All-Island Animal Disease Surveillance 2019

Veterinary Laboratory Service
and Agri-Food & Biosciences Institute

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

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Contents

Acknowledgements

The 2019 All-Island Animal Disease Surveillance Report 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. Behind this group people, there is an extended group of colleagues, laboratory technicians, clerical staff and laboratory attendants, that support and assist our work as Research Officers and have made possible the material presented in this report.

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I would like to thank Micheál Casey (Director of the Regional Veterinary Laboratories), Damien Barrett (Surveillance and Animal by Products), and my colleagues Mercedes Gómez-Parada and Jim O'Donovan (Cork RVL), for their support and continuous encouragement throughout this project.

Cosme Sánchez-Miguel (Editor)

Cork Regional Veterinary Laboratory, DAFM.

Preface

This All-Island Animal Disease Surveillance Report (AIADSR) is the fourteenth Animal Disease Surveillance Report and the ninth report in collaboration with our colleagues from AFBI, Northern Irland and AHI.

For the third year, the data has been entirely analysed and compiled with the programming languages R and LaTeX. Both languages provide an excellent environment for data analysis, visualisation and typesetting and we hope that this edition demonstrates a clear improvement from the previous two years.

Though the AIADSR is intended for Private Veterinary Practitioners, it has always been conceived and produced in a manner that can provide valuable animal health surveillance information to other stakeholders. An effort has been made in the presentation and visualisation of the data by the inclusion of numerous tables and figures throughout the AIADSR.

The information presented in this AIADSR is only a small fraction of the considerable amount of data produced by the work undertaken in the Regional Veterinary Laboratories (RVLs). Some important topics (ovine abortion, antimicrobial resistance, zoonotic diseases, etc.) 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 caried out by the RVLs, AFBI and AHI in the Island of Ireland.

Cosme Sánchez-Miguel (Editor)

Cork Regional Veterinary Laboratory, DAFM.

Spring 2020

The gate of the cow house is flung wide
shaking it's ponytailed high winter hair out,

cows throwing on tracksuit bottoms
flopping and flapping down the lane,

breathing out after wearing high skirts
and shirts tight for four months.

The birds thrilled by it, shouting
and yelling their lines out,

dandelions leaping out of the ground,
thousands of yellow high fives,

delighted with the reassurance
that some things stay the same.

—**Maresa Sheehan**, Kilkenny RVL

Diseases of Cattle, DAFM

1 Overview of Cattle Diseases

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

This section presents the most commonly diagnosed causes of death in cattle presented for *post-mortem* examination at RVLs.

The range of diagnoses of animals submitted for *post-mortem* examination varies according to the age of the animal; thus the results in this section are presented by age category. In order to facilitate presentation and comparison, conditions which affect given systems have been grouped together.

During 2019, 2248 cattle carcasses were submitted for examination. Geographical distribution of herds submitting bovine cases, colour coded by RVL where the carcases were examined, is illustrated in Figure 1.1.

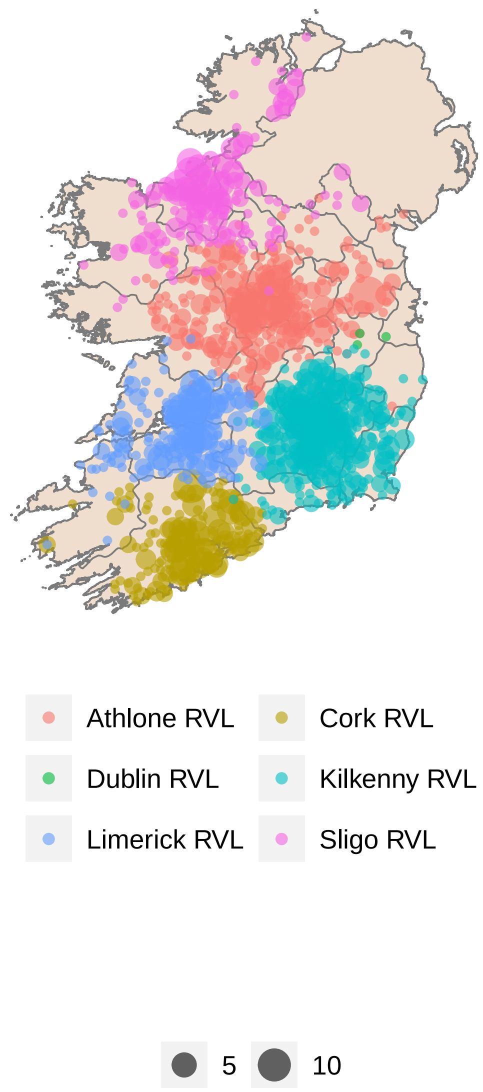

Figure 1.1: Distribution of bovine carcasses. Bovine carcasses (excluding foetuses), aggregated and mapped at their DED (District Electoral Division) and colour-coded by the Regional Veterinary Laboratory of submission (n= 2248).

Neonatal Calves (birth to one month of age)

The trend of gastrointestinal infections being the most frequently diagnosed cause of death in neonatal calves continued in 2019 (Table 1.1 and Figure 1.2). The deaths of almost thirty *per cent* of calves in this age group were attributed to gastrointestinal infections. A number of these calves were recorded as having concurrent hypogammaglobulinaemia, indicating failure of passive transfer of humoral immunity from the dam to the calf, a risk factor for neonatal infections.

Systemic infections (sepsis) continued as the second most frequently diagnosed cause of death in DAFM laboratories (Figure 1.3). In the last three years, systemic infections reached a peak of 24 *per cent* of deaths in 2016 , but in 2019 the percentage of neonatal calves with systemic infections amounted to 19.4 *per cent*.

Table 1.1: Conditions most frequently diagnosed on *post-mortem* examinations of bovine neonatal calves in 2019 (n= 609).

Category	No. of Cases	Percentage
GIT Infections	167	27.4
Systemic Infections	118	19.4
Respiratory Infections	67	11.0
Navel Ill/Joint Ill	43	7.1
GIT torsion/obstruction	42	6.9
Diagnosis not reached	25	4.1
Nutritional/metabolic conditions	25	4.1
Hereditary and developmental abnormality	24	3.9
Peritonitis	20	3.3
GIT ulcer/perforation/foreign body	15	2.5
Urinary Tract conditions	9	1.5
Integument/Musculoskeletal	8	1.3
Cardiac/circulatory conditions	7	1.1
Liver disease	7	1.1
CNS	6	1.0
Fractures/Calving injuries	6	1.0
Trauma	6	1.0
Bovine Neonatal Pancytopaenia	3	0.5
Reproductive Tract Conditions	3	0.5
Clostridial disease	2	0.3
Poisoning	2	0.3
Abscessation	1	0.2
BVD/Mucosal disease	1	0.2
Tick Borne Fever	1	0.2
Unclassified	1	0.2

Navel ill/joint ill has stayed at a level consistent with previous years at 7.1 *per cent* of diagnoses. *Escherichia coli* and *Trueperella pyogenes* were the infectious agents most frequently isolated from these cases. Similarly, the rate of peritonitis cases has stayed at 2.1 *per cent*, with *Trueperella pyogenes* and *Escherichia coli* commonly isolated from such cases.

Respiratory infections are generally responsible for about one in ten deaths in neonatal calves, and 2019 was a typical year with deaths at 11.0 *per cent*.

Nutritional and metabolic conditions equate to 4.1 *per cent* of diagnoses in neonatal calves submitted for necropsy. This category includes failure of passive transfer of humoral immunity (hypogammaglobulinaemia) and ruminal milk drinkers (Figure 1.3).

Hereditary and developmental abnormalities were recorded in DAFM laboratories in almost 3.9 *per cent* of carcasses submitted. Common diagnoses in this category include intestinal atresia and cardiac defects. Cardiac abnormalities most commonly noted were ventricular and atrial septum defects and persistent patent foramen ovale.

Figure 1.3: Inflammed ruminal mucosa (ruminitis) and diffuse parakeratosis in a calf with ruminal acidosis due to dysfunction of the reticular groove (ruminal milk drinker). Photo: Cosme Sánchez-Miguel.

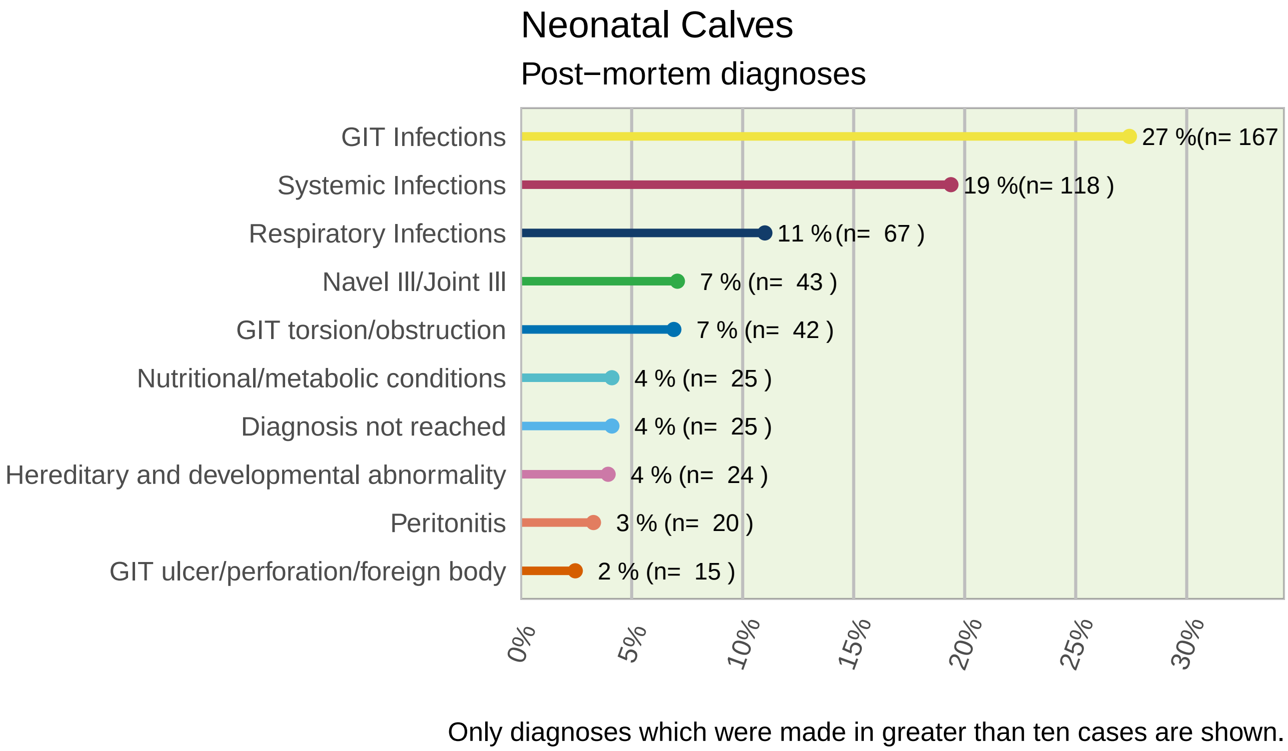

Figure 1.2: Conditions most frequently diagnosed on *post-mortem* examinations of bovine neonatal calves in 2019 (n= 609)

Calves (one to five months of age)

Figure 1.4: Multifocal nonsuppurative interstitial nephritis (white-spotted kidney), usually the result of bacteraemia in calves. Photo: Cosme Sánchez-Miguel.

Respiratory infections are by far the most significant cause of mortality among one to five-month-old calves in Ireland from the cohort of 610 animals in this age group submitted for necropsy (Table 1.2 and Figure 1.5). They accounted for 30.6 *per cent* of deaths in this age group. Examination of data for the last few years shows that respiratory infections are responsible for an increasing percentage of deaths in this age category, though this has levelled off recently. A breakdown of detected agents in these cases is presented in the Bovine Respiratory Disease section of this report.

Gastro-intestinal tract (GIT) infections (13.4 *per cent*) and GIT torsion/obstruction (9.4 percent) are the second and third most frequently diagnosed categories, together accounting for just over one in five of diagnosed causes of death. Common bacterial agents implicated include *Salmonella enterica subsp. enterica* serovar Dublin and *Escherichia coli*. Coccidia (*Eimeria spp.*) are the most frequently detected GIT pathogens in this age group. The rate of diagnosis of torsions of intestines, full mesentery, abomasum, omasum or reticulum was similar to previous years.

Navel ill/ joint ill, consequences of navel infections at birth, were diagnosed in 1.9 *per cent* of calves in this age group presented to DAFM laboratories. Diagnosis of peritonitis in this age category has remained at a consistent level, between 1 and 3 *per cent*, from 2014 to 2019.

