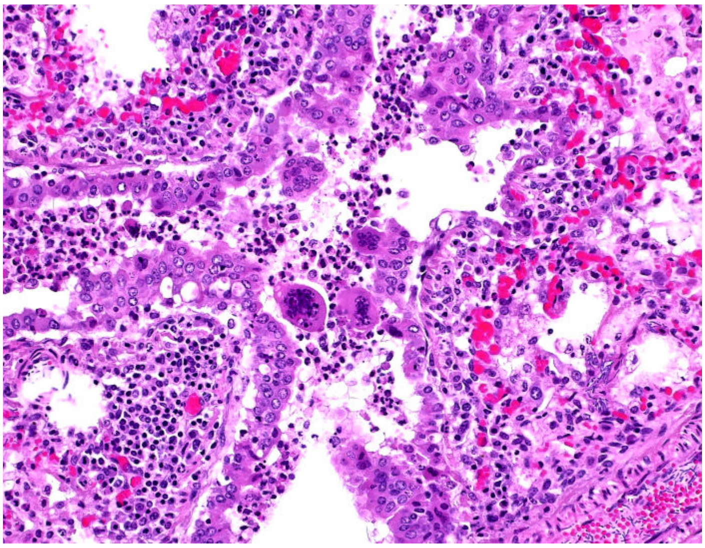


Figure 2.4: Bronchiolitis and associated syncytia in the lumen of the bronchus caused by the Bovine Respiratory Syncytial Virus (BRSV). Photo: Aideen Kennedy

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. In outbreaks, morbidity tends to be high, and the case-fatality rate can be 0–20 *per cent*.

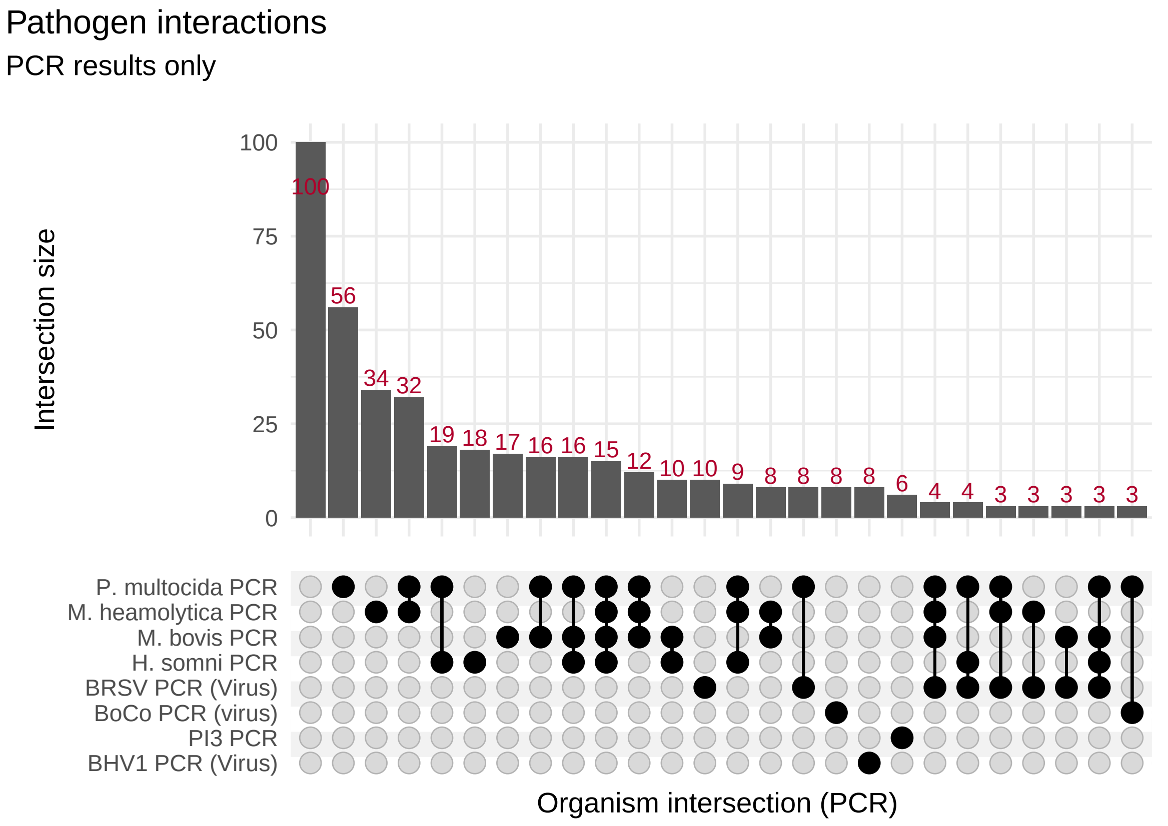
Bovine herpesvirus 1 (BHV-1) is associated with several diseases in cattle: infectious bovine rhinotracheitis (IBR), infectious pustular vulvovaginitis (IPV), conjunctivitis, abortion and encephalomyelitis, The respiratory form of IBR (BHV1) is characterised by severe hyperaemia and focal necrosis of 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.

PI3 was identified as the primary agent in 1 *per cent* of cases. Other viral agents such as bovine coronavirus and BHV4 were identified on PCR, but in conjunction with other agents

(See pathogen interactions in the Section 2.3)

2.3 Pathogen interactions

As indicated above BRD cases are often caused by infection with more than one agent. Significantly, viral infection may, in turn, predispose to bacterial infection. It is not uncommon for multiple viral and bacterial agents to be identified in BRD cases. When recording a diagnosis, the pathologist must select the agent they feel is the primary pathogen, and this reflects the numbers shown in the tables above. However, (Figure 2.5) highlights that in many cases, multiple pathogens are identified simultaneously, and while the agent may not be recorded as the primary cause of disease, it is crucial to be aware that these pathogens are in circulation.



Intersections with less than three cases were removed from the chart.

Figure 2.5: Upset plot depicting the interaction of different organisms in BRD cases diagnosed on *post mortem* examination based on PCR results during 2021.

CHAPTER 3

BOVINE ABORTION, STILLBIRTH AND PERINATAL MORTALITY

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3.1 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 the birth of a dead, full-term (i.e. more than 260 days 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 aetiology of these conditions.

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

An abortion rate of 3–5 *per cent* may be considered 'normal'. Above this, or if a number of abortions occur within a herd over a short space of time, an investigation is warranted.

Laboratory-based diagnostics play a vital role in diagnosing and mitigating abortion, stillbirth and perinatal mortality issues. However, they are only one part of the investigative process, which should also include thorough history taking, assessment of cow management and environment and peripartum management, as appropriate. 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 deaths are due to infectious agents. There is a wide range of non-infectious causes, including dystocia, dam nutrition, plant and mycotoxin ingestion, and hormonal, physical and genetic factors.

There were 1,576 abortion, stillbirth or perinatal mortality cases submitted to the Veterinary Laboratory Service (VLS) in 2021. This figure includes whole carcasses, part carcasses (e.g. foetal stomach contents only), and placentas submitted without a carcass.

Although cases were submitted throughout the year, the vast majority of submissions were from January to March and October to December. This reflects Ireland's predominantly seasonal beef and dairy systems (Figure 3.1).

3.2 Diagnostic Rate

Of all bovine abortion, stillbirth and perinatal mortality cases submitted, 899 (57 *per cent*) were undiagnosed. This figure reflects the difficulty in achieving a diagnosis in cases of this type and is comparable to other international studies (Wolf-Jäckel et al. 2020).

As mentioned, many cases of abortion, stillbirth and perinatal mortality are not associated with infection. Developmental abnormalities were diagnosed in 32 cases, although these may not have been the actual cause of death. These included intestinal atresia, cardiac defects, chondrodysplasia and other cardiovascular, musculoskeletal neurological and uro-genital abnormalities.

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

3.3 Infectious Causes

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 2021, *S.* dublin was cultured from 93 or 5.9 *per cent* of foetal cultures. As in previous years, the proportion of cases with an *S.* dublin diagnosis peaked in the second half of the year (Figure 3.1) emphasising the importance of appropriate timing of vaccination against this disease.

Table 3.1: Number of *Salmonella* Dublin isolates in foetal material in 2021 (n=1576).

Total Submissions	No. of Cases	Percentage
1576	93	**5.9**

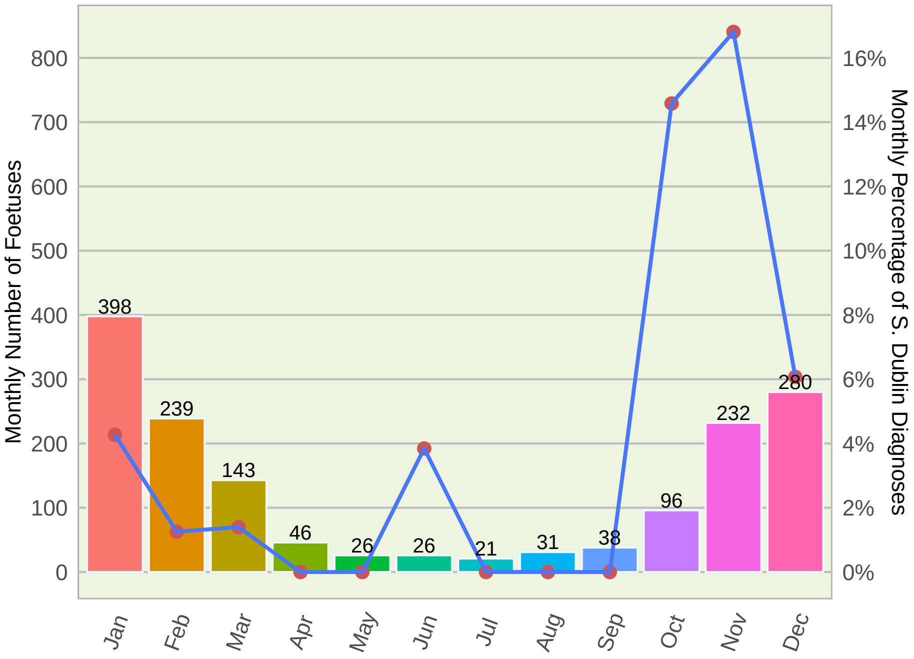

Figure 3.1: Annual distribution of foetal submissions (bars,number of submissions) and *Salmonella* Dublin isolates (line plot, as percentage) from foetal bacterial cultures as a percentage of monthly bovine submission (n=1576).

Other bacterial pathogens

T. pyogenes is a common cause of sporadic foetal death, identified in 110 cases (7.2 *per cent*) in 2021 (Table 3.2). 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 (5.7 *per cent*) and *Listeria monocytogenes* (2.9 *per cent*) abortions are often associated with feeding of poorly preserved silage (Table 3.2). Other bacteria isolated from cases in 2021 are listed in (Table 3.3). 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

Table 3.2: Frequency of detection of other primary abortion pathogens in foetal culture during 2021 (n=1576).

Organism	No. of cases	Percentage
Trueperella pyogenes	110	**7.2**
Bacillus licheniformis	88	**5.7**
Listeria moncytogenes	44	**2.9**
Aspergillus spp	27	**1.8**

Table 3.3: Combined frequency of detection of selected secondary abortion agents on routine foetal culture.

Organism	No of Cases	Percentage
No Significant Growth	1065	**69.2**
Coliforms	309	**20.1**
Streptococcus spp	67	**4.4**
Staph. spp	31	**2.0**
Other minor organisms	24	**1.6**
Listeria spp	17	**1.1**
Yeasts and Fungi	15	**1.0**
Bacillus spp	11	**0.7**
Pseudomonas spp	8	**0.5**
Mannheimia haemolytica	4	**0.3**
Pasteurella multocida	3	**0.2**
Histophilus somnus	2	**0.1**
Yersinia pseudotuberculosis	2	**0.1**
Bibersteinia trehalosi	1	**0.1**
Campylobacter fetus	1	**0.1**

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 the pathogen actually responsible for foetal or perinatal death.

Fungal pathogens

Aspergillus spp were isolated from 27 cases (1.8 *per cent*). This is also often associated with feeding of contaminated foodstuffs. Other fungi and yeasts were found in 15 cases (1 *per cent*) (Table 3.3).

Viral pathogens

Foetal tissue tests for viral pathogens associated with bovine abortion, stillbirth and perinatal mortality are carried out under specific circumstances. These viruses include (Table 3.4) bovine herpesvirus-1 (BHV-1), bovine herpesvirus-4 (BHV-4), bovine virus diarrhoea virus

(BVD) and Schmallenberg virus (SBV). Of the 182 cases tested for BHV-1 via PCR, one positive (0.5 *per cent*) and two inconclusive results were returned. 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. Of 61 cases tested for BHV-4 via PCR, one case tested positive and one other inconclusive. The role of BHV-4 in the reproductive disorders of cattle is currently unclear, and there are no vaccines available against the virus. No cases tested positive for BVD or SBV.

Table 3.4: Frequency of detection of viruses in foetal material during 2021.

Virus	Inconclusive	No virus detected	Positive	Percentage
BHV-1	2	**179**	1	0.5
BHV-4	1	**59**	1	1.6
SBV	0	**86**	0	0.0

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 primary 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 also depends on the specific sections of foetal tissue examined. Antibody ELISA results can be affected by the degree of autolysis of the sample and the age and immunocompetence of the foetus. In 2021, *N. caninum* was diagnosed in 41 cases. This figure may be falsely reduced as samples are not submitted for histopathology or antibody ELISA in all cases.

> **Zoonotic Risks**: many pathogens that cause abortion in cattle can also cause serious human disease. Some can even be shed during apparently normal parturition. Appropriate protective measures should be implemented, including personal protective equipment and disinfection. This refers not only to aborted and stillborn cases but also to assisting any calving.

There is no effective treatment or vaccine for *N. caninum* currently available. Control is dependent on the 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).

Polymerase Chain Reaction (PCR)

With the aim of increasing the diagnostic rate in cases of foetal death, 2021 saw the introduction of a new ruminant abortion PCR package to the Veterinary Laboratory Service. This allows the detection of pathogens not usually identifiable through routine culture methods. Pathogens tested for include *Anaplasma phagocytophila*, BHV-4, *Campylobacter foetus*, *Chlamydia spp.*, *Coxiella burnetii*, *Leptospira spp.* pathogenic serovars, *Listeria monocytogenes* and *Salmonella spp.* There is some overlap between the tests included in the package and those already offered in the service.

It is important to note that PCR is extremely sensitive and that detection of an infectious agent in a foetus is not necessarily conclusive proof that the agent caused the abortion. This is especially true in the case of *Coxiella burnetii*, which infected cows can shed during normal parturition as well as in cases of foetal death.

Seventy-one pooled samples of bovine stomach content and foetal kidney (to increase sensitivity for Leptospira spp.) were submitted for testing via the abortion PCR package. Of these, one tested positive for BHV-4, two tested positive for *C. foetus*, and two tested positive for *Leptospira spp.* pathogenic serovars, six tested positive for *L. monocytogenes* and seven tested positive and one inconclusive for *Salmonella spp.*

CHAPTER

4

BOVINE MASTITIS

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The Veterinary Medicines Regulation (*Regulation (EU) 2019/6)*, due to be implemented in the EU in 2022 legislates for the authorisation, use and monitoring of veterinary medicinal products. Key objectives of the legislation include the promotion of prudent and responsible antimicrobial use to minimise antimicrobial resistance (AMR) in animals and to prevent the spread of antimicrobial-resistant bacteria into the food chain. Knowledge of the pathogen profile at farm level, antimicrobial sensitivity testing and understanding of previous treatment outcomes are important when a veterinary practitioner is dealing with disease situations on farms.

Cellcheck, the national mastitis control programme, coordinated and facilitated by Animal Health Ireland (AHI) recommends that there should also be ongoing collection and testing of milk samples from animals with clinical or subclinical mastitis, both to guide individual clinical decisions and equally importantly, as part of the broader assessment and monitoring of mastitis pathogen challenge(s) and antibiotic resistance patterns on the farm.

A number of private laboratories and the Department of Agriculture, Food and the Marine (DAFM) laboratories offer a milk culture and antimicrobial sensitivity testing service. The private laboratories participate in a proficiency testing (PT) scheme offered by the DAFM. AHI has designated laboratories that perform consistently well in the PT scheme as 'Cellcheck Partner Laboratories', the list of which is available in the AHI webpage

In 2021, 1,683 bovine milk samples were received by DAFM laboratories for testing. In 41 of

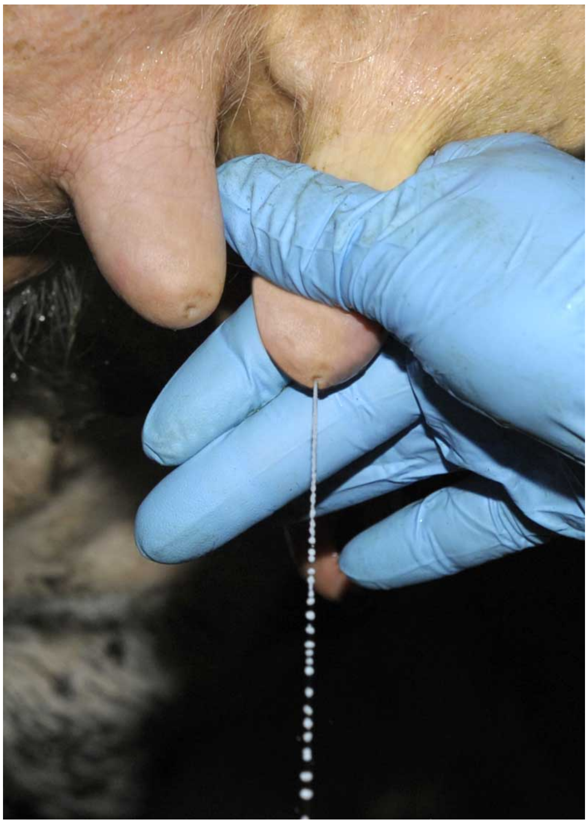

Figure 4.1: Collecting a milk sample for culture. Photo: Animal Health Ireland.

those samples more than one significant mastitis pathogen was isolated, so a total of 1,724 results were obtained from the sample set. The Table 4.1 and Figure 4.3 summarise the results.

> 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.

Contaminated samples

Contamination is an ongoing issue which significantly affects the outcome of laboratory testing. It presents significant result interpretation challenges to the laboratory analyst, veterinary practitioner and farmer. Contamination most often results from a poor sampling technique, but it can be compounded when the sample is poorly stored, and takes too long, at ambient temperature, to reach the laboratory. Culture of these samples typically results in the growth of a mix of bacteria after 24 hours (Figure 4.2). The samples are disposed of at that stage, before any antimicrobial sensitivity testing is initiated.

Figure 4.2: Mixed bacterial growth on a blood agar plate following culture of a contaminated milk sample. Photo: Alan Johnson.

Table 4.1: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2021 (n=1724).

Result	**No. of cases**	**Percentage**
Contaminated	428	**24.8**
Staphylococcus aureus	369	**21.4**
No Significant Growth	266	**15.4**
Streptococcus uberis	208	**12.1**
E. coli	190	**11.0**
Other Isolates	106	**6.2**
Bacillus spp.	56	**3.2**
Non-aureus staphylococci	49	**2.8**
Streptococcus dysgalactiae	28	**1.6**
Trueperella pyogenes	13	**0.8**
Non-aureus staphylocci	8	**0.5**
Strep. agalactiae	3	**0.2**

4.1 *Staphylococcus aureus*

Staphylococcus aureus continues to be the most commonly isolated mastitis pathogen in the RVLs (Figure 4.4). *Staph. aureus* typically spreads from cow-to-cow by contact with infected milk on cluster liners or on milker's hands. It can be difficult to cure, particularly during lactation and culling is frequently the best option in older infected cows with persistently high somatic cell counts.

The relative frequency of *Staphylococcus aureus* has fallen over the last 10 years but has been rising again from 2019 (14.1 *per cent*) to 12.1 *per cent*.

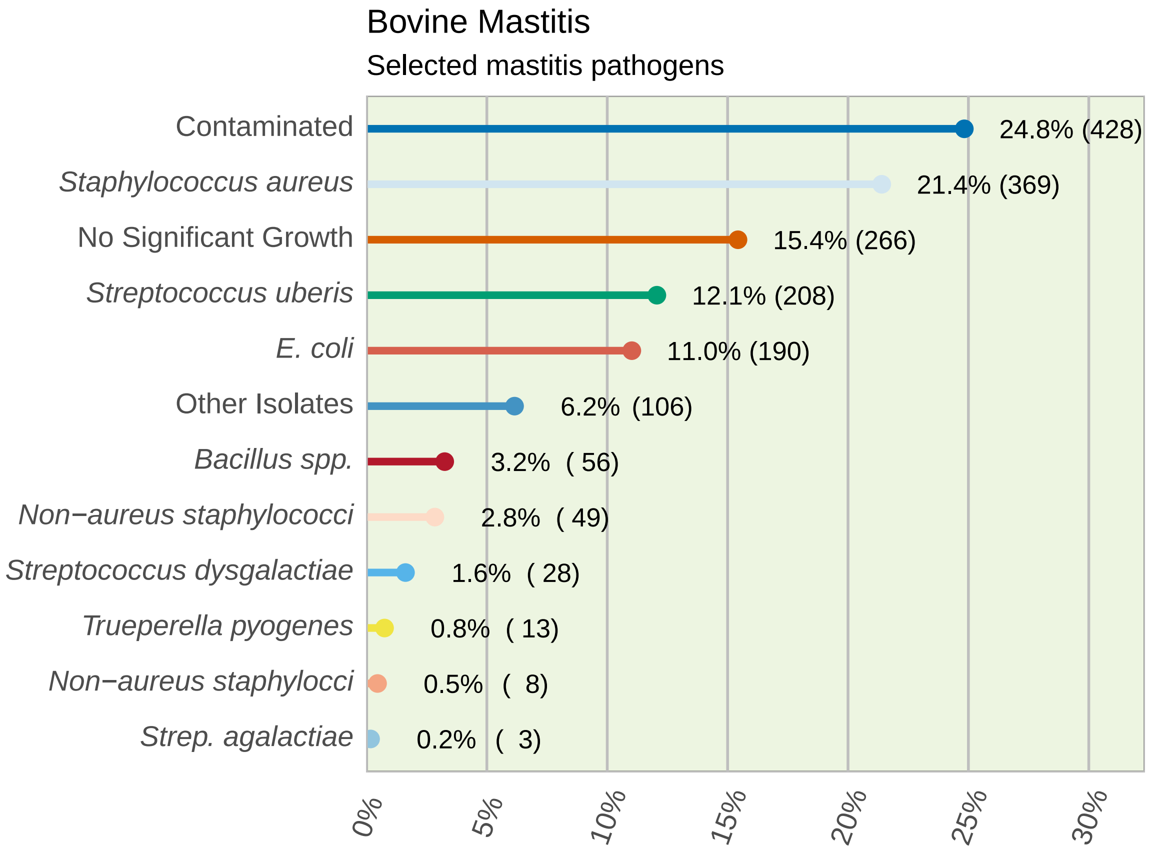

Figure 4.3: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2021 (n=1724).

4.2 *Streptococcus uberis*

This organism is often described as an environmental mastitis pathogen. It is usually associated with faecal contamination of surfaces. Sub-optimal housing and poor udder hygiene can increase the risk of infection. In addition, *Strep. uberis* has some characteristics of a contagious pathogen and can be spread from cow-to-cow at milking time.

The relative frequency of *Streptococcus uberis* has risen over the last 10 years but has fallen slightly from 2020 (14.1 *per cent*) to 12.1 *per cent*.

4.3 Other mastitis pathogens

The relative frequency of isolation of *E. coli* in 2021 was 11 *per cent*, down from 13 *per cent* in 2020. As with other bacteria, care must be taken when interpreting the significance of an *E. coli* positive result. If isolated with other environmental contaminants, it may be considered to be a contaminant itself and of little significance. More significance may be attached to the result if it is isolated as a pure growth.

Figure 4.4: Pure growth of *Staphylococcus aureus* on a blood agar plate. Photo: Alan Johnson.

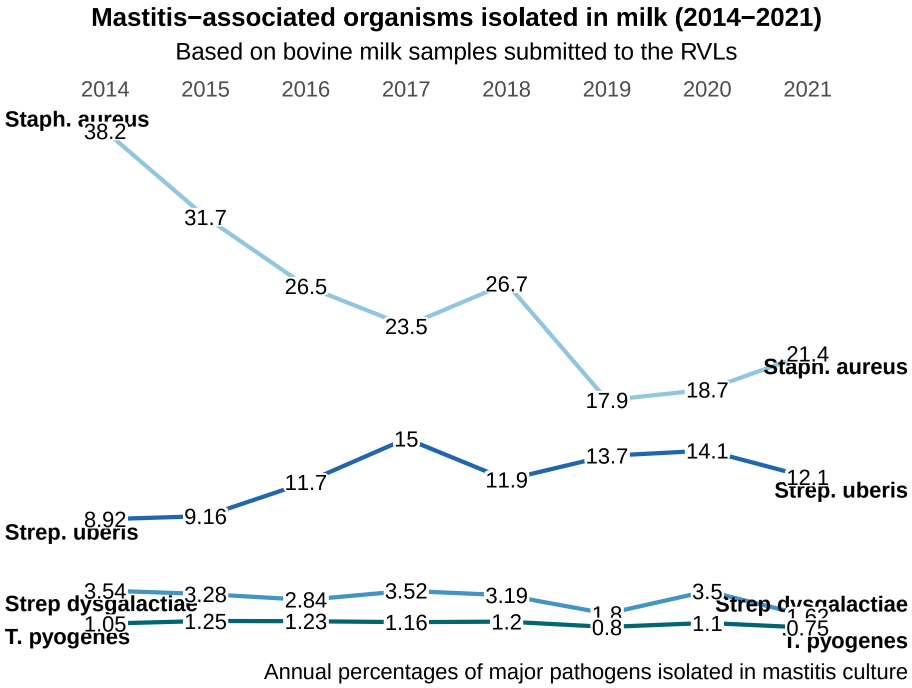

Figure 4.5: Mastitis-associated Organisms Isolated in Milk (2014-2021).

Streptococcus dysgalactiae resides mainly in the cow's udder, in teat wounds, and also in the environment. It can therefore occur as either a cow-associated or environment-associated mastitis pathogen. It was isolated on 28 occasions during 2021, a relative frequency of 1.6 *per cent*.

Streptococcus agalactiae was a rare isolate from milk simples in 2021, identified in just three simples (relative frequency of 0.2 *per cent*).

Non-aureus staphylococci (also known as coagulase-negative staphylococci) were isolated in 57 samples (a relative frequency of 3.3 *per cent*). These included *Staph. xylosus*, *Staph. chromogenes*, *Staph haemolyticus* and *Staph. sciuri* isolates. The quality of sampling can affect the recovery of these non-aureus staphylococci as they can be present on teat skin, so the presence of other bacteria (contaminants) on the culture plate may suggest that these are contaminants and not of clinical significance.

CHAPTER 5

NEONATAL ENTERITIS

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Bovine Neonatal Enteritis is the most common cause of death in calves during their first month of life. The degree of exposure to viral, protozoal, and bacterial enteric pathogens and the presence of predisposing factors will determine if calves are affected by this condition. These predisposing factors include failure of passive transfer of colostral immunity and stressors such as a history of dystocia, adverse weather, and suboptimal nutrition. Exposure to pathogens can be lowered through sub-optimal hygiene in the areas of calving, feeding, housing and calf handling (Lorenz et al. 2011).

Rotavirus was the most common cause of enteritis in calves in 2021, consistent with previ-

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 2021.

Organism	No. of Tests	Positive	Percentage
Rotavirus	1566	503	**32.1**
Cryptosporidia	1604	401	**25.0**
Campylobacter jejuni	1413	126	**8.9**
Giardia	958	47	**4.9**
E.Coli K99	1170	13	**1.1**
Salmonella Dublin	1536	15	**1.0**
Coronavirus	1521	5	**0.3**

ous years. This pathogen typically affects calves less than three weeks old. Rotavirus preferentially targets the mature villous enterocytes and spares the crypts, generally causing villous atrophy. Malabsorption and fluid loss into the intestinal lumen will then occur, leading to diarrhoea (Foster and Smith 2009). Virus shedding by infective animals increases pathogen exposure to cohorts and younger animals. Therapeutic measures consist of oral and, if necessary, parenteral rehydration. Control of this condition includes general preventative measures such as hygiene and adequate colostrum management; specific control measures include vaccination of cows pre-calving, a method which is extremely reliant on the transfer of immunity via colostrum.

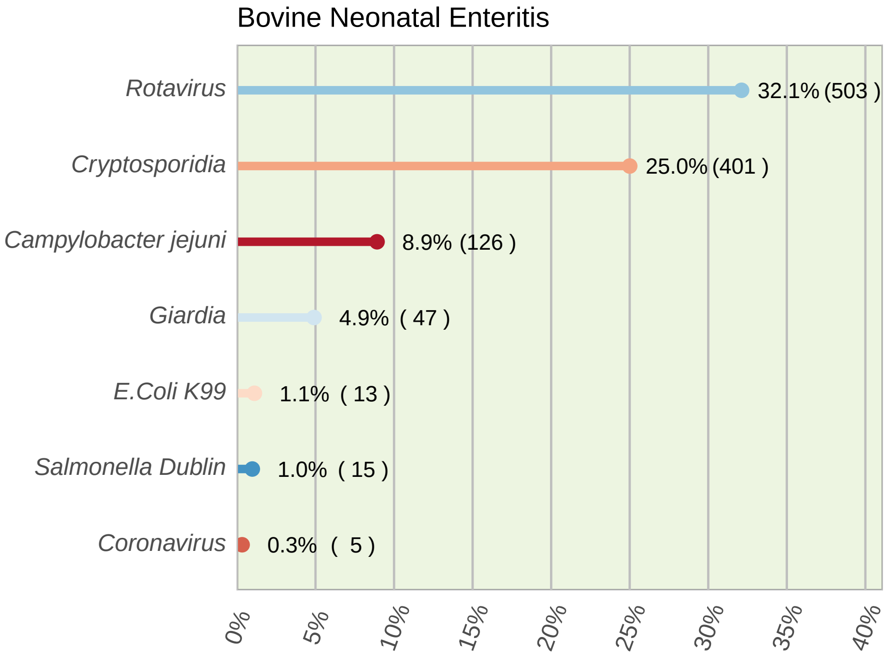

Figure 5.1: Relative frequency of enteropathogenic agents identified in calf faecal samples (neonatal enteritis package) tested in 2021. Percentage of positive results. Total samples examined varies with the agent, see Table 5.1

Bovine coronavirus has a similar pathogenesis to rotavirus but is detected much less frequently in 2021 than in other years.

Cryptosporidium parvum is the second most commonly detected pathogen in neonatal calves. In 2021 detection rates climbed again after several years of decline. Both *C. parvum* and rotavirus can concurrently infect the same animal. Infection is by the oral-faecal route and induces severe villous atrophy in calves. *C parvum* oocyst shedding occurs as early as three days and peaks at two weeks of age (Figure 5.3). Shedding can continue to occur in older cattle; however, diarrhoea is rarely caused by *C. parvum* after three months of age. Diarrhoea can last from 5–12 days, so continued milk feeding is necessary along with oral rehydration to prevent death from malnutrition. Halofuginone may be used for the prevention of this disease while paromomycin can be prescribed as a therapy. General disease control measures such as hygiene around the housing and handling of calves are still vital. Advice on effective disinfectants for use against *C. parvum* may be found in the resources page of the AHI webpage.

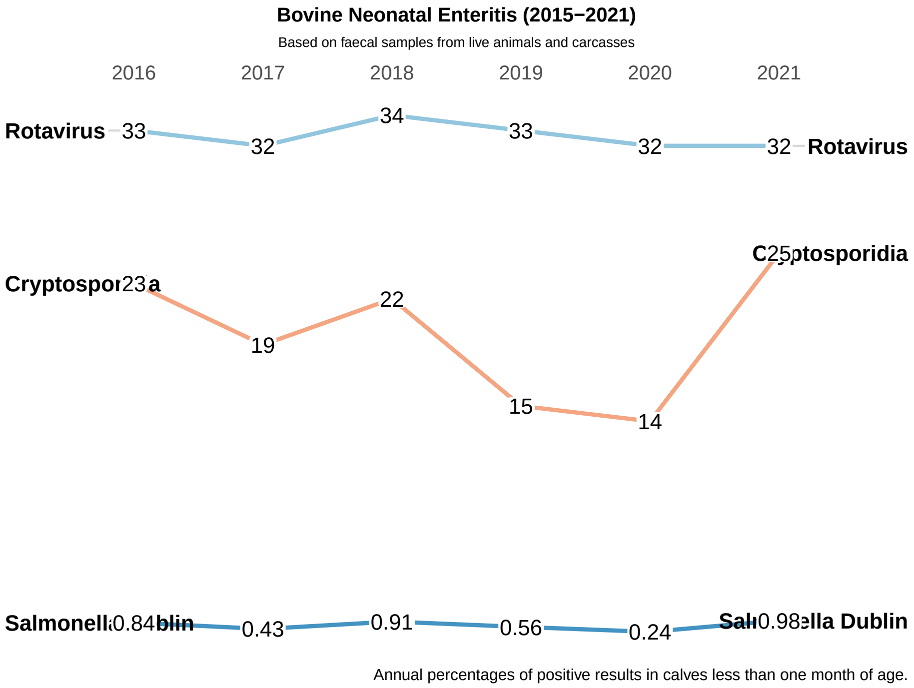

Figure 5.2: Trends in the incidence of Rotavirus, Cryptoporidia and *Salmonella* Dublin enteritis in calves less than one month.

Escherichia coli K99 is an enterotoxigenic *E. coli* that primarily causes disease in calves in the first three days of life; producing a heat-stable toxin that causes secretory diarrhoea. Samples from calves older than one week are not routinely tested for *E. coli* K99. Control by vaccination of cows pre-calving is common; this is again reliant on good colostrum management.

Salmonella Dublin. Enteritis due to *Salmonella enterica* subspecies Dublin was detected at low levels during 2021, following declining prevalence over the previous decade. This enterotoxigenic, invasive bacterial pathogen can be controlled by vaccination. A more virulent subspecies, *Salmonella* Typhimiurium, was not isolated in young calves in 2021.

Coccidiosis is an enteritis most often caused by infection with *Eimeria zuernii* or *Eimeria bovis*; *Eimeria alabamensis* has been reported in outbreaks of watery diarrhoea in northern Europe. Coccidiosis typically affects older calves from three weeks to nine months of age. Clinical signs are of diarrhoea and dysentery (bloody diarrhoea), sometimes accompanied by tenesmus (straining) (Figure 5.4). Outbreaks are generally linked to conditions of high infectious pressure; hygiene around housing, feeding and handling are vital control measures. There are a number of therapeutics available, however these are more effectively used prophylactically. Advice on effective disinfectants for use against coccidia can be found in the resources page of the AHI webpage.

Campylobacter jejuni and *Giardia* organisms, the importance of which as a cause of bovine neonatal enteritis are uncertain. However, both are important zoonoses, and calf faecal samples are monitored for their presence. If either of these zoonoses is detected, care should be taken by people handling animals from the herd, especially if immunocompromised. Both

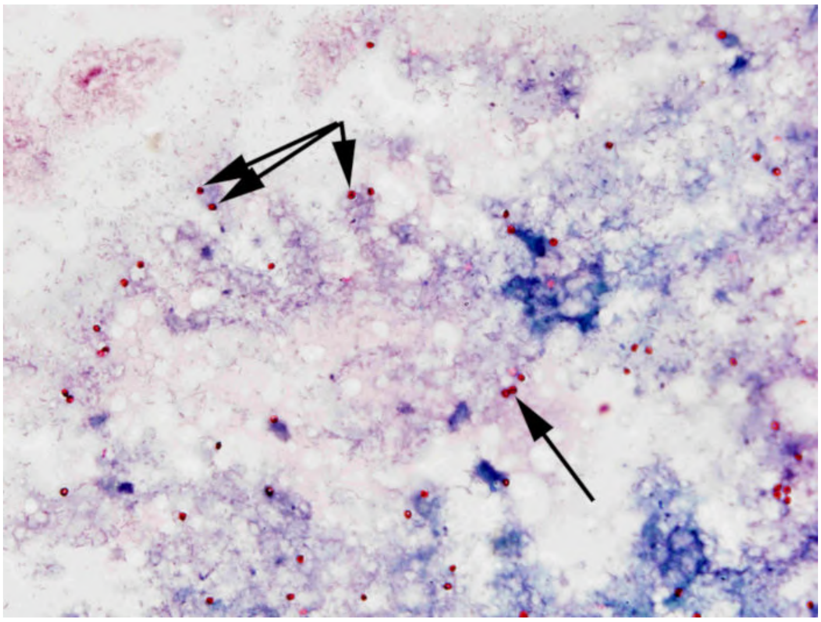

Figure 5.3: Oocysts of *Cryptosporidium parvum* in bovine faeces, observed by modified Ziehl-Neelsen staining. Photo: Ian Hogan.

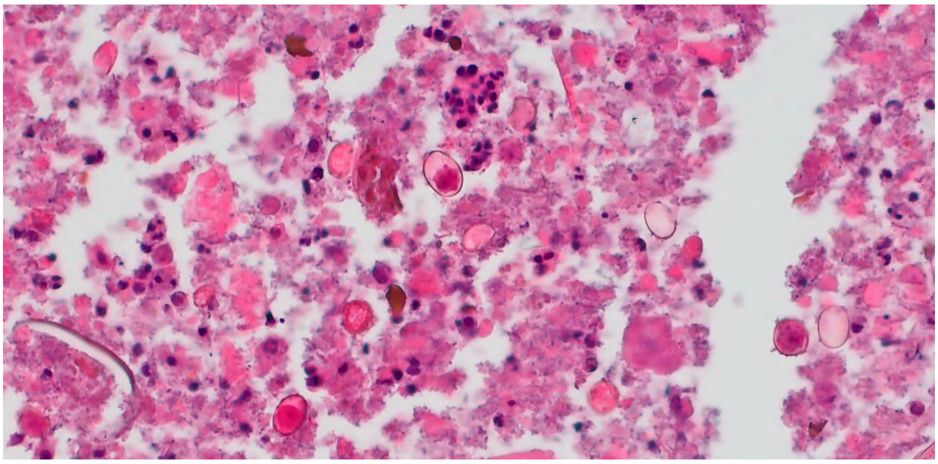

Figure 5.4: Coccidial life stages in the intestine of a calf. Photo: Maresa Sheehan.

were detected in a substantial minority of cases during 2021.

Clostridial enterotoxaemia, a rapidly fatal disease usually caused in calves by *Clostridium perfringens* type C, is not commonly diagnosed in bovines. In 2021 it was detected in older cattle, but not in calves.

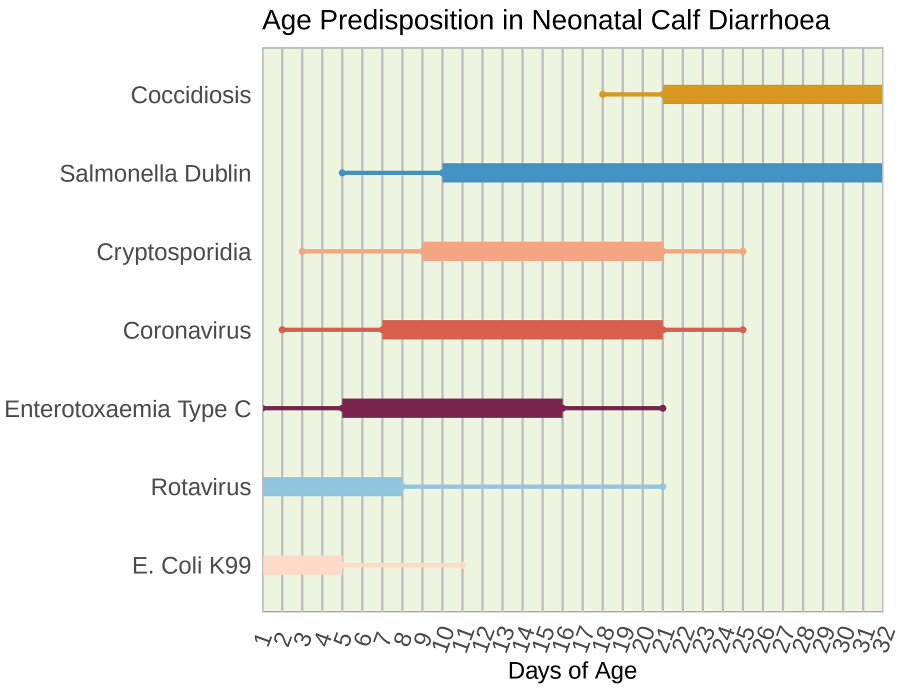

Figure 5.5: Agent and age predisposition in neonatal calf diarrhoea, the thick area represents the most likely period of disease

CHAPTER 6

ZINC SULPHATE TURBIDITY TEST

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The Zinc Sulphate Turbidity (ZST) test indirectly measures the passive transfer of Immunoglobulins from the dam to neonate via colostrum; these immunoglobulins provide protection from common infectious diseases that cause illness and death in calves.

> 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.

A single ZST test provides limited information on the efficacy of colostrum management

Table 6.1: Zinc Sulphate Turbidity Test Results in 2021 (n=950).

Submission type	Status	No. of samples	Mean	Percentage
Diagnostic	Optimal	370	28.6	**61**
Diagnostic	Adequate	136	16.4	**23**
Diagnostic	Inadequate	97	7.9	**16**
Carcass	Optimal	87	27.9	**25**
Carcass	Adequate	86	15.7	**25**
Carcass	Inadequate	174	7.1	**50**

practices within a herd. To best determine whether there is an adequate transfer of passive (colostral) immunity, it is recommended that multiple samples, up to twelve, are taken from two to 10 day old healthy calves.

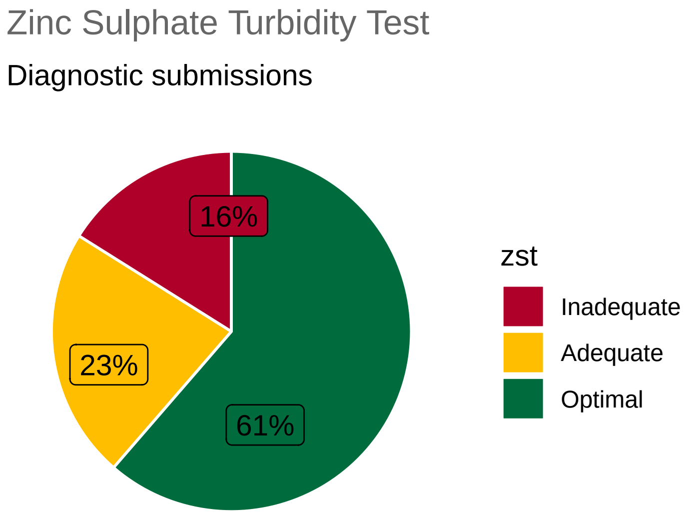

Figure 6.1: Results of ZST from submitted bovine blood samples in 2021 (n=603).

One-day-old calves are unsuitable for ZST testing as circulating levels of immunoglobulin peak 36 hours after colostral ingestion. The ZST test is also not useful in calves older than 14 days old as the test does not distinguish between colostral and endogenous Immunoglobulins. Testing healthy calves is preferable as Immunoglobulin levels decrease during illness due to antigen binding and/or loss through the kidney/intestine. In dehydrated calves, ZST levels can be increased due to haemoconcentration.