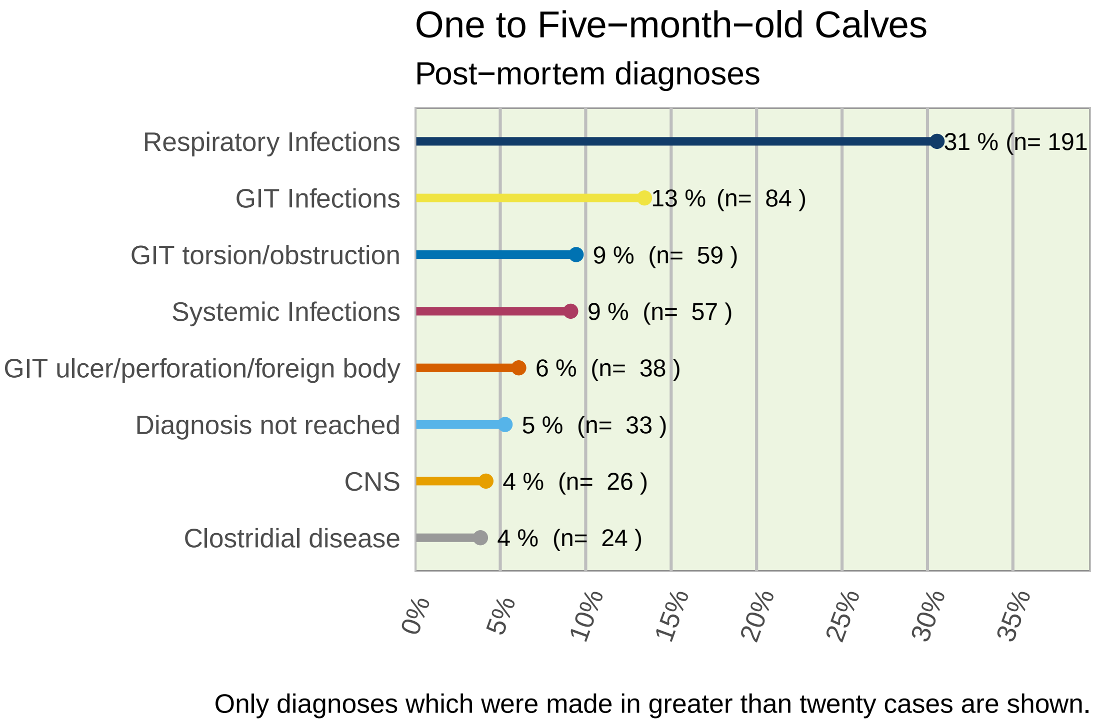

Figure 1.5: Conditions most frequently diagnosed on *post-mortem* examinations of calves (1–5 months old) in 2019 (n= 610)

Table 1.2: Conditions most frequently diagnosed on *post-mortem* examinations of calves (1-5 months old) in 2019 (n= 610)

Category	No. of Cases	Percentage
Respiratory Infections	191	30.6
GIT Infections	84	13.4
GIT torsion/obstruction	59	9.4
Systemic Infections	57	9.1
GIT ulcer/perforation/foreign body	38	6.1
Diagnosis not reached	33	5.3
CNS	26	4.2
Clostridial disease	24	3.8
Urinary Tract conditions	19	3.0
Nutritional/metabolic conditions	16	2.6
Cardiac/circulatory conditions	12	1.9
Navel Ill/Joint Ill	12	1.9
Poisoning	12	1.9
Peritonitis	10	1.6
Tuberculosis	9	1.4
Liver disease	8	1.3

GIT ulcers and perforations continued to be a frequent diagnosis in 2019, accounting for 6.1 *per cent* of diagnoses. Perforating abomasal ulcers, leading to leakage of stomach contents and peritonitis, accounted for the majority of these cases.

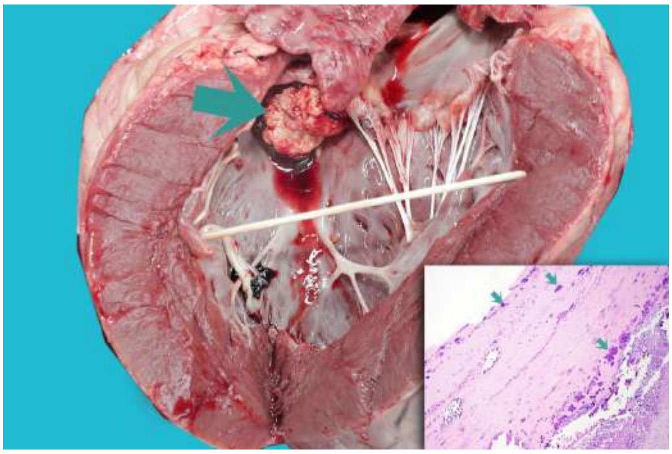

Figure 1.6: Vegetative valvular endocarditis (arrow) in the aortic valve. The mass was formed by fibrin and bacterial colonies of *Listeria monocytogenes* (small arrows). Photo: Cosme Sánchez-Miguel.

Nutritional and metabolic conditions were diagnosed in 2.6 *per cent* of calves. The leading diagnoses in this category were ruminal acidosis and malnutrition.

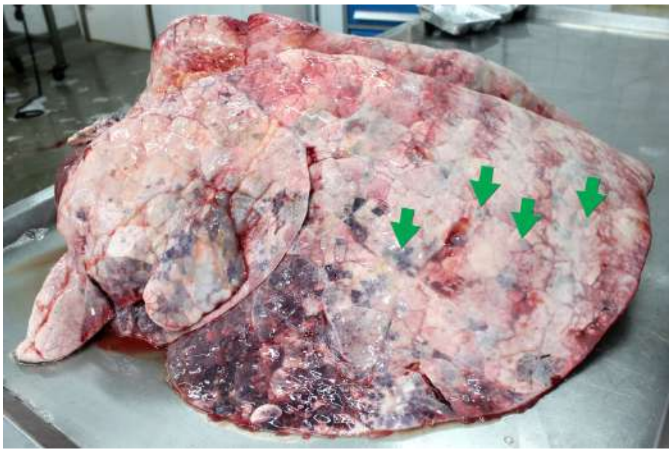

Figure 1.7: Embolic pneumonia secondary to the rupture of a hepatic abscess (caudal vena cava thrombosis) initially caused by the dissemination of ruminal bacteria to the liver after a herd incident of ruminal acidosis. Photo: Cosme Sánchez-Miguel.

Weanlings (six months to one year of age)

As in previous years, respiratory infections were the most commonly diagnosed cause of mortality (30.6 *per cent*) in this age group (Table 1.3 and Figure 1.10).

GIT infections were identified as the second most common cause of death in six to twelve month-old weanlings causing 18.6 *per cent* of mortalities in this age group.

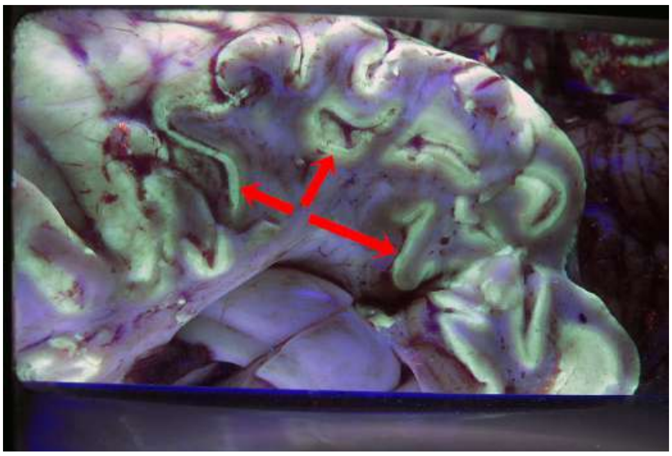

Figure 1.8: Brain dispaying laminar pattern of autofluorescence (arrows) caused by necrosis of the grey matter in thiamine deficiency (acute polioencephalomalacia or cerebrocortical necrosis). Photo: Cosme Sánchez-Miguel.

Table 1.3: Conditions most frequently diagnosed on *post-mortem* examinations of weanlings (6–12 months old) in 2019 (n= 367)

Category	No. of Cases	Percentage
Respiratory Infections	122	30.6
GIT Infections	74	18.6
Clostridial disease	42	10.5
Diagnosis not reached	32	8.0
Systemic Infections	28	7.0
CNS	20	5.0
Nutritional/metabolic conditions	17	4.3
Cardiac/circulatory conditions	9	2.3
GIT ulcer/perforation/foreign body	9	2.3
GIT torsion/obstruction	8	2.0
Liver disease	6	1.5

Clostridial diseases were the third biggest grouping of cause of mortality in this age group (10.5 *per cent*)

Diseases of the central nervous system (CNS) were diagnosed in 5.0 *per cent* of carcases in Ireland in 2019. Diseases in this category include cerebrocortical necrosis (Figure 1.8), encephalopathies, encephalitis/meningitis and thromboembolic meningoencephalitis.

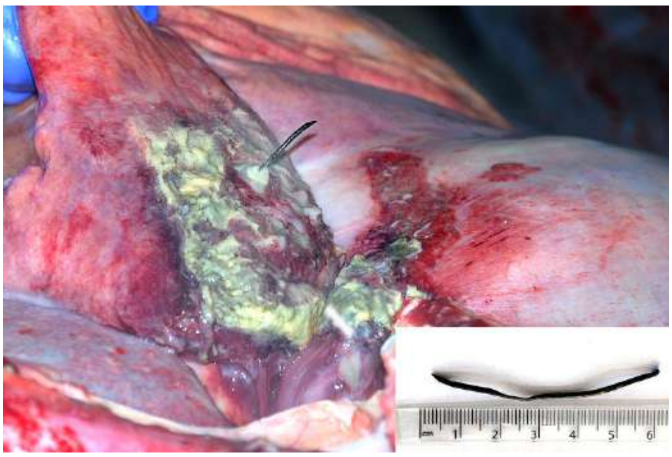

Figure 1.9: Piece of wire penetrating the reticular wall of a cow with traumatic reticuloperitonitis (*hardware disease*) and associated suppurative pericarditis (not shown). Photo: Cosme Sánchez-Miguel.

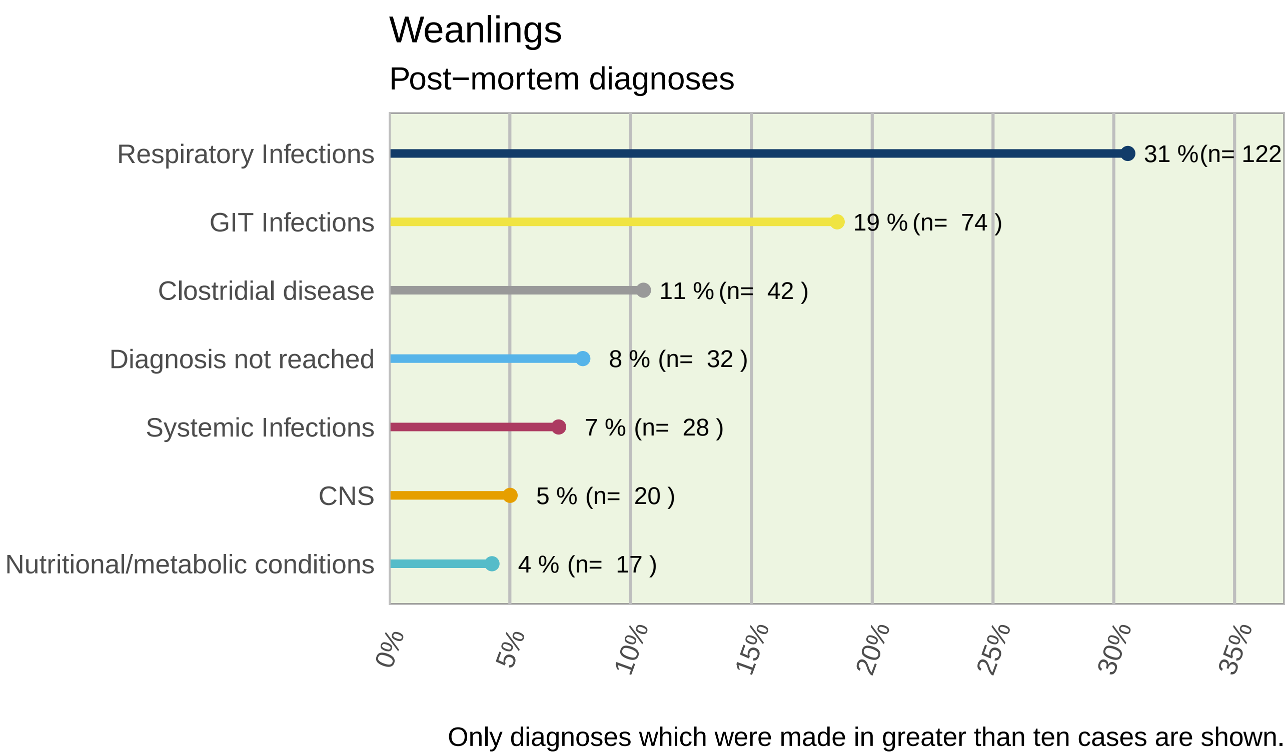

Figure 1.10: Conditions most frequently diagnosed on *post-mortem* examinations of weanlings (6–12 months old) in 2019 (n= 367)

Adult Cattle (over 12 months of age)

Similar to previous years, respiratory diseases accounted for 17.7 *per cent* of adult deaths, (Table 1.4 and Figure 1.11). This statistic has remained roughly static in Ireland since 2014.

Cardiac/circulatory system conditions were the third biggest diagnosis in adult cattle in Ireland, occurring in 10 *per cent* of cases. Endocarditis (Figure 1.6), pericarditis, caudal vena cava thrombosis (Figure 1.7), haemorrhage and haemolytic disorders were common diagnoses in this category.

Clostridial disease only accounted for 7.3 *per cent* of adult cattle deaths diagnosed. This category includes diseases such as blackleg, malignant oedema, botulism and tetanus. Cases of GIT ulceration/perforation and foreign body accounted for 4.6 *per cent* of deaths, a slight decrease on rates in previous years. Hardware disease or traumatic reticuloperitionitis (Figure 1.9) account for a significant proportion of these cases every year. Peritonitis diagnoses equated to 4.0 *per cent* in Ireland, in keeping with the trend of previous years.