> Clinical history provided in the laboratory submission forms is in many cases minimal but one would suspect many single samples come from sick calves. Samples from sick calves are not suitable to evaluate colostrum management as disease processes will affect circulating immunoglobulin. Immunoglobulin will be lost from circulation, as it binds with antigen, or through protein-losing conditions such as enteropathy and nephropathy. Dehydration, on the other hand, may lead to artificially high ZST results through haemoconcentration.

Measurement of serum total protein is another way to assess for failure of passive transfer (FPT). This test is useful for monitoring colostrum management in healthy calves, but it is not suitable for sick, dehydrated or dying calves. The analysis can be carried out either in farms with a refractometer, or in veterinary clinics using an in-house biochemistry analyser. When used for screening, 80 *per cent* of samples should show values above 55 *g/l*.

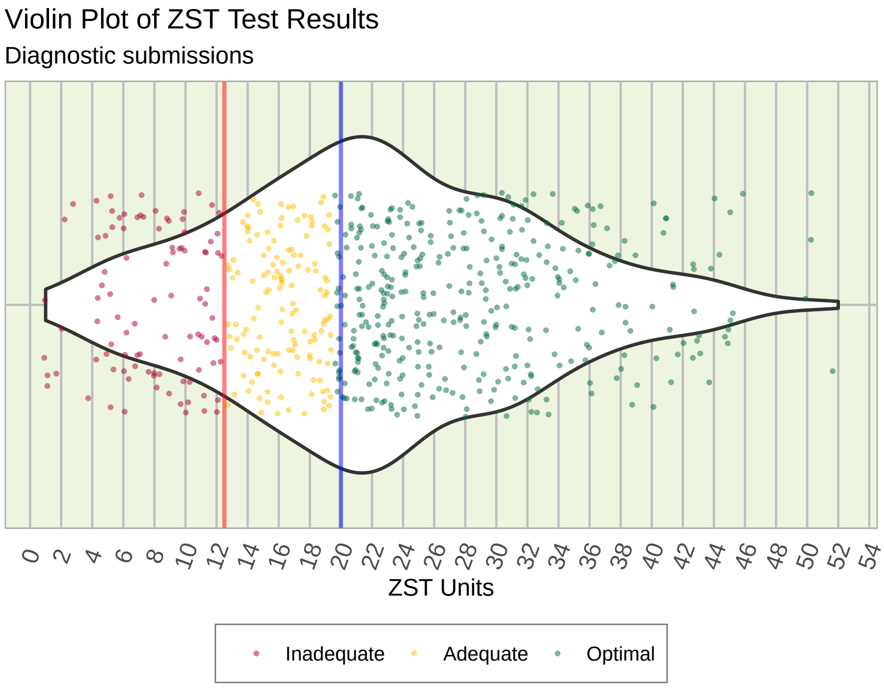

Figure 6.2: Distribution of ZST test results during 2021. Optimal colostral immunity is defined as greater than 20 units (blue line), adequate between 12.5 and 20 units and inadequate less than 12.5 units (red line). The width of the white area at each point of the x-axis is proportional to the number of samples returning a ZST result of that value (n=603).

In 2021, DAFM tested 950 blood samples for ZST (Table 6.1). Of these, 603 were blood samples from calves sent by PVPs, diagnostic submissions, and 347 were blood samples collected from calves submitted for *post mortem* examination, carcass submissions.

Compared to 2020 figures (n=1045), the percentage of diagnostic samples with optimal levels of passive immunity transfer has decreased by six points from 67 *per cent* last year. Percentages for adequate and inadequate passive immunity transfer have increased by two and four points, respectively. Percentages within the carcass samples remain the same.

Of the 603 diagnostic blood samples tested, 370 samples (61 *per cent*) showed optimum levels of Immunoglobulins, 136 (23 *per cent*) showed adequate levels, and in 97 samples (16 *per cent*) the transfer of passive immunity was considered inadequate (Figures 6.1 and 6.2).

Chapter 7

Bovine Parasites

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7.1 Trichostrongylidae

Members of the trichostrongylidae family include *Cooperia*, *Ostertagia*, *Haemonchus* and *Trichostrongylus*. In Europe, the two main pathogenic genera of this family affecting cattle are *Ostertagia* and *Cooperia*. Due to a lack of prior exposure and with no resulting development of immunity, this can lead to the development of significant morbidity and even mortality in first grazing season (FGS) calves in the face of significant pasture challenge with infective third-stage larvae. Disease may be characterised by a range of clinical signs such as diarrhoea, anorexia and sudden weight loss (Urquhart et al. 1987). In some cases, death may also occur. However, in subclinical infections, which are far more common, animal performance is impacted, resulting in reduced live weight gain and a potential decline in milk yields (Charlier et al. 2007; Stromberg et al. 2012).

Although the majority of faecal samples did not have *trichostrongylidae* eggs detected in them using the McMaster method (limit of detection 50 eggs per gram of faeces), it can be seen in (Figures 7.2 and 7.3) that a greater number of samples have evidence of gastrointestinal parasitism from September to November as judged by increases in the percentage of positive samples. This is a result of a build-up in pasture challenge over the course of the grazing season.

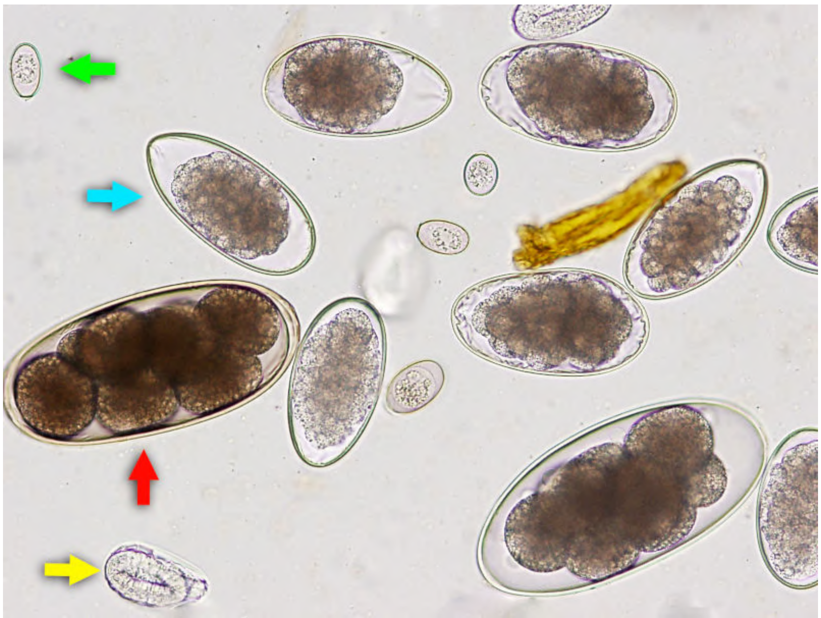

Figure 7.1: Modified McMaster fecal egg counting. Microscopic appearance of parasitic eggs and oocysts in a faecal smear: *Trichostrongyles* (blue arrow), *Nematodirus* (red arrow), Larvated *strongyloid* egg (yellow arrow) and *coccidial oocysts* (green arrow). Photo: Cosme Sánchez-Miguel.

Table 7.1: Number of bovine faecal samples tested for Trichostrongylidae eggs in 2021 and results by percentage (n=4221).

Result	No. of samples	Percentage
Negative	3132	**74.2**
Low (50-200 epg)	581	**13.8**
Medium (200-700 epg)	282	**6.7**
High (>700 epg)	226	**5.4**

Table 7.2: Number of bovine faecal samples tested for *Nematodirus* eggs in 2021 and results by percentage (n= (n=4220).

Result	No. of samples	Percentage
Negative	4146	**98.2**
Low (50-200 epg)	49	**1.2**
Moderate (200-700 epg)	23	**0.5**
High (>700 epg)	2	**0.0**

7.2 *Nematodirus spp.*

Although considered a far more significant parasite in sheep, it can potentially give rise to disease in calves in exceptional circumstances where these is significant pasture challenge. Nonetheless, and similar to previous years, the majority of bovine samples do not have *Nematodirus spp.* eggs detected in them using routine flotation methods.

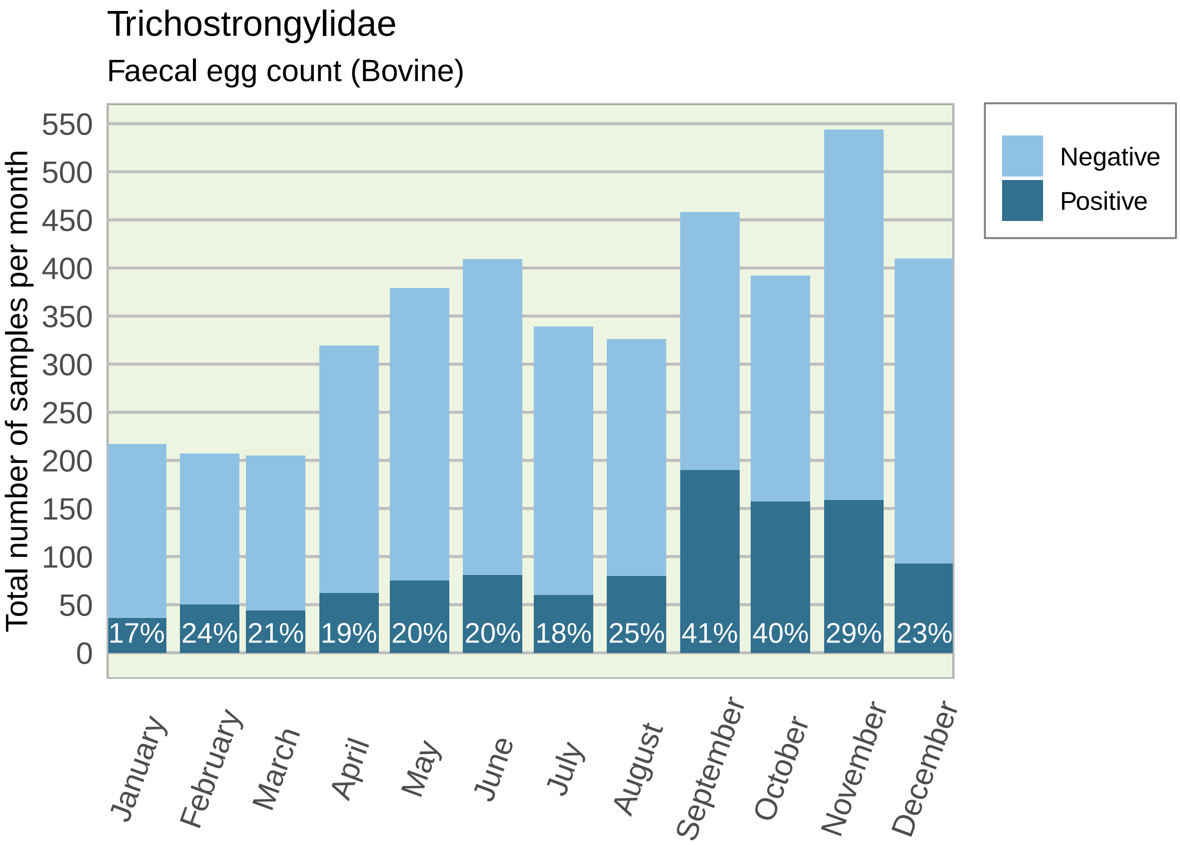

Figure 7.2: Stacked count of bovine faecal samples (all ages) tested per month for *Trichostrongylidae* during 2021. The percentage in each bar represents positive samples (n=4221).

7.3 *Coccidia spp*

Although a number of *Eimeria spp.* may affect cattle, the three most important species are *E. alabamensis*, *Eimeria bovis* and *E. zuernii*, with the latter two being the main species in calves/weanlings. Clinical signs of the disease include diarrhoea, tenesmus and acute weight loss. In the absence of overt clinical signs, the disease may be characterised by poor growth rates. In addition to animal age, other risk factors for the development of this condition include areas on farms that tend to be heavily stocked (e.g., around water or feed troughs) or when animals are indoors in unhygienic conditions (Figure 7.5). Concurrent disease and any stress-inducing events are also regarded as risk factors.

In the majority of faecal samples submitted for examination, coccidial oocysts were not detected (Table 7.3), with only 6 *per cent* of samples indicating a moderate to severe infection. However, given that most of these samples are likely to have originated from clinically affected animals, where oocyst production may decline in the latter stages of the disease, care should be exercised in overinterpreting these results. In order to ensure an accurate diagnosis, it is always advised to sample multiple animals in an affected group.

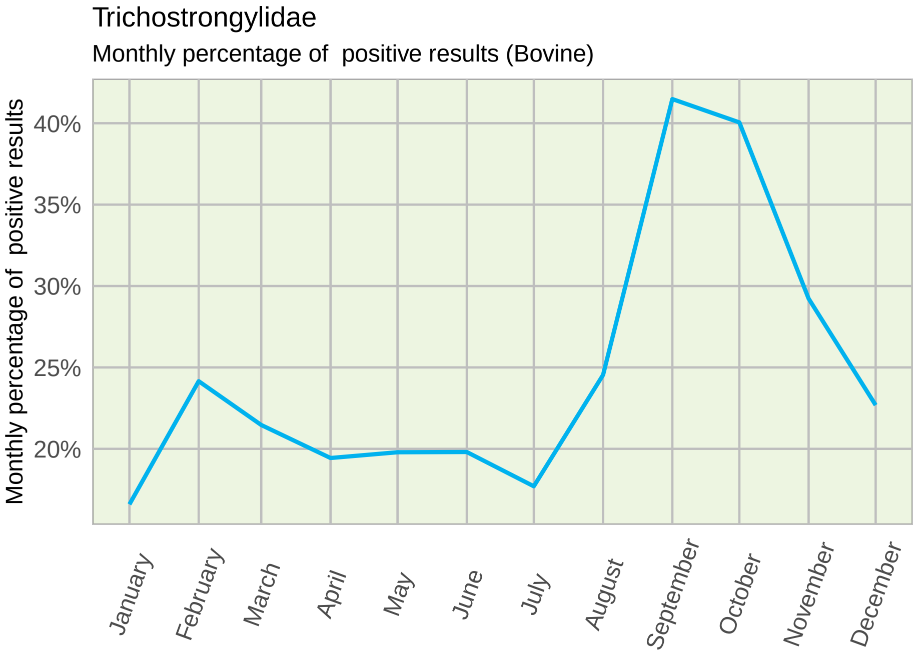

Figure 7.3: Percentage of positive bovine faecal samples for *Trichostrongylidae* eggs in 2021 (n=4221).

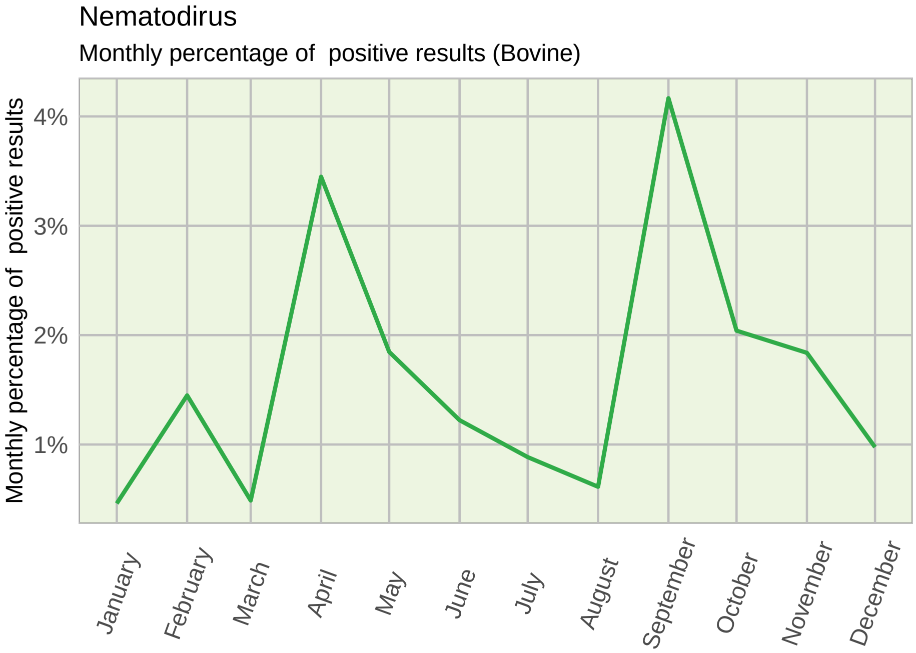

Figure 7.4: Percentage of bovine faecal samples testing positive for *Trichostrongylidae* eggs in 2021 (n=4221).

Table 7.3: Number of bovine faecal samples submitted in 2021 (all ages) for detection of coccidial oocysts and results by percentage, (n=4465).

Result	No. of samples	Percentage
Not Detected	3415	**76**
Light Infection	797	**18**
Moderate Infection	159	**4**
Heavy Infection	53	**1**
Severe Infection	41	**1**

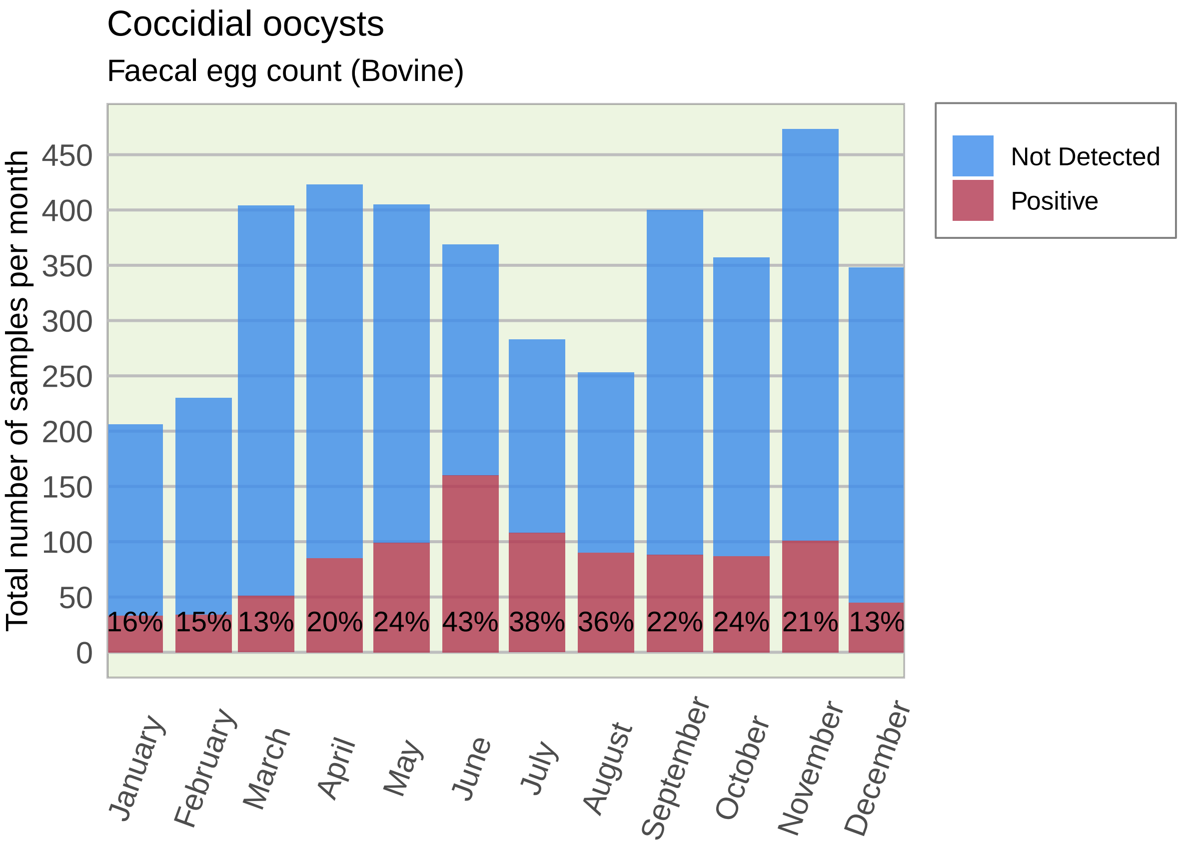

Figure 7.5: Stacked number of bovine faecal samples (all ages) tested for coccidial oocysts in 2021. The percentage in each bar represents the number of positives (n=4465).

7.4 Rumen and Liver Fluke

Both the liver fluke, *Fasciola hepatica* and the rumen fluke *Calicophoron daubneyi* are the two main trematodes in cattle in Ireland. Sieving and the subsequent sedimentation of faecal samples, which have been previously mixed in water, is the main method used for the detection of fluke eggs. As can be seen from the tables below, rumen fluke eggs are more commonly detected in faecal samples. Given that the shedding of liver fluke eggs is intermittent and typically in low numbers, the sampling of multiple animals in a cohort is advised.

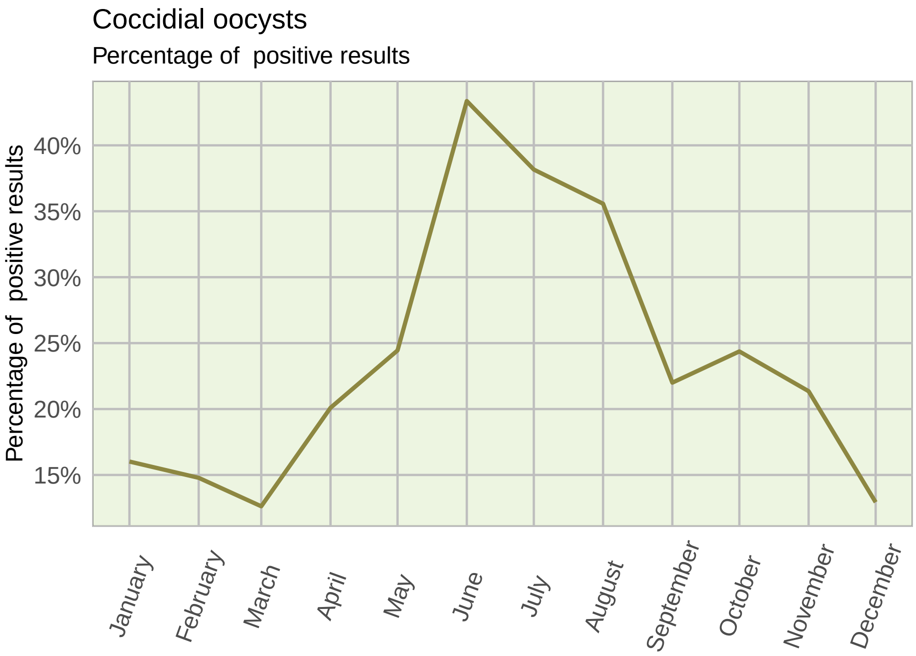

Figure 7.6: Percentage of bovine faecal samples testing positive for coccidial oocysts in 2021 (n=4465).

Table 7.4: Number of bovine faecal samples submitted in 2021 (all ages) for detection of liver fluke eggs and breakdown of positive and negative results (n=3563).

Result	No. of samples	Percentage
Liver fluke eggs not detected	3505	**98**
Positive liver fluke eggs	58	**2**

Liver Fluke

Liver fluke infection tends to be chronic in cattle, resulting in ill-thrift and poor performance. In sheep, chronic disease can occur, but infection may also result in more acute clinical signs, causing sudden death in cases of heavy challenge. Similar to previous years, the percentage of bovine faecal samples with liver fluke eggs detected in them remains low.

Paramphistomosis

Over the past decade or so, there has been a dramatic increase in awareness in the UK and Ireland of the parasite commonly known as rumen/stomach fluke (Figure 7.8) owing to reports of its increased detection and clinical effects on cattle and sheep here. Prior to this, it was generally only regarded as a parasite of significance in tropical and subtropical areas of the world. Disease in cattle mainly involves younger age groups, whereas in sheep and goats, all ages can potentially be affected.

The reason(s) for this increased prevalence of infection in the UK and Ireland has yet to

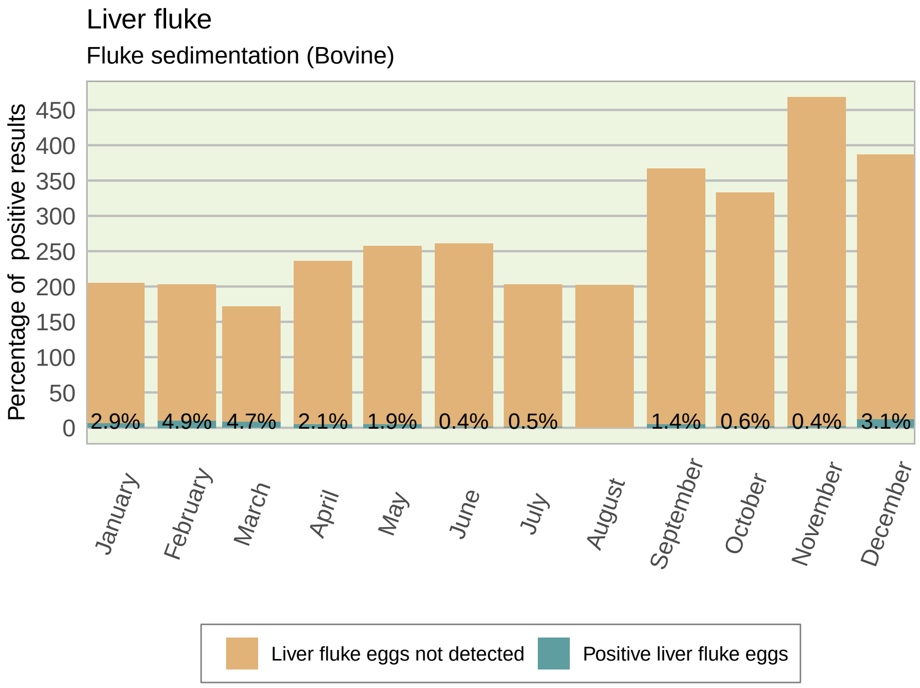

Figure 7.7: Stacked number of bovine faecal samples (all ages) tested for liver fluke in 2021. The percentage in each bar represents the number of positive samples per month (n=3563).

Table 7.5: Number of bovine faecal samples submitted in 2021 (all ages) for detection of rumen fluke eggs and breakdown of positive and negative results (n=3563).

Result	**No. of samples**	**Percentage**
Rumen fluke eggs not detected	2603	**73**
Positive rumen fluke eggs	960	**27**

be fully elucidated. It may be due to a number of factors such as the introduction of a new species of rumen fluke in imported livestock, the use of narrow spectrum flukicides or the expansion of pre-existing populations due to climate change (milder and wetter winters).

Although the detection of rumen fluke infections is now commonplace on UK and Irish farms, reports of disease outbreaks are relatively rare. Nonetheless, when they do occur, the associated losses can be significant. With this in mind, rumen fluke must always be considered a possible cause of disease in young cattle and sheep of all ages either at pasture or shortly after removal from a pasture where clinical signs include diarrhoea, ill thrift, inappetence and weight loss.

As can be seen from Table 7.5 below, 27 *per cent* of bovine faecal samples had rumen fluke eggs detected in them using sedimentation of faecal suspensions. With regard to treatment advice and the significance of these results, the finding of rumen fluke eggs in faecal samples of animals that are thriving and producing well does not indicate that treatment for rumen fluke is necessary.

Figure 7.8: Rumen fluke (*Calicophoron daubneyi*) at high magnification in the ruminal wall of cow. Photo:Cosme Sánchez-Miguel.

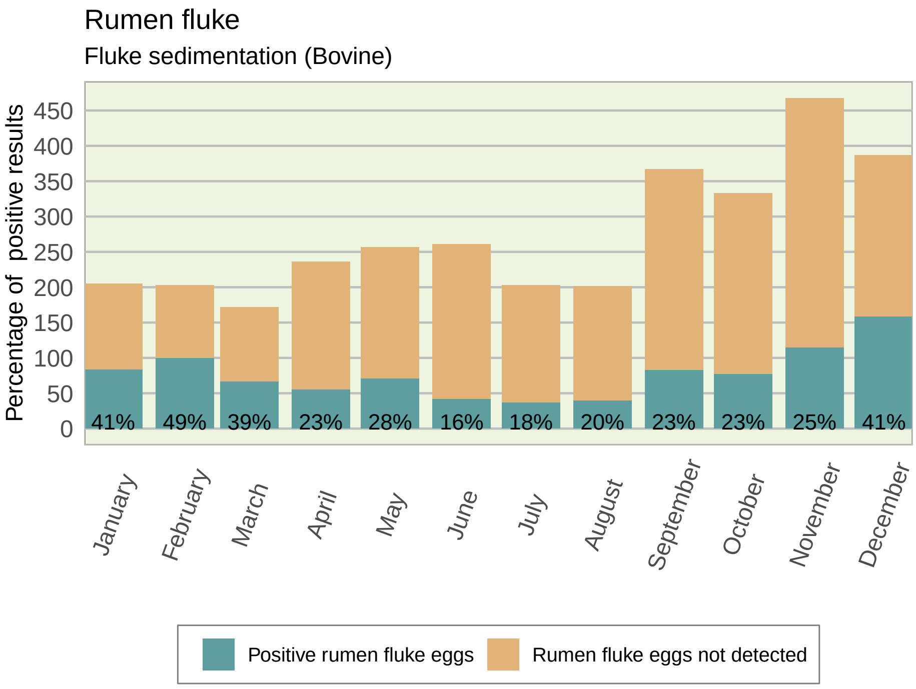

Figure 7.9: Stacked count of bovine faecal samples (all ages) tested for rumen fluke. The percentage in each bar represents positive samples (n=3563).

Part II

Ovine Diseases

CHAPTER 8

OVERVIEW OF SHEEP DISEASES

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In the sheep census, the population of sheep in Ireland was just over 3.7 million with 35,186 flocks. This gives an average of 106 sheep per flock, but the flock size is skewed with many flocks below 100 and few above 300 (Gov.ie Sheep Goat census). The national population of breeding ewes has fluctuated in that time from about 1,900,000 in 1985, to a peak of 4,800,000 in 1993, to a level of 2,800,000 in 2020 (Central Statistics Office, Ireland).

The health status of a flock has major implications for the productivity, welfare and profitability of sheep farming (Hosie and Clark 2007). The health status of the flock also affects the potential for antimicrobial and anthelmintic resistance. Health issues which have a big effect on productivity include lameness, teeth problems and mastitis. The iceberg diseases include ovine pulmonary adenocarcinoma (OPA), maedi visna (MV), caseous lymphadenitis (CLA), Johnes disease (JD) and Border disease (BD). Iceberg diseases are slow-onset diseases which cause chronic wasting and are referred to as iceberg diseases, as the thin, wasting ewes are the tip of the iceberg, with the vast majority of their negative health issues and productivity losses hidden below the surface (Ogden et al. 2019).

Internal and external parasites are also major issues for sheep health and productivity; they are dealt with in a separate section.

Parasitic disease and respiratory disease were the most commonly diagnosed causes of death in sheep of all ages in Ireland, with septicaemic disease being the commonest in younger lambs in Ireland. Colibacillosis, ovine neonatal enterotoxaemia (*watery mouth*)

Table 8.1: Conditions most frequently diagnosed on *post mortem* examinations of lambs in 2021 (n=856).

Disease	No. of Cases	Percentage
GIT Infections	195	**22.8**
Systemic Infections	137	**16.0**
Respiratory Infections	112	**13.1**
Clostridial disease	108	**12.6**
Nutritional/metabolic conditions	44	**5.1**
GIT torsion/obstruction	37	**4.3**
Diagnosis not reached	33	**3.9**
CNS	30	**3.5**
Poisoning	23	**2.7**
Urinary Tract conditions	21	**2.5**
Other	20	**2.3**
Trauma	19	**2.2**
Liver disease	18	**2.1**
GIT ulcer/perforation/foreign body	15	**1.8**
Autolysis	9	**1.1**
Navel Ill/Joint Ill	9	**1.1**
Peritonitis	8	**0.9**
Abscessation	6	**0.7**
Hereditary and developmental abnormality	6	**0.7**
Reproductive Tract Conditions	6	**0.7**

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

and cryptosporidiosis were common causes of enteric disease diagnosed in young lambs. Listeriosis remained the most frequently diagnosed central nervous system (CNS) disease, cerebrocortical necrosis (CCN) and louping ill were the next two commonest. Copper and *Pieris spp.* (including varieties such as Forest Flame, Little Heath Green & Variegated) were the most commonly diagnosed causes of poisoning in 2021 in DAFM laboratories.

8.1 Ovine carcass submissions to the RVLs

The Regional Veterinary Laboratories (RVLs) of the Department of Agriculture, Food and the Marine (DAFM) are engaged primarily in scanning (passive) surveillance by gathering data from *post-mortem* and clinical sample submissions. Analysis of this data provides an insight into trends of disease incidence and causes of mortality on Irish farms, thereby informing decision-making relevant to disease control at a national level.

Tables and charts are generated with test results and *post mortem* diagnoses from voluntary submissions of material (carcasses and clinical samples) to RVLs by farmers through their

Table 8.2: Conditions most frequently diagnosed on post mortem examinations of adult sheep (over one year of age) in 2021 (n=586). Note: the 'Other' grouping is a combination of multiple minor categories that have less than five cases.

Disease	No. of Cases	Percentage
Respiratory Infections	88	**15.0**
GIT Infections	58	**9.9**
Nutritional/metabolic conditions	56	**9.6**
CNS	52	**8.9**
Systemic Infections	47	**8.0**
Diagnosis not reached	38	**6.5**
Poisoning	37	**6.3**
Liver disease	36	**6.1**
Clostridial disease	26	**4.4**
Autolysis	22	**3.8**
Cardiac/circulatory conditions	22	**3.8**
Other	22	**3.8**
Reproductive Tract Conditions	17	**2.9**
Trauma	15	**2.6**
Mastitis	14	**2.4**
GIT torsion/obstruction	12	**2.0**
Peritonitis	11	**1.9**
Abscessation	7	**1.2**
Urinary Tract conditions	6	**1.0**

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

private veterinary practitioners (PVPs). Therefore, it should be noted that data reflects only those cases where the PVPs considered it appropriate to request a laboratory investigation and the herdowner was motivated to deliver the carcass to an RVL.

Diagnoses of submission during 2021 are shown in Table 8.1 in lambs under one year and in Table 8.2 and in adult sheep (over one year of age).

8.2 Sentinel sheep flock survey

In 2016 DAFM Regional Veterinary Laboratories carried out a study that assessed sheep mortality and cause-specific mortality in 33 sentinel sheep flocks in Ireland (Murray et al. 2019).

Methods

Sentinel flocks were requested to submit carcases of all sheep that died to the regional veterinary laboratories (RVLs) of the Department of Agriculture, Food and Marine during a calendar year (2016). Postmortem examinations were performed on 1247 submissions to Athlone, Kilkenny and Sligo RVLs.

Results

The median overall submission rate was 13.8 *per cent* (range from 2.5 *per cent* to 35.8 *per cent*) per adult female sheep in the flock in January 2016. The median fetal, perinatal, lamb and adult submissions per adult female sheep in the flock in January 2016 were 2.1 *per cent* (ramge from 0.0 *per cent* to 15.2 *per cent*), 3.5 per cent (from 0.0 *per cent* to 20.0 *per cent*), 3.0 *per cent* (from 0.0 *per cent* to 12.4 *per cent*) and 2.8 per cent (from 0.8 *per cent* to 7.1 *per cent*), respectively. The frequency of detection of categories of postmortem diagnoses in fetuses, perinates, lambs and adults are presented.

Conclusions

Comparisons with existing passive surveillance findings reflect some differences in the relative frequency of detection of certain categories of disease suggesting that sentinel flock surveillance could usefully supplement existing passive animal disease surveillance activities for ovine disease.

CHAPTER 9

CLOSTRIDIAL DISEASES IN BOVINE AND OVINE

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Clostridium spp. are widespread in the environment and some species can cause disease in animals, both housed and at pasture. They are mostly gram-positive obligate anaerobes and clinical disease is associated with rapid bacterial overgrowth and subsequent toxin release. The growth of *Clostridium spp. post mortem* contributes to the putrefaction and bloat of the carcass so it is important to carry out a post mortem examination as soon as possible after death to improve the chances of reaching a definitive diagnosis.

Blackleg, associated with *Clostridium chauvoei*, and enterotoxaemia associated with *Clostridium perfringens* were the most diagnosed clostridial diseases in the Regional Veterinary Laboratories in 2021.

Broadly, clostridial disease can be categorised into three different groups:

1. **Enterotoxaemic**: the production and release of toxin within the intestines of susceptible animals, and subsequent absorption into the circulation, e.g. Pulpy Kidney disease (*C. perfringens* type D)

2. **Histotoxic**: growth of bacteria in a tissue with release of toxin and extensive tissue destruction, e.g. Blackleg/Myositis (*C. chauvoei*), Malignant Oedema (*C. septicum*/*C. sordelli*), Black Disease (*C. novyi*)

Table 9.1: Clostridial disease diagnosed in bovine carcasses in 2021 (n=126).

Disease	No. of Cases	Percentage
Blackleg	85	**67.5**
Enterotoxaemia	19	**15.1**
Clostridial Myositis	5	**4.0**
Malignant Oedema	4	**3.2**
Tetanus	4	**3.2**
Botulism	3	**2.4**
Black Disease	2	**1.6**
Clostridial Enterotoxaemia	2	**1.6**
Pulpy Kidney Disease	2	**1.6**

3. **Neurotoxic**: growth of bacteria and release of toxins which damage nerves e.g., Tetanus (*Clostridium tetani*) and botulism (*Clostridium botulinum*)

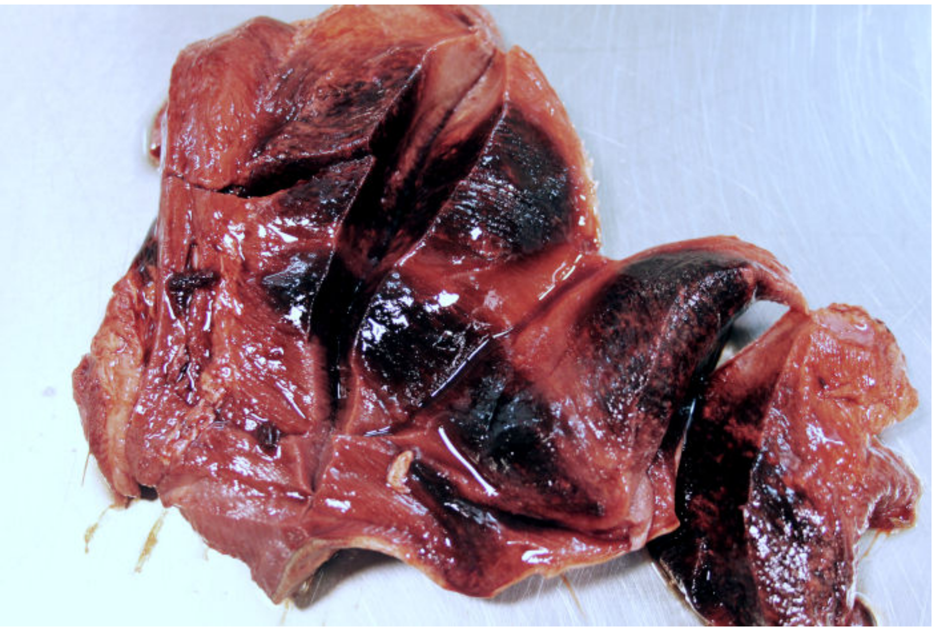

Figure 9.1: Necrotic muscle fibres (redback) in the tongue of a weanling with clostridial myositis (Blackleg). Photo: Denise Murphy.

9.1 Methods used in the RVLs to help diagnose clostridial disease

1. **History**: A good history is very important. Bovine botulism, for example may be suspected where the history included potential exposure to poultry litter and clinical signs of flaccid paralysis.

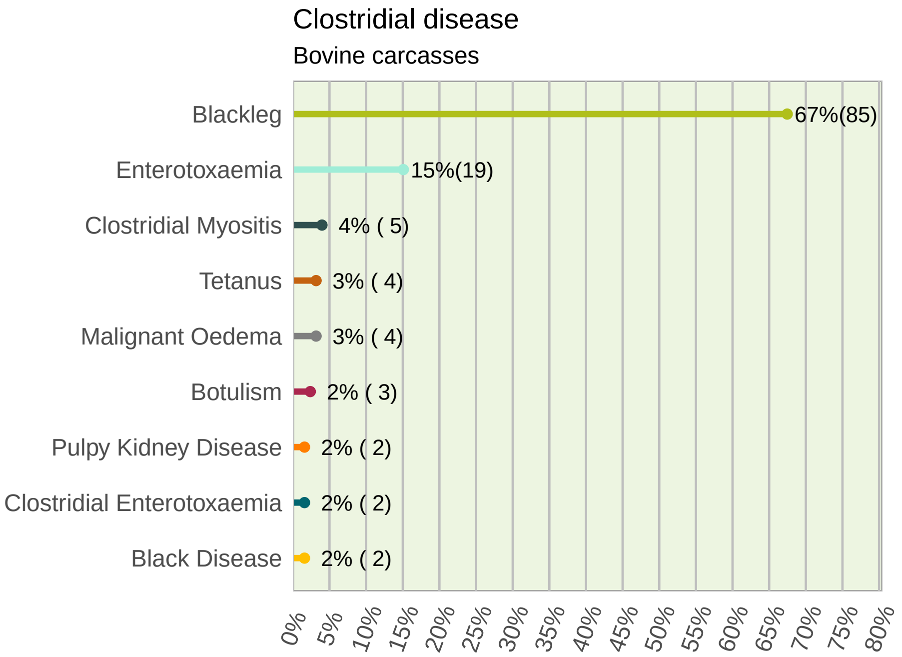

Figure 9.2: Clostridial disease diagnosed in bovine carcasses in 2021 (n=126) as a percentage of the total number of clostridial diseases.

2. **Gross *post mortem* findings**: Blackleg may be suspected where black, dry, crepitous lesions are seen in skeletal muscle, often with the smell of rancid butter. There may also be an accompanying fibrinous pericarditis.

3. **Anaerobic culture** may result for example in the growth of *Clostridium novyi* (Black Disease) from a necrotic liver lesion.

4. **Fluorescent Antibody Testing** is an effective way to detect different types of clostridial diseases associated with *Clostridium chauvoei*, *Clostridium septicum*, *Clostridium sordelli* and *Clostridium novyi*.

5. **ELISA testing for *Clostridium perfringens* toxins**: These tests are used to detect three of the major toxins (alpha, beta and epsilon) produced by *Clostridium perfringens*. Diseases associated with *Clostridium perfringens* are grouped into seven types (A to G) depending on the toxins they are linked with. The most common, *pulpy kidney disease* is caused by *C. perfringens* type D and is associated with the alpha and epsilon toxins. Epsilon toxin is considered to be one of the most potent bacterial toxins (Uzal and Songer 2008).

> The significance of an ELISA positive result for alpha toxin is difficult to interpret as it is found in the intestines of healthy animals. Beta toxin is rapidly destroyed by trypsin. There are low levels of trypsin in the intestines of neonatal lambs, as colostrum and early milk contain trypsin inhibitors This means that clostridial diseases associated with beta toxin tend to occur in young lambs less than 10–21 days. In contrast to beta toxin, epsilon toxin requires trypsin present in the intestine to be activated. This may explain why slightly older lambs are more commonly affected with the clostridial diseases associated with epsilon toxin (e.g., pulpy kidney disease).

6. **Histopathology** can also be helpful in the diagnosis of clostridial-associated disease. Focal symmetrical encephalomalacia lesions for example, and pooling of proteinaceous fluid around blood vessels in the brain are lesions strongly associated with pulpy kidney disease, caused by *Clostridium perfringens*.