Table 1.4: Conditions most frequently diagnosed on *post-mortem* examinations of adult cattle (over 12 months old) in 2019 (n= 505)

Category	No. of Cases	Percentage
Respiratory Infections	92	17.7
Diagnosis not reached	58	11.2
Cardiac/circulatory conditions	52	10.0
Clostridial disease	38	7.3
GIT Infections	37	7.1
Systemic Infections	35	6.7
GIT ulcer/perforation/foreign body	24	4.6
Nutritional/metabolic conditions	23	4.4
Poisoning	22	4.2
Peritonitis	21	4.0
Liver disease	18	3.5
CNS	15	2.9
Integument/Musculoskeletal	12	2.3
Abscessation	11	2.1
Babesiosis	9	1.7
Mastitis	9	1.7
Urinary Tract conditions	9	1.7
GIT torsion/obstruction	7	1.4
Tumour	7	1.4
Unclassified	6	1.1

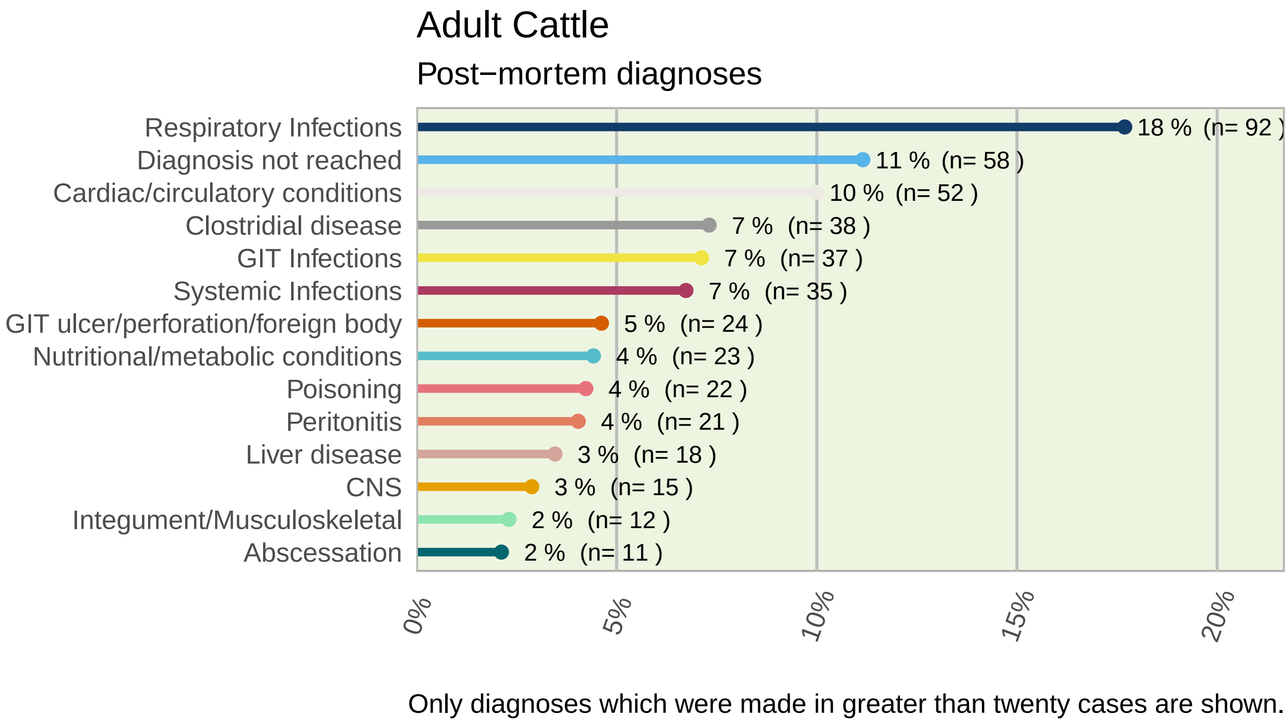

Figure 1.11: Diagnoses of adult cattle. Conditions most frequently diagnosed on *post-mortem* examinations of adult cattle (over 12 months old) in 2019 (n= 505)

References

Zachary, J (2016). Pathologic Basis of Veterinary Disease. *Mosby*. DOI: https://www.ebook.de/de/product/25867964/james_f_dvm_phd_zachary_pathologic_basis_of_veterinary_disease_expert_consult.html.

2 Johne's Disease

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

Table 2.1: Summary of MAP positive faecal cultures by breed and gender in 2019

Breed	Female	Male	Total
Holstein Friesian	24 (48.0)	0 (0.0)	24 (44.4)
Limousin	12 (24.0)	3 (75.0)	15 (27.8)
Jersey	4 (8.0)	0 (0.0)	4 (7.4)
Friesian	2 (4.0)	1 (25.0)	3 (5.6)
Simmental	3 (6.0)	0 (0.0)	3 (5.6)
Aberdeen Angus	1 (2.0)	0 (0.0)	1 (1.9)
Belgian Blue	1 (2.0)	0 (0.0)	1 (1.9)
Charolais	1 (2.0)	0 (0.0)	1 (1.9)
Norweigian Red	1 (2.0)	0 (0.0)	1 (1.9)
Shorthorn	1 (2.0)	0 (0.0)	1 (1.9)

In total, fifty eight positive MAP faecal cultures, from 48 different herds, were recorded in 2019 (Table 2.1). Over 90 *per cent* of positive animals were female. A mixture of dairy and beef breeds recorded positive results. Over 40 *per cent* of positive samples however, were from Holstein Friesians . It should be noted figures recorded do not represent a national prevalence, they relate to faecal culture positive results identified in DAFM labs and do not include data from private laboratories.

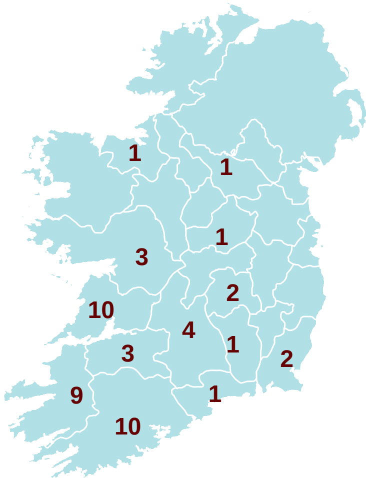

Figure 2.1: Number of herds by county with at least one animal diagnosed with JD by faecal mycobacterial culture in 2019.

Latency is a common feature of mycobacterial disease; animals can remain sub-clinically infected without showing any clinical signs of the disease for many years. Clinical disease is reported to occur most frequently in cattle aged 2—5 years. In line with this, based on a number of assumptions, it is estimated that 50 *per cent* of animals that tested positive in 2019 were displaying symptoms of JD before five years of age (Figure 2.3). At the time of analysis, all male animals that had a positive result in 2019 were no longer alive and only 14 *per cent* of positive female animals were still alive (Figure 2.4).

Figure 2.2: Thickened and corrugated intestinal mucosa (granulomatous enteritis) in the ileum of a cow with Johne's disease (*Mycobacterium avium ssp. paratuberculosis*). Photo: Aideen Kennedy.

JD transmission

In many herds, initial introduction of MAP usually occurs as result of acquiring an infected but clinically normal animal. In 2019, a number of animals that subsequently recorded MAP faecal culture positive results underwent multiple herd movements throughout their lifetime, potentially allowing spread of the disease. Three was the greatest number of herd movements recorded by a positive animal, excluding movements to a factory or knackery (Table 2.2). This was a reduction from a maximum of 5 movements in 2018.

Once MAP is introduced to a herd, infection with MAP is understood to occur, primarily, as a calf. Animals younger than six months are believed to be the most susceptible. Neonates are considered to be at highest risk of acquiring MAP infection due to increased permeability of intestines during the

Table 2.2: Statistics of the movements of cattle with JD excluding movements to factory or knackery.

Minimun	Median	Maximun
0	1	3

Table 2.3: Number of JD positive animals detected in the herd of birth by faecal culture.

Homebread	Number of Animals
No	25
Yes	29

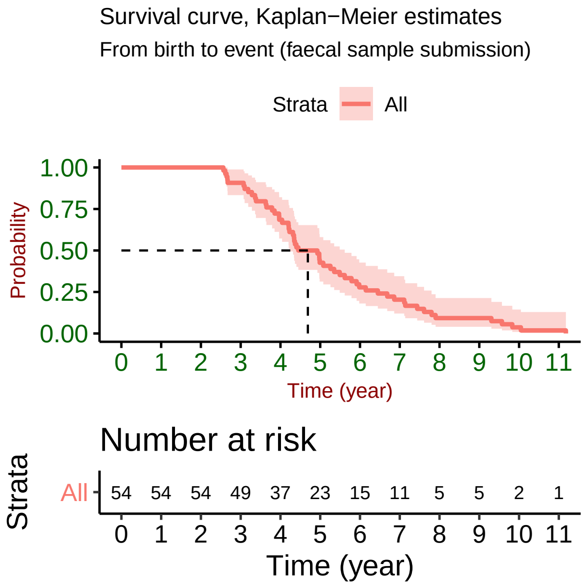

Figure 2.3: Survival curves measure how much time elapsed before a certain event occurred. In this case, the event is represented by submission of a faecal sample to an RVL. An assumption is made that faecal samples are submitted soon after the animal displays diarrheoa unresponsive to treatment. 50 % of animals may have displayed symptoms consistent with the disease by five years of age. The graph on the bottom represents number of animals at risk of developing symptoms overtime.

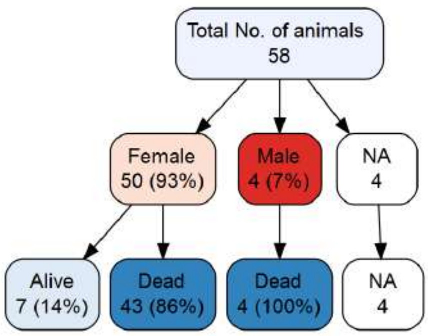

Figure 2.4: Status of animals diagnosed with Johnes disease in 2019 as per the 25th of May, 2020. Information for four animals was unavailable at the time of the analysis.

first 24 hours of life and an immature immune system. Older animals are believed to be less susceptible; however, infection can still occur. Severity and rate of JD progression in individual animals are dependent on MAP exposure dose and age at time of infection. Infection usually occurs via the faecal-oral route, although in-utero transmission can also occur. Exposure of calves to adult faeces is the most important risk factor in MAP transmission. Faecal-oral transmission is facilitated by faecal contamination of feedstuff and calf's environment, with highest environmental risk factors for neonatal infection being faecal contamination of udders and calving pens. Colostrum and milk from infected cows can also contain quantities of MAP capable of infecting calves. Feeding pooled colostrum or milk from multiple cows of unknown MAP status is considered to increase risk of infection within a herd.

JD Diagnostics

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

Faecal culture is generally taken as the reference test for MAP. An advantage of culture is that detection of MAP in faecal samples confirms presence of viable MAP in an animal. Due to absent or intermittent shedding of bacteria early in the disease process, sensitivity of culture can be low. Specificity, however, is almost 100 *per cent*. Due to the fastidious nature of MAP, culture takes a number of weeks. Polymerase Chain Reaction (PCR) is another faecal based test used to detect DNA of MAP, it offers a rapid method of detecting MAP status.

Enzyme Linked Immune Sorbent Assay (ELISA) examines the host's immune response to MAP and is extensively used for routine diagnosis. ELISA is favoured as a screening test due to its relatively low cost, compared to faecal culture or PCR. ELISAs also provide faster results when compared to culture methods. ELISA relies on identifying serum antibodies to a particular antigen as an indicator of infection. It is important to note that a positive ELISA reaction is NOT confirmation of JD. The specificity of MAP ELISA tests can be influenced by tuberculin testing and by exposure to non-MAP environmental mycobacteria (giving rise to false positive results). The sensitivity of MAP ELISA tests is influenced by stage of infection, high in animals with clinical disease but low in infected animals that are shedding few MAP organisms (where false negative results may arise).

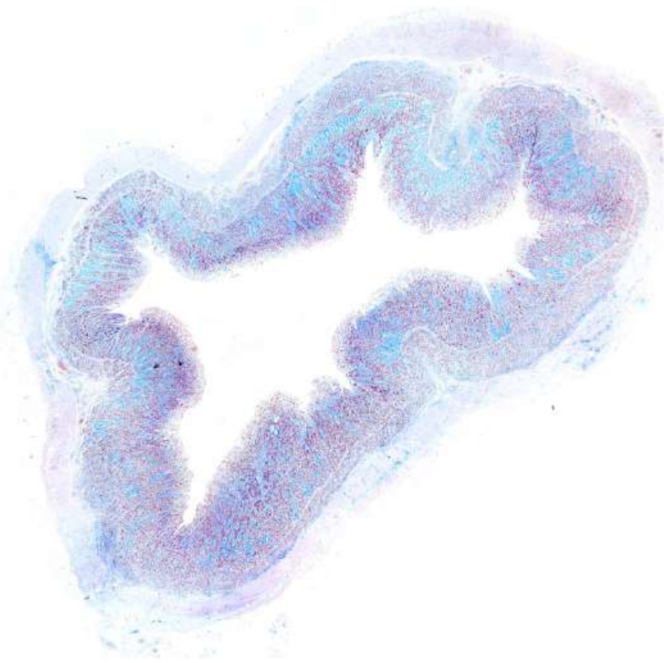

Figure 2.5: Intestinal section with granulomatous inflammation of the epithelium showing numerous MAP acid-fast bacilli stained red (Ziehl-Neelsen stain). Photo: Cosme Sánchez-Miguel.