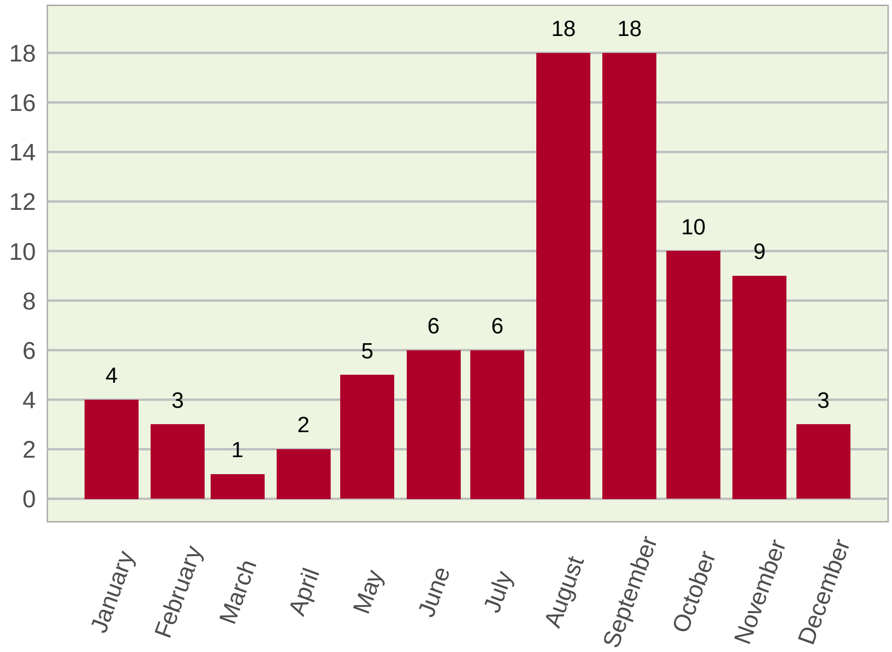

Figure 9.3: Occurrence of blackleg diagnoses in RVLs in 2021, by calendar month (n=85).

There has been an almost two-fold increase in the number of clostridial disease cases diagnosed in 2021 compared to 2020 (126 versus 64 bovine and 134 versus 71 ovine cases). This may be due to failure to vaccinate or to complete a primary course properly or possibly due to incorrect timing or failure to administer the booster to provide passive immunity to offspring.

Blackleg/clostridial myositis was the most commonly diagnosed clostridial disease in cattle (67 *percent* of cases) in 2021 (Table 9.1). It is a highly fatal disease, the occurrence of which peaked in Autumn of 2021 (Table 9.2) and was most seen in 6–12-month-old weanlings (Table 9.2). Lesions were most often recorded in the skeletal musculature but were also seen occasionally in the tongue and heart.

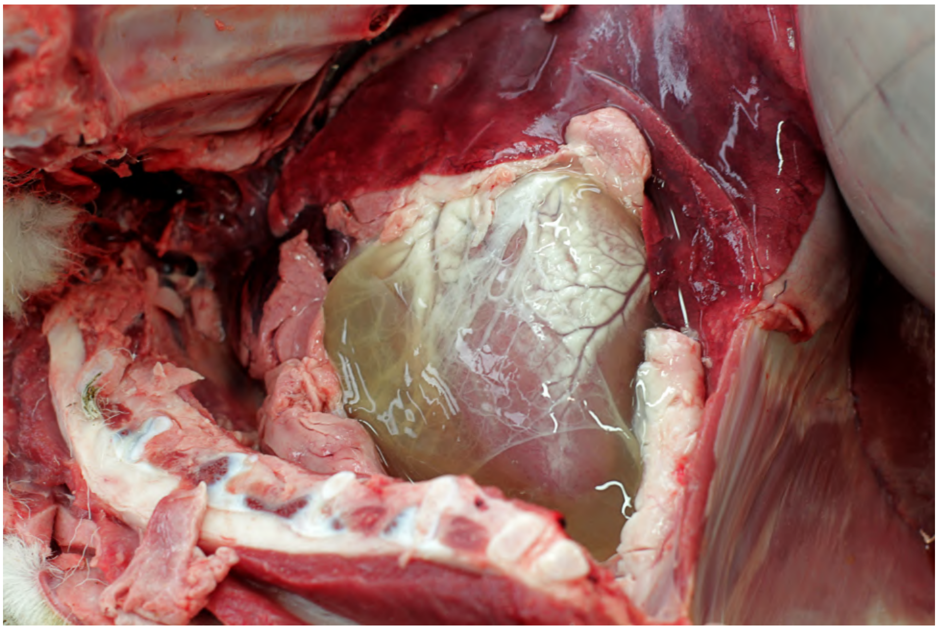

Figure 9.4: Open paricardium with clotted pericardial fluid as a result of *Clostridium perfringens* type D enterotoxemia. Photo: Cosme Sánchez-Miguel.

Table 9.2: Blackleg disease diagnosed in bovine carcasses by age group in 2021 (n=85).

Age Group	No. of Cases	Percentage
Weanling (6-12 months old)	44	**52**
Calves (1-5 months old)	25	**29**
Adult Cattle (over 12 months old)	16	**19**

Table 9.3: Pulpy kidney disease diagnosed in ovine carcasses in 2021 (n=134).

Disease	No. of Cases	Percentage
Clostridial Enterotoxaemia	63	**47.0**
Pulpy Kidney Disease	59	**44.0**
Black Disease	6	**4.5**
Blackleg	3	**2.2**
Malignant Oedema	2	**1.5**
Clostridial Myositis	1	**0.8**

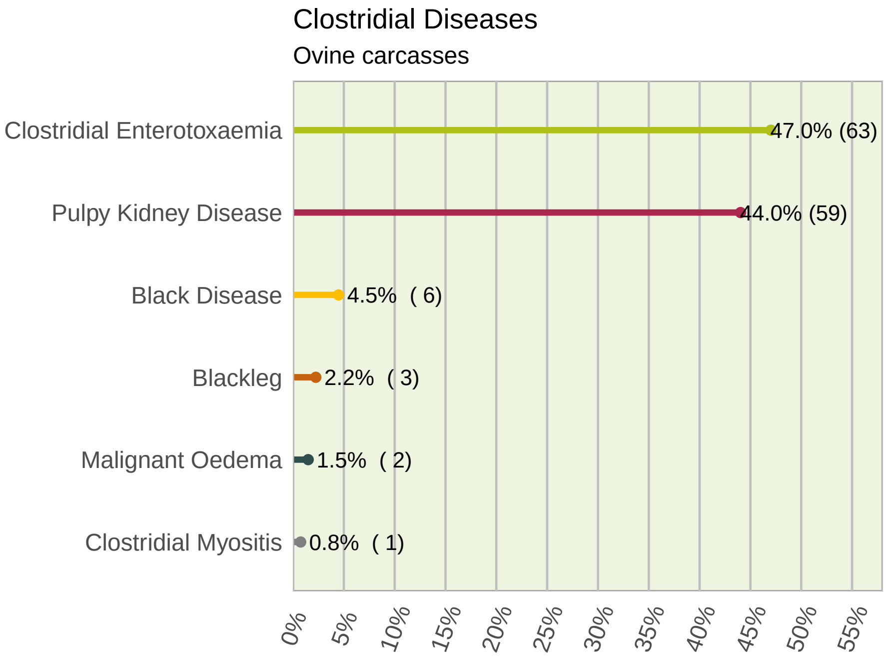

Figure 9.5: Clostridial disease diagnosed in ovine carcasses in 2021 (n=134) as a percentage of the total number of clostrial diseases.

Multivalent clostridial vaccines are very effective for both cattle and sheep, and their use is recommended for prevention of disease. It is very important that vaccines are stored and administered correctly to reduce vaccine failure and that animals are vaccinated according to manufacturer's guidelines.

Enterotoxaemia was the most common clostridial disease seen in sheep in 2021. Pulpy kidney disease is one form of enterotoxaemia, and both accounted for over 90 *percent* of ovine clostridial disease cases (Table 9.3). Fibrin clots in the pericardial sac (Figure 9.4), glucosuria and soft kidneys are characteristics of *pulpy kidney disease*. The incidence of this disease peaked in April 2021 (Table 9.6) and fast-growing lambs were the type of animal most affected. The history often included recent introduction to lush pasture or highly fermentable carbohydrates. Many were found dead, but some had acute-onset neurological signs before death. The disease was also occasionally diagnosed in calves in 2021.

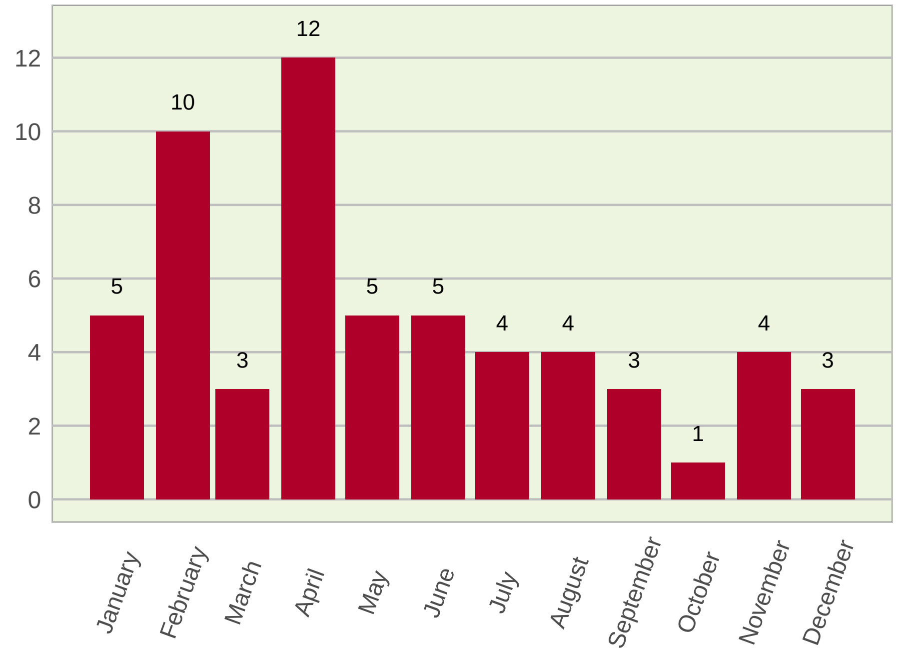

Figure 9.6: Occurrence of diagnosis of pulpy kidney disease in RVLs in 2021, by calendar month (n=59).

CHAPTER

10

OVINE ABORTION

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The two main causes of ovine abortion in Ireland remain unchanged, they are Enzootic Abortion of Ewes (EAE) and Toxoplasmosis. EAE detection has increased from 17.5 *per cent* in 2020 to 31.9 *per cent* in 2021. Toxoplasmosis infection has remained largely unchanged.

Both these agents are zoonotic, considerable care should be taken when handling sheep before and after lambing. Pregnant women should not have contact with sheep flocks during lambing, or with dirty overalls and other equipment that may be contaminated.

Practical tips for when abortions are occurring include:

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

Table 10.1: Ovine foetuses examined by Toxoplasma PCR in 2021, (n=346).

PCR Result	No of Cases	Percentage
No Pathogen detected	266	76.9
Inconclusive	13	3.8
Positive	67	19.4

10.1 *Toxoplasma gondii*

Toxoplasmosis is caused by *Toxoplasma gondii*. The source of infection is most commonly contaminated cat faeces. A single cat dropping can infect a large number of ewes. 50 grams of cat faeces could potentially contain 10 million oocysts and approximately 40 oocysts can cause infection. Young cats are believed to be the greatest risk as older cats will have immunity. Heavy infections may cause up to 50 *per cent* infertility but typically it presents as an ongoing problem resulting in a reduction in lamb numbers by approx. 6 *per cent*. Infection can result in infertility, mummified foetuses, abortions, stillbirths and weakly lambs. The percentage of positive results obtained in ovine foetuses or foetal material by PCR and/or serology are shown in Figure 10.3 (a).

Figure 10.1: White foci on the cotyledons representing areas of necrosis and calcification associatefd with Toxoplasma gondii infection. Photo: Maresa Sheehan.

10.2 *Chlamydophila abortus*

EAE is caused by the bacteria *Chlamydophila abortus*. Ewes are infected by the oronasal route. Lambs fostered on to an aborted ewe can be infected from vaginal discharges on the udder and wool.

Table 10.2: Toxoplasma PCR and Toxoplasma serology (Agglutination Test) test results in 2021 (n=439).

Result	No of Cases	Percentage
Positive	88	20
Negative	351	80

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

Figure 10.2: Cotyledonary and intercotyledonary placentitis associated with EAE infection. Photo: Maresa Sheehan.

Table 10.3: Percentage of *Chlamydophila abortus* PCR results in ovine foetuses in 2021 (n=345).

PCR Result	No of Cases	Percentage
No Pathogen detected	186	**54**
Positive	110	**32**
Inconclusive	49	**14**

Ewes usually become infected during one lambing season, have a normal lambing, but are latently infected and abort the subsequent pregnancy. The organisms become active after day 90, causing a placentitis and near-term abortions, stillbirths or birth of live, but sickly, lambs.

Ewes are rarely unwell. Aborted lambs appear grossly normal for the stage of gestation, but a placentitis will be grossly visible.

Ewes do not abort a second time due to EAE (they may abort from other infectious causes),

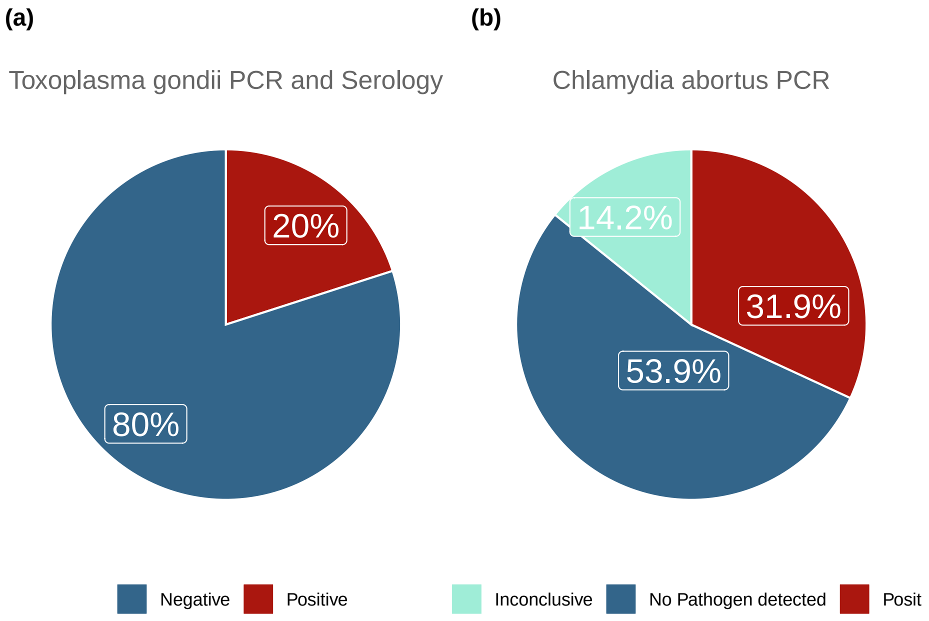

Figure 10.3: Pie charts showing (a) the Toxoplasma gondii PCR and serology (Agglutination Test) and (b) the *Chlamydophila abortus* PCR test results in ovine foetuses in 2021.

but they can excrete infection in smaller amounts from vaginal fluids at subsequent *normal* lambing. The percentage of positive results obtained in ovine foetuses or foetal material by PCR and/or serology are shown in Figure 10.3 (b).

10.3 Other Organisms

In addition to testing for *Toxoplasma gondii* and *Chlamydophila abortus*, culture is routinely carried out on RVL ovine foetal submissions, typically on stomach contents, and placenta if supplied. In the majority of cases in 2020 this resulted in no significant growth (56.4 *per cent*, on Table 10.4).

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

From the 391 ovine foetuses cultured, E. coli (25.6 *per cent*) was the most common isolate. While *E. coli* can cause abortion in sheep it can be difficult to determine in the individual

Table 10.4: Combined frequency of detection of selected secondary abortion agents on routine foetal culture of ovine foetuses (n=667).

Organism	No of Isolates	Percentage
No Significant Growth	376	**56.4**
Coliforms	171	**25.6**
Streptococcus spp	17	**2.5**
Staph. spp	11	**1.6**
Trueperella pyogenes	8	**1.2**
Bacillus licheniformis	6	**0.9**
Campylobacter spp	5	**0.7**
Listeria spp	5	**0.7**
Mannheimia haemolytica	4	**0.6**
Pseudomonas spp	3	**0.4**
Aspergillus spp	2	**0.3**
Campylobacter fetus	2	**0.3**
Salmonella dublin	2	**0.3**
Salmonella spp	2	**0.3**
Bibersteinia trehalosi	1	**0.1**
Yeasts and Fungi	1	**0.1**

case whether it is the abortefacient or just a contaminant. *Truperella pyogenes* was isolated in 1.2 *per cent* of the cases. Pathogens associated with poor quality feed, and causes of sporadic abortion, such as *Bacillus spp.* (0.9 *per cent*), *Listeria spp.* (0.7 *per cent*), and *Aspergillus spp.* (0.3 *per cent*) were isolated occasionally. *Salmonella* Dublin (0.3 *per cent*) and *Campylobacter fetus* (0.3 *per cent*) were also identified rarely.

10.4 Investigations of Ovine Abortions

Always submit placentas with freshly aborted foetuses to the laboratory when investigating ovine abortion. The importance of submitting a placenta in cases of ovine abortion cannot be overstated, both the gross and histopathological appearance and it's use as a matrix for testing, are essential diagnostic tools. The diagnostic rate for ovine abortion is low (approx. 50 *per cent*) across the globe, therefore repeated submissions together with blood samples from dams may be necessary to reach a diagnosis.

10.5 Control of the main two causes of abortion

Separation of aborting ewes from the rest of the flock and careful disposal of aborted material is always advised, but particularly in the case of EAE and other bacterial causes of abortion e.g. Campylobacter infection.

Biosecurity; EAE can enter the flock through the purchase of a latently infected breeding animal.

EAE aborting ewes should not be used as foster mothers. Ewes do not abort a second time due to EAE (they may abort from other infectious causes), but they can excrete infection in smaller amounts from vaginal fluids at subsequent “normal” lambing. The use of oxytetracycline in the face of an outbreak should be discussed with a veterinary practitioner.

Vaccination has a key role to play in protecting your flock against the two main causes of abortion. Ewes should be vaccinated against the two main causes of abortion at least 4 weeks pre-breeding. Although it is generally believed that one vaccine each for EAE and Toxopalsma is sufficient for lifelong protection the necessity for a booster after a number of years should be discussed with a veterinary surgeon. Care must be taken not to administer antibiotics when administering live vaccination and as the agents are zoonotic care must be taken with their administration.

CHAPTER 11

OVINE PARASITES

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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 (Figure 11.2) (Craig 2018). 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 are not commonly reported here (Rinaldi et al. 2015). Nonetheless, with potential climate changes, *Haemonchus* may become more prevalent.

The number of faecal samples that were categorised as either medium or high burden (41 *per cent*) is greater than last year's figure of 28 *per cent*. Although it is beyond the scope of this

Table 11.1: Number of ovine faecal samples tested for Trichostrongylidae eggs in 2021 and results by percentage (n=2129). The ranges assume the absence of *H. contortus* in the faecal sample.

Result	No. of samples	Percentage
Negative	844	**40**
Low (50-250 epg)	418	**20**
Medium (250-750 epg)	375	**18**
High (>750 epg)	492	**23**

Figure 11.1: Texel Ram Lamb with Perineal Faecal Staining Due to Parasitic Gastroenteritis. Photo: James O'Shaughnessy.

report to fully interrogate these figures, it may simply reflect a selection bias. Other potential, more noteworthy reasons include anthelmintic treatment failure or a lack of anthelmintic treatments in the first instance. Either way, 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.

11.2 Nematodirus

A number of different *Nematodirus* species can potentially affect sheep (e.g. *Nematodirus filicollis*, *N. spathiger* and *N. battus*). However, by far, the most important of these is *N. battus* (Jansen 1973). This species can give rise to severe disease in lambs six to twelve weeks of age, characterised by scouring, dehydration and even death (Kingsbury et al. 1953). The life cycle of *N. battus* is dissimilar to that of other roundworms in that it takes almost a year before the egg hatches, releasing the infective third-stage larvae. Although the hatching of eggs can also occur at different times of the year (e.g. autumn) (Urquhart et al. 1987), there is typically a mass hatch of eggs in late spring or early summer (April–June), leading to a build-up of infective larvae on pasture. Infection is characterised by profuse diarrhoea, dehydration and weight loss.

Based on this year's data, the greatest number of positive samples occurred in early summer. This is to be expected given the typical annual pattern of egg hatching. It is important to recognise that although *Nematodirus eggs* were not detected in 88 *per cent* of samples, it still does not preclude this roundworm from being responsible for disease in certain cases given that much of the pathology is attributed to the larval stages of this roundworm.

Benzimidazoles (white drenches) remain the treatment of choice for *Nematodirus* infections

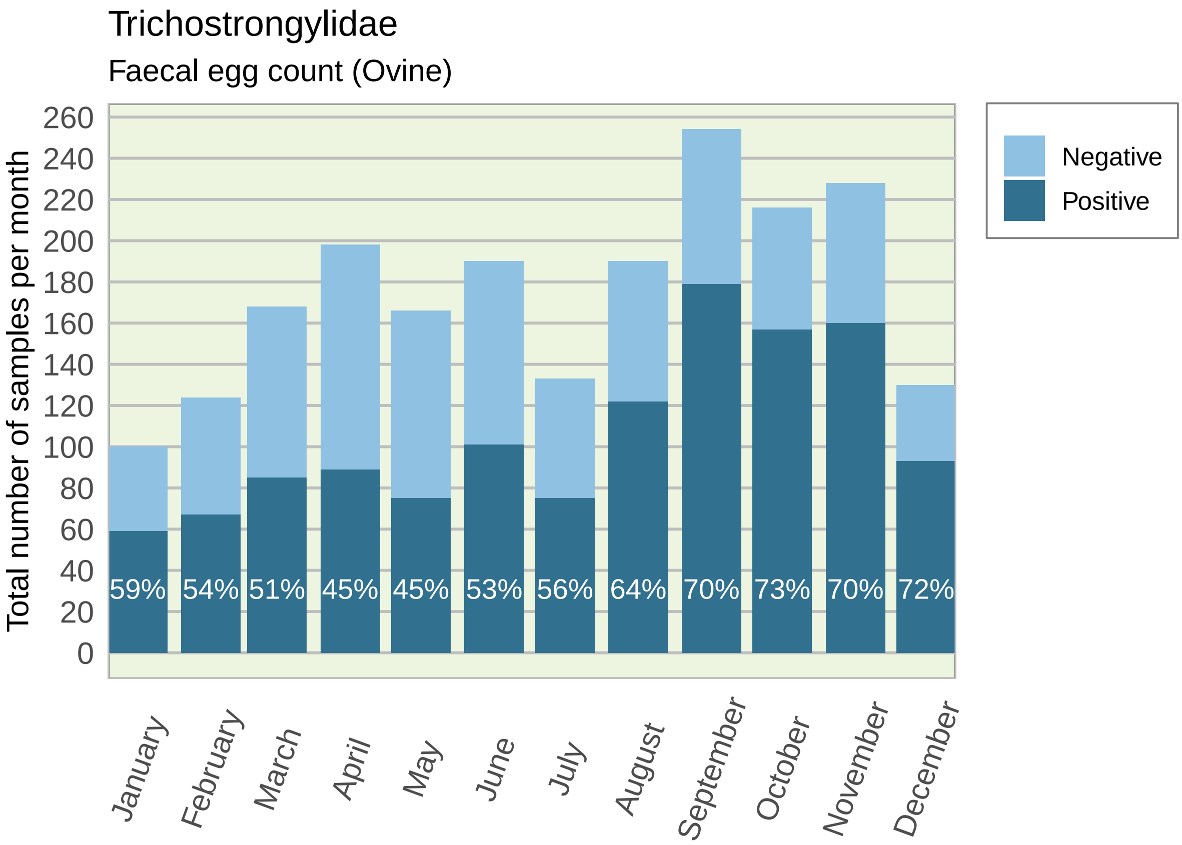

Figure 11.2: Stacked count of ovine faecal samples (all ages) tested per month for *Trichostrongylidae* during 2021. The percentage in each bar represents positive samples (n=2129).

Table 11.2: Number of ovine faecal samples tested for *Nematodirus* eggs in 2021 and results by percentage (n= (n=2129).

Result	No. of samples	Percentage
Negative	1867	**87.7**
Low (50-150 epg)	112	**5.3**
Moderate (>150-300 epg)	90	**4.2**
High (>300 epg)	60	**2.8**

and are effective against both larval and adult stages. The use of this anthelmintic class as the first-choice treatment option will also help to reduce the exposure of other worms, such as *Trichostrongylus* and *Teladorsagia*, to the other anthelmintic classes (e.g., macrocyclic lactones) at a point in the grazing season when treatment for these may not be necessary.

11.3 Coccidiosis

Eimeria is a genus of ubiquitous protozoans that give rise to the condition commonly known as coccidiosis (Keeton and Navarre 2018). Although a number of *Eimeria spp.* may affect

Table 11.3: Number of ovine faecal samples submitted in 2021 (all ages) for detection of coccidial oocysts and results by percentage, (n=2051).

Result	No. of samples	Percentage
Not Detected	1221	**60**
Light Infection	567	**28**
Moderate Infection	163	**8**
Heavy Infection	67	**3**
Severe Infection	33	**2**

lambs, the two most important species are *Eimeria ovinoidalis* and *E. crandallis* (Sargison 2004). Clinical signs of the disease include diarrhoea, tenesmus and acute weight loss (Keeton and Navarre 2018). However, the subclinical disease also commonly occurs and is characterised by poor growth rates. In addition to animal age, other risk factors for the development of this condition include areas on farms that tend to be heavily stocked (e.g. around water or feed troughs) as well as concurrent disease and any stress-inducing events (e.g. dietary changes, weaning) (Jolley and Bardsley 2006).

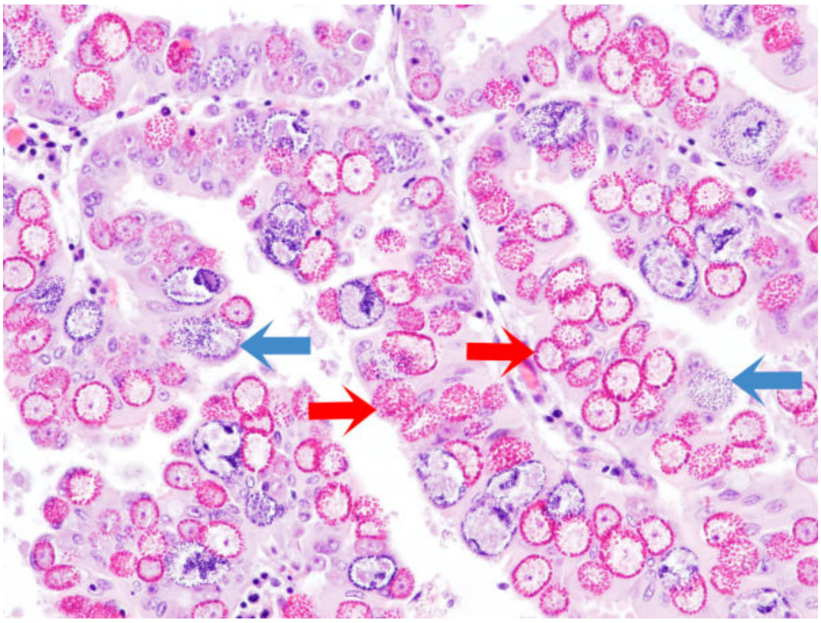

Figure 11.3: Microscopic photography if the intestinal villi of a sheep with coccidiosis showing the merozoites diferenciated into gametes, the red arrows show the macrogametes and the blue arrows the microgametes. Photo: Cosme Sánchez-Miguel.

Although a large majority of this year's samples (88 *per cent*) either did not have coccidial oocysts detected in them or had very low counts, these results must be carefully interpreted as peak oocyst shedding in faeces is not always coincident with clinical signs of disease. With regards to the small number of moderate to severe infections, these results must similarly be viewed with caution as some species of coccidia are far more pathogenic than others, and the presence of their oocysts in faecal samples may be far more noteworthy. To overcome some of these shortcomings in relation to the diagnosis of coccidiosis, it is advised to sample multiple animals within the same group.

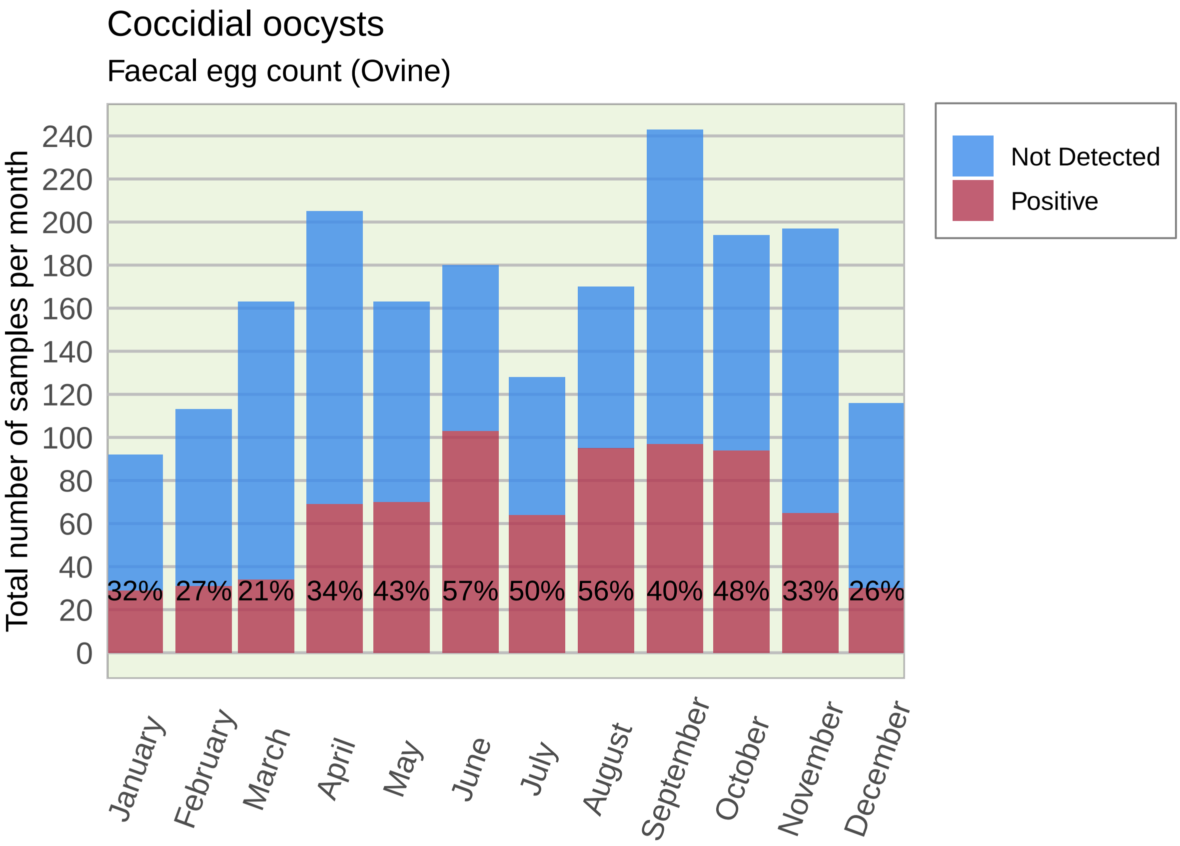

Figure 11.4: Stacked number of ovine faecal samples (all ages) tested for coccidial oocysts in 2021. The percentage in each bar represents the number of positives (n=2051).

11.4 Liver fluke and rumen fluke

In contrast to cattle, where liver fluke infection tends to be chronic only, infection in sheep may also result in more acute clinical signs, causing sudden death in cases of heavy challenge.

Table 11.4: Number of bovine faecal samples submitted in 2021 (all ages) for detection of liver fluke eggs and breakdown of positive and negative results (n=1854).

Result	No. of samples	Percentage
Liver fluke eggs not detected	1724	**93**
Positive liver fluke eggs	130	**7**

The number of samples positive for liver fluke (7 *per cent*) is similar to last year's data, where 8 *per cent* of samples had liver fluke eggs present. It should always be borne in mind that the finding of liver fluke eggs in any faecal sample is always a significant result.

Although there has been a large increase in the diagnosis of rumen fluke infections over the last decade in the UK and Ireland, clinical disease is uncommon (generally seen in young

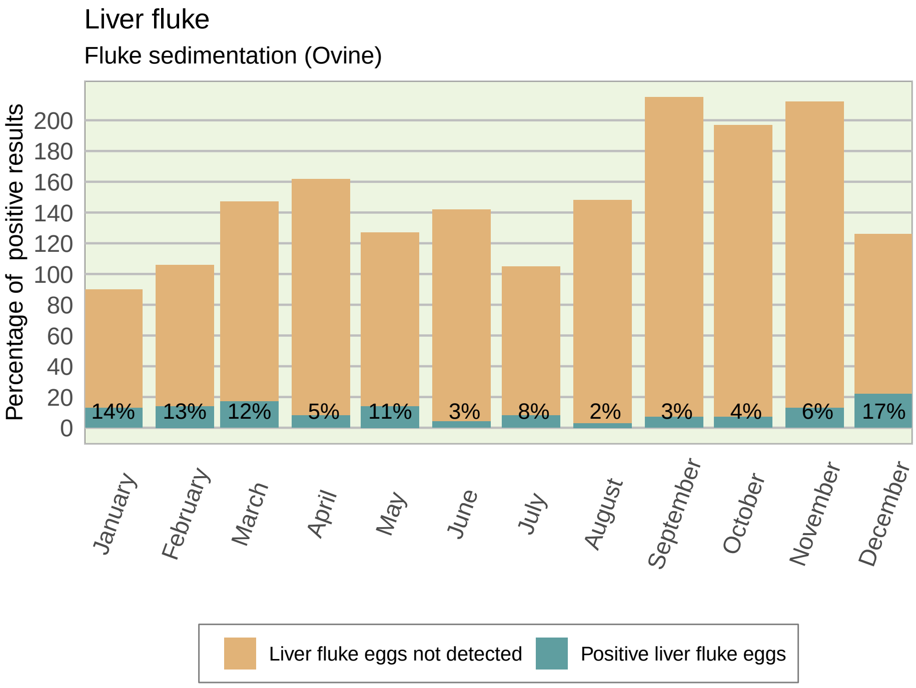

Figure 11.5: Stacked number of ovine faecal samples (all ages) tested for liver fluke in 2021. The percentage in each bar represents the number of positive samples per month (n=1854).

cattle or sheep of any age). Nonetheless, when they do occur, the associated losses can be significant. Clinical signs such as severe diarrhoea and sudden weight loss (or death in some cases) (O'Shaughnessy et al. 2018) are due to the pathology caused by the juvenile stages.

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

Table 11.5: Number of ovine faecal samples submitted in 2021 (all ages) for detection of rumen fluke eggs and breakdown of positive and negative results (n=1854).

Result	No. of samples	Percentage
Rumen fluke eggs not detected	1462	**79**
Positive rumen fluke eggs	392	**21**

The figure for this year's rumen fluke-positive samples (21 *per cent*) is again broadly similar to last year's data, where 20 *per cent* of samples were positive for rumen fluke eggs. These figures appear to reflect a continuing expansion of this species of trematode in Irish livestock. Although the percentage of positive samples increased from last year, cases of the acute disease remain very uncommon.

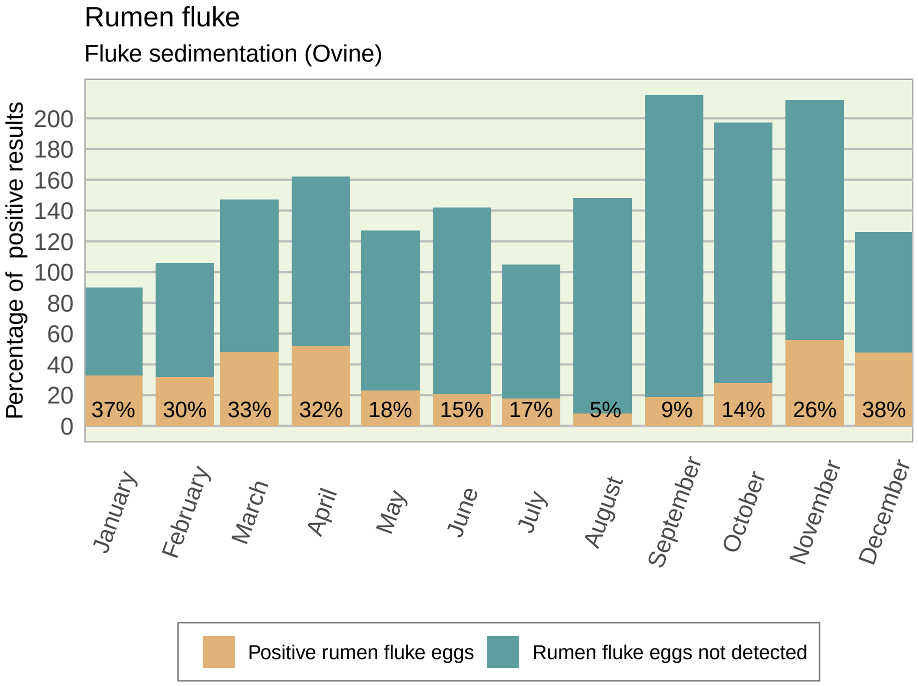

Figure 11.6: Stacked count of ovine faecal samples (all ages) tested for rumen fluke. The percentage in each bar represents positive samples (n=1854).

Part III

Other Species

CHAPTER 12

DISEASES OF PIGS

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In 2021 DAFM laboratories carried out necropsy examinations on 244 pig carcases. Additionally, 2296 non-carcase diagnostic samples were submitted from pigs for a range of diagnostic tests to assist veterinarians with disease investigation and/or surveillance on Irish pig farms. These figures are comparable with 2020 submissions. Similar to previous years, pigs submitted for necropsy examination were predominantly from weaner & piglet stages of growth and almost exclusively from intensive, large-scale pig farming units.

12.1 *Post mortem* Diagnoses.

The most frequent disease diagnoses from pig necropsy submissions during 2021 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.

As with previous years, pneumonia/pleuropneumonia and enteritis remained the most commonly diagnosed diseases in pig carcases submitted for examination. This is consistent with intensive pig production systems' disease prevalence worldwide, with both enteritis and pneumonia representing the most common disease categories impacting large scale pig production. Both of these disease categories are often addressed initially using antibi-

Table 12.1: Diagnoses in pigs on *post-mortem* examinations. (n=234).

Diagnosis	Count	Percentage
Other	50	**21.4**
Abortion	28	**12.0**
Enteritis	28	**12.0**
Bact/Sept/Tox*	25	**10.7**
Pneumonia	24	**10.3**
Pleuropneumonia	18	**7.7**
Arthritis	17	**7.3**
Meningitis	16	**6.8**
Colitis	13	**5.6**
Congenital tremor	6	**2.6**
PMWS	5	**2.1**
Trauma	4	**1.7**

Note:
The 'Other' grouping combines multiple minor categories with less than three cases.
* Bacteraemia/septicaemia/toxaemia

otic interventions on farms where they occur to reduce production losses. Subsequent long term control intervention such as using vaccinations can reduce disease incidence.

Pneumonia and pleuropneumonia were the most frequent diagnoses reached in DAFM labs pig *post mortem* investigations in 2021, accounting for 18 *per cent* of all diagnoses reached. All porcine respiratory disease investigations at DAFM labs undergo bacterial, viral and histopathological testing, to determine the pathogens and inflammatory pattern present. Pneumonia in pigs typically is a result of many interacting risk factors including; infectious agents (viral and bacterial), environmental conditions, management and genetic factors. Pneumonia in pigs is rarely exclusively due to infection with a single pathogen, thus the term Porcine Respiratory Disease Complex (PRDC) is used to describe this syndrome. PRDC is a significant cause of morbidity, mortality and economic loss both at farm level and at meat factory level for the pig industry. In DAFM investigated cases the most commonly isolated bacterial agent from pneumonia cases was *Actinobacillus pleuropneumonia*, which was isolated in half of all cases of pleuropneumonia/pneumonia examined. In many cases a viral pneumonic agent was also detected with, influenza virus, porcine reproductive and respiratory syndrome virus and porcine circovirus 2 being the routinely tested for and detected from pneumonic lung samples.

Actinobacillus pleuropneumoniae is one of the most prevalent bacterial pulmonary pathogens in pigs worldwide and was the most commonly detected bacterial pathogen in pneumonia/pleuropneumonia cases investigated by DAFM labs. In its most virulent form, *Actinobacillus pleuropneumoniae* causes severe diffuse fibrinohaemorrhagic necrotising pleuropneumonia, which is rapidly fatal in all ages of pigs. In 2021 four *Actinobacillus pleuropneumoniae* isolates were serotyped from various submitting farms and serotypes 8, 7 & 2 were identified in the isolates examined. However, given the low number of isolates examined, this should not be interpreted as demonstrating which serotypes are more/less prevalent in Ireland at this time.

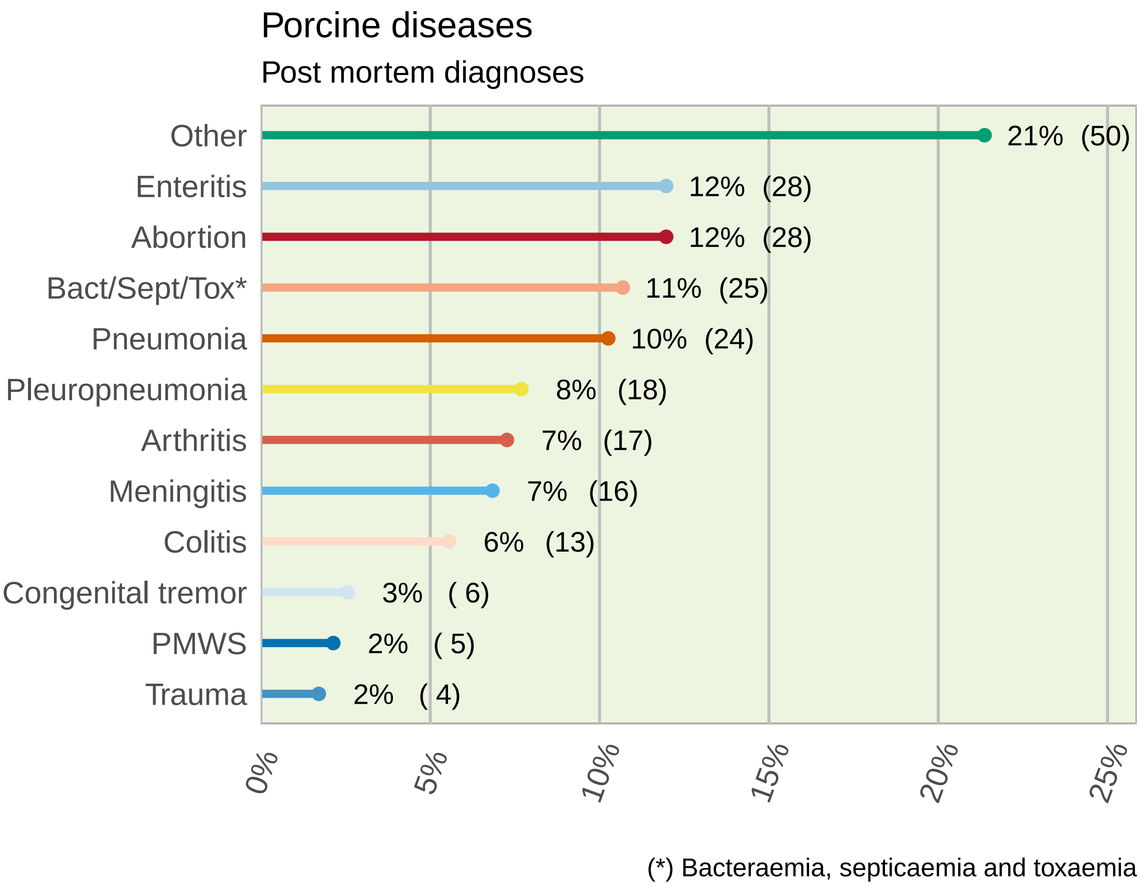

Figure 12.1: Diagnoses recorded in pigs and foetuses submitted for *post-mortem* examinations. Note: the 'Other' grouping combines multiple minor categories with less than three cases. (n=234).

A porcine bacterial respiratory pathogen multiplex PCR test was reinstated by DAFM labs in quarter 4 of 2021. Over the reminder of the year, 27 samples were tested for *Actinobacillus pleuropneumoniae*, *Haemophilus parasuis* and *Mycoplasma hyopneumoniae* using this test. There was one detection of *Haemophilus parasuis* and three detections of *Mycoplasma hyopneumoniae* using this method. 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 favour their growth in artificial media while for others the presence of systemic antibiotics impedes bacterial growth in culture. Nonetheless bacterial culture isolates are necessary for antimicrobial sensitivity testing.

Enteritis

Enteritis accounted for the second most common disease category diagnosed in pig carcases submitted to DAFM labs in 2021, representing 12 *per cent* of cases diagnosed. Most were from neonatal enteritis investigations. DAFM Labs operates a proactive porcine neona-

Figure 12.2: Pig pneumonia. Photo: Margaret Wilson

tal enteritis investigation service for pig farms and veterinarians on account of the significant morbidity and economic loss along with increased use of antibiotics, cases of neonatal enteritis in pigs can cause in affected herds. Multiple agents can cause neonatal diarrhoea in pigs and often more than one agent can be involved in an outbreak on a farm. The most commonly identified infectious agents in cases examined by DAFM Labs were, Rotavirus, *E. coli*, *E. coli* 0157, *Clostridium difficile*, *Salmonella* spp. and *Coccidia*.

Bacteraemia

Bacteraemia was the third most common diagnostic category accounting for 10.7 *per cent* of diagnosis. The majority of bacteraemia cases had *Streptococcus suis* isolated. *Streptococcus suis* is one of the most common pig pathogens worldwide. It is a commensal bacterium of pigs typically passed from a sow to her litter. Only virulent strains cause disease, resulting in bacteriaemia and attendant; polyserositis, meningitis, arthritis or pneumonia. Once virulent *Streptococcus suis* strains emerge within a herd, they are shed and spread to cohort pigs. In 2021 a subset of eleven *Streptococcus suis* isolates were serotyped from various submitting farms and serotypes 1, 2, 3, 7, 9, 15 and 28 were identified in the isolates examined. Given the low number of isolates examined and the farm specific nature of these isolates, this cannot be interpreted as demonstrating which serotypes are more/less prevalent in Ireland at this time. *Streptococcus suis* isolated from pig carcases in DAFM labs also routinely undergo antimicrobial sensitivity testing.

A number of specific classical diseases of pigs were investigated by DAFM labs over the course of 2021 a selection of which are presented below.

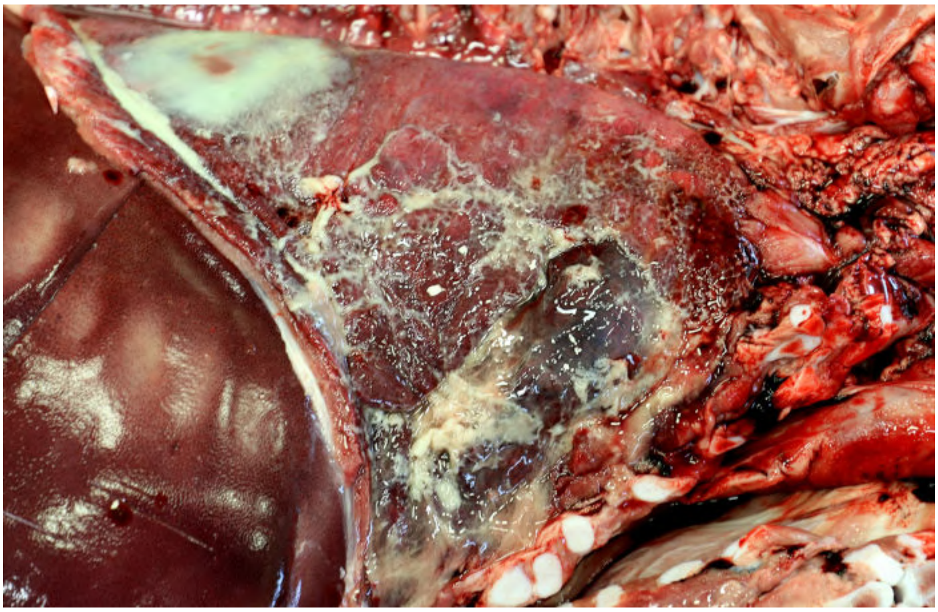

Figure 12.3: Strep suis Porcine Lung with severe diffuse fibrinous pleurisy. Photo: Margaret Wilson

Congenital Tremor

Six piglets from a 700-sow herd were submitted with suspected congenital tremor. The farm had lost 60 piglets with similar symptoms over the previous few weeks. On *ante mortem* examination piglets were alert and responsive and had righting reflexes. They all displayed constant body wide tremor when recumbent, this was more pronounced while standing. Additionally there was hypermetria of hindlimbs when standing and excessive repetitive flexion of hindlimbs when unbalanced.

> **Congenital tremor** is a syndrome of newborn piglets which display temors of variable intensity and which have lesions of hypomyelination or demyelination of the brain and/or spinal cord. There are six different types of Congenital tremor categorised based on causative agents and major histopathological lesions

No significant gross lesions were identified. Histopathological examination of the brain and spinal cord using specialist cytological staining identified multifocal reduced myelination and myelin vacuolation of the cerebellar white matter in all piglets. These findings are consistent with a type A congenital tremor.

Documented causes of type A congenital tremor in piglets include; Classical swine fever, PCV2, and genetic factors. DAFM labs conducted testing for; Atypical porcine pestivirus, Pan-pestivirus, Porcine Parvovirus and PCV2 by PCR which were all negative. On the basis of these results an exclusionary diagnosis of idiopathic congenital tremor type A was reached.

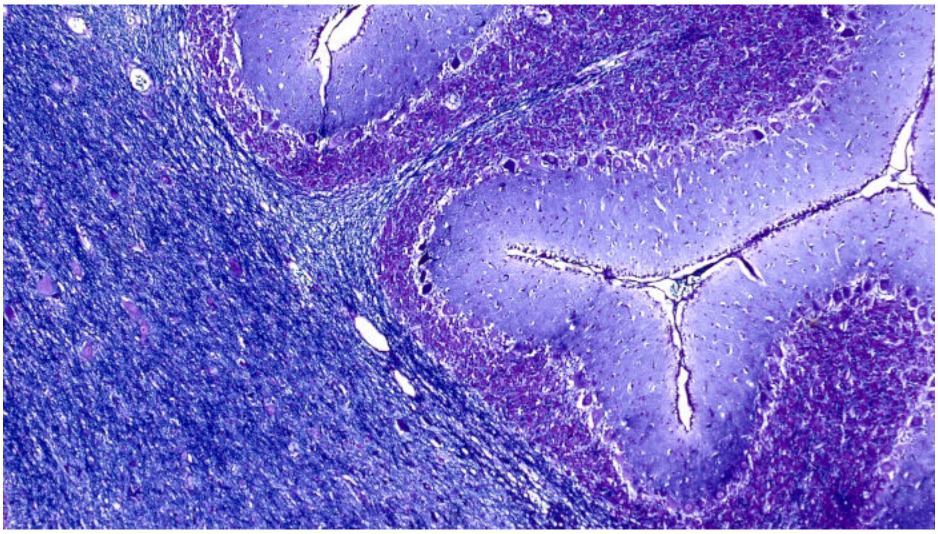

Figure 12.4: Piglet Congenital Tremor Cerebellar Demyelination Luxols fast blue. Photo: Margaret Wilson,

RICKETS

Four weaner pigs were submitted for investigation of ataxia and paresis in an 800 sow unit. On gross *post mortem* investigation two of the four pigs had enlarge growth plates of multiple ribs, known as rachitic rosary.

Histopathological examination of the affected ribs showed enlarged resting, multiplication and hypertrophic zones and retained cartilage cores. Bone Ash analysis detected a large reduction in bone ash compared to reference levels. The gross, histological and bone ash results supported a diagnosis of rickets in both these animals.

Rickets is defective bone mineralisation in growing animals. It is most commonly encountered in pigs aged between 2–6 months and is most commonly as a result of dietary causes. A diet inadequate either in calcium, phosphorus or active Vitamin D can result in development of rickets in pigs.

Salmonella Culturing

Routine bacterial culturing of porcine tissues from *post mortem* samples includes Salmonella culture. Five porcine cases were identified with *Salmonella typhimurium* infection in 2021. Confirmed *Salmonella typhimurium* isolates are notified to the local District Veterinary Office (DVO). Commercial pig producers are obliged to have a Salmonella control program documented for their farms and slaughtered pigs are routinely screened for Salmonella antibodies throughout the year, with results fed back to the farm of origin and slaughter plants.

Figure 12.5: Nodular thickened growth plates in the costo-condral junction (rachitic rosary) of a pig with rickets. Photo: Margaret Wilson

12.2 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. ASF is a notifiable disease and PVPs are reminded to notify DAFM if they suspect presence of the disease by contacting their local DVO or the National Disease Emergency Hotline at 1850 200 456. An ASF factsheet for vets detailing the clinical signs of ASF is available on the African swine fever page on the DAFM website. DAFM also produced a biosecurity leaflet specifically aimed at nonintensive pig farms and an ASF factsheet for farmers, both of which are available to download from the African Swine Fever page on the website.

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

Exotic Disease Surveillance Data

In 2021, 430 pigs were sampled for *Brucella suis*. In addition 2,075 samples were collected through the Abattoir based Surveillance collection. These samples were screened for Aujeszky's, African Swine Fever and Classical Swine Fever.

CHAPTER 13

POULTRY DISEASES AND SURVEILLANCE

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13.1 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 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 (OIE) within 24 hours of confirmation of the disease. These notifiable subtypes can be associated with acute clinical disease in chickens, turkeys, and other birds. Other subtypes such as LPAI H6- are not notifiable under the legislation, however they still can cause losses in production.

Active surveillance:

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

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 and Salmonella, and , to increase Avian Influenza surveillance, samples are also tested for AI by Agar Gel Immunodiffusion test for Avian Influenza (AGID). In 2021, 10975 poultry samples were tested by this method through the PHP (Table 13.1).

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 2021, 6859 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, 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 here the List of Target Species for Avian Influenza Surveillance

In 2021, 307 wild birds were tested by passive surveillance; from those 5 whooper swans tested H5N8 positive and 2 knots were H5N3, all of them of high pathogenicity (HPAI). 67 other wild birds tested positive for H5N1 in 2021; all of them were HPAI, except 6 strains where pathogenicity was not confirmed. The H5N1 strain was first detected in a Peregrine Falcon and was followed by detections in Mute and Whooper Swans, White-tailed Eagle, Magpies, Crow, Herring gull, Water Rail, Merlin, Brent Goose, Greylag Goose, Greater white Fronted Goose, Kestrel, across all counties in Ireland.

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.

For more information on Avian Influenza check: For more information on Avian Influenza check: Avian influenza (bird flu) (www.gov.ie)

In 2021, as part of the Avian Influenza National Programme, one duck game flock tested positive for H6N8 and a second one for H3N8 plus H5N2 (LPAI).

Later in the year, after a Peregrine falcon tested positive for H5N1 HPAI, two turkey fattening flocks, one broiler breeder flock, one Table egg layer flock and two duck fattening flocks were affected by the H5N1 HPAI strain (Table 13.1) (See Appendix 1 at the end of the poultry section).

Table 13.1: Avian influenza surveillance testing during 2021 in Ireland.

2021	No Animals tested	Non- notifiable AI subtypes	Notifiable H5 and H7 subtypes
Poultry- Poultry Health Programme (AGID test) (a)	10975	2 x duck game flocks	0
Poultry –H5 and H7-EU Surveillance (HI test) (b)	6859	0	0
Poultry - AI ELISA (diagnostics)	1983	2 x duck game flocks as above	0
Wild birds - PCR	307	0	5 x H5N8 HPAI; 2 x H5N3 HPAI; 67 x H5N1 (61 HPAI and 6 x pathogenicity not determined)
Poultry - PCR (c)	1336	2 x duck game flocks (1 x H6N8), (1 x H5N2 LPAI + H3N8)	6 flocks H5N1 HPAI (2 x turkey flock H5N1, 1 x broiler breeder, 1x table egg layer, 2 x fattening duck)

[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

13.2 Avian Mycoplasma Surveillance

Active surveillance

The Poultry Health Programme (PHP) operated by DAFM includes surveillance for poultry mycoplasmosis. Mycoplasmas 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 can infect chickens, turkeys and game birds. Ducks and geese can also become infected particularly when associated with infected chickens.

Table 13.2: Official Sampling for Poultry Health Programme and EU AI surveillance during 2021 in Ireland

Type of submissions	Test	No. Tests	Positive
National-Poultry Health Programme	M. gallisepticum SPAT	25955	0
National-Poultry Health Programme	Avian Influenza AGID	10975	0
National-Poultry Health Programme	M. meleagridis SPAT	1630	0
National-Poultry Health Programme	Salmonella arizonae 'H' SAT	1230	0
EU-H5 H7 HI -Surveillance	Avian Influenza H5	6859	0
EU-H5 H7 HI -Surveillance	Avian Influenza H7	6859	0

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

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 2021, 25955 and 1630 serum samples were screened for *M. gallisepticum* and *M. meleagridis*, respectively, at the CVRL as part of DAFM PHP programme (Table 13.2).

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

Table 13.3: Number of Salmonella culture Tests from on-farm samples during 2021 in Ireland

Avian Production Type	No. Samples	No. Positive Flocks
Boiler	82	0
Broiler Breeder	772	2 (a)
Broiler Grandparent flocks	2	0
Layer and Layer breeder	400	0
Turkey Fattener	16	0
Turkey Breeder	10	0

[a] Two isolates were S. Enteritidis, both originating from the same flock. The flock was restricted and depopulated.

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.

13.3 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 13.3). Last year, 1230 serum samples were screened for *S. arizonae*.

In parallel, DAFM carries out the EU Salmonella Surveillance by collecting samples on-farm and confirming detected serotypes by culture (Table 13.3). 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 2021, 1282 samples from farms were analysed; of these, *Salmonella spp.* was detected in one broiler breeder flock (Table 13.3).

Table 13.4: Paramixovirus- 1 (PMV-1) testing during 2021 in Ireland.

PMV1 PCR testing 2020	No birds	positive events/cases	Strain virulence
wild birds	77	9	Virulent
captive/racing	27	7	Virulent
poultry	210	0	0

13.4 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 Paramixovirus type 1-APMV1-). 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 passive surveillance. In 2021, a total of 77 wild birds, 27 captive/racing birds, and 210 poultry were tested. 5 racing pigeons, 9 wild pigeons and 2 rock doves were positive for Pigeon PMV-1 and were confirmed as the Virulent strain (Table 13.4).

13.5 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 (Table 13.5) and carcasses of animals are submitted to the RVLs where they are sampled (Figure 13.1). In 2021, 48 birds were confirmed positive for Marek's Disease, 72 for Infectious Bronchitis, 18 for *M. synoviae*, 24 for *M. gallisepticum*, 2 pneumovirus and 421 (from around 200 different flocks) for Infectious Laryngotracheitis by PCR (Table 13.5).

In 2021, the most common diagnosis in poultry carcasses submitted to the RVLs was enteritis and Avian Influenza, followed by bacteraemia, hepatitis, pneumonia and Infectious Laryngotracheitis.

13.6 Case reports in poultry (DRVL)

During 2021, an outbreak of **H5N1 HPAI** occurred in Ireland, affecting broiler breeders, turkeys, layers and ducks. *Post-mortem* examinations were carried out on all AI suspects.

Table 13.5: PCR testing of submitted samples (PVP and RVL submissions) in 2021

Pathogen	Animals tested	Positive
Infectious laryngotracheitis *	763	421
Infectious Bronchitis	89	72
Mycoplasma gallisepticum *	105	48
Marek's Disease	102	24
Mycoplasma synoviae *	101	18
Avian pneumovirus	50	2
Chlamydia psittaci *	169	1

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

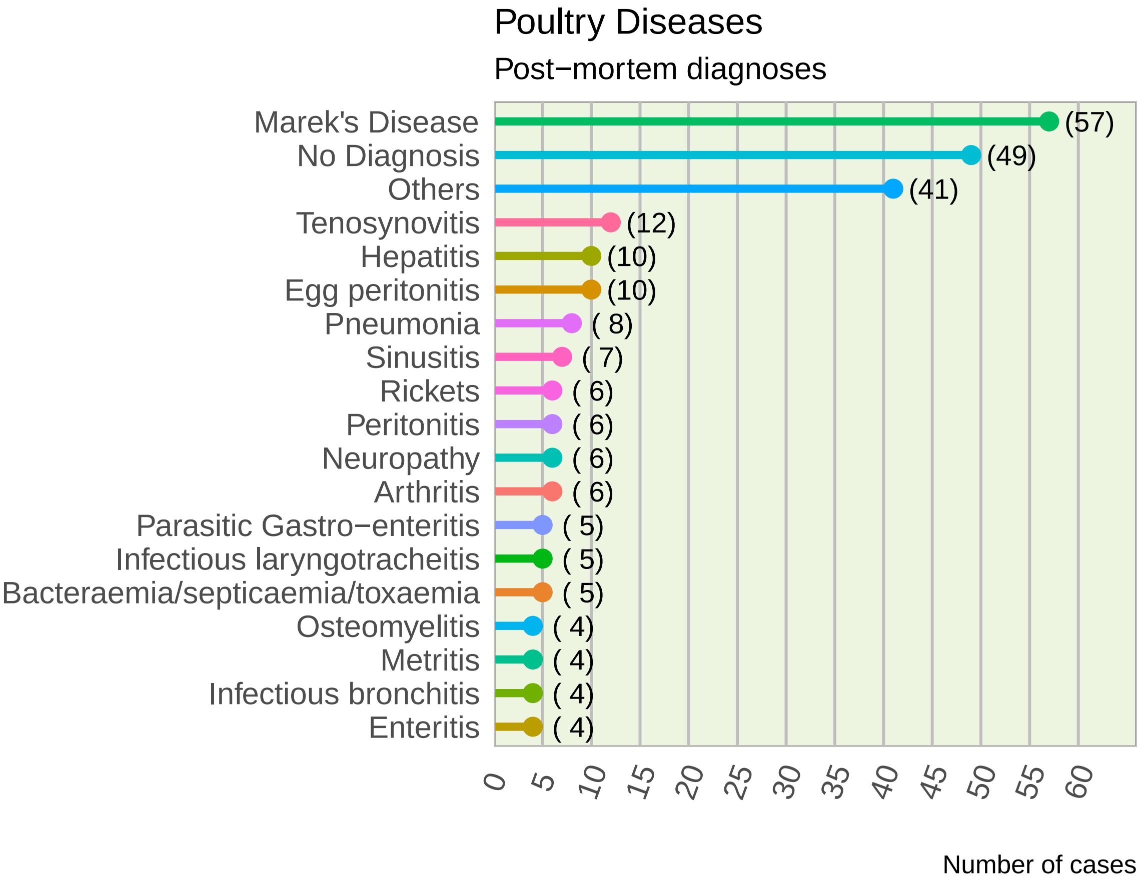

Figure 13.1: Disease diagnosed in poultry carcasses in 2021.

In H5N1 positive birds, multifocal necrosis was seen in the liver, spleen, pancreas, brain, intestine and trachea. The diagnoses in H5N1 negative suspects included infectious laryngotracheitis (ILT), hepatic amyloidosis, erysipelas and thiamine deficiency.

ILT was diagnosed in 11 weeks old layers. Clinically they had closed eyes and were panting. Grossly the birds exhibited multifocal necro-haemorrhagic rhinitis and tracheitis. Multifocal marked lymphoplasmacytic tracheitis and multifocal ulceration were seen on histopathological examination. Marked acanthosis and multifocal ballooning degeneration were seen within the oesophagus and there was multifocal necrotising and lymphoplasmacytic conjunctivitis. Eosinophilic intranuclear inclusions were seen in syncytia. The diagnosis was confirmed by PCR. ILT was also diagnosed in a 1-year-old backyard rooster, that clinically had ocular swelling with discharge. Grossly there was a moderate amount of cream material adhered to the oesophageal mucosa and similar material was seen in one conjunctival sac. The infraorbital sinuses were filled with mucus. Marked multifocal lymphoplasmacytic tracheitis, and conjunctivitis were seen. The animal was positive for ILT on PCR.

ILT is a viral disease caused by Gallid herpesvirus type 1 (GaHV-1). Severe epizootics of the disease cause high morbidity (90–100 *per cent*) and mortalities of 20 *per cent* or higher, but usually mortalities are in the range of 5–20 *per cent*. The disease can be spread both by direct and indirect contact. Naïve birds may become infected following exposure to contaminated equipment, or personnel. Birds that recover may be a potential source of infection in future as they may start shedding virus under stressful circumstances. Both recombined and attenuated vaccines are available.

Erysipelas was diagnosed in table layers. Grossly the birds exhibited epicardial petechiae, coelomitis and splenomegaly. Bacterial hepatitis and splenitis were seen characterised by bacterial colonies, necrosis and thrombosis. Erysipelas was also diagnosed in a 4-month-old turkey which was found dead. On gross examination the crop was full. A *cooked* appearance to breast muscle was reported. Histologically there were fibrin thrombi within the liver and spleen. *Erysipelothrix rhusiopathiae* was isolated from viscera in both cases.

Erysipelas is a bacterial disease caused by Gram positive bacterium, *Erysipelothrix rhusiopathiae*. This disease affects most poultry species and is also zoonotic. The main signs in flocks vary from high mortality to egg production losses. Gross lesions in birds that have died during an outbreak include signs of septicaemia. The incubation period for this bacterium is 1–7 days. The prevention of erysipelas is based on biosecurity measures. When outbreaks occur antibiotics, and vaccination are recommended for subsequent flocks.

Thiamine deficiency was diagnosed in 6-week-old broiler breeders. Affected birds presented with a star gazing posture. No abnormalities were reported on gross examination. Histologically there was scattered vacuolation of acinar cells within the pancreas and multifocal cystic enteropathy in the duodenum. These findings may be seen in vitamin B1 deficiency. The affected flock responded to Vit B1 therapy.

Deficiency of thiamine leads to extreme anorexia (with weight loss and leg weakness), polyneuritis, and death. The affected animals may also exhibit blue comb. The star gazing position is caused by paralysis of the anterior muscles of the neck. The main causes of thiamine deficiency are low dietary levels, excess amprolium (coccidiostat), or consumption of mouldy food.

In addition to these diagnoses in AI suspects, Marek's disease, *Enterococcus hirae* infection and *Syngamus trachea* were also diagnosed in 2021.

The cutaneous form of **Marek's disease** was diagnosed in 8 cases of 56-day-old broilers. Marek's disease was also diagnosed in adult backyard hens which had hepato-, and splenomegaly and thickening of the wall of the proventriculus. The diagnosis was confirmed on PCR.

Marek's disease is caused by alpha herpesvirus and usually affects birds older than 4 weeks of age. Affected birds are often paralysed. Grossly the bursa may be enlarged or atrophied. There may be skin and muscle involvement, eye involvement, and peripheral nerve infiltration. Histologically the lesions consist of T-cell neoplasms. The incubation period in experimentally induced animals is 5 days. The control and prevention of Marek's disease is not easy as the virus is present within the environment, where it persists for a long time. Additionally affected animals shed the virus constantly and some birds may be latently infected. Vaccination for Marek's disease together with biosecurity are considered effective.

Enterococcus hirae was diagnosed in 5-day-old table egg layers, which had opisthotonos and were lying on their sides. Grossly there were no changes. On histopathological examination the brain contained multifocal acute necrosis associated with fibrin thrombi in capillaries. *Enterococcus sp.* was isolated from brain swabs. *E. hirae* has been associated with encephalomalacia in young chickens and causes increased mortality in broiler flocks due to septicaemia and endocarditis. Bacterial contamination at the time of hatching may lead to mortality in young chickens. Additionally, faecal contamination of hatching eggs may lead to embryo mortality.

Syngamus trachea was diagnosed in 2-week-old peafowl. The birds presented with lethargy and open beak breathing. The birds had empty crops, tan-coloured livers and green caecal contents. Histologically there was parasitic tracheitis. *Syngamus trachea* is a nematode that affects turkeys, geese, guinea fowl, pheasants, peafowl, and quails. The parasite has also been reported in chickens. *Syngamus trachea* leads to laboured breathing causing inflammatory nodules within the trachea. Earthworms, slugs and snails serve as intermediate hosts. The encysted larvae remain vital for up to 4 years.

Other diagnoses in 2021 included fowl cholera, aspergillosis, gout, amyloidosis, mycoplasmosis, yolk sacculitis, adenovirus, lymphoid leukosis, Gumboro disease, colisepicaemia, histomoniasis, wooden breast, intestinal, hepatic and ovarian tumours.

13.7 Appendix: H5N1 HPAI Epizootic in Ireland in 2021 #appendix

- On the 3rd of November of 2021 a H5N1 highly pathogenic (HPAI) Avian Influenza Virus was confirmed in a Peregrine Falcon in Co. Galway.

Index case

- On the 19th of November, a PVP submitted samples from a commercial turkey fattening flock. Turkeys had sudden increase in mortality with high number of birds showing dullness and depression.

- After notification to the authorities, restriction of the farm, and farm investigation took place.
- On the 20th , birds were confirmed positive for H5N1 HPAI.

Subsequent outbreaks

The second outbreak was confirmed in a Broiler breeder flock which was presented increased mortality. Next, a Table Egg Layer flock was affected by the H5N1 strain, which had 50 *per cent* mortality in some parts of the flock. Subsequently, another turkey flock and two more fattening duck flocks showing some neurological signs, shivering, depression, changes in feed and water intake and green diarrhoea were confirmed positive for H5N1 HPAI (Figure 13.2).

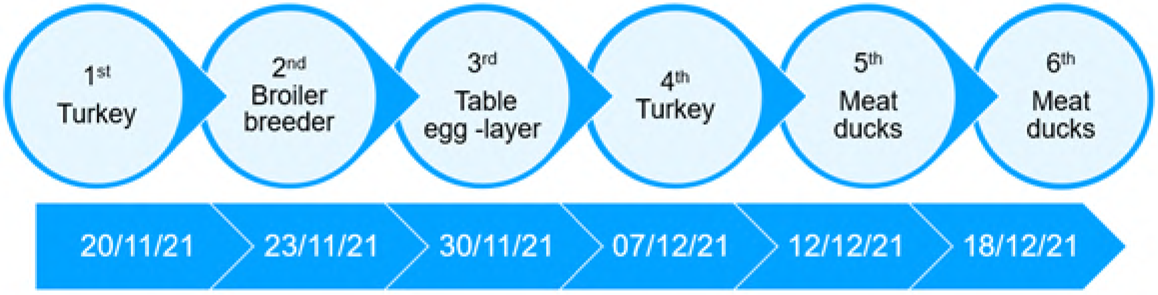

Figure 13.2: Time-line of the 6 confirmed cases of H5N1 HPAI in Ireland in 2021

- 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 . All of them tested positive for H5N1 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:

- 3km radius as a Protection zone
- 10km radius as a Surveillance Zone.
- 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: 2022-01-ireland-hpai.pdf (woah.org)

Other detections in wild birds and mammals

Simultaneously to the poultry outbreaks, more than 65 wild birds were confirmed as positive for H5N1 PCR in Ireland.

Also, Ireland detected the first case of a fox positive for H5N1 HPAI which was found at the same location as other dead geese in Co. Donegal.

Further laboratory analysis

Twenty-five H5N1 positive samples were sent to the European Reference Laboratory for Avian Influenza in Italy (IZSVe) and to UK (APHA) for further genome sequencing.

Preliminary analysis of the hemagglutinin fragment (HA) of the virus shows that that the viruses from Ireland were associated to HPAI H5N1 viruses circulating in Europe in 2020 and newly introduced from October 2021. Whole genome sequencing showed that that the Irish viruses belong to three different genotypes originated from reassortment with HPAI and LPAI viruses.

The viruses detected in the fox and the goose -that were found in same location-, clustered together in the phylogenetic trees of all AI virus fragments, indicating high similarity of both viruses. However, the virus found in the fox presented a mammalian adaptive marker which has been associated with an increased virulence and replication in mammals in other studies.

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 check: Avian influenza (bird flu) (www.gov.ie)

Part IV

Miscellaneous Topics

CHAPTER

14

ZOONOTIC DISEASES

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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 2021, DAFM laboratories isolated and identified or otherwise detected a number of zoonotic agents, some of which are discussed below.

14.1 Campylobacteriosis

During 2021, DAFM Laboratories isolated *Campylobacter jejuni* in two bovine herds, including one bovine foetus. It was also isolated from one ovine flock from a canine faecal sample.

Campylobacteriosis caused by *Campylobacter jejuni* is usually asymptomatic in animals but it can cause gastrointestinal disease in humans. In animals, *Campylobacter spp.* can be found in both healthy and diarrhoeic animals. It can cause acute enteritis in many domestic animals. In cattle and sheep, some species of Campylobacter are reported to cause abortion (*C. jejuni*, *C. fetus* subs. *fetus*).

Campylobacteriosis is recognised as the most commonly reported cause of gastrointestinal disease in humans in the European Union (EU) since 2005. In 2021, there were 3151 confirmed cases of human campylobacteriosis reported in Ireland (HSPC, 2022). 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 infection.

14.2 Coxiellosis (Q fever)

During 2021, DAFM tested 624 bovine sera for antibodies to *Coxiella burnetii*, the causative agent of Q fever. Ninety-six sera from 26 different herds tested positive. Of the 178 ovine sera tested, one sample tested positive.

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

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

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

Table 14.1: Number of Listeria spp. isolated in DAFM Laboratories in 2021.

Species	Bovine herds (Carcass)	Bovine Herds (Foetus)	Ovine herds
L. monocytogenes	11	44	7
L. ivanovii	0	0	1
Listeria spp.	1	8	0

14.3 Listeriosis

During 2021 in DAFM Laboratories, *Listeria spp.* were isolated from 64 bovine samples (Table 14.1), mainly from cultures of foetal stomach contents. In ovines, Listeria spp.* was isolated from eight submissions, three of which were ovine foetuses. *L. monocytogenes* was the species most frequently isolated, but *L. ivanovii* was isolated in one ovine foetus (Table 14.1).

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, particularly among the elderly, the immunocompromised and pregnant women. In 2021, there were 16 confirmed human cases of listeriosis in Ireland (HSPC 2022, provisional data).

14.4 Salmonellosis

During 2021, DAFM Laboratories isolated *Salmonella* from 122 bovine foetuses submitted to the regional veterinary laboratory network; the most common serotype was Salmonella *enterica* Dublin, isolated from 116 of these foetuses. *Salmonella* Dublin was also isolated from two ovine foetuses. In bovine samples other than foetuses submitted during 2021, DAFM Laboratories isolated *S.* Dublin from eight bovine carcasses and three ovine carcasses. *S.* Typhimurium was isolated from nine bovine (diagnostic and carcass) and four porcine (carcass) submissions.

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

Infection of food-producing animals with *Salmonella* presents a serious public health risk because food products of animal origin are considered to be a significant source of human infection. In 2021 in Ireland there were 173 confirmed human cases of salmonellosis (HSPC, provisional data). Transmission of Salmonella 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.

14.5 Yersiniosis

Yersinia spp. were isolated from five submissions in 2021. *Yersinia pseudotuberculosis* was the species most commonly isolated. *Y. pseudotuberculosis* causes enteric infections which are often subclinical in wild and domestic animals, and humans. It is reported as a sporadic cause of abortion in cattle; in 2021 it was isolated from two bovine foetuses and from a two week old lamb with septicaemia.

Three species of Yersinia are pathogenic for animals and humans; *Y. pestis* (aetiological agent of plague), *Y. enterocolitica* and *Y. pseudotuberculosis*. Most human infections are caused by *Y. enterocolitica*, and *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. In humans, Yersinia spp. cause gastrointestinal disease and mesenteric lymphadenitis, and complications such as reactive arthritis, erythema nodosum, bacteraemia and sepsis may occur. Provisionally, there were nineteen confirmed cases of yersiniosis in Ireland in human patients in 2021 (HSPC, 2022). These cases occurred in several age groups, but most cases (12/19) were reported in people aged 65 and older.

CHAPTER 15

MYCOBACTERIAL DISEASE

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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 TB

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.

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. Approximately 6000 such samples are submitted to the NRL each year. They mainly comprise abattoir slaughter check samples submitted as part of DAFM's passive surveillance programme, *post mortem* (PM) samples from singletons or inconclusive tuberculin skin test animals or PM samples from special TB investigations.

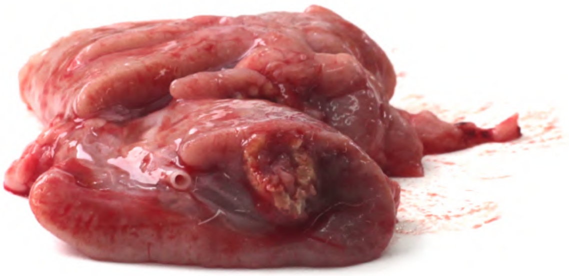


Figure 15.1: Cut section of the caudal mediastinal lymph node in a bullock with with mycobacterial granuloma and calcification. Photos: Cosme Sánchez-Miguel

Histopathology testing is applied to all samples with gross lesions (Figure 15.1). On histopathology, where a TB granuloma is detected, a TB diagnosis is made; on the other hand, where an alternative diagnosis is ascertained, TB can be ruled out. There is no requirement to then carry out bacterial culture on samples with a histological diagnosis; however, tissues from these samples are stored in the freezer and can be retrieved later if necessary. All inconclusive samples 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 almost consistently isolates *Mycobacterium bovis*.

Whole Genome Sequencing (WGS)

WGS is a laboratory process which determines the DNA sequence of an individual organism's genome. Five years ago, the Food Microbiology division adopted WGS. Over those five years, demand for WGS has been continually expanding. Table 1 below illustrates the great breadth of its current utility. In November 2020, the national reference laboratory (NRL) introduced WGS for routine use. Currently, the NRL is working towards accreditation of the

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

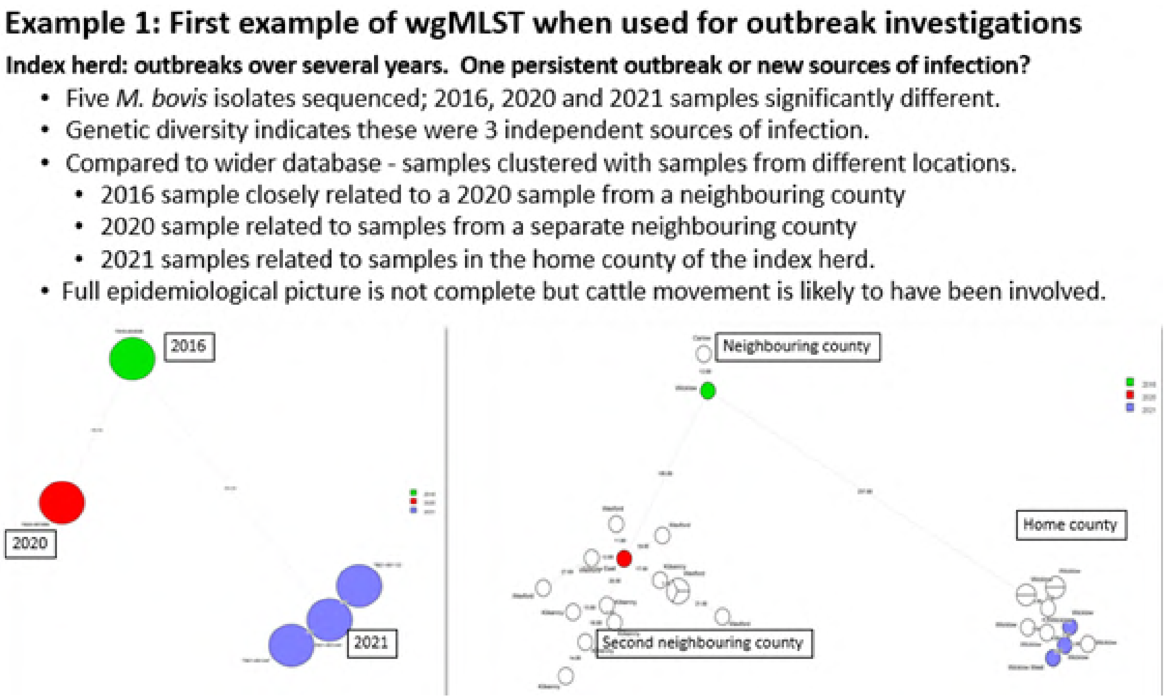
Laboratory area involved	Work carried out
AMR NRL	Resistance gene determination
Salmonella NRL	Serotyping and outbreak analysis
Listeria NRL	Outbreak analysis/Investigations
Staphylococcus NRL	Toxin gene detection and outbreak analysis
VTEC NRL	Toxin gene detection and outbreak analysis
Campylobacter 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

WGS technique for *M. bovis*, which it has already achieved for several other areas listed in Table 15.1.

The technique requires the extraction of DNA material from a *Mycobacterium bovis* isolate, a process which can take up to one day to complete. The extracted DNA must then undergo a process called library preparation, which takes another day's work and is required to read the DNA. Sequencing takes three days, and a pool of up to 22 samples can be sequenced at any time. It is an expensive process, costing DAFM approximately 100€per sample. The raw data generated by sequencing undergoes quality checking, involving computer analysis and a special software application called BioNumerics to process the WGS data. The sequence data is processed for *de novo* assembly, allele calling and spoligotyping (A classical PCR-based method for genotyping). De novo assembly is the process where the raw sequencing data is assembled into the almost complete genome, which in the case of *Mycobacterium 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 *Mycobacterium bovis*). The difference between these allele calls allows us to determine the relatedness from one sample to another in a process called whole genome multilocus sequence type (wgMLST). The laboratory regards a finding of greater than seven allelic differences between samples as representing a significant divergence among those samples.

The process then changes from data gathering and processing to data interpretation with a view to epidemiological utility. The target sample/herd is compared to all the samples in the database, starting with wgMLST to determine relatedness. If one or more related samples are detected, metadata such as species, location, age of samples, contiguous herds, movement history and or any other epidemiological data provided by the VIs that are part of the investigation 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 part of the process is done manually and is particularly labour intensive. It can take hours of work to process a single query if there are multiple related samples. 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 provides a higher degree of resolution to differentiate between isolates of *Mycobacterium bovis*, which can be a very useful epidemiological tool to help in outbreak investigations. It also has a comparable resolution to an SNP-based approach.



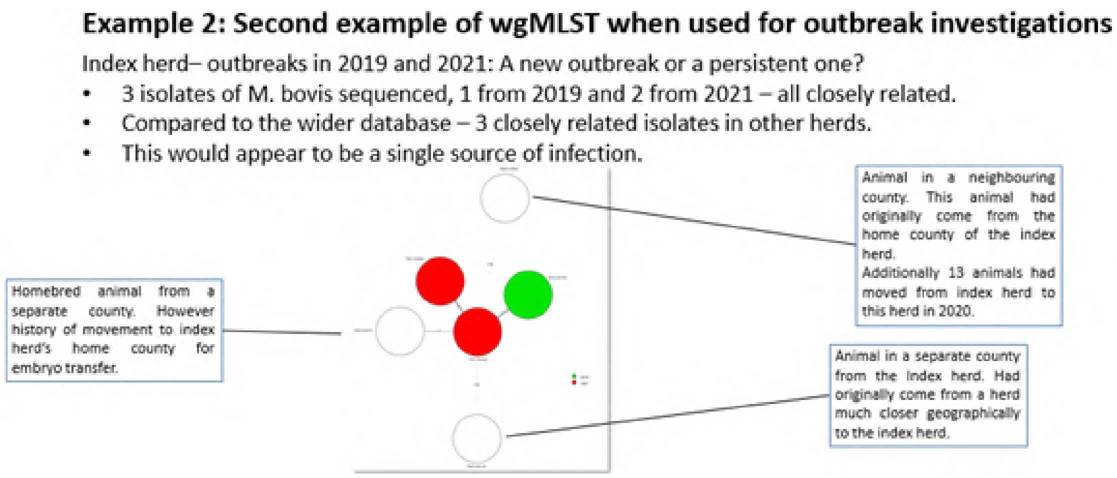
Example 1: First example of wgMLST when used for outbreak investigations

Index herd: outbreaks over several years. One persistent outbreak or new sources of infection?

- Five *M. bovis* isolates sequenced; 2016, 2020 and 2021 samples significantly different.
- Genetic diversity indicates these were 3 independent sources of infection.
- Compared to wider database - samples clustered with samples from different locations.
  - 2016 sample closely related to a 2020 sample from a neighbouring county
  - 2020 sample related to samples from a separate neighbouring county
  - 2021 samples related to samples in the home county of the index herd.
- Full epidemiological picture is not complete but cattle movement is likely to have been involved.

Figure 15.2: Example 1

In the first 18 months of use, WGS has been applied to 1,393 isolates of *Mycobacterium bovis*. The isolates which have been sequenced are representative of all counties in Ireland and multiple species: bovine (1082), badger (234), deer (21), alpaca (19), pigs (11), and other (26). The following are just two examples where WGS has recently been put to practical use.



Example 2: Second example of wgMLST when used for outbreak investigations

Index herd– outbreaks in 2019 and 2021: A new outbreak or a persistent one?

- 3 isolates of M. bovis sequenced, 1 from 2019 and 2 from 2021 – all closely related.
- Compared to the wider database – 3 closely related isolates in other herds.
- This would appear to be a single source of infection.

Homebred animal from a separate county. However history of movement to index herd's home county for embryo transfer.

Animal in a neighbouring county. This animal had originally come from the home county of the index herd.
Additionally 13 animals had moved from index herd to this herd in 2020.

Animal in a separate county from the Index herd. Had originally come from a herd much closer geographically to the index herd.

Figure 15.3: Example 2

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

15.2 Johne's Disease

Introduction

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

Pathology

Gross pathological change is characterised by thickening and corrugation of the intestinal mucosa, most prominent in the ileum (Figure 15.4). Pathological changes also occur in other parts of the small and many, though not in all cases; the large intestine is also affected by lesions.