Post mortem examination

On *post mortem*, gross and microscopic lesions associated with JD are primarily confined to the intestine and mesenteric and ileo-caecal lymph nodes. Gross lesions are characterised by thickening and corrugation of intestinal mucosa, most prominent in distal ileum and ileo-caecal valve. Histological lesions associated with JD can vary widely; villi are frequently fused and mucosa is invariably thickened, infiltration of macrophages -including giant cells- is commonly identified in the submucosa and acid fast bacilli are commonly present (Figure 2.5). JD cannot be diagnosed solely on *post mortem*, diagnosis needs to be confirmed by faecal culture and/or histology (intestine/lymph nodes).

Control Programme

A voluntary national JD control programme is on-going in Ireland under the guidance of Animal Health Ireland. The aim is to provide pathways for test-negative and test-positive herds to demonstrate progress towards an improved herd assurance for JD. Primary aspects of this programme involve identification of potentially infected animals via either milk or blood ELISA testing and confirmation relying on faecal based testing. Highlighting on farm management practices using veterinary risk assessment and management plans (VRAMP) is commonly used as a tool in a number of control programmes, including AHI's JD control programme (Animal Health Ireland, 2020). VRAMP is a task shared between the farmer and a trained local vet familiar with his/her farm which facilitates identifying specific high risk management practices occurring on such farm that may facilitate spread of JD. Repeat visits allow monitoring of successful implementation of management changes. Full details of the programme are available on the AHI website.

Acknowledgement

Dr Kevin Kenny (TB Section, DAFM) for providing the JD dataset and Alma Wilson (Cork RVL, DAFM) for sorting the data for analysis.

References

Animal Health Ireland (2020). *Irish Johne's Control Programme*. http://animalhealthireland.ie/?page_id=340.

3 Clostridial Diseases

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Clostridial diseases are found in most countries throughout the world. They are a common cause of sudden/acute death in cattle and sheep seen in the Regional Veterinary Laboratories for *post mortem* examination. This is despite the availability of low-cost vaccines against a large number of clostridial diseases. For most of these diseases, the course is very acute; therefore the most common sign associated with many of the clostridial diseases is sudden death. The most important clostridial diseases, and the bacteria which are usually responsible for them, in an Irish context, are summarised in Table 3.1.

Table 3.1: The most important clostridial diseases in an Irish context, and their causes. Courtesy Surveillance Division DAFM

Clostridial Disease	Causative organism	Species affected
Blackleg	C. chauvoei	Mainly cattle
Malignant oedema	C. septicum, sordelli, chauvoei, and novyi	Mainly cattle
Black disease (infectious necrotic hepatitis)	C. novyi	Cattle and sheep
Botulism	C. botulinum	Mainly cattle
Pulpy kidney disease (PKD)	C. perfringens	Sheep
Enterotoxaemia (other than PKD)	Clostridium perfringens	Cattle and sheep
Braxy	C. septicum	Mainly sheep
Bacillary haemoglobinuria	C. haemolyticum	Cattle and sheep
Tetanus	C. tetani	Many species
Emphysematous abomasitis	Various species	Mainly cattle

Clostridial spp. cause significant disease in both sheep and cattle and are encountered regularly in *post mortem* room submissions. They also cause disease in other species including goats and pigs. Typically, clostridial disease presents as acute disease or sudden death and mortality approaches 100% in most cases. See Tables 3.2 and 3.3 and their corresponding Figures 3.2 and 3.5.

Timing of occurrence of clostridial disease

Since the risk factors for the different diseases vary, the diseases tend to occur all year round, albeit at different levels. However, there are notable seasonal effects in the occurrence of the individual diseases. Blackleg is a good example. Occurrence of blackleg tends to peak in late summer and autumn. This is borne out by the RVL data which have been plotted in Figure 3.1

Pulpy kidney disease in sheep likewise exhibits strong seasonality in its pattern of occurrence. Here

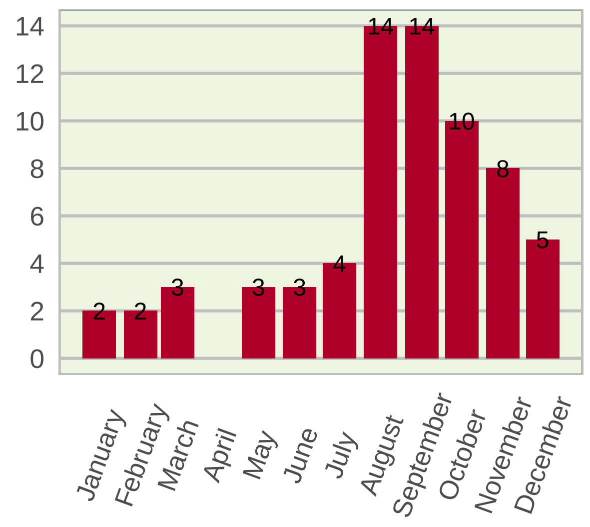

Figure 3.1: Occurrence of diagnosis of blackleg diagnoses in RVLs in 2019, by calendar month (n= 68).

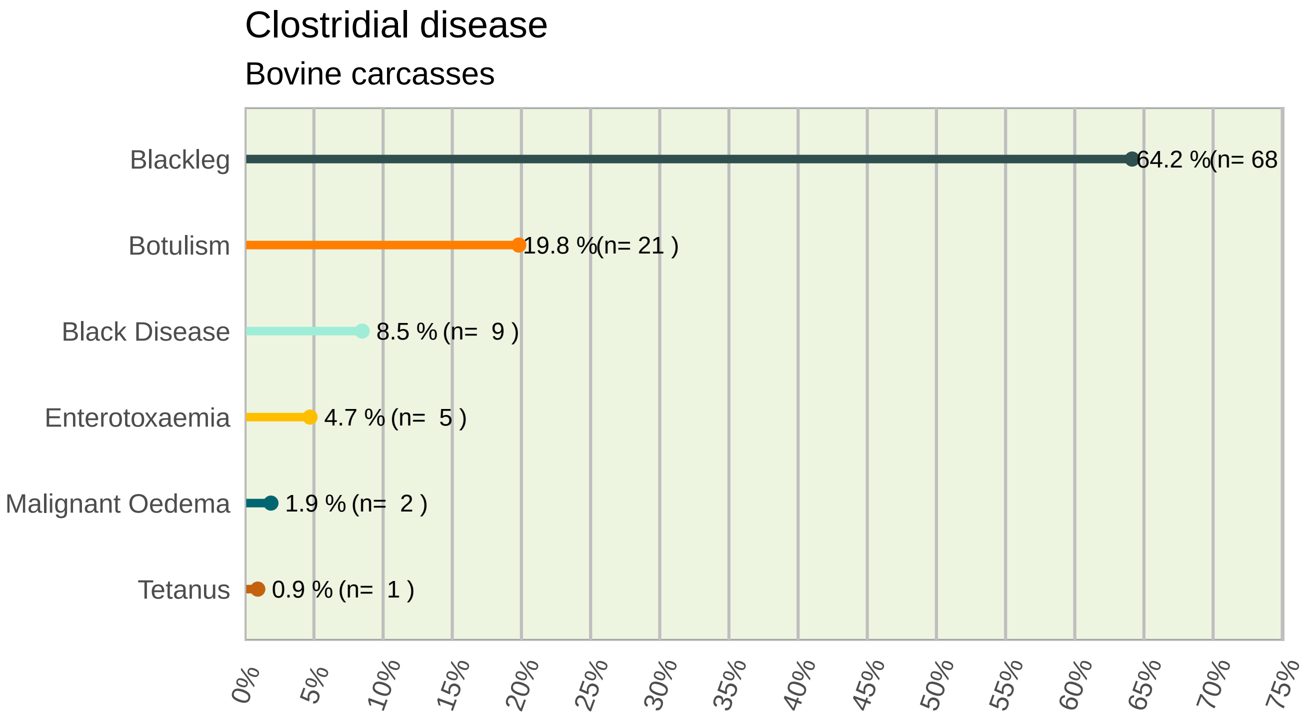

Figure 3.2: Clostridial disease diagnosed in bovine carcasses in 2019 (n= 106) as a percentage of the total number of clostrial diseases.

Table 3.2: Clostridial disease diagnosed in bovine carcasses in 2019 (n= 106).

Disease	No. of Cases	Percentage
Blackleg	68	64.2
Botulism	21	19.8
Black Disease	9	8.5
Enterotoxaemia	5	4.7
Malignant Oedema	2	1.9
Tetanus	1	0.9

Figure 3.3: Blackleg lesion (severe necrotising myositis) in the tongue muscles. Photo: Maresa Sheehan.

the peak is in late spring and early summer, as shown in Figure 3.4.

The smaller number of diagnoses of clostridial disease in sheep overall reflects the lower number of submissions of sheep carcases to the regional veterinary laboratories compared to cattle. Pulpy kidney disease is by far the most common clostridial disease diagnosed in sheep. As is the case with cattle, diagnoses of black disease tend to cluster in the north-west.

Blackleg

Blackleg is the most frequently diagnosed clostridial disease in bovine submissions; it is commonly, but not exclusively, associated with the detection of *Clostridium chauvoei* (Table 3.2 and Figure 3.2). The pathogenesis of this disease requires pre-existence of bacteria in tissue that, in conjunction with favourable circumstances such as trauma, establish anaerobic conditions which allow bacterial proliferation and toxin production, the latter causes severe local necrotising myositis (Figure 3.3) and systemic toxaemia. Cases encountered in *post mortem* rooms frequently have a typical rancid butter odour and affect muscles of the limbs, tongue and heart.

Botulism

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

Malignant Oedema

Malignant oedema can be caused by a number of *Clostridial spp.* including *C. septicum*, *chauvoei*, *sordellii* and *novyi*. The epidemiology and pathogenesis of this disease differ from blackleg in that bacteria is introduced through a wound and causes focally extensive skin gangrene and oedema of the subcutaneous and intramuscular connective tissue, there is less frequent involvement of underlying muscle.

Enterotoxaemia

Enterotoxaemia is a disease caused by *Clostridium perfringens* that causes significant losses in both cattle and sheep (Tables 3.2 and 3.3, and Figures 3.2 and 3.5). This micro-organism can be a normal inhabitant in the intestine of most species including humans. When the intestinal environment is altered by sudden changes in diet or other factors, *C. perfringens* proliferates in large numbers and produces several potent toxins that are absorbed into the general circulation or act locally with usually devastating effects on the host. Enterotoxaemia diagnosis presents a diagnostic challenge as this bacteria is a normal inhabitant of the gut; therefore, demonstration of toxins is essential.

Table 3.3: Clostridial disease diagnosed in ovine carcasses in 2019 (n= 70).

Disease	No. of Cases	Percentage
Pulpy Kidney Disease	38	54.3
Enterotoxaemia	11	15.7
Abomasitis- emphysematous	9	12.9
Black Disease	5	7.1
Blackleg	2	2.9
Enterotoxaemia-Clostridial	2	2.9
Bacillary Haemoglobinuria	1	1.4
Braxy	1	1.4
Malignant Oedema	1	1.4

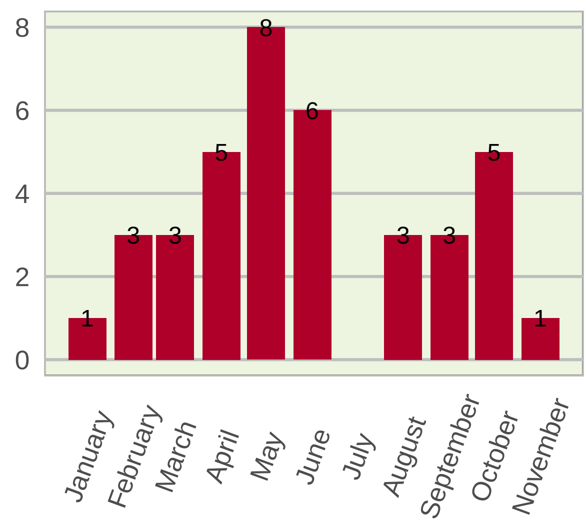

Figure 3.4: Occurrence of diagnosis of pulpy kidney disease in RVLs in 2019, by calendar month (n= 38).

However, as some of the toxins can be present in small amounts in clinically normal animals, the presence of concurrent gross lesions and histopathological changes is required for the diagnosis to be confirmed.

In lambs, *C. perfringens type A* produces a rare form of acute enterotoxemia known as yellow lamb disease, clinically characterised by depression, anemia, icterus and hemoglobinuria (Uzal and Songer, 2008). In cattle, it has been associated with haemorrhagic enteritis, indistinguishable from that caused by *Types B* and *C*. It has also been proposed as a cause of acute

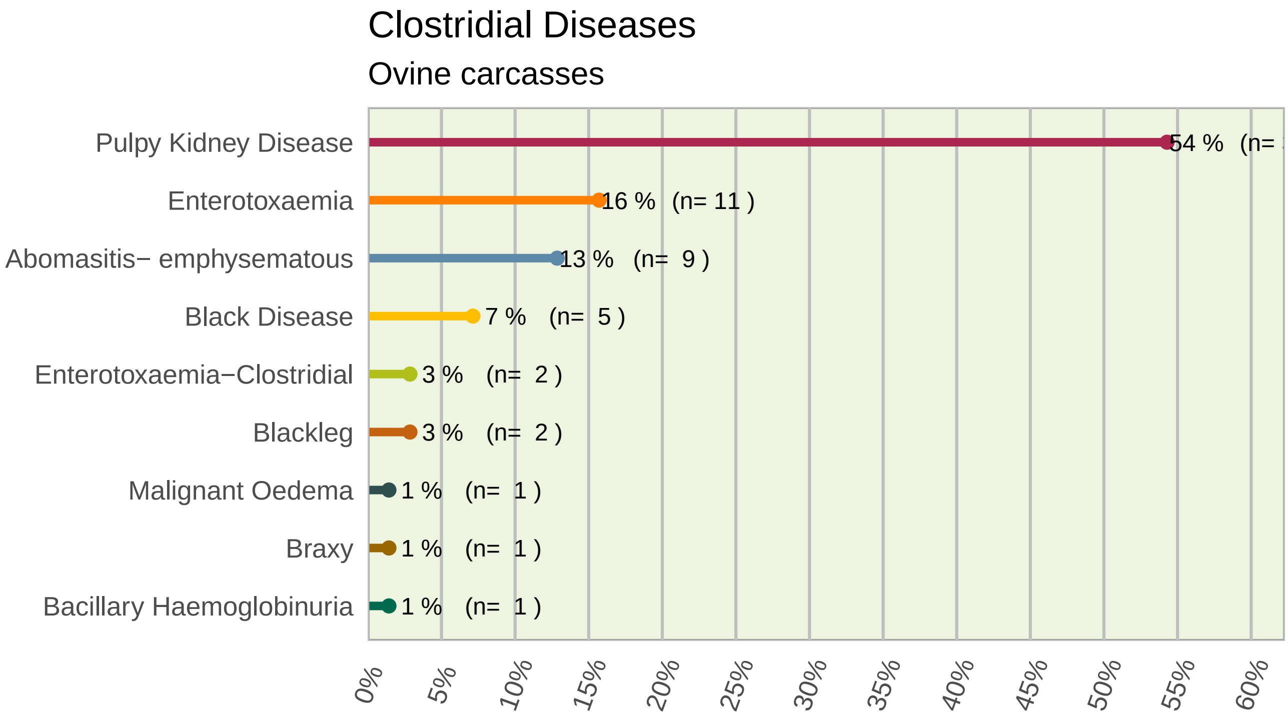

Figure 3.5: Clostridial disease diagnosed in ovine carcasses in 2019 (n= 70) as a percentage of the total number of clostrial diseases.

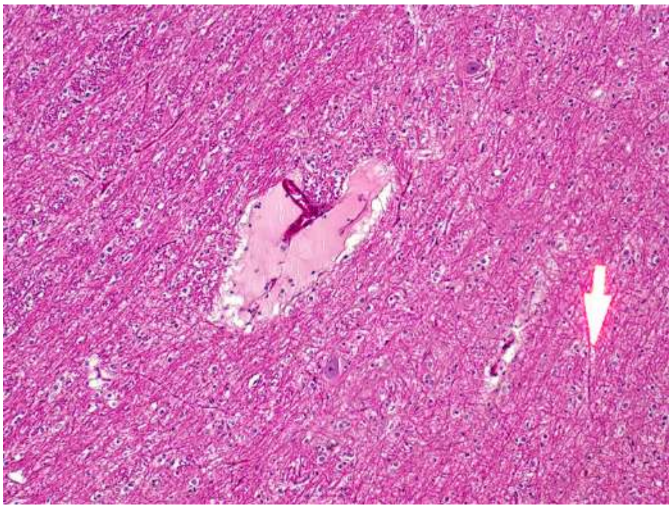

Figure 3.6: Perivascular oedema in the brain associated with vascular compromise due to Epsilon toxin-Pulpy kidney. Photo: Maresa Sheehan.

deaths in calves due to clostridial abomasitis and of jejunal haemorrhage syndrome in adult cows. The latter is a disease entity sporadically diagnosed in the veterinary laboratory service and, consequently, no definitive conclusions on its aetiology can be made (Van Kruiningen et al., 2009; Songer and Miskimins, 2005).

Clostridium Perfringens Type B and *C* can cause sudden death, with or without haemorrhagic enteritis, in lambs and calves, and struck in adult sheep. *Clostridium perfringens Type D* produces epsilon toxin, which causes vascular endothelial damage (Figure 3.6) resulting in typical lesions of *Focal Symmetrical Encephalomalacia* (FSE) and pulpy kidney. In the *post mortem* room, detection of fibrin clots in the fluid of the pericardial sac (Figure 3.7) is a reliable indicator of epsilon toxin involvement.

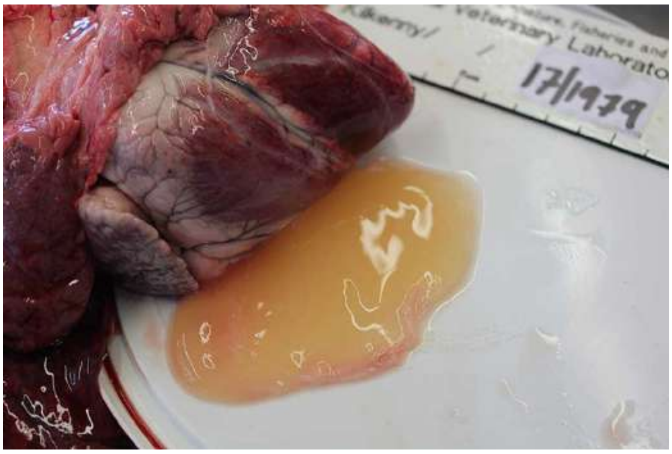

Figure 3.7: Fibrin clot in pericardial sac associated with clostridial enterotoxaemia. Photo: Maresa Sheehan.

Black Disease

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

Braxy

Braxy is caused by *Clostridium septicum* and is typically seen in animals submitted after grazing frozen/snow-covered pasture. It causes necrosis, ulceration, congestion and emphysema of the abomasal wall.

Figure 3.8: Haemorrhagic and emphysematous abomasitis associated with *Clostridium sordellii*. Photo: Maresa Sheehan.

Clostridial abomasitis

Abomasitis caused by *Clostridium sordellii* has a similar *post mortem* presentation. Histopathology will reveal a severe necrotising abomasitis (Figure 3.8) with intra-lesional bacilli. Gross signs and histopathology must concur with isolation/FAT detection of bacteria, as *C. sordellii* and septicum are normal inhabitants of the gut.

Clostridial Vaccination

Vaccination using a multivalent vaccine is recommended for the protection of animals against clostridial diseases. Due to the ubiquitous nature of agents involved, vaccination should be considered an essential component of herd/flock management. However, in a recent study into sheep mortality by regional veterinary laboratories, fifteen flocks that reported vaccinating against clostridial disease recorded a clostridial disease diagnosis. This finding is not wholly unexpected as vaccination of flocks does not infer sterile immunity, nor does detection of a pathogen on *post mortem* necessarily infer causation. Without data on vaccine storage, administration frequency or checks to validate that all submitted animals actually received the vaccine, it is impossible to be more specific about the reasons for these findings. However, it can be speculated that at least some clostridial disease in lambs may be due to insufficient maternal transfer of immunity to newborn lambs or waning of passive immunity in older lambs. Uzal and Songer (2008) and Songer and Miskimins (2005) reported that, although widely used, there can be variations in individual responses or manufacturer's vaccine quality, when determining the response of sheep flocks to multivalent clostridial vaccination (Murray et al., 2019).

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4 Bovine Respiratory Disease

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Bovine respiratory disease (BRD) remained a significant cause of morbidity and mortality in cattle throughout 2019. BRD typically has a multifactorial aetiology and results from complex interactions between pathogens, environmental factors and host factors. Stressors such as transportation, overcrowding, weaning, mixing and inadequate ventilation can negatively affect the defence mechanisms of the host. Numerous infectious agents are associated with BRD. Often an initial pathogen (e.g. viral agents) will alter the defence mechanisms of the animal, allowing the colonisation of the lower respiratory tract by additional agents, e.g. bacteria.

Clinical signs consistent with BRD include pyrexia, depression, anorexia and loss of condition, serous to muco-prurulent ocular and/or nasal discharges, increased respiratory rate and effort with a variable abdominal component, stridor breathing and/or the presence of a cough, abnormal lung sounds ranging from an absence to the presence of crackles and wheezes and increased heart rate.

Following exposure, disease outcome depends on a range of pathogen, host and environmental effects. To cause BRD, pathogens must successfully manipulate or evade host defences, including the resident microflora, mucociliary escalator, antimicrobial peptides and proteins, and innate and adaptive immune responses (Ackermann, Derscheid, and Roth, 2010; Caswell, 2014).

Good management practices, early detection of disease and appropriate treatment of infection are critical to avoid, minimise and control disease outbreaks.

Figure 4.1: Characteristic cranioventral fibrinous bronchopneumonia (arrows) caused by *Mannheimia haemolytica*. Photo: Cosme Sánchez-Miguel.

Bacterial Bovine Respiratory Disease

In 2019, 462 submitted carcasses were diagnosed as BRD on *post mortem* examination. A breakdown of the number of cases, by agent and age group, can be seen in Table 4.1 . Where two or more organisms may have been identified, the final diagnosis represents what would have been considered by the pathologist as the primary cause of disease.

In 2019, in line with other years, bacterial agents were identified as the leading cause of BRD and were identified in 57 *per cent* of submissions (Table 4.2 and Figure 4.3). *Mannheimia haemolytica* (Figure 4.1) and *Pasturella multocida* (Figure 4.2) are *Gram-negative* commensals of the nasopharynx and an important cause of respiratory disease in cattle, sheep and goats. In particular, causing the cattle disease known as shipping fever or bovine pneumonic pasteurellosis/ mannheimiosis. Healthy animals can carry *M. haemolytica* and *P. multocida* as commensals without developing clinical signs. 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

Table 4.1: Number of cases and percentage (%) by age of the general pathogenic groups detected in the BRD cases diagnosed on *post mortem* examination (n= 462).

Organism Group	Calves	Weanlings	Adult Cattle	**Total**
Bacterial	154 (60.9)	62 (50.8)	47 (54.7)	**263 (57.0)**
Viral	29 (11.5)	34 (27.9)	10 (11.6)	**73 (15.8)**
Parasitic	28 (11.1)	19 (15.6)	15 (17.4)	**62 (13.4)**
No agent identified	38 (15.0)	6 (4.9)	14 (16.3)	**58 (12.6)**
Other	3 (1.2)	1 (0.8)	0 (0.0)	**4 (0.9)**
Fungal	1 (0.4)	0 (0.0)	0 (0.0)	**1 (0.2)**

Note:
Calves:1-5 months old,
Weanlings: 6-12 months old
Adult Cattle: over 12 months old

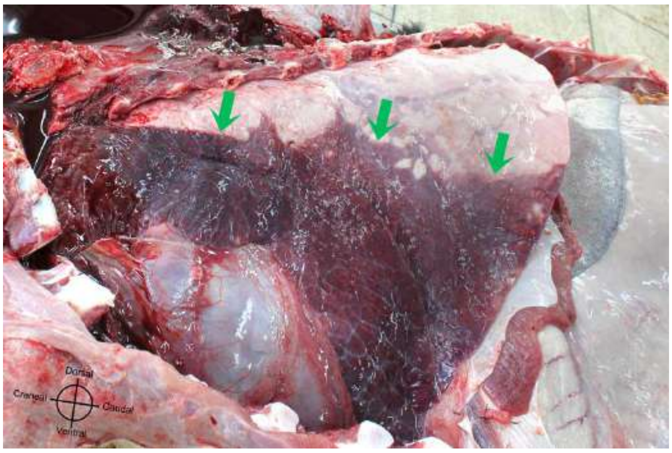

Figure 4.2: Suppurative bronchopneumonia. Cranioventral consolidation (arrows) of the lungs involving 60 *per cent* of the lungs caused by *Pasteurella multocida*. Photo: Cosme Sánchez-Miguel.

lower respiratory tract, invading the tissues of an immunocompromised animal. Transmission can occur also through aerosols or via direct contact with animals with BRD. During 2019, the most frequently detected bacterial pathogens associated with BRD were *P. multocida*, *M. haemolytica M. bovis* and *Bibersteinia trehalosi*, which accounted for nearly half of all agents diagnosed on *post mortem* examination (see Table and Figure). Increased numbers of *P. multocida*, *M. haemolytica* and *M. bovis* were reported compared to the previous year (Figure 4.3). Bacterial pathogens were reported most frequently in the calf age group (0–5 months of age).

Mycoplasma bovis is associated with a characteristic bronchopneumonia and, in severe cases, multifocal pulmonary caseous necrosis; it can also cause arthritis and otitis media. *M. bovis* associated pneumonia can occur at any age. It has been associated with outbreaks in feedlot cattle and sometimes is followed by an outbreak of polyarthritis following the initial respiratory presentation. It can also cause mastitis in dairy animals. *M. bovis* is capable of causing pneumonia on its own or as part of the *BRD complex* where viral infections often cause the initial insult that damages the respiratory mucosa. This can reduce the activity of the cilia and weaken the immune defences of the respiratory tract. The animal's immune status is important in the development of mycoplasma pneumonia; failure of passive transfer is a risk for the increased severity of respiratory disease in young calves.

Similar to the rest of the pneumonia pathogens, nonspecific respiratory defences can be compromised by many risk factors such as viral pathogens, changes in environmental temperature, heat or cold stress, overcrowding, transport, poor air quality and poor nutrition. *M. bovis* is capable of persisting with or without causing clinical disease for variable periods of time making shedding patterns challenging to predict (Carty, 2017).