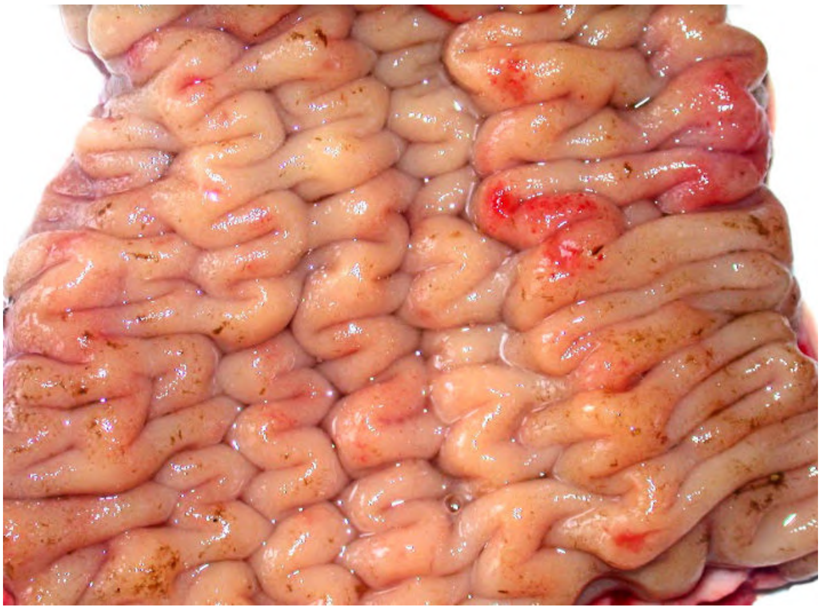
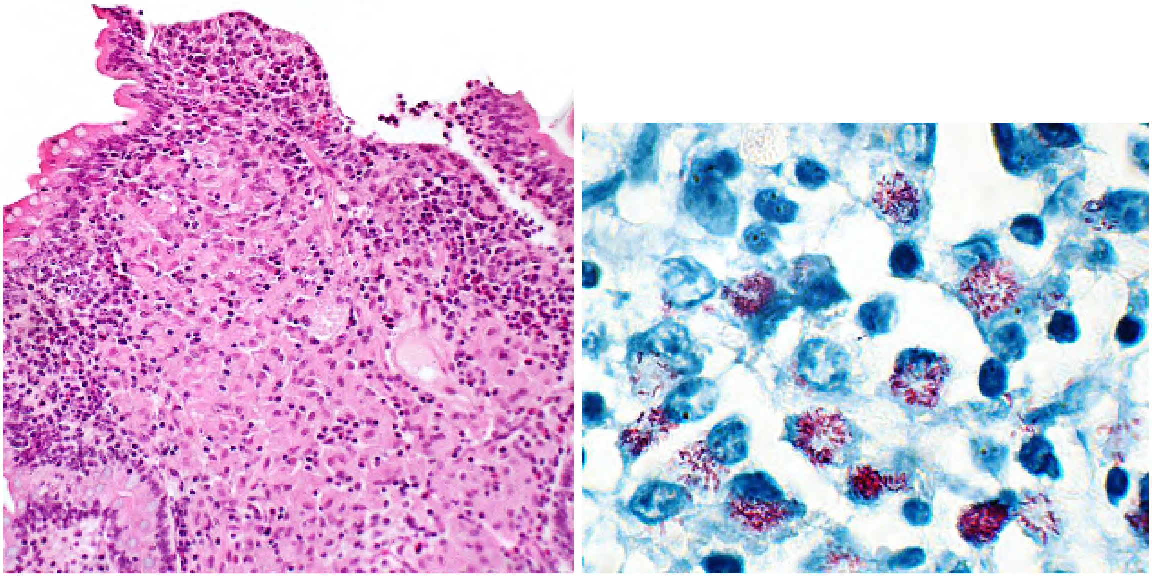


Figure 15.4: Thickening and corrugation on the mucosal surface of the ileum in a cow which had Johne's disease manifested by ill thrift and diarrhoea. Photo: Colm Brady.

On histopathology, intestinal change is characterised by granulomatous infiltration of the intestinal lining with distortion and effacement of intestinal structures (Figure 15.5-a). 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 15.5-b).



(a) H-E staining **(b)** Ziehl-Nielsen staining

Figure 15.5: (a) Granulomatous inflammation in the terminal ileum of a cow which had Johne's disease manifested by ill thrift and diarrhoea, H-E staining. (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.

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. This latency provides a significant challenge for epidemiological investigations and control of JD on Irish farms, not least because the diagnosis can be difficult.

Diagnosis

Ante mortem diagnostic tests can be divided into two categories, direct tests that detect the presence of the causative agent—MAP. The direct tests identify the presence of MAP itself by bacterial culture or 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.

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 absent in the early stages of JD, the sensitivity of bacterial culture is low.

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 the turnaround time for the test is just a few days. However, low shedding of MAP until later in JD offers the same challenges for PCR as has already been described for culture.

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 exposure to other mycobacteria, potentially producing false positive results. In short, a positive ELISA reaction is not confirmation of JD. The sensitivity of ELISA is also influenced by the stage of infection, which is higher in animals with clinical disease and marked shedding of MAP. However, sensitivity is lower in infected subclinical animals and either not shedding or shedding lower numbers of MAP, making false negative results more likely.

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-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 33 faecal samples in 2021. In the case of 32 samples, the faecal samples were submitted from a bovine animal, while in the case of one sample, MAP infection was confirmed in a goat.

Control Programme

Animal Health Ireland manages the Irish Johne's Control Programme. 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 the 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 to reduce 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 Animal Health Ireland webpage.

CHAPTER 16

WILDLIFE

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As part of DAFM's wildlife disease surveillance exercises and also in assisting the National Parks and Wildlife Service (NPWS) in investigating suspected wildlife crimes, DAFM's Veterinary Laboratories examined a number of wildlife species annually and 2021 was no different.

Figure 16.1: Newly fledged juvenile peregrine falcon (*Falco peregrinus*) in the Partry Mountains, Co. Mayo. Photo: Mícheál Casey).

Since 2011, the DAFM Veterinary Laboratories, the NPWS and the State Laboratory have been managing suspected wildlife crimes through the RAPTOR (Recording and Addressing Persecution and Threats to Our Raptors) Programme. This programme has several components, including x-rays, *post mortem* examination and toxicology testing. In 2021, 30 birds were examined in the DAFM veterinary laboratories under the RAPTOR programme, including buzzards (n=9), barn owls (n=3), kestrels (n=3), peregrine falcons (n=2) and white-tailed eagles (n=2). 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. Samples from a barn owl found dead in Co. Mayo tested positive for flocoumafen and brodifacoum, widely used anticoagulant rodenticides, while flocoumafen was also detected at elevated levels in a peregrine falcon found in Co. Cork. Brodifacoum was also detected in liver samples collected from a kestrel that had been found dead in Co. Tipperary and had significant thoracic haemorrhages at *post mortem* examination. A red grouse that had been found in the wind turbine farm in Co. Cork was examined at *post mortem* and found to have a broken back and internal haemorrhages consistent with trauma. Trauma was also suspected as the cause of death in the case of a barn owl that had been found dead in Co. Offaly. At *post mortem* examination, there were lacerations on the liver surface and blood clots in body cavity. Kidney lead levels were within normal ranges and toxicology samples submitted to State Lab for testing were negative.

Figure 16.2: Kestrel (*Falco tinnunculus*). The liver and kidney of this raptor contained confirmed positive levels of bromadiolone. Photo: Colm O'Muireagáin

The NPWS submitted three mute swans to DAFM laboratories for *post mortem* examination, having been found dead in Co. Tipperary. X ray images taken of all three birds showed the presence of small radiopaque spots consistent with shotgun pellets. There was significant haemorrhage around the liver, heart or lungs of the three birds, and one bird's wing was also fractured. Lead shot was recovered from each bird. Toxicology testing was negative, and it was concluded that they had died from fatal haemorrhage resulting from shotgun injuries.

In 2021, DAFM veterinary laboratories examined 19 rabbits and 9 hares. The rabbits examined included wild and some domesticated rabbits, e.g. from pet farms. The primary reason for their submissions was ongoing surveillance for Rabbit Viral Haemorrhagic Disease 2 (RHD2), 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 'spillover' host. In 2021, 11.1 *per cent* (n=1) of hares and 57.9 *per cent* (n=11) of rabbits tested were positive for RHD2. The single positive hare was from the slob lands in Wexford, while the positive rabbits were from counties Kerry, Cork, Kilkenny, Laois, Galway and Donegal. Coccidiosis was the second most common other cause of death identified in rabbits and hares, accounting for 21.4 *per cent* of deaths.

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 2021, 398 foxes were sampled and tested, and there was no evidence of infection with this parasite.

CHAPTER 17

ANTIMICROBIAL RESISTANCE

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AMR (antimicrobial resistance) has been recognised as one of the greatest potential threats to human health in the past decade. AMR in veterinary bacterial pathogens can be associated with treatment failure, economic losses and animal welfare issues, while AMR bacteria from both human and animal sources can contaminate the environment. The first (2017–2020) and second (2021–2025) Irish National Action Plans on antimicrobial resistance recognise the connectedness of AMR in human health, animal health and the environment and take a *One Health* approach to tackling the issue, with stakeholders from all three fields contributing to the initiative (IRELAND'S NATIONAL ACTION PLAN ON ANTIMICROBIAL RESISTANCE). Antimicrobial susceptibility testing (AST) of veterinary pathogens has been recognised as an important strategic intervention in the national action plans.

In order to support appropriate prescribing, AST is undertaken by the Department of Agriculture Food and the Marine (DAFM) Regional Laboratories on bacteria that are recovered from samples from sick animals. This is undertaken according to international standards using a *disc diffusion* method, whereby paper discs containing antimicrobials of veterinary significance are placed on a layer of bacteria on the surface of a solid agar plate. A subset of these bacteria (a maximum of one per herd) are subsequently tested using a second method called "broth microdilution", which allows susceptibility to additional antimicrobials, in particular antimicrobials used exclusively in human medicine, to be assessed.

The level of bacterial growth in the presence of the antimicrobials is measured, allowing them to be categorised as susceptible, intermediate or resistant to that compound. Antimicrobial susceptibility testing is intended to provide guidance on prescribing to veterinary practitioners; however, treatment failure can still occur if the immune status of the animal is compromised or if there is inadequate penetration into the site of infection.

More information on antimicrobial susceptibility testing can be found on the VETERINARY IRELAND JOURNAL webpage.

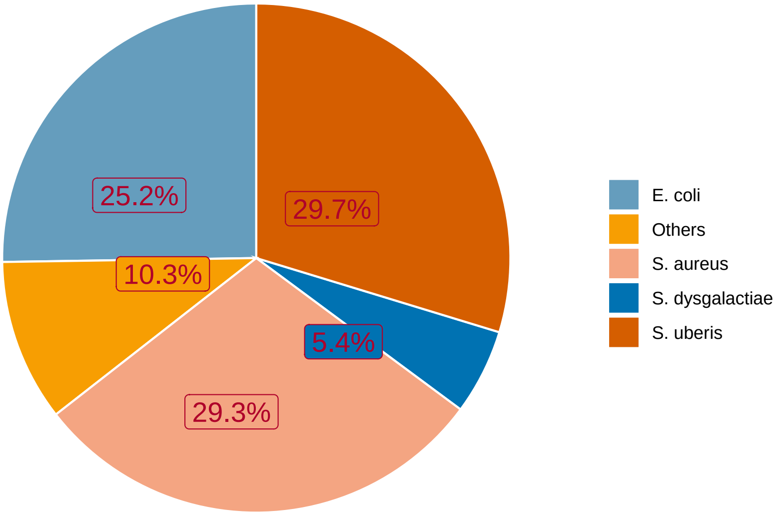


Figure 17.1: Other: *Staphylococcal* and *Streptococcal spp*, *Aerococcus spp*, *Aeromonas hydrophila*, *Enterococcus faecalis*, *Enterococcus faecium*, other *Enterococcus*, *Hafnia alvei*, *Klebsiella pneumoniae*, *Lactococcus spp*, *Pasteurella multocida*, *Pseudomonas spp* and *Serratia marescens*.

17.1 Mastitis Pathogens

Overall, 515 bacterial isolates from milk submitted from individual herds due to clinical or sub-clinical cases of mastitis underwent disc diffusion (Figure 17.1).

Staphylococcus aureus

Isolates of *Staphylococcus aureus* (*S. aureus*) collected from 151 dairy farms in 2021 were tested using disc diffusion (Figure 17.2). Cefoxitin is employed to screen for methicillinresistant *S. aureus* (MRSA), which is considered a superbug causing difficult to treat infections in humans.

Table 17.1: Antimicrobials used for antibiotic ausceptibility 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

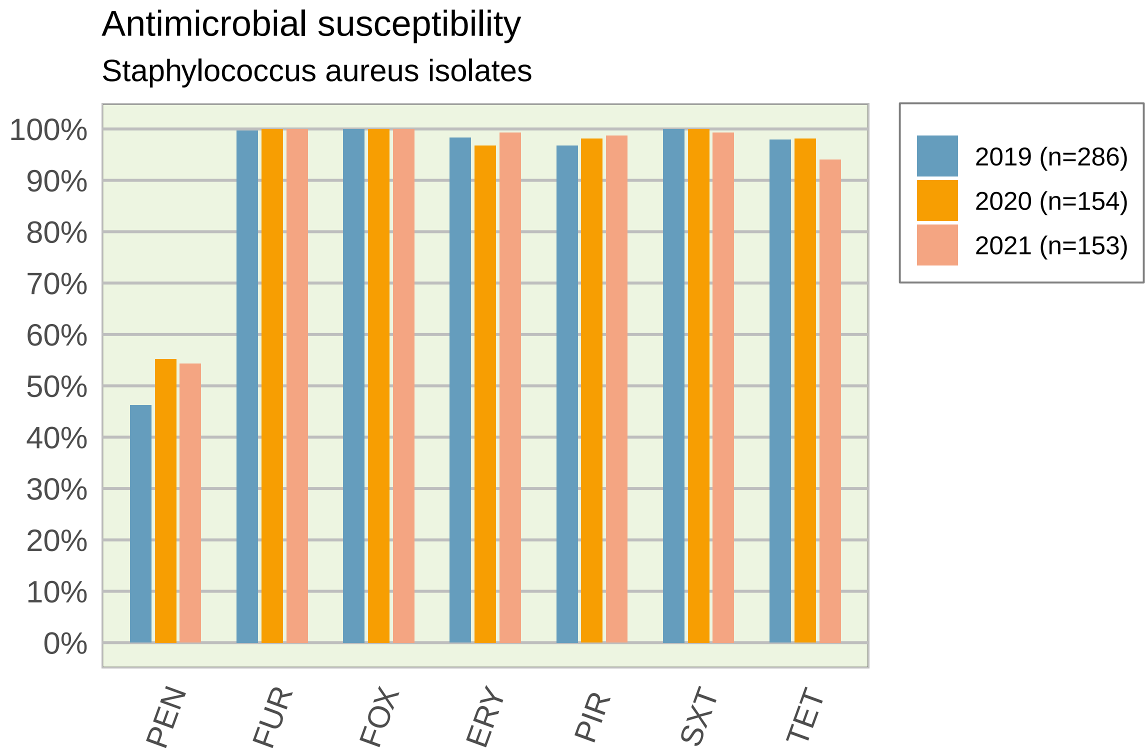
Note:
DD: Disc Diffusion;
BM: Broth microdilution;

[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.



PEN: penicillin, FUR: ceftiofur, FOX: cefoxitin,
ERY: erythromycin, PIR: pirlimycin,
SXT: sulfamethoxazole and trimethoprim, TET: tetracycline.

Figure 17.2: Percentage of antimicrobial susceptibility among *Staphylococcus aureus* isolates from bovine mastitis samples in 2019, 2020 and 2021.

Fifty-two *per cent* of the isolates were susceptible to all antimicrobials tested. Susceptibility of *S. aureus* to the early β-lactam antimicrobial penicillin increased from 46.2 *per cent* in 2019 to 55.2 *per cent* in 2020 and 54.3 *per cent* in 2021, and all isolates each year were susceptible to the 2nd and 3rd generation cephalosporins, cefoxitin and ceftiofur. Cefoxitin is used to screen for the presence of Methicillin Resistant *Staphylococcus Aureus* (MRSA), which is rarely reported in milk samples in Europe (El Garch et al. 2020).

Two isolates were resistant to erythromycin, an antimicrobial of the macrolide class which is critically important in human medicine. One of these isolates was also resistant to pirlimycin, a lincosamide; resistance to both antimicrobial classes may be linked as they share the same mode of action. The overall levels of susceptibility to these antimicrobials increased slightly from 2020 (by 2.6 *per cent* and 0.6 *per cent*, respectively) and were comparable to those recently reported in other European countries such as France (Anses, 2021).

Susceptibility to tetracycline decreased slightly in 2021 with respect to previous years (Figure 17.2) and was 4 *per cent* lower in 2021 compared to 2020. Only 0.66 *per cent* of isolates were multi-drug resistant (MDR) (i.e. resistant to three or more different antimicrobial classes).

A subset of 90 randomly selected isolates were further tested using an extended panel of antimicrobials, in broth microdilution. Included in the panel were linezolid and vancomycin, which may be used in human medicine as last resort compounds for the treatment of methicillin-resistant *Staphylococcus aureus* (MRSA). The veterinary isolates were susceptible to all compounds, apart from chloramphenicol, gentamicin and kanamycin (98.8 *per cent* susceptible to each).

Coagulase-negative *Staphylococcus spp.*

Twenty-four coagulase-negative *staphylococci* (CoNS) (mainly *S. haemolyticus* (n=9), *S. xylosus* (n=6), *S. epidermidis* (n=3), *S. chromogenes* (n=4) and *S. cohnii* (n=1) were tested by disc diffusion (Figure 17.3). The levels of susceptibility of CoNS to penicillin were lower in Ireland than reported recently in France (ANSES-Resapath 2021).

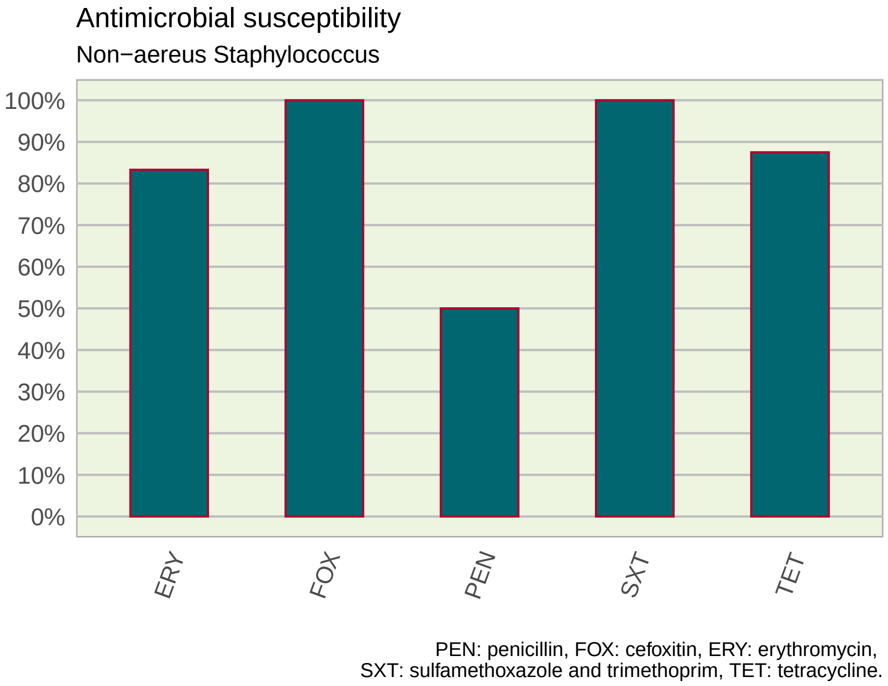


Figure 17.3: Percentage of antimicrobial susceptibility in 24 CoNS isolates from bovine mastitis samples in 2021.

No resistance to cefoxitin or trimethoprim- sulfamethoxazole was recorded. Three isolates were resistant to erythromycin, with an additional one showing intermediate resistance. Susceptibility to tetracycline was higher than in France, but lower than Danish results (Chehabi et al. 2019).

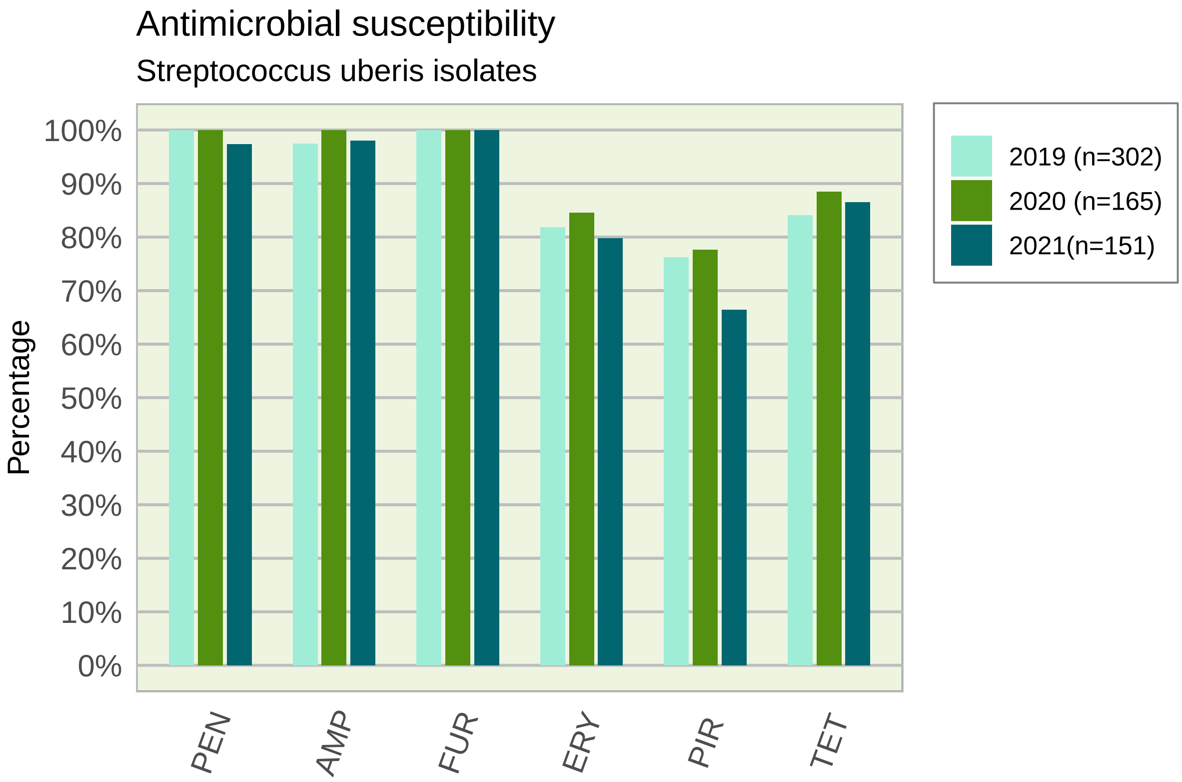
Twenty-two isolates were also tested using broth microdilution. No resistance to linezolid or vancomycin was recorded, but two isolates were resistant to clindamycin, which can also be used as an alternative treatment for Staphylococcal infections in humans.

Streptococcal species

Streptococcus uberis (n=151) and *Streptococcus dysgalactiae* (n=28) isolates were also tested using a disc diffusion panel.

Streptococcus uberis

The percentage of *Streptococcus uberis* (*S. uberis*) isolates susceptible to each antimicrobial (except ceftiofur) was lower in 2021, compared to the previous two years. Susceptibility to penicillin and ampicillin decreased by 2.7 *per cent* and 2 *per cent* respectively, in 2021 as compared to 2020.



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

Figure 17.4: Percentage of antimicrobial susceptibility among *Streptococcus uberis* isolates from bovine mastitis samples in 2019, 2020 and 2021.

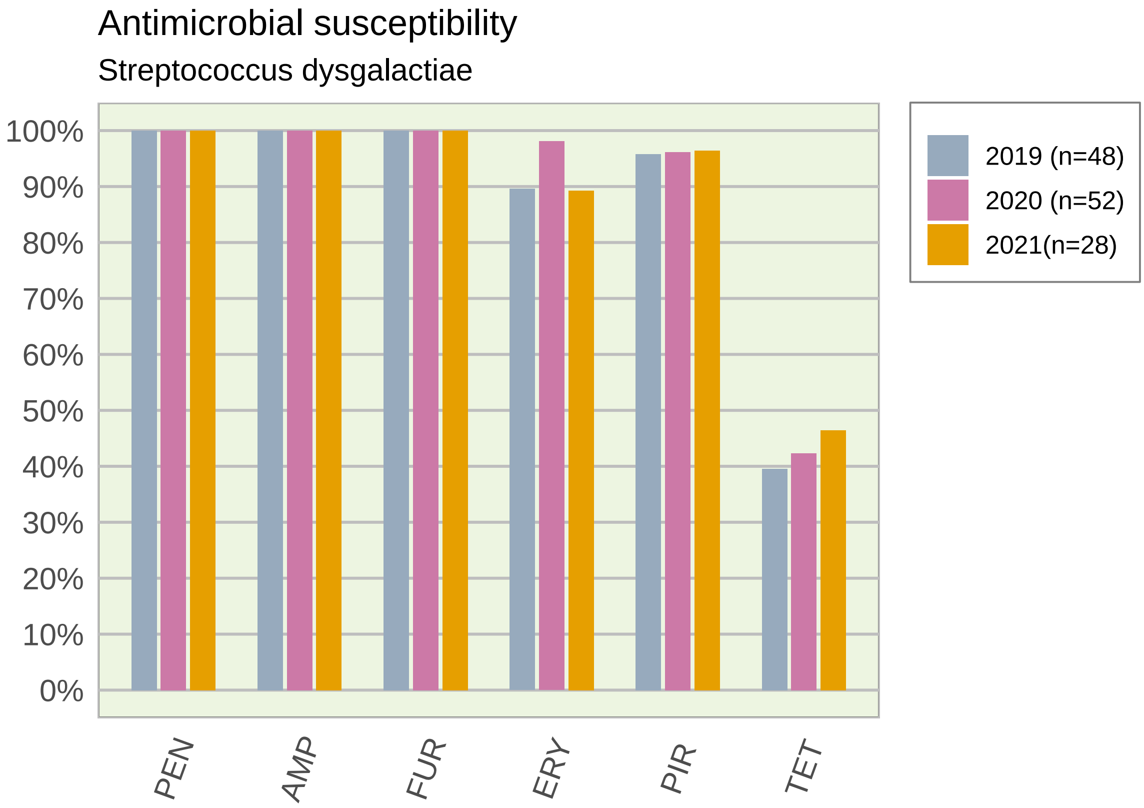
Streptococci rarely successfully acquire exogenous β-lactam resistance genes, therefore high levels of susceptibility to this antimicrobial class are common.

Similarly, susceptibility to pirlimycin, tetracycline and erythromycin in *S. uberis* fell by 11.2 *per cent*, 5.1 *per cent* and 2*per cent*, respectively, in that period. Susceptibility to erythromycin and pirlimycin in other European countries varies from about 97 *per cent* in the UK to 83 *per cent* in France (UK-VARSS 2021, ANSES-Resapath 2021).

For those isolates where broth microdilution was performed (n=70), additional antimicrobials that are relevant in human medicine for the treatment of streptococcal infections were tested. Susceptibility to vancomycin and clindamycin was 100 *per cent* and 53.6 *per cent*, respectively.

Streptococcus dysgalactiae

As in previous years, all *Streptococcus dysgalactiae* (*S. dygalactiae*) were susceptible to β-lactam antimicrobials (penicillin, ampicillin and ceftiofur) (Figure 17.5). One isolate was resistant to both erythromycin and pirlimycin (3.6 *per cent*). An additional one was resistant to erythromycin only. Similar isolates were also recovered in 2020 (n=1) and 2019 (n=2).



P: ampicillin, FUR: ceftiofur, ERY: erythromycin, PIR: pirlimycin, TET: tetracycline.

Figure 17.5: Percentage of antimicrobial susceptibility among *Streptococcus dysgalactiae* isolates from bovine mastitis samples in 2019,2020 and 2021.

Susceptibility to tetracycline increased over the three-year period from 39.6 *per cent* in 2019 to 42.3 *per cent* in 2020 and 46.4 *per cent* in 2021.

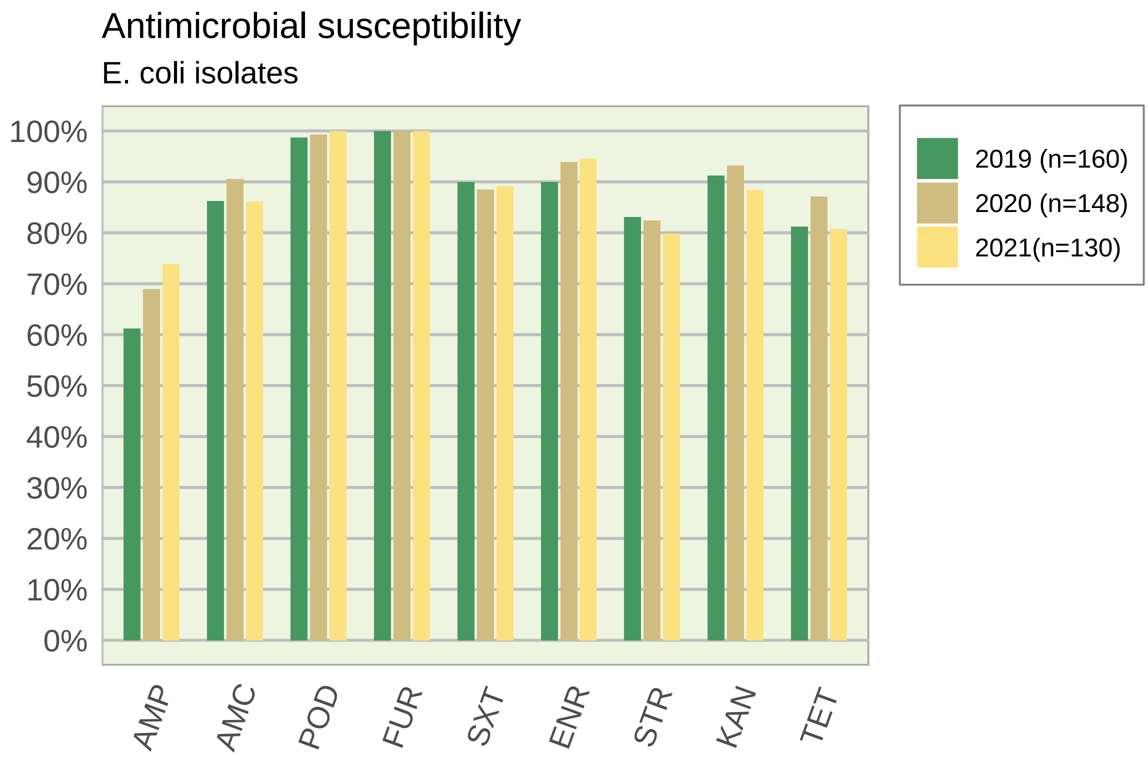
The levels of resistance to tetracycline, erythromycin and pirlimycin in *S. dysgalactiae* in other European countries is higher than those seen in Irish isolates (UK-VARSS 2021, ANSES-RESAPATH 2021).

Nine isolates were tested by broth microdilution. All 9 isolates were susceptible to vancomycin and 1 was resistant to clindamycin, two antimicrobials that may be used as alternative therapeutic treatment in streptococcal infections in humans.

Escherichia coli

Mastitis caused by *Escherichia coli* (*E. coli*) often resolves with supportive care, but severe cases may require antimicrobial treatment.

A total of 130 *E. coli* isolates from individual milk samples were screened in 2021 using disc diffusion. Of these, 65.1 *per cent* were susceptible to all antimicrobials tested. Susceptibility to amoxicillin/clavulanic acid decreased to 86.2 *per cent* in 2021, compared to 2020 (90.5 *per cent*) and 2019 (86.3 *per cent*) (Figure 17.6). All isolates were susceptible to ceftiofur and cefpodoxime. These antimicrobials are extended spectrum cephalosporins (β-lactam), which are high priority and critically important (HP-CIA) in human medicine and bacteria, including *E. coli*, which are resistant to them are termed *extended spectrum β-lactamase producers* (ESBLs).



AMP: ampicillin, AMC: amoxicillin−clavulanate, FUR: ceftiofur,
ENR: enrofloxacin, KAN− kanamycin, STR: streptomycin,
TET: tetracycline, SMX: trimethoprim− sulfamethoxazole, POD: cefpodoxime..

Figure 17.6: Percentage of antimicrobial susceptibility among *E. coli* isolates from bovine mastitis samples in 2019,2020 and 2021.

Susceptibility to the fluoroquinolone compound, enrofloxacin, another HP-CIA, has exhibited an increasing trend over the last three years (90 *per cent*, 93.9 *per cent* and 94.6 *per cent* in 2019, 2020 and 2021, respectively) (Figure 17.6). Susceptibility to trimethoprim-sulfamethoxazole increased by 0.7 *per cent*, whereas susceptibility to streptomycin, kanamycin and tetracycline decreased, most notably for tetracycline with a 6.4 *per cent* reduction in the most recent year of testing. Fourteen percent of the *E. coli* isolates were MDR.

Seventy-seven isolates were tested using additional antimicrobials. These included the HP-CIAs meropenem, from the carbapenem class of antimicrobials which is licensed exclusively for human use and colistin a glycopeptide which is also used for the treatment of serious MDR infections in people. All isolates were susceptible to these compounds, as well as to amikacin, an aminoglycoside frequently used in hospitals, and tigecycline which is a CIA considered a last resort antimicrobial in human medicine.

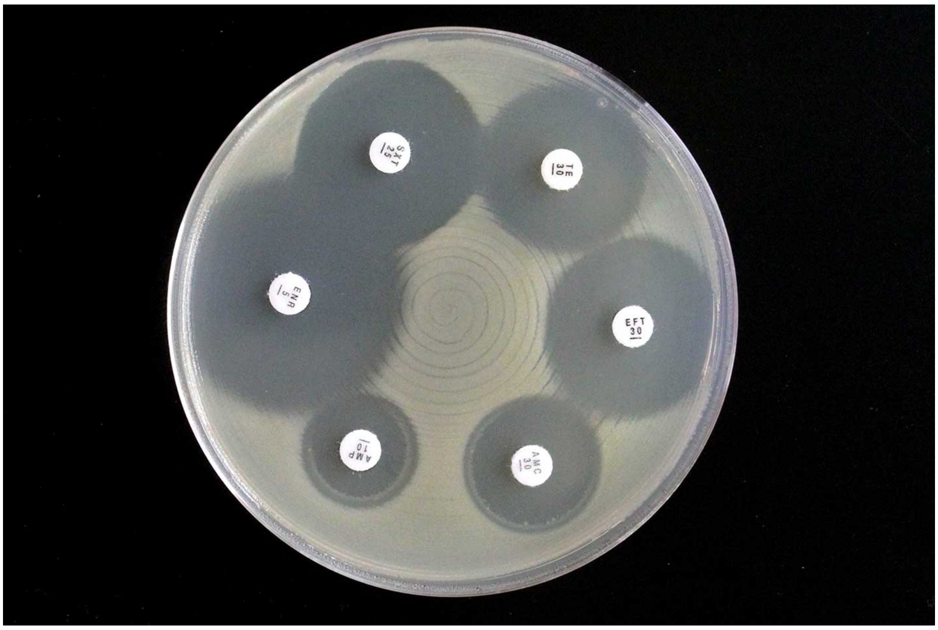


Figure 17.7: Antibiotic sensitivity test illustrating thin paper disks containing antibiotic placed on an agar plate with growing bacteria. Note the clear zone of inhibition, where bacteria growth around antibiotic disk has been inhibited. Photo: Pat Sheehan.

17.2 Enteric bacteria

As well as being a mastitis pathogen, *Escherichia coli* is a normal constituent of the gut flora of animals, but virulent strains can cause serious disease in multiple species and humans.

E. coli from birds

Avian pathogenic *E. coli* (APEC) are an example of virulent strains that can cause colibacillosis in birds (e.g. septicaemia, respiratory and yolk sac infections). *E. coli* from yolk sacs, internal organs and faeces of birds (broilers, turkeys, hens and exotic species) were tested using disc diffusion (n=42) and additional micro dilution (n=39). In almost half of these cases, *E. coli* was associated with disease; the remainder of isolates were considered to be commensal bacteria.

Resistance was frequently detected to ampicillin (40 *per cent*), tetracycline (26.2 *per cent*) and to trimethoprim- sulphamethoxazole (16.7 *per cent*). More than a third of isolates were susceptible to all antimicrobials (38.5 *per cent*) and 17.9 *per cent* were multi-drug resistant. A high proportion of *E. coli* (82.1 *per cent*) were susceptible to fluoroquinolones and no resistance to extended spectrum cephalosporins was recorded.

Commensal *E. coli* from healthy birds at slaughter in Ireland in 2020 also were most frequently resistant to antimicrobials commonly used in agriculture (ampicillin, tetracycline and sulfamethoxazole) and and a comparable proportion of these exhibited complete susceptibility (32% *per cent* and multi-drug resistance (19.4 *per cent*) (European Food Safety Authority and European Centre for Disease Prevention and Control 2022).

E. coli from pigs

Sixteen *E. coli* from pigs, four of which were serotypes associated with disease in this species, were screened. High levels of resistance to ampicillin (68.7 *per cent*), tetracycline (68.7 *per cent*) and trimethoprim- sulfamethoxazole (62.5 *per cent*). Half of the isolates were resistant to streptomycin and reduced susceptibility to fluoroquinolones was evident in 18.8 *per cent*.

Resistance levels to some antimicrobials were higher compared to isolates from healthy animals that year, in particular ampicillin and tetracycline (28.2 *per cent* and 51.8 *per cent*, in healthy animals, respectively); since resistance in *E. coli* is linked to antimicrobial usage, this may be explained by medication of these individual animals prior to sampling.

E. coli from bovines

Ten isolates of *E. coli* from bovines, cultured from sites other than the mammary gland, were tested using broth microdilution. Four were fully susceptible and three were found to be resistant to five (n=2) or six (n=1) antimicrobial classes (β-lactams, phenicols, fluoroquinolones, trimethoprim- sulphonamides, tetracycline +/- aminoglycosides). Bacterial septicaemia in a calf was caused by an *E. coli* strain which was resistant to extended spectrum cephalosporins (a HP-CIA class which includes ceftiofur), sulphamethoxazole and tetracycline.

Extended spectrum cephalosporin resistance was also reported at very low levels (≤ 7 *per cent*) in sick calves in the UK (UK-VARSS 2021) and France (Anses, 2021) in 2020 and in Irish beef at retail in 2021 (≤ 2 *per cent*).

These findings of MDR and HP-CIA resistance are concerning as many of these cases were chronic in nature and are likely to have been associated with antimicrobial treatment failure.

Salmonella

In 2021, *Salmonella* was the second most frequently reported cause of bacterial gastroenteritis in humans in the EU, affecting almost 53,000 people. Therefore, DAFM undertakes monitoring of AMR in *Salmonella* in healthy pigs and broilers and slaughter, as part of a Europe-wide harmonised surveillance programme and in samples from sick animals that are submitted to the laboratory network.

Salmonella infections in animals can cause reproductive, septicaemic or enteric disease-however, many species, particularly cattle and pigs, can be lifelong asymptomatic carriers of the bacterium, which is shed intermittently in the faeces. In 2021, 41 *per cent* of pig caecal (intestinal) samples taken from healthy pigs at slaughter harboured *Salmonella*. The administration of antimicrobials to animals with *Salmonella* infections has been associated with increased rates of shedding and the emergence of concerning AMR, including resistance to antimicrobials (fluroroquinolones and extended spectrum cephalosporins) that are used to treat Salmonella in humans.

As a result, antimicrobial susceptibility testing of *Salmonella* was carried out due to its public health significance, using antimicrobials used in both human and veterinary medicine, rather than as a tool to inform prescribing of antimicrobials.

Thirty-five isolates from bovines were tested; these originated from cases of abortion (n=20), enteritis (diarrhoea)(n=10), septicaemia (n=3) and sudden death (n=2). Most (including all abortion associated isolates) were of the *Salmonella* serovar (subtype) *Salmonella* Dublin (n=24). Five isolates were *Salmonella* Typhimurium, its monophasic variant, which can infect a wide range of hosts, including humans. The majority (67 *per cent*) were fully susceptible and low levels of resistance to sulphamethoxazole (14.3 *per cent*), amoxicillin (11.4 *per cent*) and tetracycline (8.6 *per cent*) were recorded. Single isolates were resistant to chloramphenicol and ciprofloxacin, a HP-CIA. Three isolates were multiple drug resistant (MDR).

Eighteen isolates from sheep were screened. In most cases the cause of disease or sudden death was multi-factorial and many animals had high parasite burdens, suggesting that *Salmonella* infection was an incidental finding. *Salmonella enterica* subsp, *diarizonae*, a subtype which has been described in 20 *per cent* of asymptomatic sheep (Weber et al. 2022), comprised most isolates (n=11). No resistance was recorded in any isolates from ovine samples.

In contrast almost half (46 *per cent*) of *Salmonella* from sick pigs (n=13) were MDR and only 30.7 *per cent* were fully susceptible. Isolates comprised mainly monophasic *S.* Typhimurium (n=5), *S.* Typhimurium (n=3) or *S.* Give (n=3). Very high levels of resistance to ampicillin (70 *per cent*) and sulphamethoxazole (69 *per cent*) were observed. Resistance to tetracycline (46 *per cent*) and trimethoprim (31 *per cent*) was moderate and two isolates were resistant to chloramphenicol. The percentage of isolates resistant to sulfamethoxazole and ampicillin was higher (>10 *per cent*) than from healthy pigs sampled at slaughter in Ireland in 2021.

Campylobacter

Campylobacter is also a common cause of gastrointestinal illness in humans. It is frequently isolated from asymptomatic healthy animals.

The six *C. jejuni* isolates from bovines (n=6) and sheep (n=1) were fully susceptible. All five *C. coli* (2 bovine, 1 ovine, 2 porcine) were resistant to tetracycline. Three (2 bovine, 1 porcine) were also resistant to ciprofloxacin, and one of these had additional erythromycin resistance. Both ciprofloxacin and erythromycin are critically important I the treatment of severe human infections. Resistance to these antimicrobials are commonly reported in *C. coli* from healthy pigs (ciprofloxacin and erythromycin) and *C. jejuni* from broilers (ciprofloxacin) in Europe, including Ireland (European Food Safety Authority and European Centre for Disease Prevention and Control 2022).

17.3 Respiratory pathogens

Mannheimia haemolytica (*M. haemolytica*) and *Pasteurella multocida* (*P. multocida*) form part of the normal microbiome of the naso-pharyngeal region of healthy animals but can cause disease when an animal is stressed, or co- infected with respiratory viruses.

Antimicrobial agents licensed for the treatment of bacterial respiratory disease in animals include HP-CIAs, such as enrofloxacin, marbofloxacin and ceftiofur as well as macrolides, which are of critical importance in the treatment of patients. Table 17.1 summarises the antimicrobials used for AST on bacteria associated with respiratory disease.

Mannheimia haemolytica

In 2021, isolates of *M. haemolytica* from 71 cattle and 35 ovine, most of which (87 *per cent*) were diagnosed with pneumonia, underwent susceptibility testing using a panel of discs. No resistance to enrofloxacin, ceftiofur or florfenicol was detected. Most bovine isolates were susceptible to the macrolides tulathromycin (92.5 *per cent*) and tilmicosin (95.7 *per cent*). Three isolates from sheep had intermediate readings for tulathromycin but all were tilmicosin susceptible.

In addition, 30 bovine and 15 ovine isolates were tested by broth microdilution using penicillin, ampicillin, tetracycline and spectinomycin. Resistance to tetracycline was detected in 20 *per cent* of ovine and 7 *per cent* of bovine isolates. Tetracycline resistance was also recorded in 11 *per cent* of bovine *M. haemolytica* isolates in 2020. No resistance to ampicillin or spectinomycin was observed, but 20 *per cent* of *M. haemolytica* from both species had intermediate readings for penicillin.