Histophilus somni (formerly *Haemophilus somnus*) was detected in 10 *per cent* of cases of BRD. *H. somni* a *Gram-negative* member of the *Pasteurellaceae* family is a commensal organism of cattle. 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 the circulation. The CNS form is called thrombotic meningoencephalitis (*TME*), previously called *TEME*. All age groups of animals can be infected with *H. somni*, but six months to 2 years tend to be the most frequent age of animals affected. Clinical signs include depression, high temperatures, dyspnoea, discharge from eyes and nose and some animals can display stiffness.

In 2019, other less commonly encountered bacterial organisms included *Trueperella pyogenes* (formerly *Arcanobacterium pyogenes*) *Bibersteinia trehalosi* and *Salmonella dublin* (Table). *T. pyogenes* is an opportunistic bacterium related to various pyogenic infections in animals. A great variety of clinical manifestations has been attributed to *T. pyogenes* infections in domestic animals, including mastitis, pneumonia and

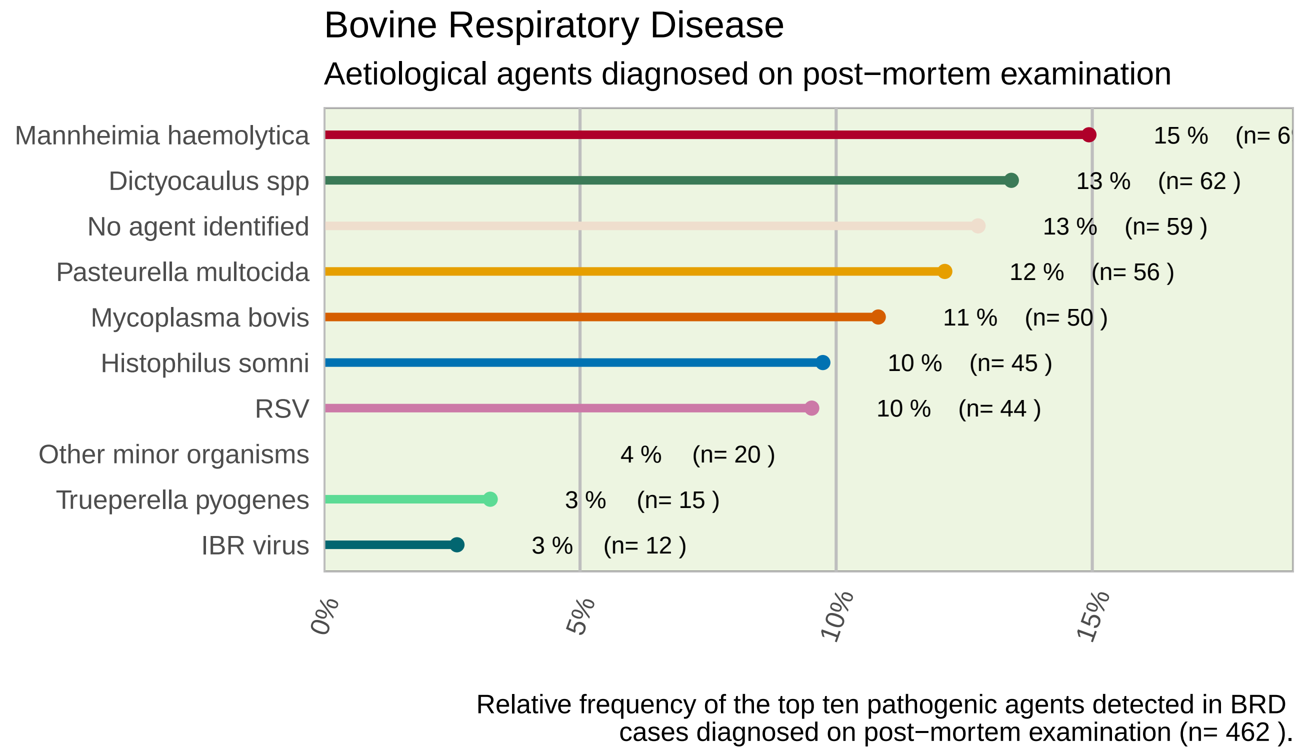

Figure 4.3: Relative frequency of the top ten pathogenic agents detected in BRD cases diagnosed on *post-mortem* examination, (n= 462).

Table 4.2: Number of cases and relative frequency of the top ten pathogenic agents detected in BRD cases diagnosed on *post-mortem* examination (n= 462).

Organism	No. of cases	Percentage
Mannheimia haemolytica	69	14.9
Dictyocaulus spp	62	13.4
No agent identified	59	12.8
Pasteurella multocida	56	12.1
Mycoplasma bovis	50	10.8
Histophilus somni	45	9.7
RSV	44	9.5
Other minor organisms	20	4.3
Trueperella pyogenes	15	3.2
IBR virus	12	2.6

metritis. Usually, it is a secondary pathogen in pneumonia where tissues have been previously acutely damaged by other pathogenic respiratory agents.

Bibersteinia trehalosi (previously known as *Pasteurella trehalosi*) is a commensal organism of upper gastrointestinal tract. It is thought that under stressful conditions the bacteria can multiply rapidly and spread to the lungs and other organs, causing an acute systemic infection. *B. trehalosi* is an important pathogen of sheep, typically associated with acute systemic infections causing death in growing lambs. *B. trehalosi* is comparatively infrequently identified as a pathogen in cattle; however, isolates are typically associated with bronchopneumonia.

Salmonella dublin was detected as the causative pathogen in one calf diagnosed with respiratory disease. Enteric, septicaemic, and reproductive disorders are all possible manifestations of Salmonella infection, with pneumonia being a common manifestation of *Salmonella dublin* infection in calves.

Table 4.3: Count and percentage by age goup of the general specific organisms detected in BRD on *post mortem* examination, (n= 462)

Organism Group	Calves	Weanlings	Adult Cattle
BHV4	0 (0.0)	1 (0.8)	2 (2.3)
Bibersteinia trehalosi	5 (2.0)	3 (2.5)	2 (2.3)
BVD virus	1 (0.4)	0 (0.0)	0 (0.0)
Coronavirus	2 (0.8)	1 (0.8)	2 (2.3)
Dictyocaulus spp	28 (11.1)	19 (15.6)	15 (17.4)
Histophilus somni	31 (12.3)	7 (5.7)	7 (8.1)
IBR virus	2 (0.8)	6 (4.9)	4 (4.7)
Mannheimia haemolytica	36 (14.2)	11 (9.0)	22 (25.6)
Mycobacterium bovis	0 (0.0)	0 (0.0)	1 (1.2)
Mycoplasma bovis	30 (11.9)	14 (11.5)	6 (7.0)
No agent identified	38 (15.0)	6 (4.9)	14 (16.3)
Other	3 (1.2)	1 (0.8)	0 (0.0)
Other minor organisms	9 (3.6)	6 (4.9)	5 (5.8)
Pasteurella multocida	34 (13.4)	19 (15.6)	3 (3.5)
Pasteurella spp	0 (0.0)	2 (1.6)	0 (0.0)
PI3	2 (0.8)	1 (0.8)	0 (0.0)
RSV	21 (8.3)	22 (18.0)	1 (1.2)
Salmonella dublin	1 (0.4)	0 (0.0)	0 (0.0)
Trueperella pyogenes	10 (4.0)	3 (2.5)	2 (2.3)

Note:
Calves:1-5 months old,
Weanlings: 6-12 months old
Adult Cattle: over 12 months old

Viral Bovine Respiratory Disease

Viral agents were implicated as the primary cause of 15.8 *per cent* of BRD cases diagnosed on *post mortem* examination during 2019, with the highest frequency reported in weanling (6–12 months of age) (Table 4.3 and Figure 4.4). A range of viruses are involved in the BRD complex and may lead to the development of broncho-interstitial pneumonia. Often, two or more viruses are present simultaneously. Importantly, viral infection may, in turn, predispose to bacterial infection. Bovine respiratory syncytial virus (BRSV) and bovine herpesvirus-1 (BHV1) were counted among the most frequently identified viral pathogenic agents, found in 10 and 3 *per cent* of all of BRD cases diagnosed on *post mortem* examination, respectively (Table 4.3).

Incidence trend graphs (Figure 4.8) show increased reports of BRSV in the last number of years. BRSV infections are associated with respiratory disease in young animals. Although capable of independently producing primary respiratory disease, it is an important component of the BRD complex affecting cattle younger than one year and occasionally adults. Initial exposure to BRSV can produce acute pneumonia, with subsequent exposure usually resulting in milder disease. The spectrum of clinical signs can range from mild to life-threatening in susceptible cattle. In outbreaks, morbidity tends to be high, and the case-fatality rate can be 0—20 *per cent*. Fever, dyspnoea, anorexia and depression are typical clinical signs. Gross lesions can include caudally diffuse pneumonia with subpleural and interstitial emphysema along with intralobular oedema.

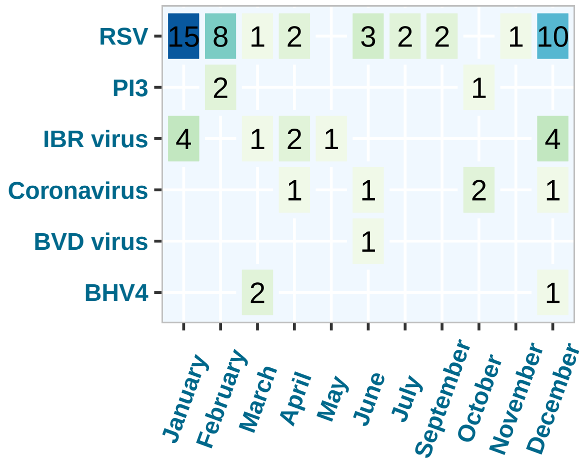

Figure 4.4: Viral respiratory infections in carcasses. Monthly number of viral pneumonia diagnoses by primary microorganism in 2019.

BHV1 can be divided into three subtypes; *subtype 1.1* and *subtype 1.2a* are associated with the development of infectious bovine rhinotraceitis (IBR), *subtype 1.2b* is associated with infectious pustular vulvovaginitis and balano-posthitis (Raaperi, Orro, and Viltrop, 2014). IBR is a highly contagious infection, occurs by inhalation and requires contact between animals spreading quickly through the group. 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.

Figure 4.5: The trachea showing numerous lungworm and large amounts of clear foamy fuild, indicative of pulmonary oedema. Photo: Cosme Sánchez-Miguel.

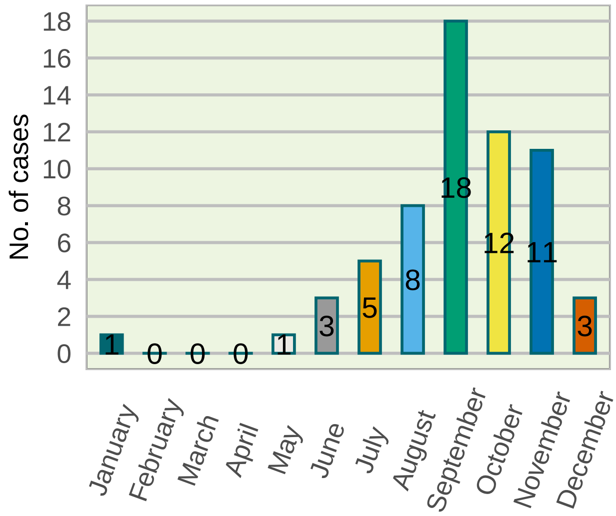

Figure 4.6: Number of diagnoses of parasitic bronchopneumonia by month during 2019 (n= 62).

Parainfluenza 3 (PI3), bovine herpesvirus 4 (BHV4), bovine viral diarrhoea (BVD) and bovine coronavirus (BoCo) virus were found sporadically but in very low numbers (Table 4.3) in cases of BRD in 2019.

Most BHV-4 infections are subclinical. The involvement of BHV-4 in respiratory and genital diseases of cattle, and possibly clinical mastitis is most likely in synergism with other pathogens (**Thiry2000**). It is, therefore challenging to evaluate the impact of the infection in livestock.

Bovine coronavirus (BCoV) is occasionally shed by healthy cattle but is also associated with three recognised clinical syndromes: calf enteritis, adult winter dysentery and bovine respiratory disease. Stress plays a significant role in the dissemination of infection, with stressors such as the comingling or transport of cattle identified as triggers for viral replication and shedding. Respiratory signs include fever, serous discharge, sneezing and coughing. The virus replicates in the nasal and tracheal epithelium.

Parasitic Bovine Respiratory Disease

From 2010 to 2017, the RVLs observed an increase in cases of parasitic pneumonia peaking at 21 *per cent* of diagnosed BRD submissions in 2017 (Figures 4.6 and 4.7). A reduction in case incidence was reported in 2018 (9.4 *per cent*). During 2019, *Dictyocaulus* species were detected in 13.4 *per cent* of BRD submissions (Table). Lungworm infections are associated with cattle that are or have been recently at pasture and tend to occur in the late summer and autumn. Grossly, adult lungworms are usually found in the caudal bronchi (Caswell et al., 2012); however, in heavy infections they can be present in large numbers in all airways Figures 4.5.

Irish summer temperatures are typically optimal for larval development. If the weather is warm and humid, infective larvae may be present on pasture within one week of being passed in faeces. *D. viviparous* is a parasite that can cause disease in relatively low numbers, and dangerous levels of infection can be acquired even after one day of grazing contaminated pasture. Clinical signs can range from an intermittent cough in mildly affected animals to air hunger and severe difficulty breathing.