Resistance patterns to the HP-CIAs, enrofloxacin and ceftiofur, in cattle isolates were similar to those seen in the UK (UK-VARSS 2021), where complete susceptibility was also recorded.

Table 17.2: 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	.
Ampicillin	BM	BM	DD	BM
Ceftiofur	DD	DD	DD	BM
Fluoroquinolone				
Enrofloxacin	DD	DD	BM	BM
Tetracyclines				
Tetracycline	BM	BM	DD	BM
Phenicol				
Forfenicol	DD	DD	BM	BM
Macrolide				
Tulathromycin	DD	DD	.	BM
Tilcosin	BM	DD	.	BM
Erytromycin	.	.	DD	.
Aminoglycoside / aminocyclitols				
Spectinomycin	BM	BM	.	.
Pleuromutilin				
Tiamulin	BM	.	.	BM
Lincosamide				
Clindamycin	.	.	BM	.

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

However, in contrast to Irish findings, very low levels of resistance to several antimicrobials, including fluoroquinolones, were seen in *Mannheimia* from sheep in the UK.

Pasteurella multocida

P. multocida, which was recovered from the lungs of 121 bovines (mainly calves), was tested using a panel of discs comprising ceftiofur, enrofloxacin, florfenicol and tulathromycin. Further screening was undertaken on 47 of these isolates, using penicillin, ampicillin, tetracycline, tiamulin, tilmicosin and spectinomycin.

The majority (116) of bovine isolates (121) were susceptible to all antimicrobials and no resistance was detected to β-lactam antimicrobials (penicillin, ampicillin, ceftiofur) or tiamulin. Three isolates were found to be multi-drug resistant–all were resistant to tetracycline, enrofloxacin and macrolides (tulathromycin and tilmicosin), and one harboured additional resistance to florfenicol. Resistance to spectinomycin and tetracycline was detected in a separate isolate.

P. multocida from the lungs of 6 sheep, with a history of sudden death or ill- thrift and five pigs were also examined. Resistance (tetracycline) was only detected in a single isolate from a lamb.

The levels of resistance in bovine Pasteurella were higher than in 2020, when only two isolates were found to harbour resistance to tetracycline. The recovery of MDR *P. multocida* from cattle is concerning, especially as bacteria were co-resistant to enrofloxacin (a fluoroquinolone, HP-CIA) and macrolides. However, higher resistance levels to the macrolide and fluoroquinolone classes have been described in *Mannheimia* from cattle in the UK (20 *per cent*) (UK-VARSS 2021) and the USA (90 *per cent*) (Snyder and Credille 2020), respectively.

The genomic basis of resistance in the Irish isolates is being investigated.

Streptococcus suis

S. suis is commonly found in the upper respiratory tract of pigs and virulent strains can cause a range of clinical disease, including meningitis, arthritis, endocarditis and sudden death. Infections can cause significant economic losses, impact animal welfare and increase antimicrobial usage in affected herds.

Isolates from animals (mainly young piglets) from 14 herds were susceptible to β-lactam antimicrobials (penicillin, ampicillin and ceftiofur) but there was significant macrolide (erythromycin) resistance (42 *per cent*). Over half (62 *per cent*) were resistant to tetracycline. In comparison, erythromycin and tetracycline resistance levels were 50 *per cent* and 44 *per cent*, respectively, in 2020, but a small number of isolates (18) were tested that year also.

Susceptibility to clindamycin, florfenicol and enrofloxacin of eleven isolates was also established; clindamycin resistance was high (64 *per cent*), whereas resistance to the other two substances was not seen. Resistance trends are similar to those recent finding in the UK (UK-VARSS 2021), where no fluoroquinolone resistance was detected; however, Sweden (SWEDRES-SVARM 2020) reported some penicillin resistance in 2020, which is significant as β-lactams are frequently used to treat *S. suis* infection.

Actinobacillus pleuropneumoniae

A. pleuropneumoniae is another bacterium which can cause respiratory disease in swine, leading to considerable economic losses for herdowners. In 2021, bacteria cultured from the lungs of pigs from 12 herds underwent AST. Nine of these were resistant to tetracycline, but all were susceptible to the critically important antimicrobials ceftioufur, enrofloxacin or the macrolide compounds. The levels of resistance in *A. pleuropneumoniae* across Europe appear variable; almost no resistance was detected in Sweden (SWEDRES-SVARM 2020) whereas in the UK (UK-VARSS 2021) and France (ANSES, 2021) significant β-lactam and tetracycline resistance was reported in 2020, with the latter comparable to Irish levels.

Part V

Animal Health Ireland

CHAPTER 18

IRISH JOHNE'S CONTROL PROGRAMME

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Ireland

18.1 Bulk tank milk surveillance for Johne's disease in Ireland

Introduction

An Irish Johne's Control Programme (IJCP) has been operating in Ireland since 2017, providing coordination and funded tools for voluntary control of spread of *Mycobacterium avium subsp. paratuberculosis* (MAP), the bacterium the causes Johne's disease (JD) (Gavey et al. 2021).

The programme has 4 objectives, developed for an estimated herd prevalence of 30 *per cent* :

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

Table 18.1: The number of participating herds in the Irish Johne's Control Programme (IJCP).

Registration/year	2017/8	2019	2020	2021
New registrations	301	729	128	211
Registered herds (at year end)	939	1661	1760	1987

The IJCP operates under the direction of an Implementation Group (IG) comprising representatives of all stakeholders in the programme, including milk processors, farmers, veterinary practitioners, laboratories, milk recording organisations, technical advisors and government. The IG recognises that recruitment of more herds into the voluntary programme is critical to meeting the objectives. The number of participating herds is shown in Table 18.1.

Sergeant et al. (2019) evaluated the suitability of various JD herd-level surveillance strategies in the Irish context, in terms of herd sensitivity, positive and negative predictive values, overall cost, and utility and logistics. They applied a stochastic simulation model to these surveillance strategies, including annual individual milk or serum ELISA testing on all adult animals in the herd, cull cow sampling with serum ELISA, pooled faecal sampling, environmental sampling, and bulk tank milk ELISA (BTM). This study concluded that bulk tank milk was the lowest cost option for case detection, requiring only the cost of a single test in each herd each year; but that the case detection proportion was low, at about 15 *per cent* although can be expected to be higher in herds of higher prevalence of infection.

Modelling also showed the positive predictive value of the BTM ELISA test at about 85 *per cent*, so that some false-positive herds would be expected. These may be due to imperfect specificity of the test, or other factors such as recent TB testing or exposure to closely related bacteria in soil or water . Therefore a positive BTM result should be interpreted carefully, in consultation with the herd's regular veterinary practitioner who is familiar with the herd's health profile, and potentially using confirmatory herd testing to clarify the infection status of BMT-positive herds at significant cost.

In response to this study, the IJCP Technical Working Group which provides technical advice to the programme, recommended that bulk tank milk testing be implemented for all dairy herds in Ireland for the purpose of case detection and recruitment but not for the purpose of assurance against infection. The IG accepted this recommendation, and agreed to funding of herd testing for herds with positive BTM results.

Method

The Department of Agriculture, Food and the Marine (DAFM), a member of the IG, is conducting ongoing national BTM screening for a range of animal diseases, including JD.

Screening has been conducted twice per year, in spring and autumn, since 2019.

A milk sample from each milk supplier (dairy herd) is provided by all Irish co-operative creameries to DAFM, which conducts the laboratory testing at the Blood Testing Laboratory (BTL)

Cork. The laboratory uses a commercial ELISA test (IDvet – ID Screen Paratuberculosis Indirect Screening) that has been endorsed by Friedrich Loeffler Institute, Germany, and is also used by some of the accredited, designated laboratories in the IJCP. The ELISA test is designed to detect antibodies in milk or blood samples which are raised by animals in response to infection with MAP. Testing is performed according to the kit manufacturer's instructions, and test results are reported by BTL to DAFM. Based on the threshold values defined by IDvet, the reported sample to positive (S/P) ratios were qualitatively categorised as negative (S/P ≤0.15) or positive (S/P > 0.15).

Herds which have one or more positive BTM results are notified of this result, and advised to contact their preferred private veterinary practitioner for herd-specific veterinary advice on JD and to join the IJCP to investigate whether the positive BTM result is likely to be truly due to infection and to use the programme's funded supports to control spread of infection.

Some initial notifications to herds with positive BTM results were undertaken by DAFM regional veterinary officers in late 2020 and early 2021, but the number of these contacts is not recorded. Subsequent notifications are to be provided through upload of results to the national livestock database operated by ICBF and an automated mail-out to test-positive herds of letters and a leaflet. There is further support to recipients from a helpline, a webpage and a repeat of the recommendation to seek herd-specific veterinary advice from the herd's preferred private veterinary practitioner.

Results

There have been 6 rounds of surveillance screening undertaken thus far, in spring and autumn in each of 2019, 2020, and 2021. Testing of samples collected in spring of 2022 is pending.

For each of the six tested rounds, approximately 16,000 herds have been sampled and tested, except for the round of spring 2020 when COVID-19 restrictions on staffing constrained sampling (Figure 18.1).

The proportion of positive results per round varied between 2–7 *per cent*, average of 4 *per cent*. There is a tendency towards higher proportions of positive results in autumn rounds of testing.

16,391 herds have been tested at least once in any of the 6 sampling points; of these, 2,383 herds (14.5 *per cent*) have tested positive at least once; but 1,791 herds have tested positive only once, only 592 herds have tested positive more than once, and only 6 herds have tested positive in all six rounds (Figure 18.2).

Twenty-three herds have registered in the IJCP since their positive BTM results for 2019 were reported in late 2020 or early 2021, and their subsequent herd testing results under the programme are available for analysis. Of those 23 herds, 19 have completed at least one whole herd test; and of those 19 herds, 5 herds (26 *per cent*) have completed only negative whole herd tests, 5 (26 *per cent*) have had the presence of MAP in the herd confirmed by a positive PCR test result, and 9 herds (47 *per cent*) have had one or more animals with a

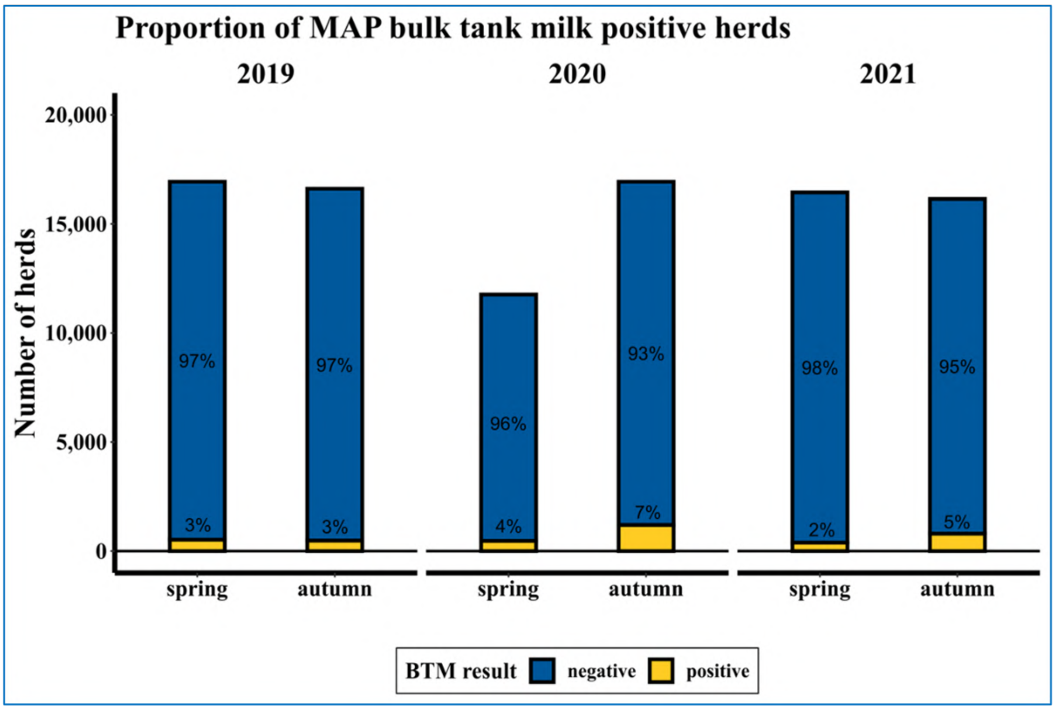

Figure 18.1: Proportion of MAP bulk tank milk positive herds.

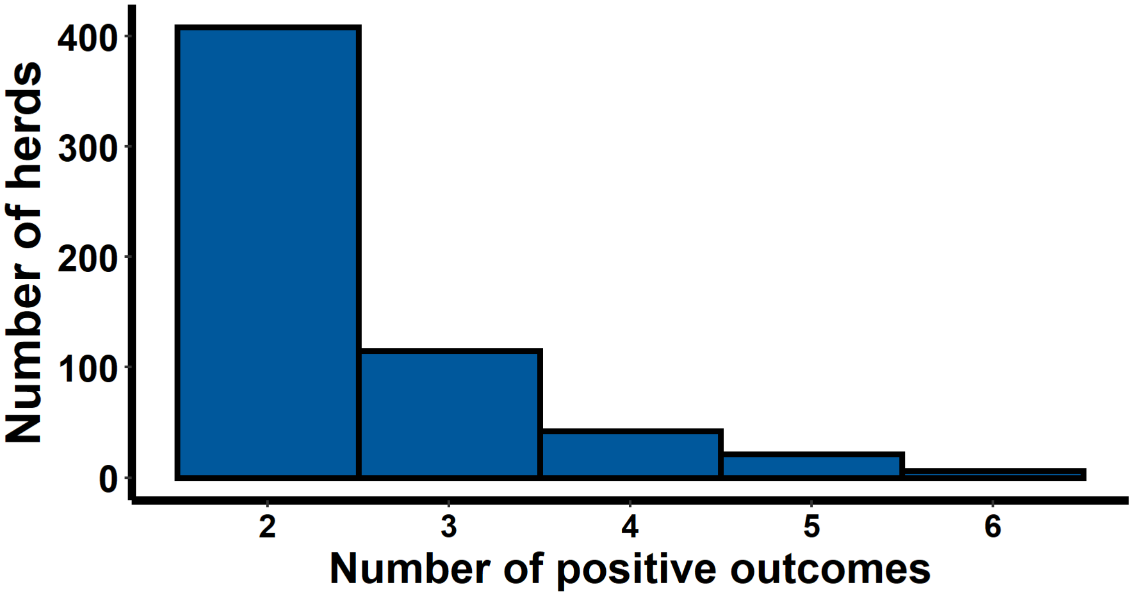

Figure 18.2: Proportion of MAP bulk tank milk positive herds.

positive or inconclusive individual ELISA test result but without a subsequent PCR test so considered by the programme to be infected (Table 18.2).

Table 18.2: Herds registered in the IJCP since positive BTM results were reported.

Year	Total	Test Negative Pathway	Test Positive Pathway
Year 1	4	.	.
Year 2	18	5	13
Year 3	1	0	1
Years 2 & 3	19	5 (26%)	14

Discussion

The evaluation of BTM as a surveillance tool for Ireland by Sergeant et al. (2019) calculated a herd sensitivity of 0.08, but very wide prediction intervals due to a combination of uncertainty about test performance and the wide range of simulated herd sizes. Given the low herd sensitivity of the test and only moderate positive predictive values at herd level, BTM ELISA testing is expected to result in both a lower case detection rate and higher numbers of false-positive herds compared with other strategies in the Sergeant et al. (ibid.) al evaluation that had higher values for both herd sensitivity and herd positive predictive value. However, the BTM testing has the lowest cost of the evaluated surveillance tools for case detection, requiring only the cost of a single annual test per herd at approximately 2.75€.

Compared to the estimated herd prevalence of 30 *per cent*, BTM testing outcomes to date with an average positive result of 4 *per cent* suggest a similar order of magnitude to the Sergeant et al. (ibid.) calculation for negative predictive value. Most herds (in the order of 90 *per cent*) that are infected were predicted to have negative BTM results, and this appears to be borne out in the results each round.

Although the proportion of herds with positive results in each round has been somewhat consistent (2–7 *per cent*, average of 4 *per cent*), the repeatability of positive results at the herd level has been much less so (Figure 18.3).

It is likely that herds returning consistently more positive results have a higher animal prevalence and/or more advanced infection in infected animals than herds with fewer positive results, so should be considered to be higher risk and likely to gain greater benefit from joining the IJCP. Herd testing completed in 19 of the BTM positive herds to date, with 73 *per cent* of herds considered infected including 26 *per cent* of herds with confirmed infection, indicates that the herd prevalence of BTM positive herds is likely to be high, which is consistent with the Sergeant et al. (ibid.) evaluation of specificity of BTM ELISA testing as being high, approaching 100 *per cent*.

The low negative predictive value, together with the low repeatability of negative results, vindicate the advice of the TWG that negative results cannot be used to support assurance against infection. They also suggest that any estimate of true herd prevalence, or calculation of trend in herd prevalence over time, would be subject to very wide confidence limits and unreliable.

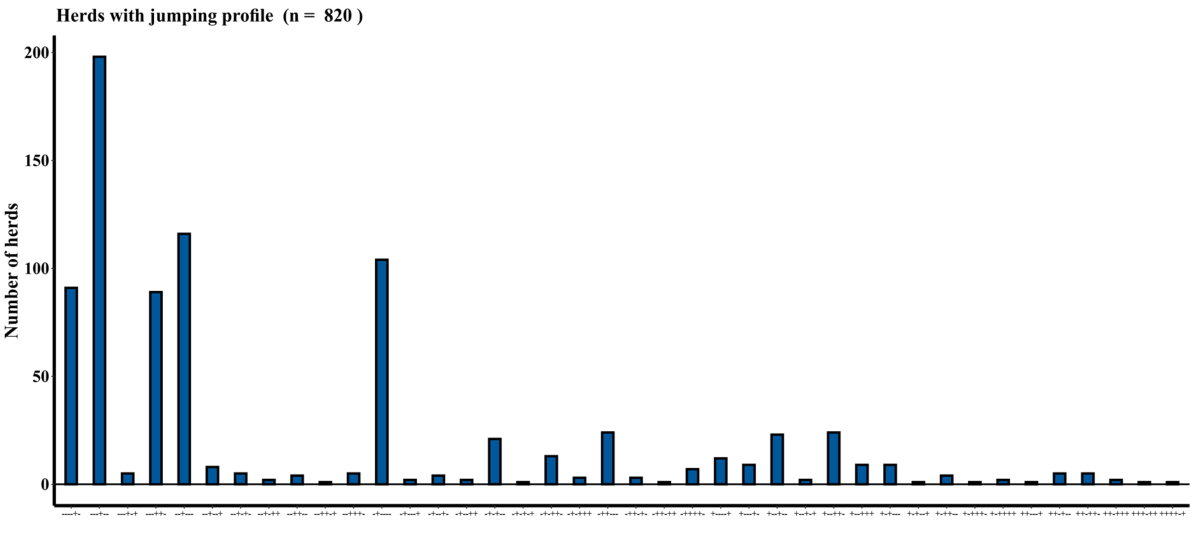

Figure 18.3: Repeatability of positive results at the herd level

Conclusion

BTM testing is providing an opportunity to identify and encourage recruitment into the IJCP of high-risk herds.

Using the cut-offs specified by the kit manufacturer, BTM testing has a low herd sensitivity and in the Irish context a low negative predictive value. It is therefore not an effective surveillance tool for the purposes of estimating herd prevalence or trends in herd prevalence over time, nor as a measure of assurance against infection.

CHAPTER 19

BOVINE VIRAL DIARRHOEA (BVD) ERRADICATION PROGRAMME

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

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 with BVD virus as defined by the OIE (OIE, 2021), having an initial positive or inconclusive result by 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 2.43 million calves were born in 2021. 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 0.03 *per cent* of calves tested in the year had positive or inconclusive results. When put in the context of all cattle in Ireland, the animal level prevalence is 0.01 *per cent*. The prevalence of breeding herds with a suspect or confirmed BVD case continued to decrease to only 0.51 *per cent* of 83,000 herds. When all herds are taken into account (circa 109k), the herd-level prevalence is 0.32 *per cent*. At

Table 19.1: Animal-level prevalence of BVD+ calves born during each year of the programme by herd type.

Year	Total	Beef	Dairy	Dual
2013	0.66	0.78	0.55	0.80
2014	0.46	0.54	0.37	0.60
2015	0.33	0.39	0.26	0.52
2016	0.16	0.21	0.12	0.23
2017	0.10	0.13	0.08	0.20
2018	0.06	0.07	0.04	0.09
2019	0.04	0.05	0.03	0.07
2020	0.03	0.04	0.02	0.06
2021	0.03	0.04	0.03	0.05

the end of the year only a handful of suspect animals remained alive, with many counties not containing any.

As in previous years, a high level of compliance with the requirement to tissue tag test these calves was observed, with results available for over 99.1 *per cent* of these calves. The overall prevalence of births of BVDV positive animals (BVD+) in 2020 continues to decline, with only 0.03 *per cent* of calves tested in the year being considered to be BVD+ with BVDV, with these being located in 0.55 *per cent* of circa 83,000 breeding herds (Table 19.1 and Figure 19.1). This represents a decrease in calf level prevalence of 25 *per cent* from that seen in 2019 and is a reduction of more than twenty-two-fold when compared to the prevalence at the start of the compulsory phase of the programme in 2013, when 0.66 *per cent* of the calves born were BVD+. At the end of the year only a handful of BVD+ remained alive, with many counties not containing any virus positive animals (Table 19.2 and Figure 19.2).

A series of enhancements to the 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.

An application for recognition of the Irish BVD programme under the AHL will be submitted by the DAFM in 2022. This will be an important step towards achieving EU-recognised BVD freedom. The conditions for freedom under the AHL include a ban on vaccination, not having had a confirmed case in the previous 18 months and having BVD-free status for 99.8 *per cent* of all herds representing at least 99.9 *per cent* of cattle. To achieve this goal the BVD Implementation Group developed a series of enhanced measures that were first introduced in 2021 to:

- Maximise the proportion of herds (including non-breeding herds) with NHS.
- Rapidly identify and resolve the small number of herds with positive/inconclusive results and minimise the risk of onward.

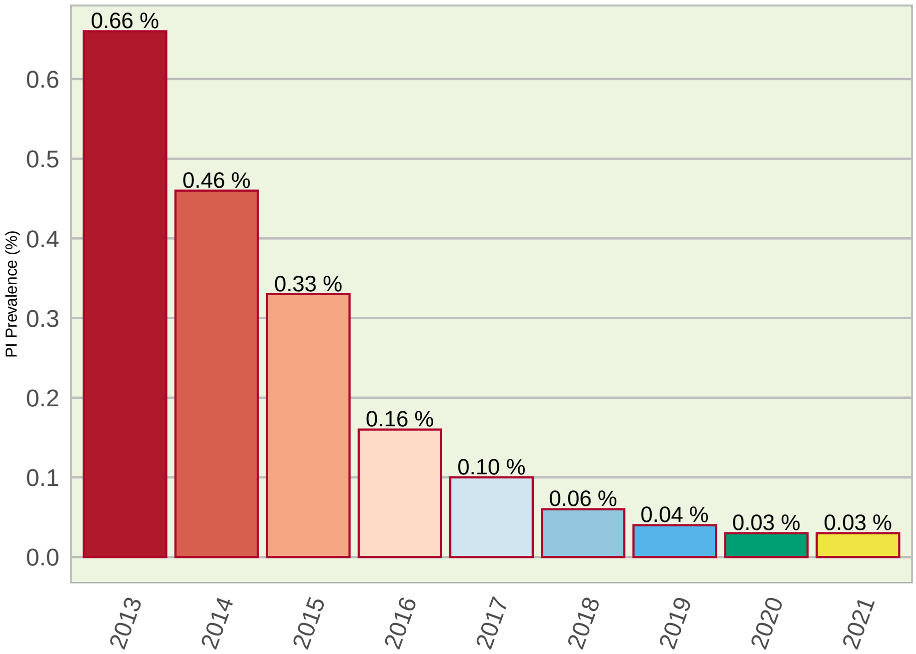

Figure 19.1: Herd-level prevalence of BVD+ calves born during each year of the programme.

Table 19.2: Breeding herd-level prevalence of BVD+ calves born during each year of the BVD eradication programme.

Year	Total	Beef	Dairy	Dual
2013	11.3	8.8	20.3	14.1
2014	7.6	5.9	13.2	11.0
2015	5.9	4.4	10.4	9.3
2016	3.3	2.4	5.7	5.1
2017	2.0	1.4	3.9	3.5
2018	1.1	0.8	1.2	1.9
2019	0.8	0.5	1.4	1.7
2020	0.6	0.4	1.0	1.1
2021	0.5	0.3	1.0	0.9

19.1 Transmission of infection.

For the majority of negative herds, the programme is similar to previous years. For herds where a positive/inconclusive result is disclosed, an immediate restriction of animal movements (as opposed to the situation previously where only retaining herds were restricted) 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 will be lifted and these include an initial three-week period of herd restriction, beginning on the date of removal of the suspect animal, which will serve 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

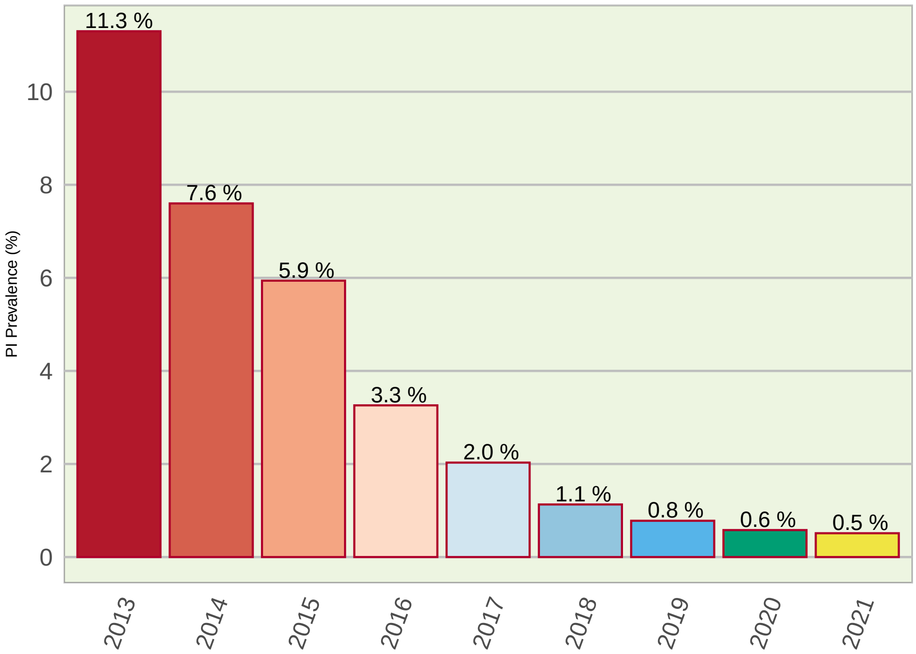

Figure 19.2: Breeding herd-level prevalence of BVD+ calves born during each year of the programme.

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 2021, over 46k animals had been blood tested and close to 37k 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 it was further reduced and took 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.

19.2 Negative herd status

A herd may 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 animal(s) deemed to be persistently infected with BVD virus from the herd in the 18 months preceding the acquisition of NHS.

By the end of 2021, over 96 *per cent* of breeding herds had acquired NHS, with a further 2,999 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.

The status of almost all animals (99.6 *per cent*) in the 83,000 breeding herds in Ireland is now known, with the main exception being a decreasing number of animals born before the start of the compulsory programme in 2013 that have neither been tested nor produced a calf. At the end of 2021 the number of these animals was approximately 400. The majority of these animals are in beef herds, and the majority are also male.

19.3 Targeted Advisory Service on Animal Health (TASAH)

Since 2017 all herds with positive results are required to undergo an RDP-funded TASAH herd investigation by a trained veterinary practitioner. These investigations seek to review herd biosecurity, identify a plausible source or sources of infection, ensure that the herd is left free from BVDV and agree farm-specific measures to prevent its re-introduction. Investigations have now been completed for 340 herds that had positive results in 2021 (95 *per cent* of positive herds). A small number have not been completed and these are now being contacted to progress the investigations.

CHAPTER 20

INFECTIOUS BOVINE RHINOTRACHEITIS ERRADICATION PROGRAMME

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During 2021, the IBR Technical Working Group activities focused on the testing and assessment of different strategies for a national IBR programme. These strategies align with the requirements of the new Animal Health Law (AHL) Regulations 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. Reducing the prevalence of IBR nationally is one of the animal health measures under Action 5 (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) of the AgClimatise Roadmap published by DAFM in 2020.

In addition to contributing to environmental sustainability, reducing the prevalence of IBR will also contribute to reducing antimicrobial usage and resistance (AMU, AMR) consistent with the goals of the Irish National Action Plan on AMR (iNAP2) and improve the profitability of the sector (economic sustainability). For example, an Irish study estimated a reduction of 250l in milk yield per cow per year in herds with a positive bulk tank milk result for IBR, which amounts to an annual cost of €62 million to the Irish dairy industry (Sayers, 2017). Addressing IBR through an EU-approved programme would also facilitate both the export of animals to the increasing number of European countries with either approved IBR programmes, or recognised freedom, and the introduction of enhanced IBR requirements for animals coming into Ireland.

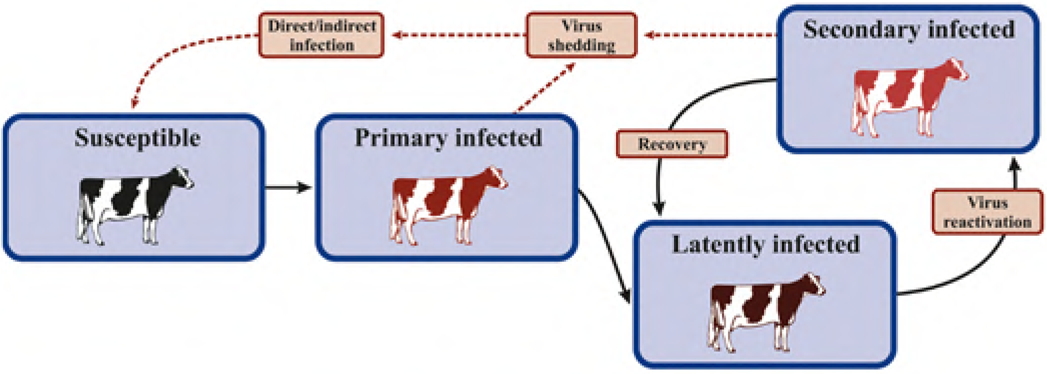

Figure 20.1: IBR infection states in the model.

A key tool for reducing prevalence in infected herds that will be central to an IBR programme is vaccination. It is encouraging to note that there has been a year-on-year increase in the number of doses sold. During 2020, over 3 million IBR vaccine doses were sold, nearly 15 *per cent* more than in the previous 12 months. However, in the absence of a formal programme, it will be necessary to continue this high level of expenditure on vaccination indefinitely.

20.1 Bulk milk surveillance

Since 2019, DAFM have undertaken national IBR surveillance of dairy herds using bulk tank milk samples, with two rounds of testing per year being undertaken each spring and autumn. The results from this testing will be made available to herd owners in 2022 through ICBF, with targeted messaging in advance of any decision on a national programme. To gain a better understanding of the results available to date, and factors associated with being test-positive, a detailed analysis by the Centre for Veterinary Epidemiology and Risk Analysis (UCD) and AHI is under way.

20.2 Modelling work

A DAFM-funded PhD student, working with the Helmholtz Centre for Environmental Research (Germany) continued working during 2021 on the development of a national IBR model. This PhD is now completed. Having demonstrated its representativeness of the national herd, a decision was made to evaluate a regional model of county Kerry which includes 5,000 farms and 400,000 animals (Brock et al. 2021). Each individual animal in the model is subject to an ageing process with animal age increasing by one week per simulation step. Ageing can trigger other processes, for example transfer between management units. In addition, each animal is assigned to one of four IBR epidemiological states as described in Figure 20.1.

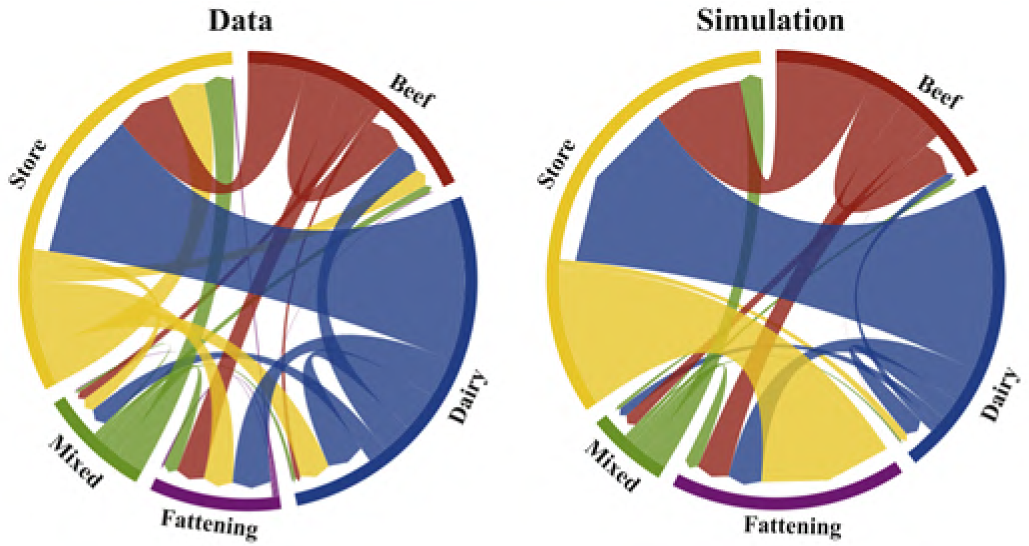

Figure 20.2: Comparison of observed (left) and simulated (right) transport flows per herd type. The thickness of the flows indicates the transport volume.

Part VI

Agri-Food & Biosciences Institute, Northern Ireland

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INSTITUTE

CHAPTER 21

BOVINE DISEASES (AFBI)

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Neonatal Calves (0-1 month old)

As in previous years enteric infections were the most frequently diagnosed cause of death in the neonatal calf group up to one month of age accounting for 35 *per cent* of cases. 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. Twenty-five cases of diarrhoea due to *E. coli* were recorded with nine 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 45 cases (28 *per cent* of the enteric infections). Coronavirus may produce an enteritis similar to that caused by rotavirus. Five cases of enteritis due to coronavirus were recorded in 2021. Transit of calves through markets increases the likelihood of exposure to *Salmonella*. Seven cases of BVDV infection were recorded in neonatal calves less than one month old in 2021. Thirty-nine cases of enteritis due to the protozoan parasite *Cryptosporidium* were diagnosed in 2021, similar to the 40 cases which were recorded in 2020.

Respiratory tract infections were the next most frequently diagnosed cause of mortality in neonatal calves accounting for 13 *per cent* of cases. *Mycoplasma bovis* was the most frequently diagnosed bacterium causing respiratory disease being recovered in 8 of the 59

Figure 21.1: Pulmonary congestion and ecchymotic haemorrhages in the lung of a 3 day old calf with colisepticaemia. Photo: Seán Fee.

cases (14 *per cent*) of respiratory infections, followed by *Pasteurella multocida* which was detected in five of the 59 cases (8 *per cent*) of neonatal respiratory infections. Less frequently identified bacteria included *Mannheimia haemolytica* in three cases and *Arcanobacterium pyogenes* (two cases). As was the case in previous years RSV was the most frequently diagnosed viral respiratory pathogen diagnosed (seven cases) followed by PI3 (four cases). Aspiration pneumonia accounted for four cases (8 *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.

Death due to septicaemic or toxaemic conditions represented 11 *per cent* (49 cases) of deaths in neonatal to one-month-old calves (Figure 21.1) . Colisepticaemia was the major cause of death in this group accounting for 32 cases (65 *per cent* of the septicaemic / toxaemic conditions) and emphasizing 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 2021. Three cases of systemic pasteurellosis were recorded in neonatal calves.

Hypogammaglobulinaemia due to inadequate absorption of colostral antibody was recorded in 46 cases and was the most frequently recorded nutritional/metabolic condition (accounting for 78 *per cent* of the diagnoses in this category) followed by 4 cases of ruminal feeders (7 *per cent* of the 59 cases in this category). Ruminal feeders develop in calves where there is a failure of closure of the oesophageal groove, and rather than bypass the rumen as it should milk enters and sours in the rumen. Good husbandry practices are important to prevent the development of ruminal feeders. These include using standardised feeding 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

Table 21.1: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for post mortem in 2021 (n=447).

Category	No. of cases	Percentage
Enteric infections	158	**35.3**
Nutritional / metabolic conditions	59	**13.2**
Respiratory infections	59	**13.2**
Septicaemia / toxaemia	49	**11.0**
Navel ill / Joint ill	38	**8.5**
Other diagnoses	28	**6.3**
Heart / circulatory system	11	**2.5**
Diagnosis not reached	9	**2.0**
GIT torsion /obstruction	9	**2.0**
Skeletal conditions	9	**2.0**
Central nervous system	7	**1.6**
Peritonitis	6	**1.3**
Gastrointestinal ulcers or perforations	5	**1.1**

Figure 21.2: Pale foci and streaks through the ventricular myocardium of a 10 day old Friesian calf with nutritional myopathy (white muscle disease). Photo: Seán Fee.

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. A single case of nutritional myopathy (white muscle disease) due to deficiency of selenium / vitamin E was diagnosed at post-mortem examination of a four-day-old calf in 2021. 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.

Navel-ill accounted for 9 *per cent* of diagnoses at post-mortem examination of neonatal

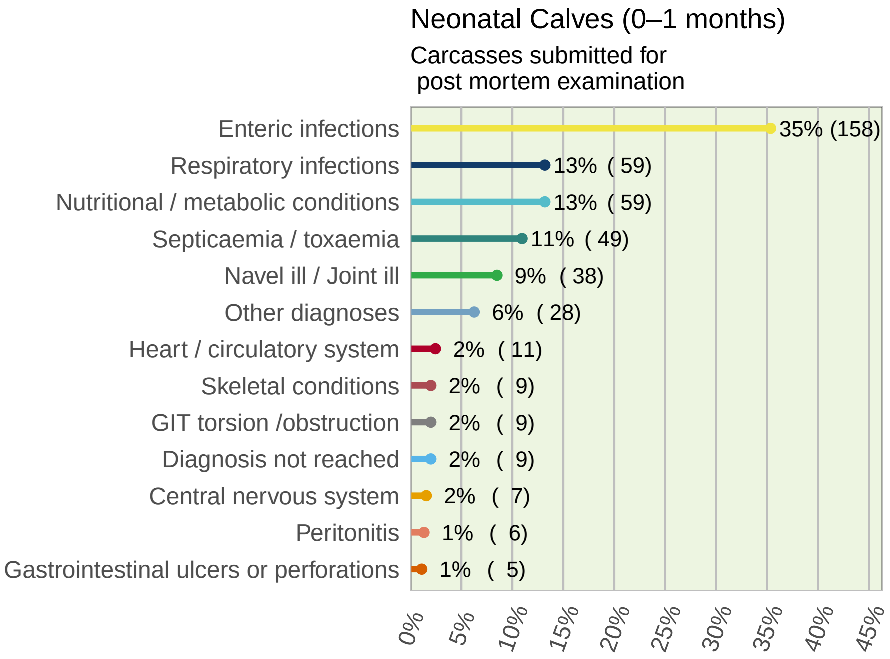

Figure 21.3: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for *post mortem* in 2021 (n=447). The absolute number of cases is between brackets.

calves (38 cases) emphasizing the need for good calving pen hygiene and the importance of dipping/spraying of the navel. Traumatic injuries likely to have been calving related injuries were diagnosed in four neonatal cases (as well as being diagnosed in three cases of stillbirth). Affected calves ranged from 2 days to 3 weeks of age. In one case two four day old calves described by the owner as being ‘humped’ and ‘dopey’ were found to have a fractured spine and ribs in one calf and fractured ribs in the second calf. Death in a three-week-old calf was attributed to compression of the trachea by large bony calluses that had formed at the thoracic inlet by exuberant repair of fractured ribs.

Calves 1-5 months old

As was the case in previous years, respiratory tract infections and pneumonia were by far the most commonly recorded cause of death in calves from one to five months of age and were recorded in more than 50 *per cent* of 383 cases. Bacterial respiratory infections were most frequently diagnosed. *Mannheimia haemolytica* was the most frequently detected pathogen and was recorded in 37 cases (representing 19 *per cent* of the 193 recorded respiratory infections), *Mycoplasma bovis* was detected in 36 cases (19 *per cent*) and *Pasteurella multocida* was detected in 25 cases (13 *per cent*). *Arcanobacterium pyogenes* was recorded in 16 cases (8 *per cent* of respiratory diagnoses) while *Histophilus somni* was recorded in six cases (3 *per cent* of respiratory infections). Parasitic pneumonia due to lungworm was recorded in nine cases. BRSV was the most commonly recorded viral respiratory infection (14 cases) followed by five cases of PI3 and two cases of IBRV. One case of aspiration pneumonia was recorded. Infections of the gastrointestinal tract represented the second most important group of diagnoses after respiratory infections in this age group. There were

36 cases of enteric infections (or 9 *per cent* of the 383 cases overall in this age group). Coccidiosis was the most frequently recorded enteric infection (nine cases or 32 *per cent* of the enteric infections recorded) followed by *Cryptosporidium* (six cases). Coccidiosis may occur in contaminated conditions such as damp, dirty straw bedding indoors or around feeding and drinking troughs contaminated with faeces outdoors. Diarrhoea is sometimes accompanied by straining and blood may frequently be observed in the faeces. Veterinary advice on treatment should be sought and attention should be paid to the hygiene of calf pens and the cleanliness and positioning of feeding troughs. Other gastrointestinal infections of note included five cases of BVD/Mucosal disease and three cases of candidiasis.

Table 21.2: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for post mortem in 2021 (n=383).

Category	No. of cases	Percentage
Respiratory infections	193	**50.4**
Enteric infections	36	**9.4**
Other diagnoses	32	**8.4**
Nutritional / metabolic conditions	23	**6.0**
GIT ulcer / perforation	20	**5.2**
Septicaemia / toxaemia	19	**5.0**
GIT torsions /obstruction	16	**4.2**
Urinary tract conditions	12	**3.1**
Cardiovascular conditions	7	**1.8**
Clostridial disease	7	**1.8**
Diagnosis not reached	7	**1.8**
Peritonitis	6	**1.6**
Nervous disease	5	**1.3**

Significant non-infectious conditions of the gastrointestinal tract included ulcers, perforations, torsions and obstruction. There were 16 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. Six cases of perforation of the abomasum were recorded and a further 14 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 (15 cases) and there were four cases of bloat. Two cases of nutritional myopathy (white muscle disease) were recorded (Figure 21.2). Nutritional myopathy in calves is most commonly observed in well-thriving suckler calves in late spring which do not have access to supplementary feed. The cases of nutritional myopathy recorded at AFBI occurred in May and June.

Septicaemic or toxaemic conditions accounted for five per cent of cases (19 cases) in one to five-month-old calves. Salmonellosis due to *Salmonella* Dublin was the most significant disease within this grouping (10 cases) followed by septicaemic pasteurellosis (three cases).