Life cycle:. Following ingestion of the infective *L3*, larvae exsheath in the abomasum. They migrate via the lymphatics and circulation until they reach lung capillaries where they cross into the alveoli. They then travel up the respiratory tree, until as adults, they are found in the trachea and large bronchi. Egg-laying occurs within 28 days of ingestion. These eggs are coughed up, swallowed, and as they pass through the intestine, they hatch, with L1 larvae excreted in faeces.

During the prepatent phase, when larvae are moving through the respiratory tract, the host immune

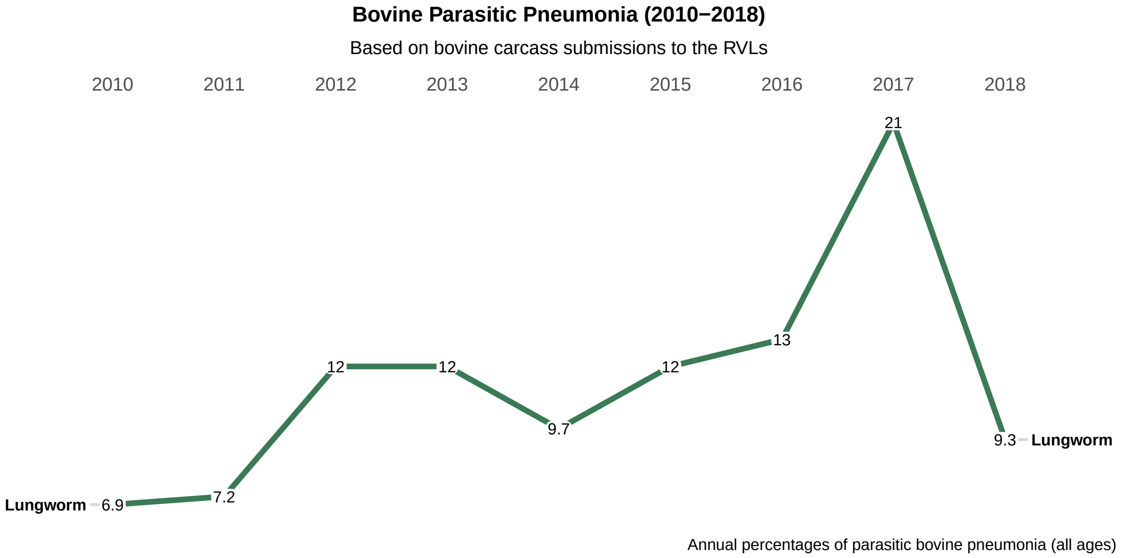

Figure 4.7: Trends in the incidence of parasitic pneumonia (*Dictyocaulus spp.*) in the carcasses (all ages) submitted to the RVLs from 2010 to 2018.

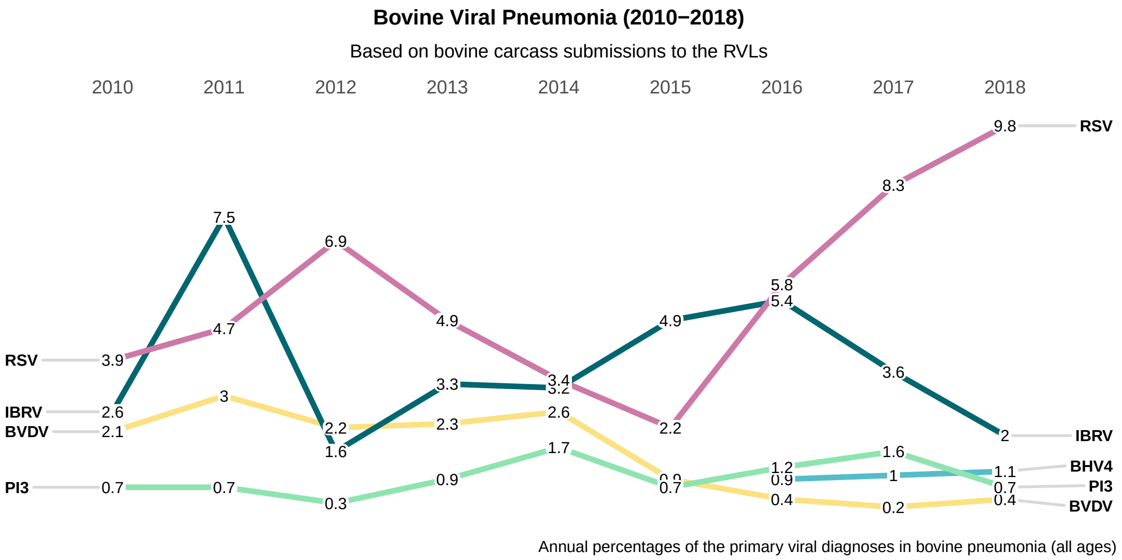

Figure 4.8: Trends in the incidence of viral pneumonia in carcasses (all ages) submitted to the RVLs from 2010 to 2017.

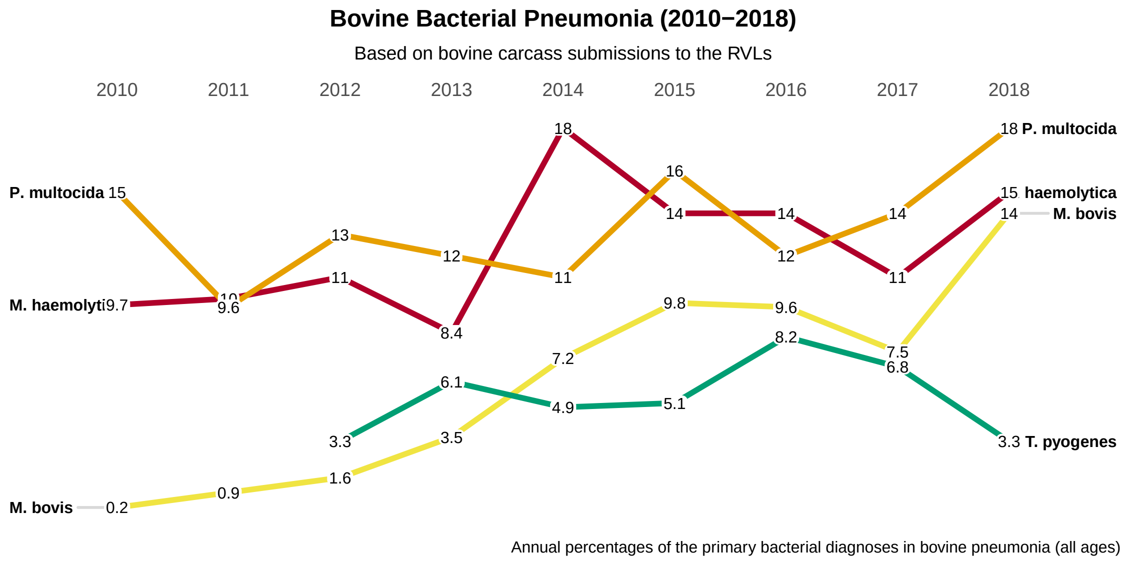

Figure 4.9: Trends in the incidence of bacterial pneumonia in carcasses (all ages) submitted to the RVLs from 2010 to 2017.

response leads to an accumulation of eosinophils, mast cells and other inflammatory cells around the parasites. Following inflammatory cell degranulation and release of inflammatory mediators, there is an accumulation of fluid and further recruitment of inflammatory cells. During the patent phase, this inflammatory response continues. In addition, there can be the aspiration of eggs into the alveoli, causing further inflammation. Infective larvae, although usually short-lived, can overwinter on pasture and can survive in pasture regrowth after silage, allowing sufficient numbers to cause disease in susceptible animals. Additionally, older animals can act as reservoirs, as some larvae may undergo hypobiosis in infected animals over the winter and resume development the following spring.

Dictyocaulosis or *hoose* is typically associated with calves in their first grazing season, as they have no previously acquired immunity. One of the most significant risk factors for disease outbreaks is grazing paddocks contaminated by calves in the previous year. Older animals can also show signs of the disease. This can occur in older animals with little immunity. Typical reasons for lack of immunity includes previous intensive anthelmintic treatment or lack of exposure to the parasite, e.g. grazing animals on newly sown pasture. In older animals, e.g. dairy cows with some level of immunity to adult stages of the parasite, a substantial larval challenge can still lead to severe coughing and milk drop. Lack of continuous exposure to lungworm allows immunity to the larval stages of the parasite to wane. During this *reinfection syndrome*, there is an intense immune and inflammatory response. The intensity of this response is such that animals may develop respiratory distress.

Diagnosis can be confirmed by identifying larvae in faecal samples using the Baermann technique. It is important to remember that clinical signs can occur in the prepatent period, so a negative Baermann doesn't rule out lungworm, this is of particular importance in the case of *reinfection syndrome* Some animals may be found dead without clinical signs being noticed, thus emphasising the importance of PM examination.

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5 Bovine Abortion

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Abortion in ruminants is a significant cause of economic loss. Laboratory diagnosis is central to managing and controlling outbreaks, limiting their spread and preventing zoonotic infections. While many pathogens can cause abortion in cattle, no single diagnostic test can be used to identify all aetiologies. Regional Veterinary Laboratories (RVLs) foetal investigations primarily focus on the most likely aetiologies and those with zoonotic potential. Brucellosis, an important disease, has been eradicated in Ireland following a successful statutory program; however, continuous surveillance remains crucial for both public and animal health considerations.

A threshold of 5 *per cent* foetal mortality rate is recommended when deciding whether to instigate an investigation, although in some instances, a cluster of cases in quick succession may be more critical in deciding to submit aborted material to the laboratory. The aetiology of bovine abortion is broad and diagnostic success rate is low. However, adequate sampling, appropriate laboratory testing, clinical history, vaccination programme and epidemiological information increase the probability of reaching an aetiologic diagnosis.

The aborted foetus, placenta and maternal serum constitute the minimum sampling requirements for an abortion investigation. The inclusion of placenta is critical for diagnosis of some mycotic and bacterial abortions where placenta is the primary tissue affected. Submission of blood samples from aborting cows can provide valuable information by either excluding some organisms, i.e. *Neospora caninum*, or reinforcing diagnosis of other agents, as is the case in *Salmonella* Dublin abortions (Mee and Sanchez-Miguel, 2015).

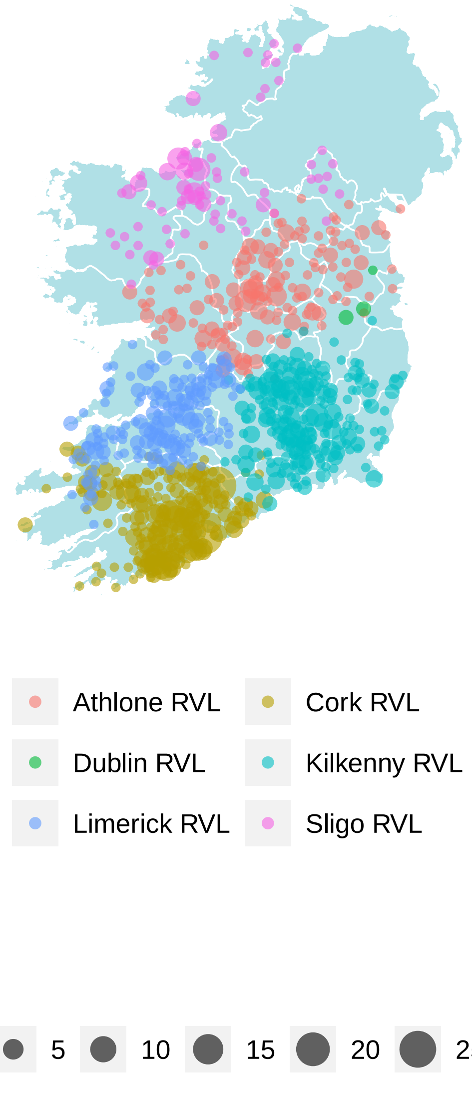

Figure 5.1: Submissions of bovine foetuses and foetal material aggregated and mapped at their DED (District Electoral Division), and colour-coded by Regional Veterinary Laboratory.

In 2019, 1574 bovine foetuses, stillbirths and foetal material (placenta, foetal organs, abomasal contents, etc.) were tested for brucellosis and routine foetal cultures in RVLs. This section presents some of the most common aetiologies diagnosed in RVLs. Bacterial, fungal and protozoal agents are the most frequent abortifacients detected; they can be divided into primary and secondary pathogens. Primary pathogens can cross an intact placenta and cause placentitis and fetopathy. Secondary pathogens are opportunistic organisms that count on maternal immunosuppression or placental damage to cause abortion.

In routine RVL foetal culture workflows, most bacteria associated with abortion in cattle can be isolated by aerobic culture from abomasal contents, placenta or foetal organs. Anaerobic culture is not usually carried out in this workflow, therefore, anaerobic bacteria may be underreported as abortifacients. Similarly, organisms that required specific media culture, e.g. *Mycoplasma spp*, *Ureaplasma* or *Chlamydophila spp*, may also be underreported.

Primary Pathogens

Agents such as *Brucella abortus*, *Salmonella* Dublin, *Leptospira harjo*, *Listeria monocytogenes*, *Aspergillus fumigatus*, *Neospora caninum*, BVDv, BHV-1, etc., are capable of crossing intact placentas causing placentitis, fetopathy and/or luteal regression; they are classified as primary abortifacients.

> Some abortifacients are zoonotic and can pose a serious threat to the health of veterinary practitioners and farmers. It is advisable to always take precautions when handling foetuses or aborted material.