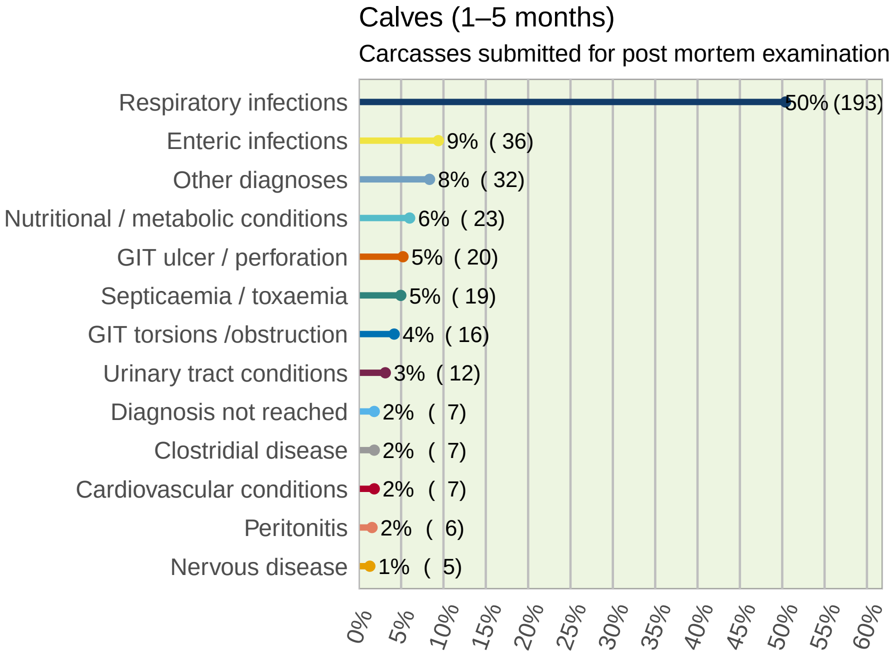

Figure 21.4: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for *post mortem* in 2021 (n=383). The absolute number of cases is between brackets.

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 gastrointestinal conditions. Bacterial infections were again the most frequent recorded cause of respiratory infections. *Mycoplasma bovis* was detected in 12 cases representing 17 *per cent* of respiratory diagnoses, *Pasteurella multocida* was detected in ten cases (14 *per cent* of respiratory diagnoses), and *Mannheimia haemolytica* in eight cases. *Arcanobacterium pyogenes* was isolated in three cases. Parasitic pneumonia due to lungworm infection was recorded in six cases meaning that lungworm was the individual infectious agent causing respiratory disease most frequently detected in this age group (representing 8 *per cent* of respiratory infections). Respiratory infections caused by viruses were detected in five cases (7 *per cent* of respiratory infections) with BRSV and IBRv most frequently recorded (two cases of each), followed by BVDV (one case).

Twenty cases of clostridial disease were recorded (13 *per cent* of diagnoses in this age group) and with most of these being cases of blackleg (18 cases or 90 *per cent* of the clostridial infections recorded). The remaining clostridial infections detected in this age group were a single case of botulism and a case of clostridial enterotoxaemia.

Gastrointestinal conditions represented 12 *per cent* of cases (18 cases) recorded in weanlings. There were four cases of intestinal torsion (22 *per cent* of the gastrointestinal conditions, three cases of abomasal ulceration and a single case of perforated abomasal ulcer and a single case of abomasal torsion). Of the more significant infectious causes of gastrointestinal disease there were two cases of BVDV/Mucosal disease, two cases of coccidiosis and two cases of coccidiosis. A single case of enteritis due to adenovirus was recorded. Enteric infections due to adenovirus usually occur sporadically in 1-8 week old calves and in feedlot animals. This case occured in an eight-month-old calf that presented dehydrated, with a bloody scour, a typical presentation of adenoviral enteritis (Figure 21.5). Affected animals usually have fever and some may die peracutely from dysentery.

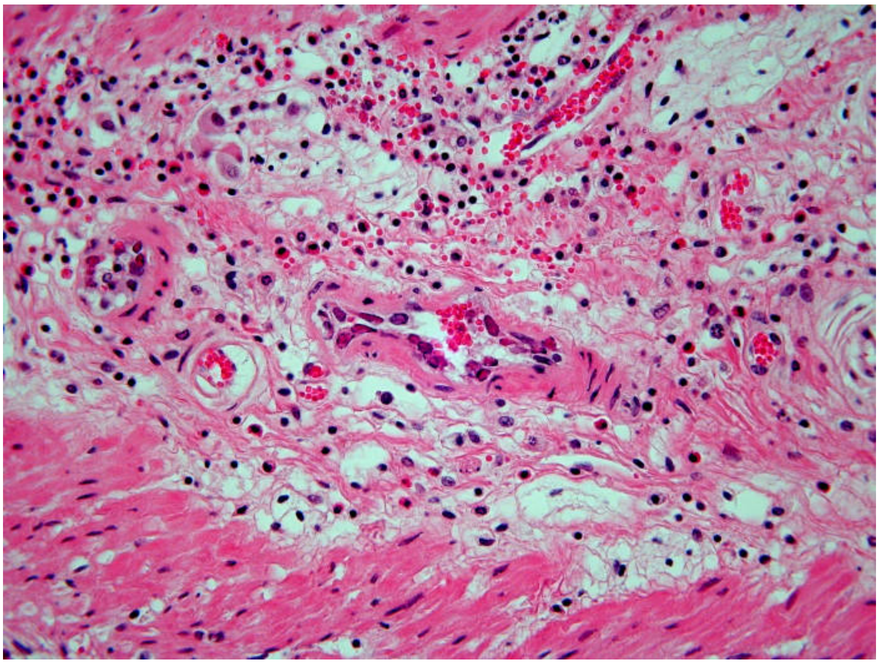

Figure 21.5: Adenoviral enteritis in an eight-month-old calf. Note the large intranuclear inclusions in endothelial cells. This calf presented with haemorrhagic diarrhoea. Photo: Clare Holmes.

Table 21.3: Conditions most frequently diagnosed in calves six to twelve months old submitted to AFBI for post mortem in 2021 (n=150).

Category	No. of cases	Percentage
Respiratory tract infections	71	**47.3**
Clostridial disease	20	**13.3**
Other diagnoses	11	**7.3**
Gastrointestinal ulcers, torsion and obstruction	9	**6.0**
Enteric infections	9	**6.0**
Diagnosis not reached	8	**5.3**
Nervous system disease	8	**5.3**
Cardiovascular conditions	7	**4.7**
Nutritional / Metabolic conditions	4	**2.7**
Liver disease	3	**2.0**

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 (>12 months old). *Trueperella pyogenes* (17 cases) was the most frequently diagnosed pathogen. *Mannheimia haemolytica*, an increasingly

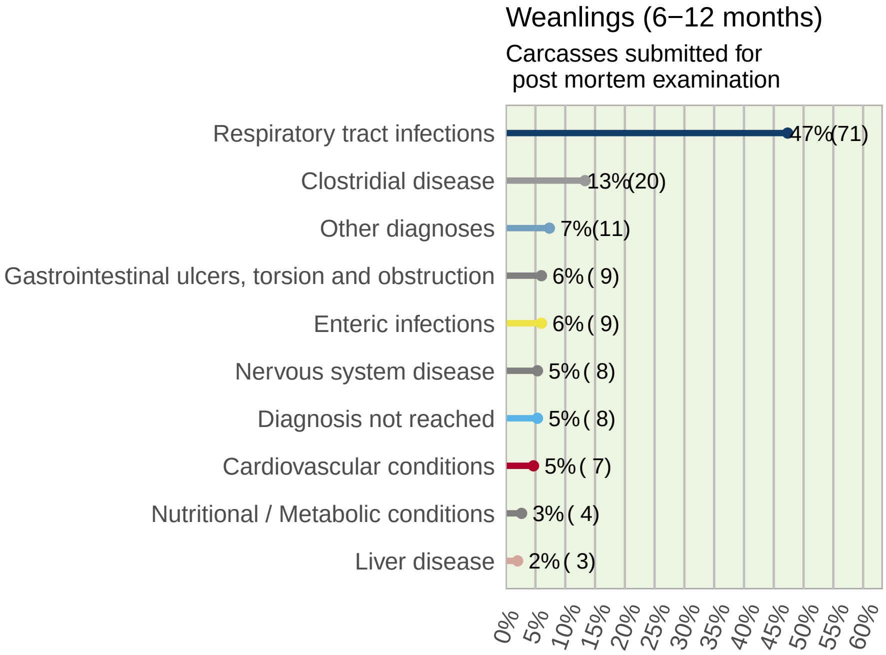

Figure 21.6: Conditions most frequently diagnosed in calves six to twelve months old submitted to AFBI for *post mortem* in 2021 (n=150).The absolute number of cases is between brackets.

Figure 21.7: Liver abscessation leading to posterior vena caval thrombosis in a four year old dairy cow. Photo: Seán Fee.

important cause of pneumonia particularly in adult cows was the next most frequently reported respiratory pathogen (14 cases of this infection were recorded representing 15 *per cent* of respiratory infections in adult bovines). *Mycoplasma bovis* (seven cases) and *Pasteurella multocida* (seven cases) were the next most frequently identified respiratory bacterial pathogens. Two cases of pneumonia due to *Histophilus somni* were recorded. Seven cases of viral respiratory infection were detected comprising four cases of BVDV infection,

Table 21.4: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for post mortem in 2021 (n=468).

Category	No. of cases	Percentage
Respiratory infections	92	**19.7**
Nutritional / metabolic conditions	49	**10.5**
Cardiac / circulatory system	46	**9.8**
Diagnosis not reached	40	**8.5**
Reproductive / mammary conditions	38	**8.1**
Clostridial disease	28	**6.0**
Other diagnoses	28	**6.0**
Liver disease	24	**5.1**
GIT ulceration / perforation / foreign body	23	**4.9**
Peritonitis	20	**4.3**
Enteric infections	16	**3.4**
Intestinal or gastric torsion / obstruction	16	**3.4**
Nervous system conditions	16	**3.4**
Poisoning	16	**3.4**
Skeletal conditions	11	**2.4**
Urinary tract conditions	5	**1.1**

two cases of BRSV, and a single case of IBR. Parasitic pneumonia (hoose) remains an important cause of death in adult cattle with five cases detected on post-mortem examination. Hoose may occur in older cattle grazing contaminated pasture where anthelmintic regimes or grazing practices are not conducive to acquiring protective immunity at a younger age. There were also six cases of atypical interstitial pneumonia or fog fever diagnosed.

Nutritional and metabolic conditions accounted for 49 cases (10 *per cent* of the cases in adult cattle). The main conditions encountered included hypocalcaemia (20 cases), ruminal acidosis (seven cases), fatty liver (five cases), hypomagnesaemia (three cases), hypophosphataemia (two cases) and ketosis (one case).

Diseases of the heart and circulatory system (46 cases) accounted for 10 *per cent* of the conditions recorded in cattle older than 12 months. The most frequently reported cardiovascular diagnosis was thrombosis of the caudal vena cava (15 cases or 32 *per cent* of cardiovascular diagnoses) (Figure 21.7). 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 12 cases of vegetative endocarditis and four cases of cardiac abscessation. Ten deaths were caused by fatal haemorrhage.

Clostridial disease was responsible for 6 *per cent* of deaths in adult cattle in N Ireland. Botulism was the most commonly diagnosed clostridial disease in adult cattle (12 cases), followed by blackleg (nine cases), black disease (six cases) and a single case of clostridial enterotoxaemia.

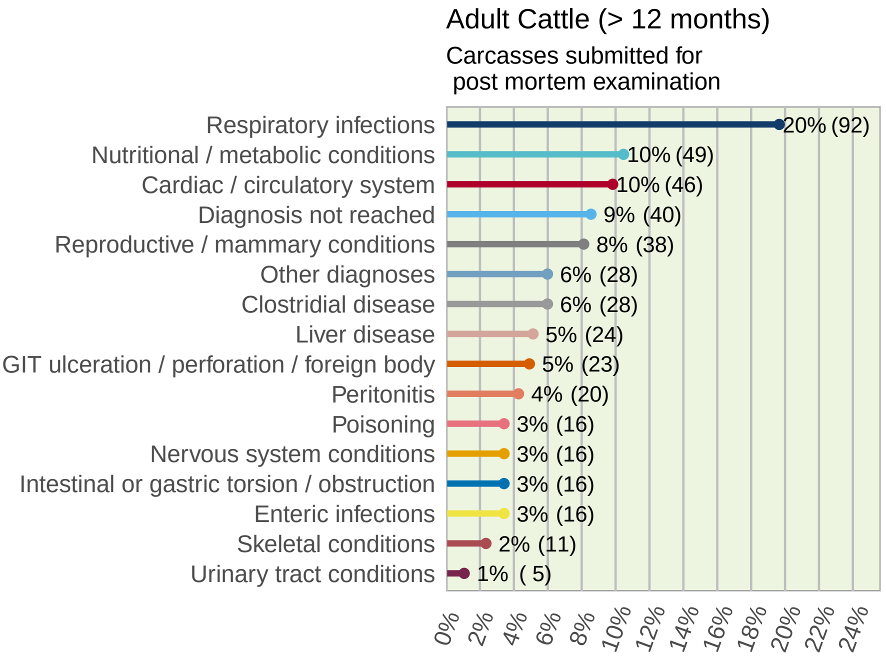

Figure 21.8: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for *post mortem* in 2021 (n=468). The absolute number of cases is between brackets.

21.1 Bovine Respiratory Diseases

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Each year bovine respiratory disease remains one of the most significant causes of morbidity and mortality.

A diagnosis based on clinical signs alone is virtually impossible due to bovine respiratory disease being a multiple aetiology syndrome. This being the case post mortem examination is an extremely important resource whereby a specific diagnosis can often be made leading to a more tailored treatment and provide the information necessary which can then be used to prevent future cases on the farm where possible.

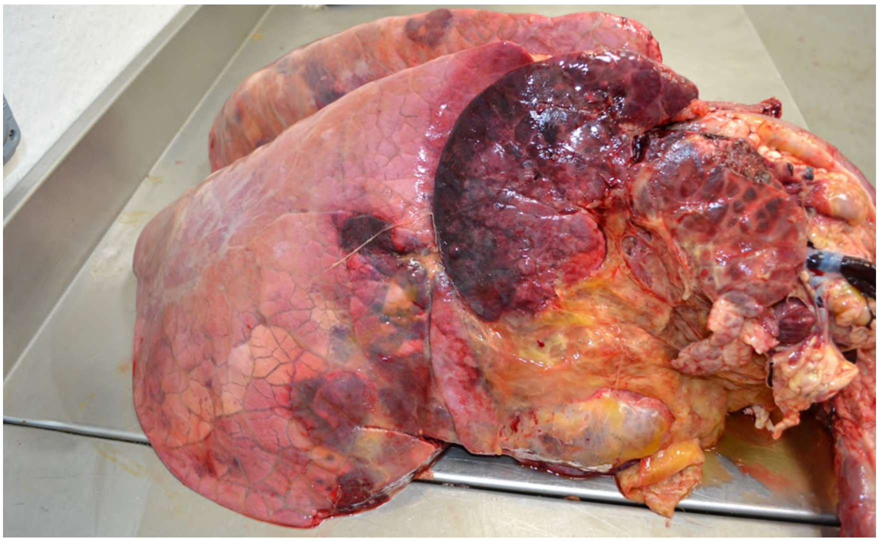

Figure 21.9: Pleuropneumonia caused by Mannheimia haemolytica. Photo: Seán Fee.

Almost all bovine animals on farm will inevitably be hosts or will be carrying some infectious agents within the respiratory tract. Disease then usually manifests when natural defences are low or when the burden of infection in the environment is overwhelming.

Cases of *Mycoplasma bovis* and *Mannheimia haemolytica* were diagnosed in similar numbers in 2021. Usually infection with *Mycoplasma bovis* manifests as a caseonecrotic bronchopneumonia. Involvement of joints or the udder in cases on farm is not unusual. Within AFBI, PCR testing is available. A positive result on PCR testing should be interpreted in conjunction with post mortem findings including histology and the clinical picture on farm. Response to treatment is known to be poor with no commercial vaccine available. The recruitment of commercial companies to produce vaccines is becoming more commonly used.

Table 21.5: Relative frequency of the different aetiological agents identified in cases of pneumonia diagnosed during post mortem by AFBI in 2021 (n=265).

Category	**No. of cases**	**Percentage**
Pasteurella haemolytica	59	**22.3**
Mycoplasma bovis	57	**21.5**
Pasteurella multocida	42	**15.8**
Trueperella pyogenes	33	**12.5**
Bovine Respiratory synthical virus BRSV	22	**8.3**
Dictyocaulus viviparus	20	**7.5**
Histophilus somnus	9	**3.4**
Parainfluenza virus 3	9	**3.4**
Infectious Bovine Rhinotracheitis (IBR)	6	**2.3**
Fungal	4	**1.5**
Bovine Viral Diarrhoea (BVD)	4	**1.5**

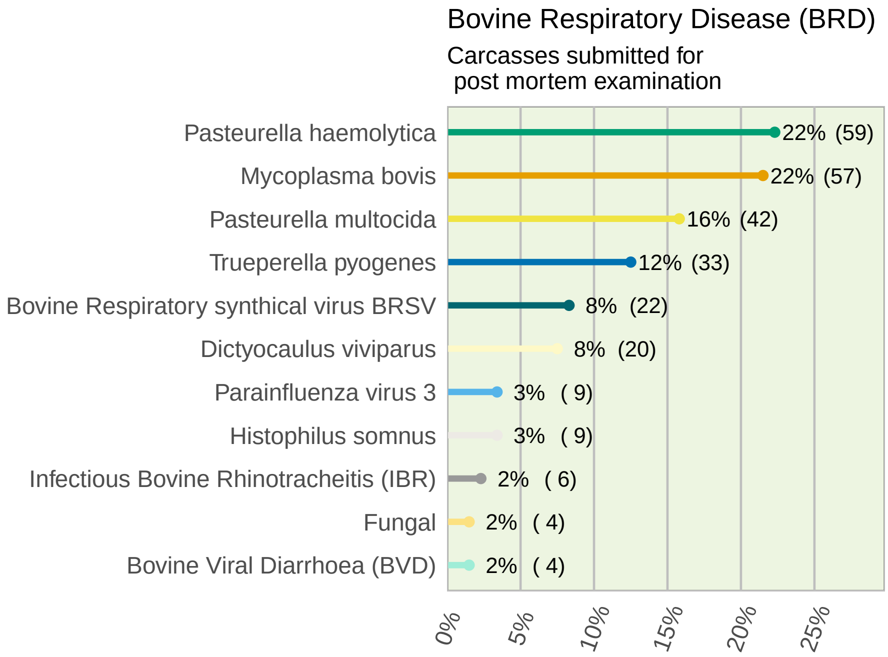

Figure 21.10: Relative frequency of the different aetiological agents identified in cases of pneumonia diagnosed during *post mortem* by AFBI in 2021 (n=265). The absolute number of cases is between brackets.

Mannheimia haemolytica often causes a severe necrotising fibrinous pleuropneumonia (Figure 21.9) with an acute presentation with the unfortunate death of the animal. It tends to be a secondary invader sitting in the background waiting for an opportunity, following infection by a respiratory virus or *Mycoplasma bovis* for instance. The bacteria is part of the normal flora of the upper respiratory tract and usually only has adverse effects within the lung when the normal defences are impaired. If antibacterial treatment is to be effective it must be started very early in the disease process before lesions become too advanced for drugs to be successful. Prevention such as vaccination as well as improved management and husbandry minimizing stress as much as possible amongst the animal groups is worth consideration.

Table 21.6: Miscellaneous diagnoses identified in cases of pneumonia diagnosed during post mortem by AFBI in 2021 (n=50).

Category	No. of cases	Percentage
Pneumonia- no organism specified	11	**22**
Aspiration pneumonia	8	**16**
Fibrinous pleurisy	7	**14**
Pulmonary embolism	7	**14**
Fog fever	6	**12**
Chronic bronchopneumonia	4	**8**
Intra-alveolar haemorrhage	2	**4**
Pulmonary haemorrhage	1	**2**
Disease of the respiratory tract	1	**2**
Periparturient respiratory distress	1	**2**
Necrotic laryngitis	1	**2**
Pulmonary oedema	1	**2**

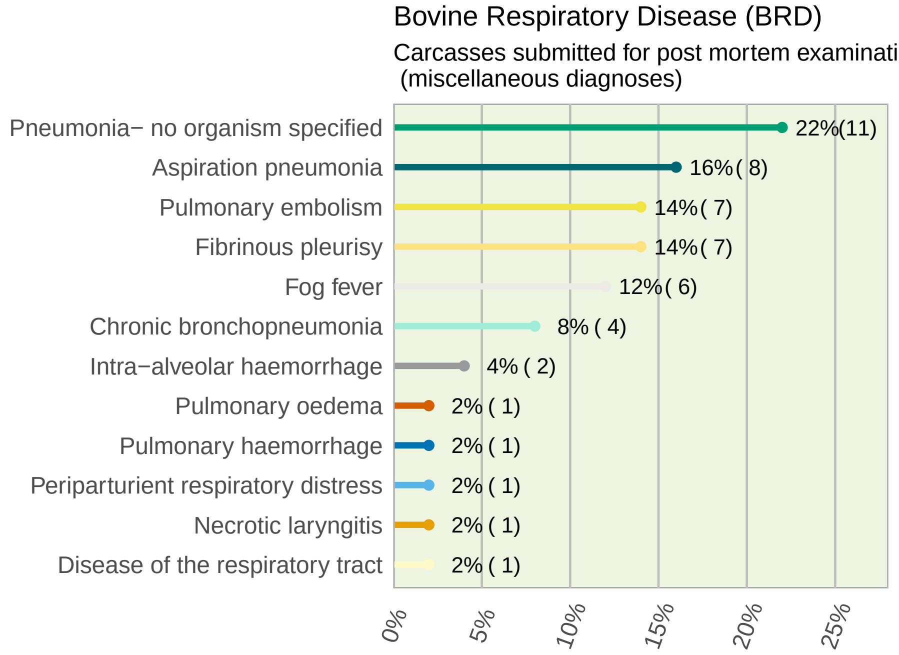

Figure 21.11: Relative frequency of the different miscellaneous diagnoses in cases of pneumonia diagnosed during *post mortem* by AFBI in 2021 (n=50). The absolute number of cases is between brackets.

Dictyocaulus viviparus (lungworm)

Cases of lungworm follow the same pattern in 2021 as 2020 with two peaks of cases diagnosed within the post mortem rooms albeit slightly earlier in 2021 than 2020.

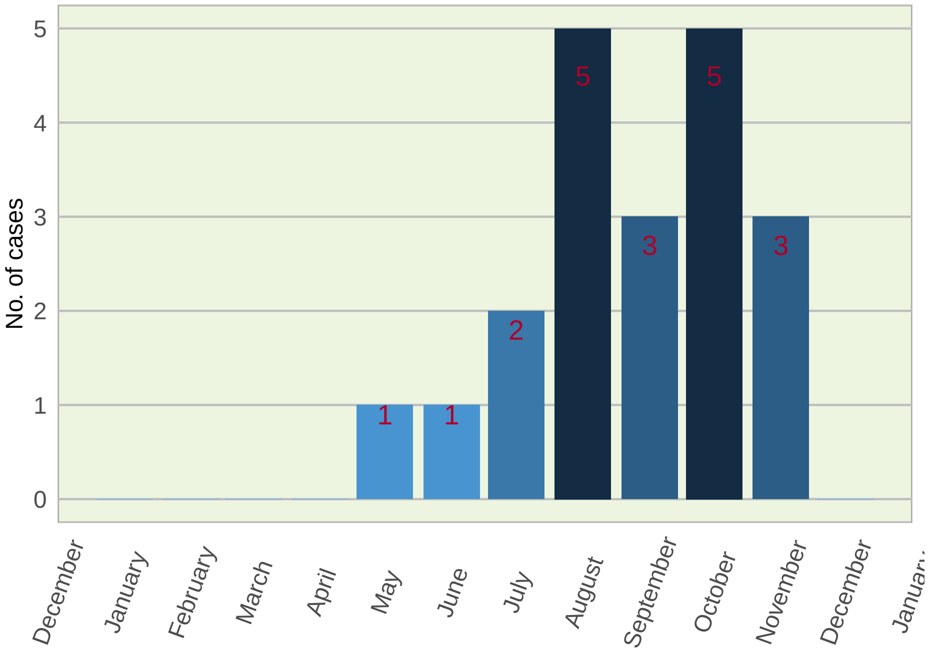

Figure 21.12: Number of lungworm cases diagnosed during *post mortem* by AFBI per month in 2021, (n=50).

Figure 21.13: Lungworm at the tracheal bifurcation. Photo: Clare Holmes.

The increase in cases was almost certainly influenced by mild wet weather.

Confirmation of diagnosis in the live animal is by identification of lungworm larvae in the faeces however the result will only be positive after patency which tends to be around 25 days following initial infection.

Animals exposed to lungworm usually develop resistance to reinfection however if immunity was never established for example in an older animal due to receiving regular worming to prevent lungworm or if immunity has waned these older cattle can succumb to ‘reinfection’ if pasture is heavily contaminated (Figure 21.13).

Anthelmintic is the usual treatment with no reported resistance to date. Live attenuated vaccine remains a good option for preventing parasitic bronchitis with good protection following the 2nd dose.

On farms with no previous history of lungworm, preventing introduction using treatment and quarantine of bought in animals is crucial.

21.2 Bovine Mastitis

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

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

Table 21.7: Bacterial isolated in milk submitted to AFBI in 2021 (n=943).

Category	No. of cases	Percentage
E.coli	307	**32.6**
Streptococcus uberis	258	**27.4**
Staphylococcus aureus	175	**18.6**
Streptococcus dysgalactiae	40	**4.2**
Bacillus cereus	36	**3.8**
Corynebacteria	33	**3.5**
Yeast	30	**3.2**
Bacillus licheniformis	28	**3.0**
Trueperella pyogenes	23	**2.4**
Fungi	10	**1.1**
Pasteurella multocida	3	**0.3**

A total of 943 isolates (Table 21.7 and Figure 21.14)were cultured from milk submitted to the lab from acute and chronic mastitis cases. The significance of the organism will depend on the cell count, the level in which the organism was isolated and whether or not it was isolated in pure culture. Isolation of 3 or more species in samples submitted suggests contamination during the sampling procedure. Interpretation of mastitis results should therefore be undertaken with care.

E.coli, an environmental cause of mastitis was the most frequently isolated organism in 2021 accounting for 32.6 *per cent* of isolates cultured, slightly down from the previous year. Risk factors include poor hygiene, suboptimal milking machine function, teat end damage and lactation. Another frequently identified environmental organism, *Streptococcus uberis* was identified in 27.4 *per cent* of submitted samples.

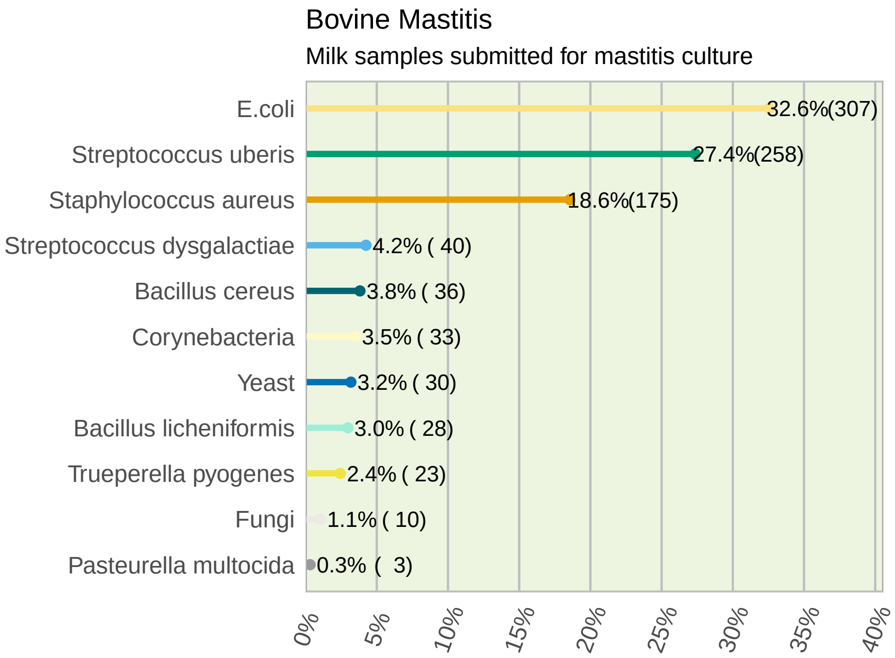

Figure 21.14: Bacteria isolated in milk samples submitted to AFBI in 2021 (n=637). The absolute number of cases is between brackets.

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 18.6 *per cent* of samples submitted in 2021. This was the third most frequently cultured mastitis associated bacterium.

21.3 Bovine Abortion

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Cases of bovine abortion comprised 27 *per cent* of all AFBI bovine post mortem submissions in 2021, compared with 33 *per cent* in 2020, with similar monthly trends of increased abortion submissions during the winter months.

Of the 346 bovine abortions AFBI examined in 2021 (Table 21.8 and Figure 21.16), an infectious agent was identified in 54 *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 dehydration, fever, malnutrition, nutrient deficiency may also induce pregnancy loss. Therefore examination of the dam, the placenta and the foetus provides the greatest opportunity to obtain a diagnosis.

Figure 21.15: Accessory lung in a bovine foetus. Photo: Pauline Sheridan.

Bacterial agents comprised 88 *per cent* of infectious diagnoses, with *Bacillus licheniformis*, *Trueperella pyogenes* and *Salmonella* species the most frequently diagnosed infectious agents occurring in 24 *per cent* of all bovine abortion submissions. The proportion of bovine abortions associated with Salmonella species was increased in 2021, with 10.4 *per cent* of bovine abortions associated with Salmonella species compared to 7.1 *per cent* in 2020. The cattle adapted serotype of *Salmonella enterica subspecies enterica*, *S* Dublin, was the predominant *Salmonella* species identified and there were several diagnoses of *Salmonella* Kottbus and a diagnosis of *Salmonella* Mbandaka. As in previous years a trend of Salmonella abortions peaking in the second half of the year was observed (Figure 21.17.

Table 21.8: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2021, (n=361).

Category	No. of cases	Percentage
No infectious agent identified	159	**44.0**
Salmonella spp	36	**10.0**
Trueperella pyogenes	27	**7.5**
E.coli	25	**6.9**
Neospora caninum	22	**6.1**
Bacillus licheniformis	20	**5.5**
Other	13	**3.6**
Bovine Viral Diarrhoea	9	**2.5**
Streptoccocal spp	8	**2.2**
Leptospirosis	8	**2.2**
Listeria monocytogenes	8	**2.2**
Foetal abnormality	6	**1.7**
Pasteurella spp	5	**1.4**
Staphylococcal spp	5	**1.4**
Thyroid hyperplasia	5	**1.4**
Foetal dystocia	4	**1.1**
Aspergillus spp	1	**0.3**

A range of bacterial agents were recovered from sporadic cases of bovine abortion, including Streptococcus species, Staphylococcus species, while *Escherichia coli* was cultured from 7.2 *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. The proportion of Leptospira and *Listeria monocytogenes* diagnoses were increased slightly from 2020 and there was a case from which *Campylobacter fetus fetus* was recovered.

Non bacterial infections were also detected in abortion cases, with a slight increase in the diagnosis rate of both *Neospora caninum* and of Bovine Viral Diarrhoea (BVD) virus, while abortions associated with fungal infections such as Aspergillus species were rarely diagnosed.

Deformities were detected in occasional foetuses including cleft palate, arythrogryposis and a case of accessory lung formation, where lung type tissue formed a large mass in the cranial abdomen (Figure 21.15). Underlying infections were not detected in these cases and no further cases were reported on the farm.

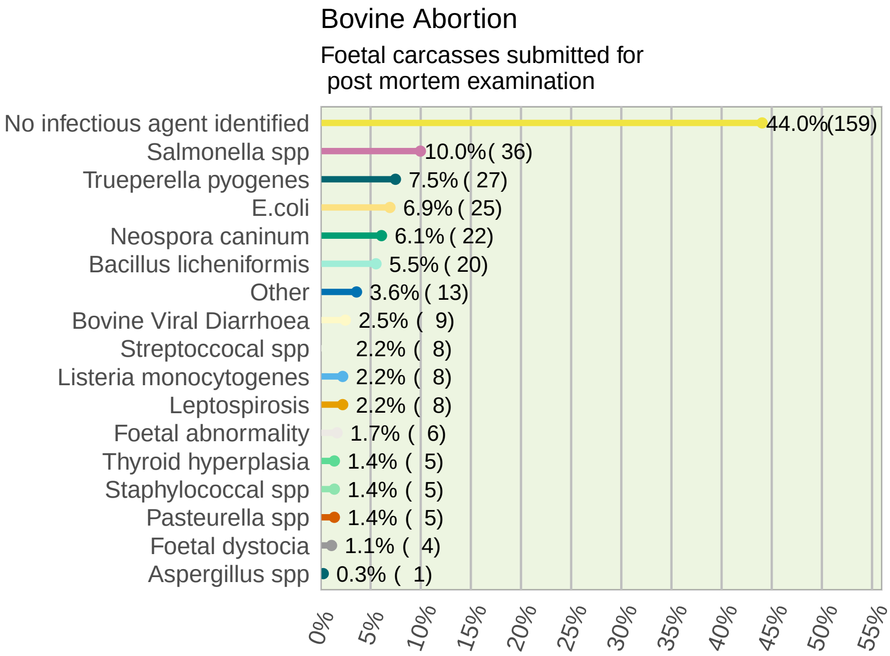

Figure 21.16: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2021 (n=361).

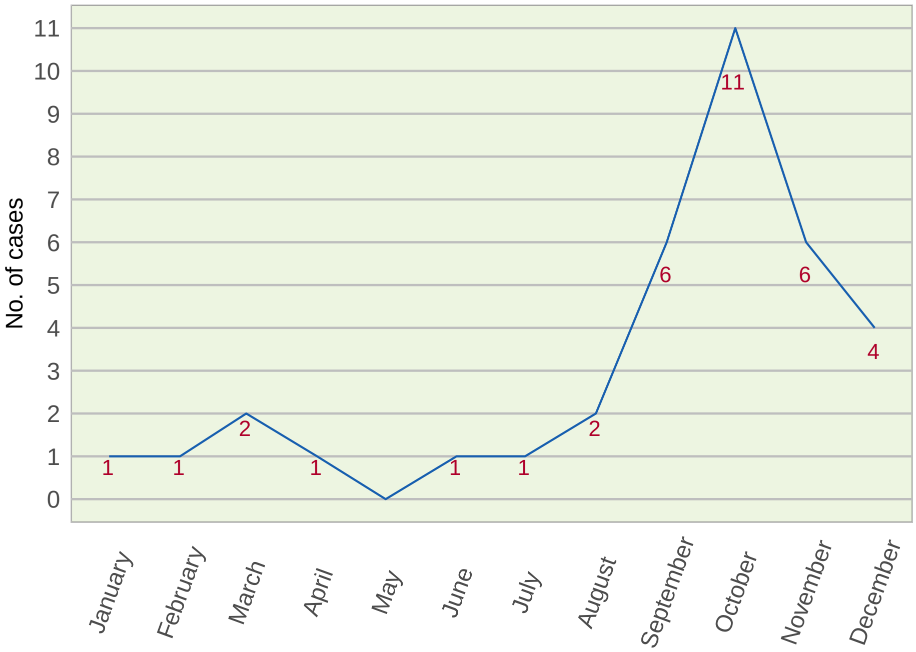

Figure 21.17: Number of abortions with a diagnosis of S. Dublin per month in 2021, showing the seasonal trend of increasing incidence during the summer and autumn months.

21.4 Zinc Sulphate Turbidity Testing

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

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

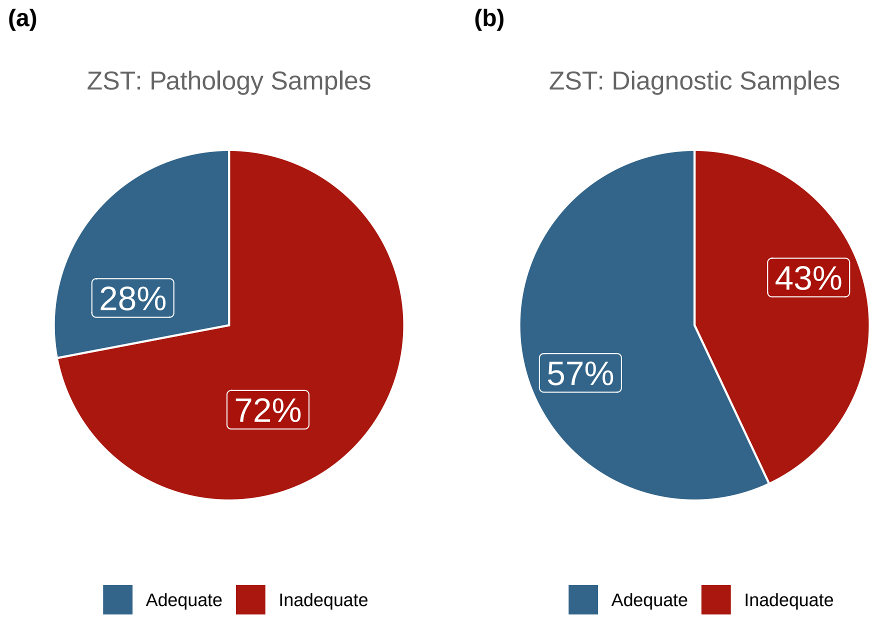

Figure 21.18: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2021 from bovine calf serum samples taken (A) at *post mortem* (n=145) and (B) submitted as diagnostic samples (n=497). Adequate colostral immunity is defined as greater than or equal to 20 units.

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

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

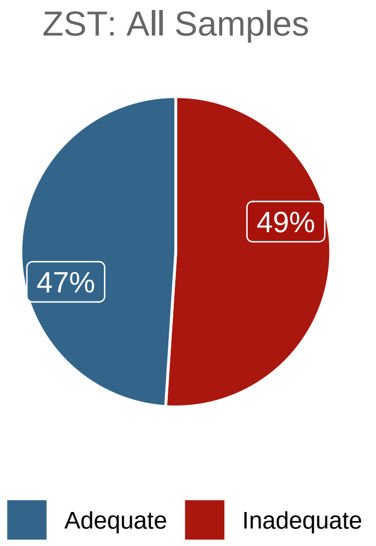

Figure 21.19: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2021 from bovine calf serum samples (n=642). Adequate colostral immunity is defined as greater than or equal to 20 units.

In 2021, a total of 642 serum samples were tested; of these 497 were diagnostic samples submitted from live calves, and 145 were obtained at *post mortem* examination. The results are shown in the following figures 21.18 and 21.19 where it can be seen that of the diagnostic samples tested, 43 *per cent* were inadequate while 57 *per cent* were adequate, whereas the results of those obtained at *post mortem* showed that only 28 *per cent* of samples were adequate while 72 *per cent* of samples tested less than 20 units and therefore indicated inadequate transfer of immunoglobulins. 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.

21.5 Bovine Neonatal Enteritis

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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. This trend is reflected in the submissions received to AFBI from calves up to one month of age, in which enteritis has for many consecutive years been the most commonly diagnosed condition in calves of this age. Submissions are made up of both faecal samples submitted by PVPs and carcasses of calves submitted for *post mortem* examination. Often calves present with a clinical history of diarrhoea, however in some cases death can occur without significant diarrhoea.

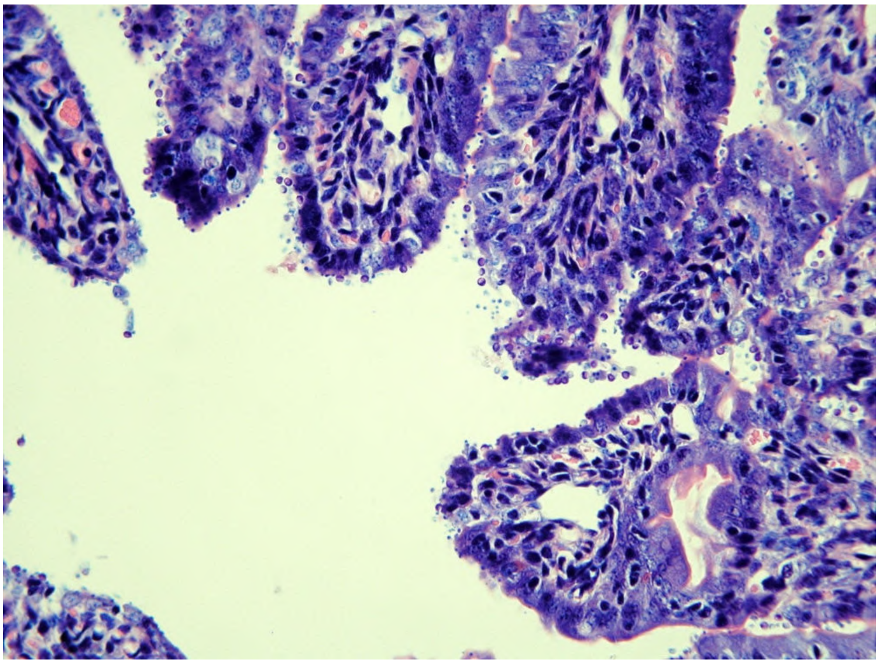

Figure 21.20: Histopathology of the gut wall showing adhered cryptosporidial organisms. Photo: Bob Hanna.

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 in order for a comprehensive diagnosis to be made and appropriate preventative and prophylactic measures to be taken, it is important that submissions are made from multiple untreated calves in the early stages of clinical disease that are representative of the herd problem. Often the disease agents are only transiently present and the changes produced are rapidly obscured by autolysis, so in the case of carcases submitted for *post mortem* examination, these should be as fresh as possible to get the maximum diagnostic value. As with all diagnostic samples, a good clinical history which includes farm type, calves affected, age of calves when first affected and management practices can improve the diagnostic value of the submission. 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.

Table 21.9: The frequency of common enteropathogenic agents identified in calf faecal samples tested by AFBI in 2021.

Organism	No. Tested	Positive	Percentage
Cryptosporidium species	764	235	**30.8**
Rotavirus	713	196	**27.5**
Coronavirus	725	49	**6.8**
Escherichia coli K99	429	38	**8.9**

In recent years, two pathogens have consistently been identified as the most commonly detected in submissions to AFBI (Table 21.9 and Figure 21.21), and 2021 followed this trend with Cryptosporidiosis and Rotavirus together contributing over 58 *per cent* of the total of 764 samples tested. In a change to recent years, however, where the relative frequencies have been very similar, in 2021 the incidence of Cryptosporidiosis was 31 *per cent* and that of Rotavirus was 28 *per cent*. Coronavirus returned to third most commonly detected pathogen, and *E coli* expressing the K99 fimbriae was the fourth most commonly detected agent as a proportion of the total submissions. Testing for *E coli* K99 is carried out in calves up to 2 weeks old.

Cryptosporidiosis, most commonly caused by *Cryptosporidium parvum*, a single-celled parasite, produces a watery diarrhoea in calves between 7 and 13 days of age. The organism infects cells of the small intestine (Figure 21.20) and heavy colonization occurs quickly through rapid replication. Animals are infected through ingestion of oocysts which have been produced in large numbers by other infected calves. The oocysts have a tough outer shell and can survive for long periods in the environment, being resistant to many commonly used disinfectants and able to withstand a wide range of temperatures, thus are difficult to remove from the environment. In addition, only a small number of oocysts are required for infection to occur, and oocysts shed by infected calves are immediately infective for other susceptible calves. To put this into perspective, a 2013 study demonstrated that as few as 17 oocysts was sufficient to cause diarrhoea and oocyst shedding, and infected calves can shed up to 3x1010 oocysts over a six day period (Shaw et al. 2020; Thomson et al. 2017).

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

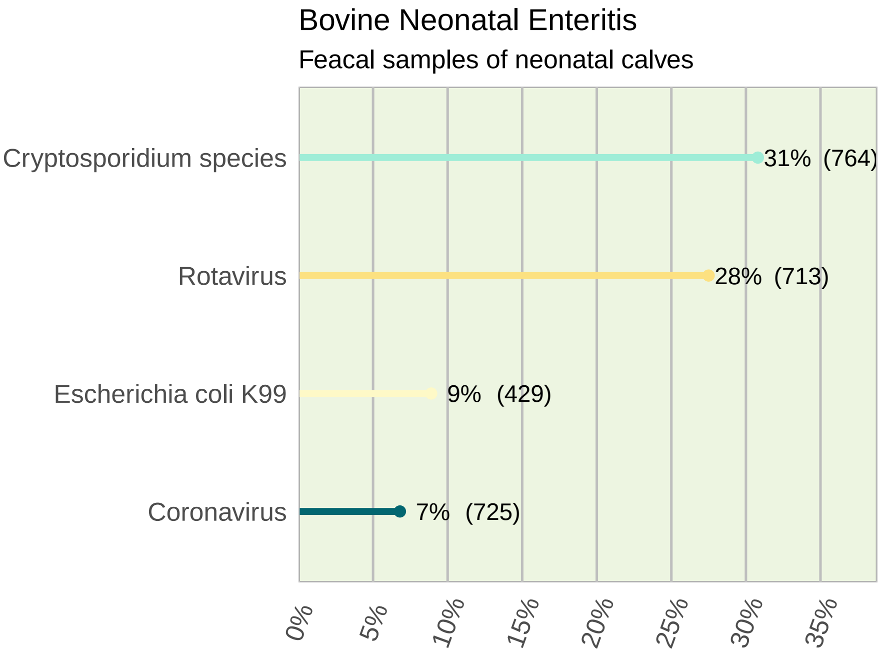

Figure 21.21: Frequency of common enteropathogenic agents identified in calf faecal samples tested by AFBI in 2021.

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

Cryptosporidium 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 calves 1 to 3 weeks old. Maldigestion leads to undigested food in the colon which causes bacterial overgrowth and increased osmotic pressure which exacerbates the diarrhoea. Rotavirus affects the upper small intestine whereas Coronavirus affects a larger proportion of the small intestine, and also frequently causes necrosis of the epithelial cells lining the colon and so causes a more severe diarrhoea.

E Coli K99 is so-called due to the fimbrial antigen it possess which allows it to attach to the epithelial cells of the small intestine. Here it produces a toxin which causes an efflux of fluid into the small intestinal lumen. The attachment factors are only present on the cells of the very immature small intestinal villi, and so the organism usually causes disease in the first 6 days of life. The severity of the fluid loss into the intestine can be such that the calves die of dehydration and electrolyte imbalance before diarrhoea is detected. Faecal samples submitted to AFBI from calves less than two weeks old are routinely tested for *E Coli* K99 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.

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 (Blanchard 2012).

21.6 Bovine Parasites

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Parasitic gastroenteritis

Ostertagia ostertagi, *Cooperia oncophora* and *Trichostrongylus* spp. are parasitic nematodes which can cause gastroenteritis in cattle. The main source of infection for calves is L3 larvae of *O. ostertagi* on the pasture, derived from eggs shed earlier in the year by older cattle harbouring infection that they acquired the previous year. Infection with *Trichostrongylus* sp. and *C. oncophora* is usually acquired from L3 larvae on the pasture that have survived from the previous autumn due to mild over-winter conditions. In calves, cycles of autoinfection in the summer and early autumn (June to September) are associated with Type 1 parasitic gastroenteritis (PGE: persistent watery diarrhoea and weight loss up to 100 kg). Later in the season, from September onwards, L4 larvae of *O. ostertagi* become inhibited in the abomasal lining, and will give rise to next year's crop of adult worms. Maturation of these worms is associated with Type 2 PGE (intermittent diarrhoea and anorexia in yearling calves in spring, with shedding of eggs on early pasture). Diagnosis of PGE is carried out by Faecal Egg Counts (FEC) on diarrhoeic faeces samples, and ideally several individual samples (up to 10) should be submitted from each group of scouring calves. Samples with a FEC of 500 eggs per gram (*epg*) and greater indicate clinically significant PGE.

In 2021, 4.0 *per cent* (number of samples examined, n =2093) of bovine faeces samples submitted to AFBI for parasitological examination had a FEC $\geq$ 500*epg* (Figure 21.22), compared to 5.1 *per cent* of samples submitted in 2020 and 3.9 *per cent* of samples submitted in 2019. The peak months for clinically significant gastrointestinal nematode infection were September to November (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 2021. 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.

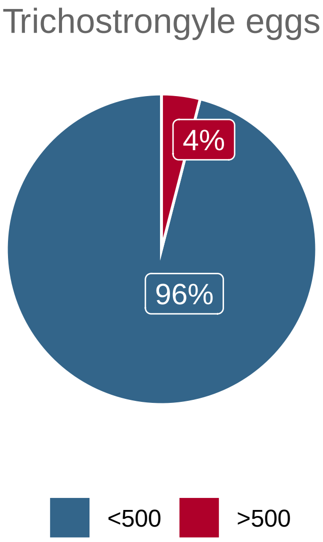

Figure 21.22: Relative frequency of detection of trichostrongyle eggs in bovine faecal samples examined by AFBI in 2021 (n=2093).

Liver fluke

In 2021, *Fasciola hepatica* incidence was 7.3 *per cent* (n = 1874) of bovine faecal samples submitted to AFBI (Figure 21.25 (a)), compared to 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 2020. 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 21.23), 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.

Figure 21.23: Galba truncatula, the snail host of Fasciola hepatica and Cotylophoron daubneyi. Photo: Bob Hanna.

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 resident in the bile ducts, leading to characteristic calcification of ducts and the pipe-stem liver appearance visible on post-mortem (Taylor et al. 2015). Fluke eggs are present in faecal samples at this stage, and diagnosis is often confirmed by ELISA testing to demonstrate fluke coproantigens in the faeces. Liver fluke infection, fasciolosis, has major economic implications for livestock productivity due to the resulting morbidity and mortality (McCann et al. 2010). Carcases that have been infected by liver fluke have poorer conformation and lower cold weight than those free of liver fluke (Sanchez-Vazquez and Lewis 2013). When clinically significant fasciolosis has been diagnosed in a herd by examination of representative faecal samples by FEC or coproantigen testing (10 individual samples is recommended for each group of cattle sharing common pasture), treatment 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).

Rumen fluke

Adult *Calicophoron daubneyi* flukes (also known as paramphistomes) (Figure 21.25 (b)) are found in the reticulum and rumen and are generally well tolerated, even with heavy burdens.

Figure 21.24: (a) Adult Cotylophoron daubneyi in the rumen of a dairy cow; (b) Liver fluke and rumen fluke eggs in a faecal sample. Photos: Bob Hanna.

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 inter-

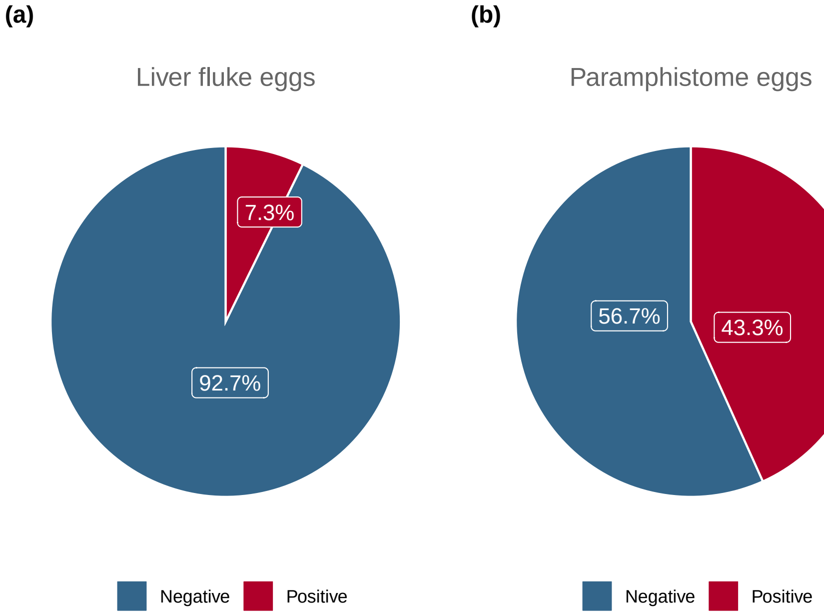

Figure 21.25: Relative frequency of detection of (a) liver fluke eggs (n=1874) and (b) paramphistome eggs (n=1877) in bovine faecal samples examined by AFBI in 2021.

mediate host, *Galba truncatula* (the same as for *F. hepatica*). However, a large number of animals with rumen fluke eggs detected in their faeces show few, if indeed any, clinical signs of disease. Incidence of positive bovine faecal samples at 43.3 *per cent* (Figure 21.24(b)) (n = 1877) shows a decline compared with that in 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 21.24 (b). 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 2021, coccidian oocysts were seen in 21.4 *per cent* (n=2103) of bovine faecal samples examined in AFBI. This level is similar to that recorded in 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 only 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.

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

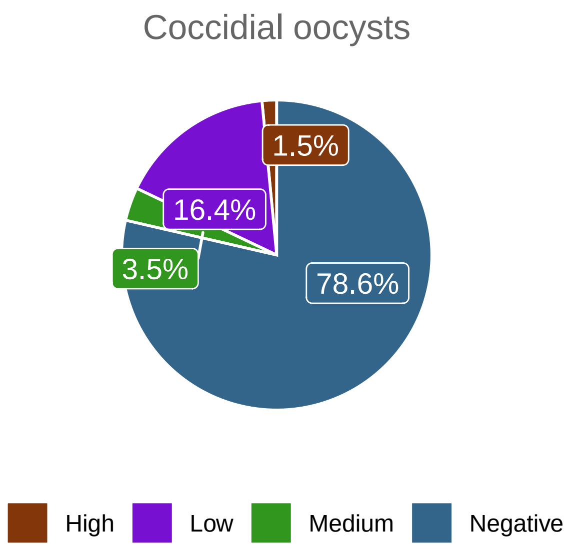

Figure 21.26: Results for bovine faecal samples tested for coccidial oocysts during 2021 (n=2103).

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.

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 291 post-mortem diagnoses of pneumonia in 2021, where the aetiological cause was identified, 20 cases (7.5 *per cent*) involved *D. viviparus* infection. The peak incidence of lungworm infection was in August to October (Figure 21.12). 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.

Johne's Disease (AFBI)

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Johne's disease (JD) or paratuberculosis is a disease of ruminants primarily, which occurs worldwide, 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.

During 2021 12,309 bovine blood and milk samples were tested by AFBI for Map antibody (ELISA) and 1151 (9.35 *per cent*) were positive, with a further 131 (1.06 *per cent*) returning inconclusive results.

1861 faecal samples were submitted to AFBI for Map PCR screening. Map was identified in 309 of the 1745 (17.71 *per cent*) bovine samples tested, with a further 13 (0.74 *per cent*) recorded as inconclusive. Map infection was also confirmed in 1 of 20 caprine faecal samples tested, and 2 of 40 ovine faecal samples tested.

The Dairy Standards of the UK based Red Tractor Assurance Scheme were updated in October 2019 and required that for every member dairy herd, Johne's disease must be managed through the implementation of a National Johne's Management Plan or equivalent scheme such as the AHWNI Johne's Control Programme (AHWNI JDCP). Farms operating in Northern Ireland were given a derogation until October 2020 to comply with this standard, to ensure access to all of the required elements.

The AHWNI JDCP is a voluntary programme with three principal components. These are enrolment, risk assessment and herd screening. Approved veterinary practitioners (AVPs) have under gone specific training provided by AHWNI. These approved vets may then can carry out an on-site farm risk assessment and disease management advisory visit (VRAMA). AHWNI has designed an online system to facilitate AVPs carrying out the Veterinary Risk Assessment and Management Plan (V-RAMP) using a web portal accessible by smart phone. In 2021 237 V-RAMPs were uploaded by AVPs using this portal.

CHAPTER 22

OVINE DISEASES (AFBI)

22.1 Overview of Seep Diseases

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The number of sheep submissions in Northern Ireland increased 2021 compared to 2020 with 558 submissions being received compared to 510.

Small ruminants under 12 months

In 2021, parasitic disease and enteric disease were the most commonly diagnosed causes of death in sheep of all ages in Northern Ireland. The relative importance of clostridial diseases and pasteurellosis remains high despite the availability of effective vaccines (Table 22.1 and Figure 22.1).

The number of sheep submissions in Northern Ireland increased 2021 compared to 2020 with 558 submissions being received compared to 510.

Table 22.1: Condition most frequent diagnoses in small ruminants aged under 12 months submitted for post mortem in 2021 (n=371).

Diagnoses	No. of cases	Percentage
Parasitic disease	98	**26.4**
Digestive diseases	53	**14.3**
Respiratory diseases	50	**13.5**
Other diseases	40	**10.8**
Septicaemia	37	**10.0**
Neurological diseases	27	**7.3**
Diagnosis not reached	23	**6.2**
Clostridial diseases*	23	**6.2**
Poisoned	9	**2.4**
Urinary diseases	6	**1.6**
Trauma	5	**1.3**

* Including pulpy kidney

Table 22.2: Condition most frequent diagnoses in small ruminants aged over 12 months submitted for post mortem in 2021 (n=258).

Diagnoses	No. of cases	Percentage
Respiratory tract diseases	50	**19.4**
Other diseases	36	**14.0**
Diagnosic not reached	32	**12.4**
Digestive tract diseases	27	**10.5**
Parasitic diseases	26	**10.1**
Reproductive diseases	22	**8.5**
Metabolic	20	**7.8**
Neurological diseases	17	**6.6**
Poisoned	12	**4.7**
Septicaemia	11	**4.3**
Urinary diseases	3	**1.2**
Clostridial diseases	2	**0.8**

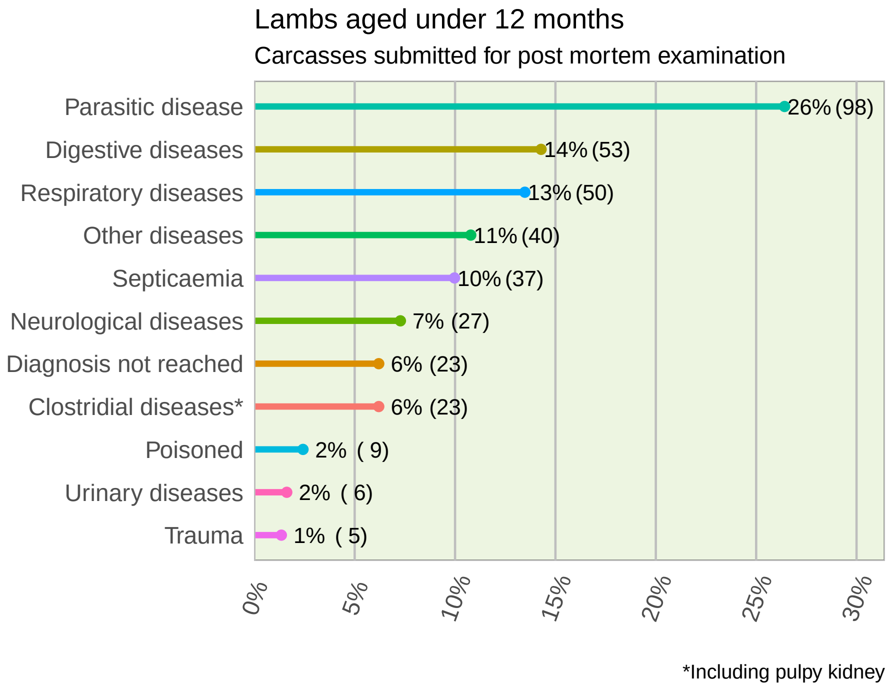

Figure 22.1: Conditions most frequently diagnosed in small ruminants aged under 12 months submitted for *post mortem* by AFBI in 2021. (n=371). The absolute number of cases is between brackets.

Small ruminants over 12 months

Mannheimia haemolytica was the most common cause of bacterial pneumonia in sheep in Northern Ireland in 2021 (Table 22.2 and Figure 22.2). *Jaagsiekte* (ovine pulmonary adenocarcinoma) was also commonly diagnosed in Northern Ireland. In 2021. Currently ultrasound scanning of the chest to detect early changes associated with tumour growth in the lungs is the best option for early diagnosis and can be used in conjunction with a routine cull ewe *post mortem* screen to establish the presence of the disease in a flock and individuals. Given the highly infectious nature of the disease and quite rapid spread within affected flocks close attention to the possibility of the presence of the disease in flocks is necessary and a flock health planning approach is often the most successful way of first raising awareness and causing early intervention.

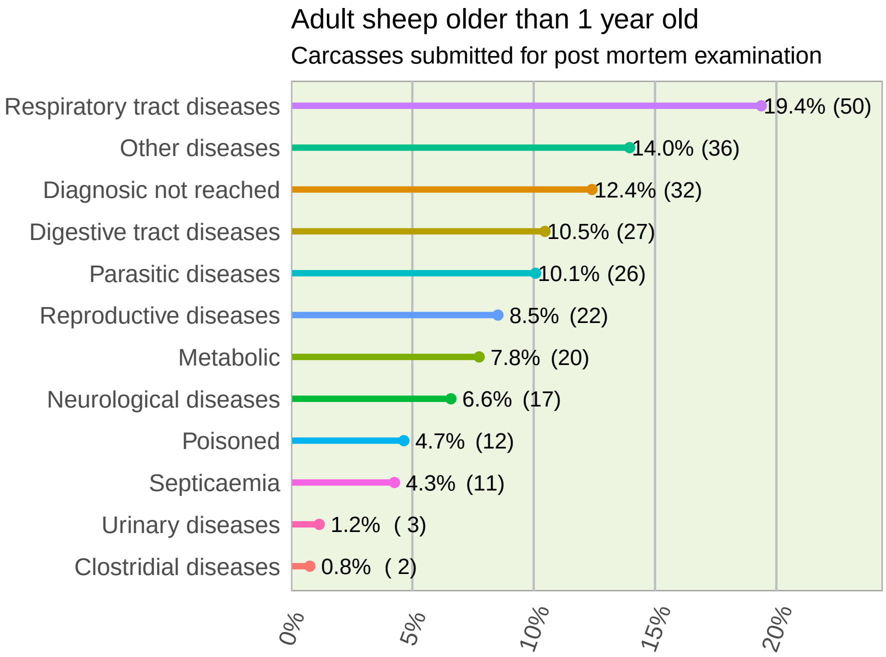

Figure 22.2: Relative frequency of the different aetiological agents identified in cases of parasitic disease of small ruminants over 12 month of age diagnosed during *post mortem* by AFBI in 2021 (n=258). The absolute number of cases is between brackets.

Table 22.3: Relative frequency of the identified infectious agents of ovine abortion from submitted foetal *post mortems* in 2021 (n= 199).

Diagnoses	No. of cases	Percentage
No infectious agent identified	63	**31.7**
Chlamydia abortus	35	**17.6**
Toxoplamsa gondii	33	**16.6**
E.coli	15	**7.5**
Other	14	**7.0**
Streptococcus	10	**5.0**
Listeria monocytogenes	9	**4.5**
Trueperella pyogenes	5	**2.5**
Foetal abnormality/still birth	5	**2.5**
Campylobacter spp	4	**2.0**
Leptospirosis	4	**2.0**
Mummified foetus	2	**1.0**

22.2 Ovine Abortion

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Specimens from 199 ovine abortions and stillbirths were examined during 2021. Significant pathogens were detected in 136 cases (68.3 *per cent*). Pathogens identified included C. abortus (35 cases, 17.6 *per cent*), T. gondii (33 cases 16.6 *per cent*), Campylobacter species (4 cases 2 *per cent*), Listeria monocytogenes (9 cases, 4.5 *per cent*), T. pyogenes (5 cases, 2.5 *per cent*), Streptococcus species (10 cases, 5 *per cent*) and E. coli (15 cases, 7.5 *per cent*), see figure 22.3.

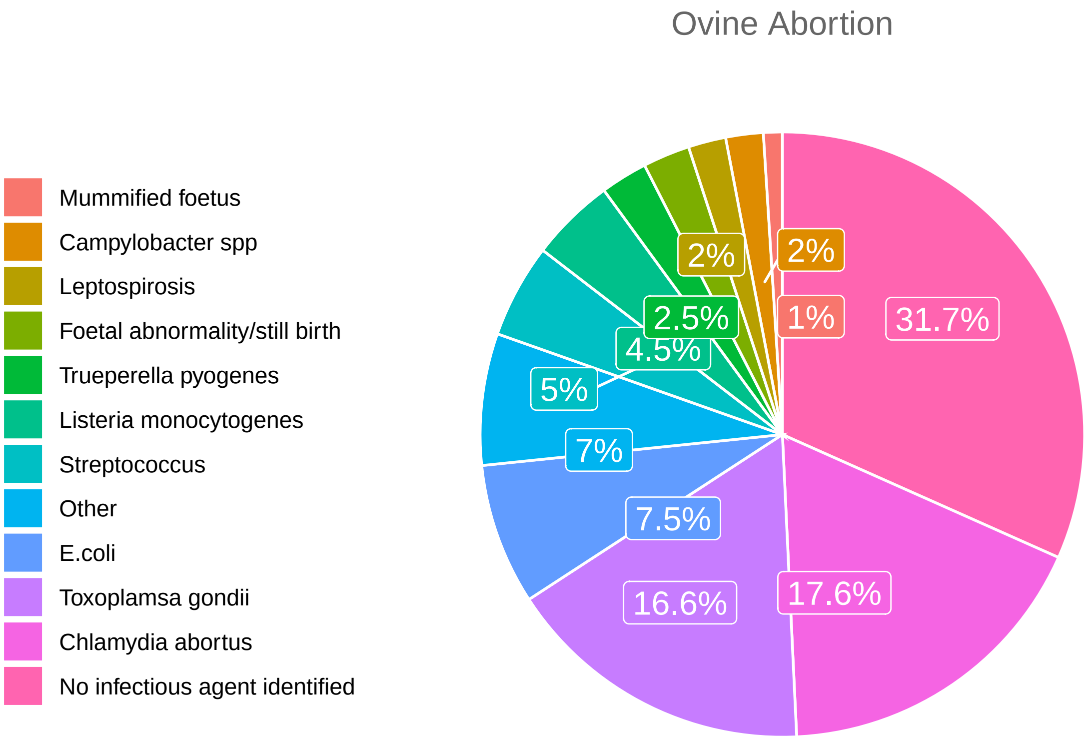

Figure 22.3: Relative frequency of the identified infectious agents of ovine abortion from submitted foetal *post mortems* in 2021 (n= 199).

22.3 Ovine Parasites

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Parasitic gastroenteritis

The nematode parasites mainly responsible for causing parasitic gastroenteritis in sheep in Northern Ireland are *Teladorsagia circumcincta*, *Trichostrongylus* spp., *Cooperia* spp. (all of which produce trichostrongyle-type eggs) and, in young lambs, *Nematodirus battus*. Faecal samples from sheep are examined in the Parasitology laboratory, AFBI, for trichostrongyle eggs, *Nematodirus* eggs, and for coccidial oocysts (Figure 22.4).

Figure 22.4: Nematodirus egg (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 22.5 and 21.22). 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.

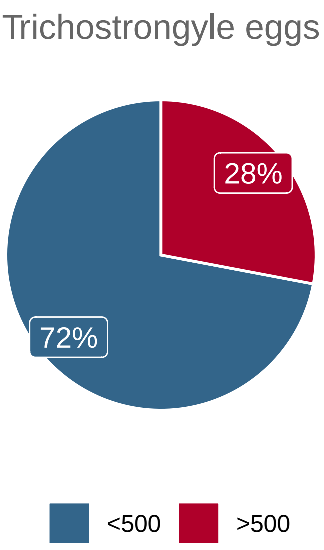

Figure 22.5: Relative frequency of detection of trichostrongyle eggs in ovine faecal samples examined by AFBI in 2021 (n=897).

The percentage of ovine samples containing ≥500 trichostrongyle eggs per gram decreased slightly from 29.1 *per cent* in 2020 to 28.0 *per cent* in 2021 (number of samples examined, n =897; (Figure 22.5), a higher figure than that recorded in 2019 (24.2 *per cent*) but similar to that in 2018 (30.5 *per cent*). Peak FECs occurred in September (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 2021. 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 (McMahon, Gordon, et al. 2012).

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

Farmers' responses to questions relating to the management of emerging anthelmintic resistance on their premises have revealed that the published SCOPS guidelines have not been widely adopted in practice, and that there is a need for improved stockholder education and closer interaction with informed veterinary practitioners, sheep advisers and laboratory staff (McMahon, McCoy, et al. 2013). The latest edition of the SCOPS (Sustainable Control of Parasites in Sheep) guidelines is accessible at the SCOOPS webpage.

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).

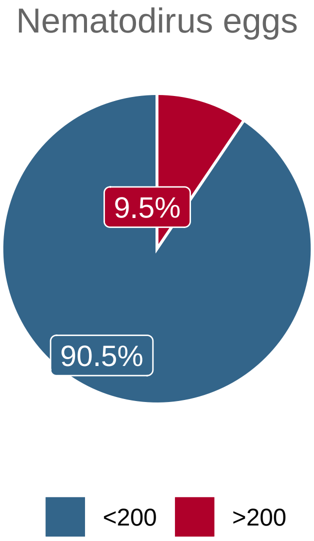

Figure 22.6: Relative frequency of detection of Nematodirus eggs in ovine faecal samples examined by AFBI in 2021 (n=898).

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 22.4) 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 898 faecal samples examined for *Nematodirus* eggs in 2021, 9.5 *per cent* were found to contain $\geq$ 200 *epg* (Figure 22.6), a small increase from the level recorded in 2020 (8.4 *per cent*), but markedly higher than the level recorded in 2019 (4.6 *per cent*).

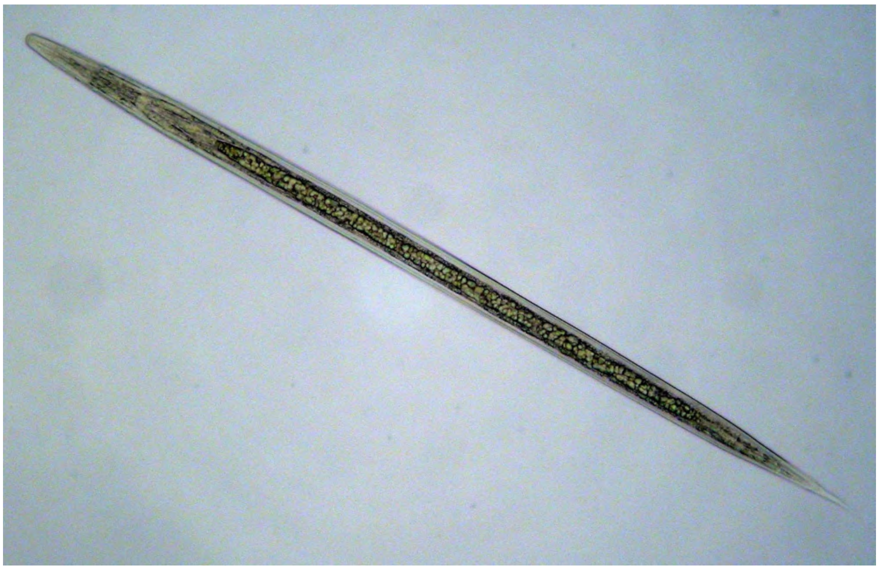

Figure 22.7: L3 larva of Nematodirus. Photo: Bob Hanna.

A recent limited study has revealed that in Northern Ireland anthelmintic resistance in *Nematodirus battus* populations to benzimidazoles, levamisole, avermectins and moxidectin is present in, respectively, 36 *per cent*, 50 *per cent*, 33 *per cent* and 75 *per cent* of flocks tested (McMahon, Edgar, 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 (ibid.).

Coccidiosis

In 2021, as in previous years, coccidial oocysts were detected more frequently in sheep than in cattle faeces samples. Of the sheep samples examined in 2021, 62.9 *per cent* (n=898) were positive for oocysts (compared to 69.2 *per cent* in 2020 and 69.4 *per cent* in 2019), but only 26.5 *per cent* exhibited moderate or high levels (Figure 22.8). However, as with infections in cattle, the oocyst count may not accurately reflect the pathological significance of the infection because the peak of shedding may have passed before samples were collected, and because there is variation in the pathogenicity of the various species of *Eimeria* involved.

Coccidiosis is an insidious disease and is frequently associated with poor thrive in lambs and calves as well as with more serious clinical disease. In sheep, the important pathogenic coccidians in Northern Ireland are *E. crandallis* and *E. ovinoidalis*. As in calves, infection can cause severe diarrhoea, often with blood, and the caecum and colon are the main parts of the intestine affected. If the animals recover, chronic damage to the intestine can lead to malabsorption problems later, with associated failure to thrive. During the acute phase of the disease the integrity of the intestinal lining is disrupted (Figure 22.9), and deaths may result from septicaemia caused by ingress of bacteria through the damaged intestine wall.

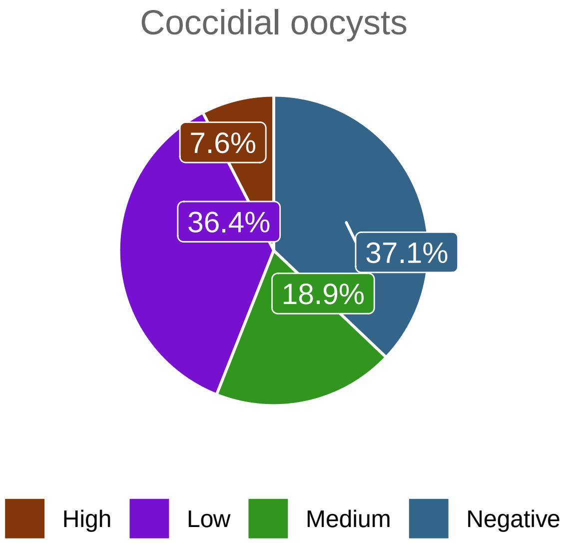

Figure 22.8: Results for ovine faecal samples tested for coccidial oocysts during 2021 (n=898).

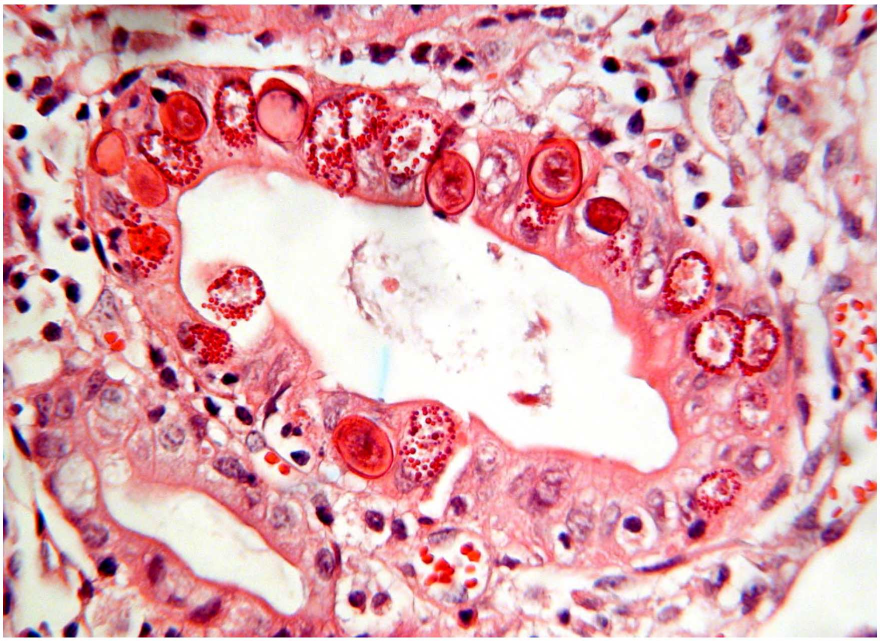

Figure 22.9: Histopathology section of coccidiosis in the gut wall of a lamb. Photo: Bob Hanna.

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 2021, rumen fluke eggs were more frequently detected than liver fluke eggs (positive FECs were recorded in 25.7 *per cent* and 11.2 *per cent* of 797 and 796 faecal samples respectively; (Figure 22.11 and 22.13). The percentage with liver fluke eggs detected showed a decrease from 2020, when 17.1 *per cent* of samples examined yielded positive results, but was still higher than the figure for 2019 (8.3 *per cent*), although significantly lower than the figure for 2018 (29.5 *per cent*). In 2021, 26.0 *per cent* of 797 faecal samples tested positive for rumen fluke eggs (compared to 24.1 *per cent* in 2020, 25.0 *per cent* in 2019 and 20.5 *per cent* in 2018).

Bearing in mind that the molluscan intermediate host (*Galba truncatula*) is the same for both types of fluke, the perceived decline in liver fluke incidence is difficult to explain. It is possible that there is increased awareness of triclabendazole resistance in flukes in Northern Ireland, resulting in a shift towards control of *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). This may have resulted in a recent decline in pasture contamination by liver fluke eggs. Of the available drugs, only oxyclozanide has proven efficacy against rumen fluke. On the other hand, the findings may reflect local climatic differences or changes in stockholder behaviour in sample submission between 2018 and 2021. The possibility of intra-molluscan competitive effects between liver fluke and rumen fluke larval stages has yet to be fully researched.

Liver fluke disease can occur in either acute or chronic forms. The acute form occurs in sheep in the autumn and early winter of those years when the climatic conditions from April

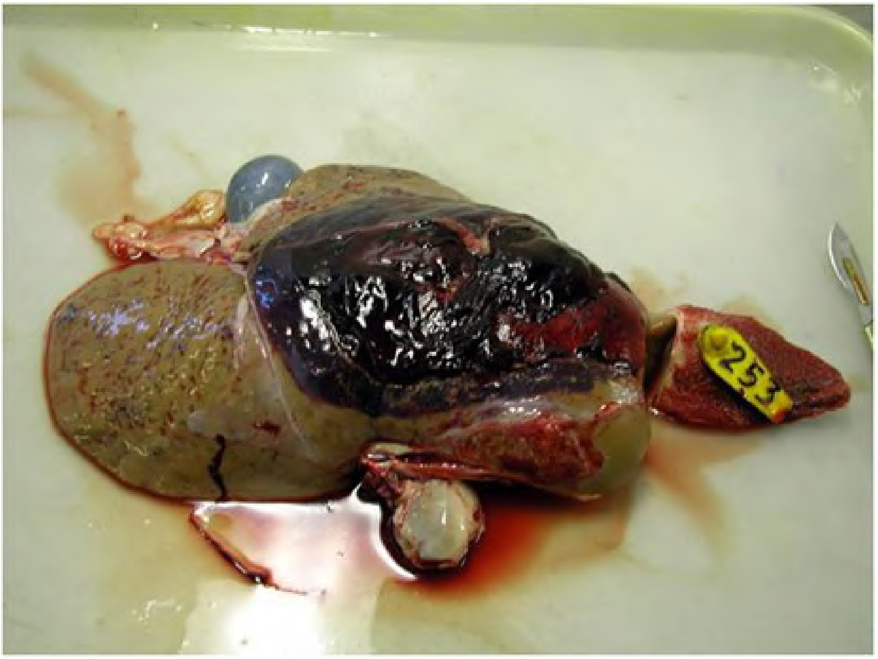

Figure 22.10: Liver haemorrhage in acute fasciolosis Photo: Bob Hanna.

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 22.10).

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 22.12). Chronic fluke infection can cause a reduction of 30 *per cent* in the growth of fattening animals and can also predispose to metabolic conditions and infectious diseases such as salmonellosis and clostridial infection. Cattle and sheep in fluke-affected areas should be fully vaccinated against clostridial disease.

All sheep farmers should review their fluke control measures in autumn. Access to snail habitats (wet and poorly drained areas) should be reduced or sheep taken off the potentially infected land and housed or moved to new clean pasture. However, in most cases, control will be based on the strategic use of anthelmintics, employing a product effective against the life cycle stages likely to be present in the flock or herd at the time of treatment.

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

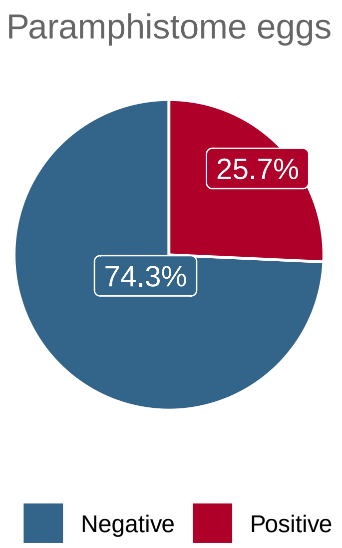

Figure 22.11: Relative frequency of detection of Paramphistome eggs in ovine faecal samples examined by AFBI in 2021 (n=797).

Figure 22.12: Adult liver flukes in the main bile duct of a sheep. Photo: Bob Hanna.

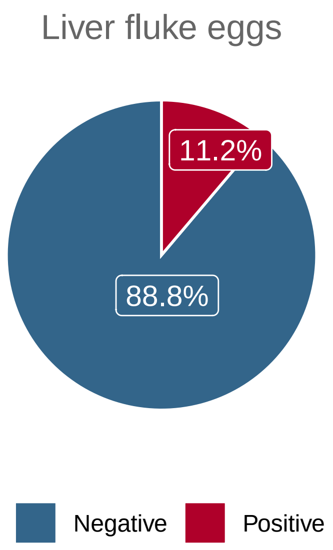

Figure 22.13: Relative frequency of detection of liver fluke eggs in ovine faecal samples examined by AFBI in 2021 (n=796).

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.

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

CHAPTER 23

PIG AND EQUINE DISEASES (AFBI)

23.1 Pig Diseases

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The pig industry in Northern Ireland continues to grow with the total pig numbers recorded in the June 2021 Agricultural census at 716, 798 up 5 *per cent* from June 2020. The increase in pig numbers was a result of a higher number of breeding pigs and fattening pigs with total female breeding herd increasing by 9 *per cent* from June 2020. 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 2021).

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*. Bacterial infections due to *Streptococcal*, *E.coli* and *Salmonella* species were predominant diagnoses.

Case reports:

Klebsiella septicaemia in preweaned piglets.

A two week old piglet was submitted with a history of sudden death. On *post mortem* examination, changes suggestive of septicaemia were evident including congestion of the carcase, excess pleural and peritoneal fluid and fibrin strands in the peritoneal cavity. *Klebsiella pneumoniae* was cultured at a high level from the spleen, lung, liver and small intestines. *Klebsiella pneumoniae subspecies pneumoniae* has emerged as a cause of septicaemia in preweaned piglets with a trend towards a seasonal pattern with outbreaks during the summer months.

Gastric ulceration in growing pigs.

A four month old fattener pig was submitted with a history of sudden death. On *post mortem* examination the carcase was pale and there was blackish fluid in the gastrointestinal tract. There was a large stomach ulcer in the *pars oesophagea* with healing by fibrosis at the edges (Figure 23.1). A small artery was protruding from the ulcerated area and the stomach contained a large blood clot. Gastric ulceration in pigs is usually restricted to the *pars oesophagea* and weaned growers are commonly affected. Most lesions are subclinical but some can be fatal with pigs either dying suddenly or following a short period of inappetance, weakness, anaemia and melena. Chronically affected pigs may show signs of inappetance, weight loss and intermittent melena. Many factors have been implicated in the aetiology of the condition with finely ground rations and increased gastric acidity important predisposing factors for their development (Jubb 2015). They can also be caused by periods of inappetance due to other diseases such as PRRSV allowing the *pars oesophagea* region to become acidic.

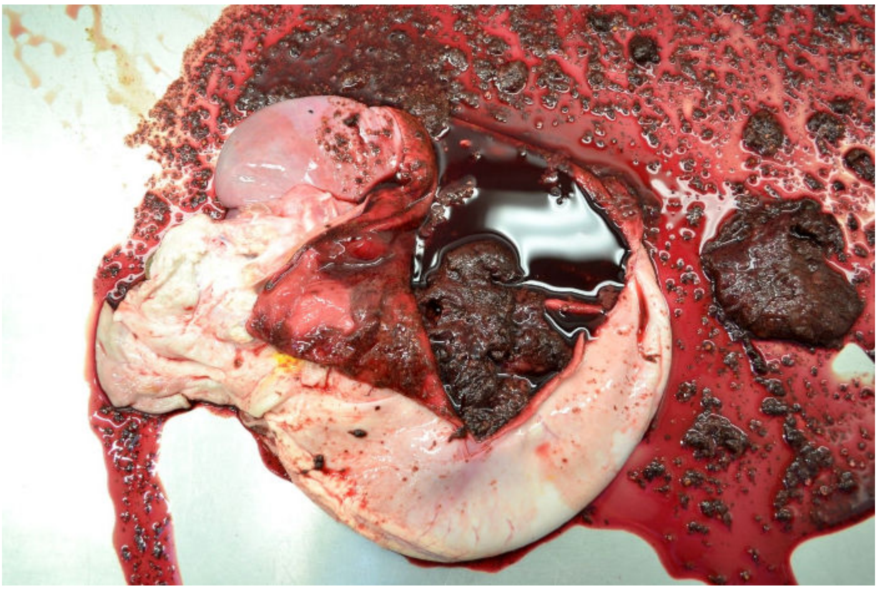

Figure 23.1: Bleeding gastric ulcer in a sow. Photo: Seán Fee.

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 Equine Diseases

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In 2021 the Disease Surveillance and Investigation branch of AFBI received 202 equine submissions, including 8 *post mortem* examinations and 194 diagnostic submissions.

Equines are submitted for routine diagnostic *post mortems* as well as *post mortems* carried out as part of welfare investigations.

There were 135 faecal samples submitted for parasitic investigation during 2021. Samples from 38 horses tested positive for *Strongylus vulgaris* eggs at $\geq$ 200 *eggs per gram*, two samples tested positive for *Strongyloides westeri* at $\geq$ 200 *eggs per gram* and two samples tested positive for liver fluke eggs. Eight skin samples were submitted for parasitic investigation and were all negative for mites and lice with one positive for *Candida* species and one positive for ringworm.

Sixty two swab samples were tested for *Taylorella equigenitalis* (Contagius Equine Metritis) and *Klebsiella pneumoniae* in 2021 with all returning negative results. Two samples tested positive for *Streptococcus equi* (Strangles) in 2021 out of seven samples submitted for this culture.

AFBI's Chemical and Immunodiagnostics branch received 36 submissions to test for Equine Viral Arteritis and 79 submissions to test for Equine Infectious Anaemia in 2021. These submissions were a combination of pre import testing submissions from DAERA and commercial freedom of infection testing prior to breeding. All samples were negative

Part VII

Appendix

CHAPTER 24

APPENDIX

24.1 R packages and LaTeX

The analysis, construction of graphics and visualisation of data for this 2021 All-Island Animal Disease Surveillance report have been conducted by using the R programming language, R version 3.5.1 (2018-07-02) (R Core Team 2018), and the RStudio integrated development environment. An adaptation of the package *memoiR* created by Eric Marcon has provided the template for this report.

Extensive use of the package bookdown (Xie 2021a) and rmarkdow (Allaire et al. 2021; Allaire et al. 2021) and the LaTeX systems were utilised in this report for formatting and typesetting the final LaTeX bookdown document.

Most of the data analysis was carried out with the packages included in *tidyverse*; the charts were plotted using the package *ggplot2* (Wickham, Chang, et al. 2020) and the tables constructed with *kableExtra* (Zhu 2021) and *finalfit* (Harrison et al. 2019).

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.

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