Salmonella *Dublin abortion.* Salmonella abortions in Ireland are predominantly associated with *Salmonella* Dublin serotype (*Salmonella enterica subsp. enterica* serovar Dublin). In 2019, 4.4 *per cent* of bovine abortions were attributed to *Salmonella* Dublin (Table 5.1). This type of abortion usually occurs in the second half of pregnancy with bacterial translocation from the intestine to the placenta. Typically, aborted foetuses are autolysed, occasionally emphysematous, and smell of *rotten eggs* due to production of hydrogen sulphide. A diagnosis of *Salmonella* Dublin can also be reached with maternal serology.

Table 5.1: Number of *Salmonella* Dublin isolates in foetal material in 2019 (n= 1587).

Result	No. of Cases	Percentage
Negative	1516	95.5
Positive	71	4.5

Table 5.2: Monthly count and percentage of Salmonella culture results in foetal material during 2019 (n= 1587).

Month	Total	Positive	Percentage
Jan	428	14	3
Feb	214	2	1
Mar	124	0	0
Apr	43	0	0
May	28	0	0
Jun	15	0	0
Jul	28	1	4
Aug	50	3	6
Sep	44	0	0
Oct	90	12	13
Nov	211	26	12
Dec	312	13	4

In non-vaccinated aborting cows a single blood sample can be up to 85 *per cent* accurate in predicting a *S.* Dublin foetal culture positive result (Sánchez-Miguel et al., 2018).

Salmonella Dublin abortions have a well documented seasonal distribution in Ireland characterised by a steady increase towards October/November, as shown in Table 5.2 and Figure 5.2; this seasonal distribution emphasises the importance of choosing the right time to vaccinate for *Salmonella* Dublin (Crilly, 2004).

During the last ten years, the incidence of *S.* Dublin abortion has decreased steadily to historical low levels (Table 5.3 and Figure 5.3). This decrease has also been coupled with a reduction in incidence in neonatal enteritis (see Chapter 6 on Bovine Neonetal Enteritis). Age is a risk factor for salmonellosis and neonatal calves between two weeks to four weeks and calves up to three months are more susceptible to the infection (Nielsen, 2013). In both abortion and neonatal enteritis, several factors may come into play, among them vaccination and antibiotic treatment.

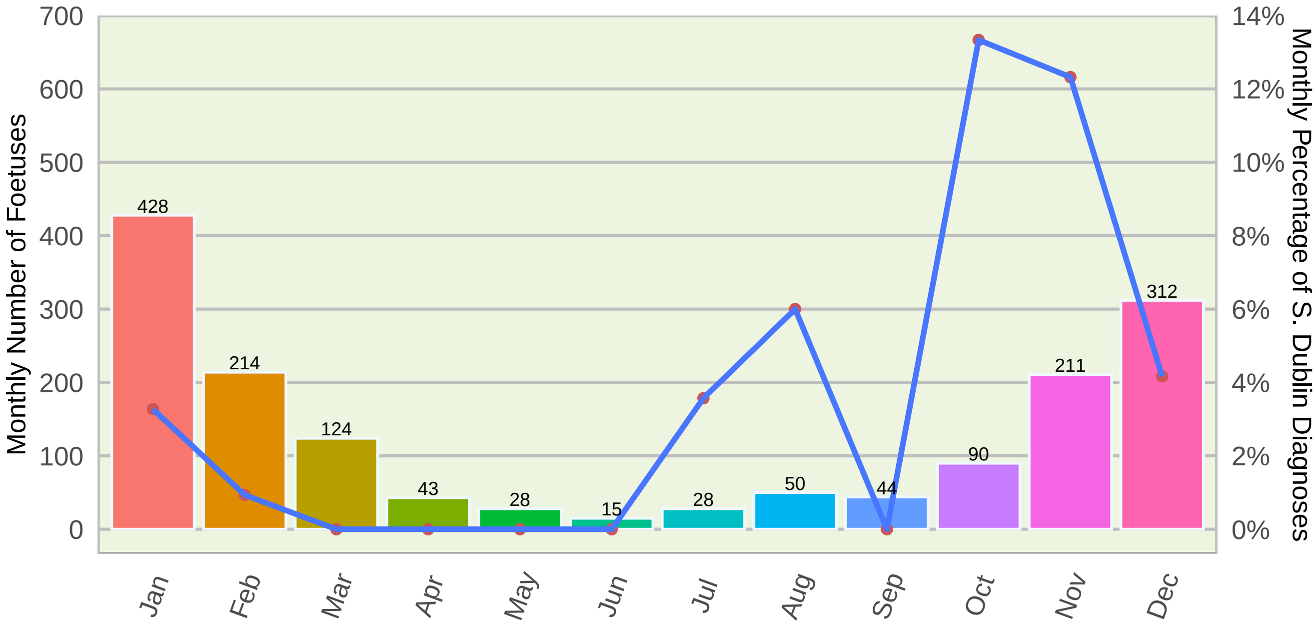

Figure 5.2: Annual distribution of foetal submissions (bars) and *Salmonella* Dublin isolates (line plot) from foetal bacterial cultures as a percentage of monthly bovine submission (n= 1587).

Table 5.3: Annual incidence of *Salmonella* Dublin in bovine foetal submissions (2010–2019)

Year	Submissions	Positive	Percentage
2010	2605	372	14.0
2011	2823	224	7.9
2012	3086	125	4.1
2013	2739	166	6.1
2014	2270	136	6.0
2015	2728	115	4.2
2016	2644	114	4.3
2017	2509	103	4.1
2018	1968	73	3.7
2019	1587	70	4.4

However, it can be inferred that the decrease in the number of BVD persistently infected (*PI*) animals in the Irish National Herd as a result of the BVD National Eradication Programme that has been in place in Ireland since 2013 (see Chapter 16 regarding the BVD Eradication Programme), may be a critical factor in the current low levels of *S.* Dublin incidence. Concomitant infection with the BVD virus leads to immunosuppression. It also makes the host more susceptible to becoming infected with, or prevents the host from clearing, *S.* Dublin infection (Nielsen, 2013).

One *Salmonella spp.* serotype other than *S.* Dublin was also isolated in a foetus; it was identified as *Salmonella Typhimurium* (Figure 5.5).

Listerial abortion. *Listeria monocytogenes* and possibly *L. ivanovii* may cause sporadic abortions in all stages of pregnancy. *Listeria spp.* are widespread in the environment; clinical disease is associated with ingestion of poorly fermented silage. Following ingestion, *Listeria monocytogenes* proliferates firstly in the placenta, then in the foetal liver causing septicaemia and, lastly, death (Figure 5.4).

The proportion of diagnosed abortions attributed to *L. monocytogenes* infection is usually low, amounting to 46 (2.9 *per cent*) of the total abortions during 2019 (Table 5.4). Most listerial abortions have a sporadic occurrence and are rarely associated with listerial encephalitis. In abortions caused by Listeria species, a markedly autolysed foetus is usually aborted in the third trimester.

Leptospiral abortion. *Leptospira hardjo* has adapted to cattle, which serve as a maintenance host. *Leptospira spp.* is labile and difficult to culture, hence diagnosis normally relies on detection of antibody titres by foetal serology or, occasionally, on Fluorescent Antibody Test (FAT) on foetal kidney smears using multivalent antisera or PCR for pathogenic

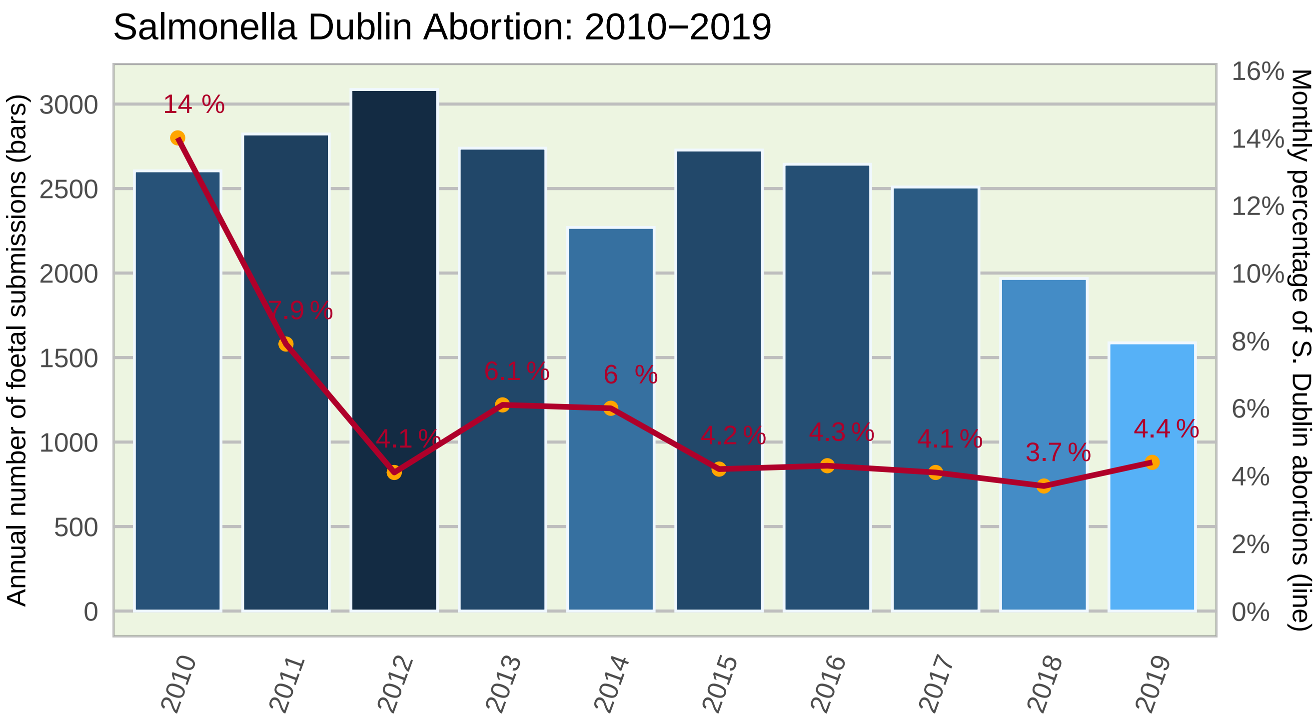

Figure 5.3: *Salmonella* Dublin abortion as annual incidence (line plot) versus the total number of annual foetal submissions (bar plot)

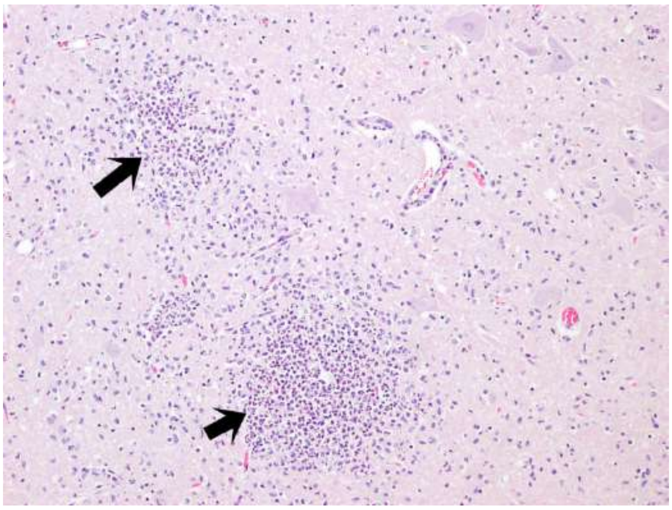

Figure 5.4: Microabscesses (arrows) observed in neurophil of the CNS as a result of listeriosis . Photo: Cosme Sánchez-Miguel.

Leptospira spp.. Leptospirosis is likely to be underdiagnosed as a cause of abortion in cattle due to poor diagnostic tests available at present. This may explain the variability in percentages of diagnosed cases from year to year and laboratory to laboratory. Abortion is frequently the only clinical sign observed in a herd, except in lactating cattle where signs of acute leptospirosis may include agalactia, mastitis, fever, haemolytic anaemia, haemoglobinuria and icterus.

Table 5.4: Frequency of detection of other primary abortion pathogens in foetal culture during 2019 (n= 1587).

Organism	No. of cases	Percentage
Trueperella pyogenes	118	7.5
Bacillus licheniformis	70	4.4
Listeria moncytogenes	46	2.9
Aspergillus spp	21	1.3

Minor Primary Abortifacients (sporadic abortions). Some bacteria can cause maternal bacteraemia, reach the gravid uterus and foetus and progress to causing sporadic abortion. Amongst them, *Truperella pyogenes*, with 118 (7.5 *per cent*) and *Bacillus licheniformis* with 70 cases (4.4 *per cent*) are listed as the most common agents of sporadic abotion.

Protozoal abortion

Since its identification in the 80's, neosporosis, caused by the protozoan *Neospora caninum*, has emerged as one of the most common infectious causes of abortion in cattle worldwide. Acutely infected dogs shed *N. caninum* oocysts in faeces, contaminating the environment. Cattle may become infected by ingesting oocysts (from infected aborted material or the environment) or by acquiring the parasite in utero. The parasite invades and multiplies within placental cells causing impairment of oxygen and nutrient transfer from mother to foetus, leading to foetal death. *N. caninum* may also reach foetal organs causing a non-suppurative inflammatory reaction; foetal brain, followed by myocardium, are the preferred sites to detect characteristic lesions (Figure 5.5).

In 2019, *N. caninum* was detected in 65 foetuses, either by foetal serology, histological examination or by both methods. This figure represents a similar proportion of cases in 2019 compared to 2018, 4.1 *per cent* and 4.0 *per cent* of the total number of foetuses respectively; however, it is essential to bear in mind that not every submitted foetus is tested for *N. caninum*.

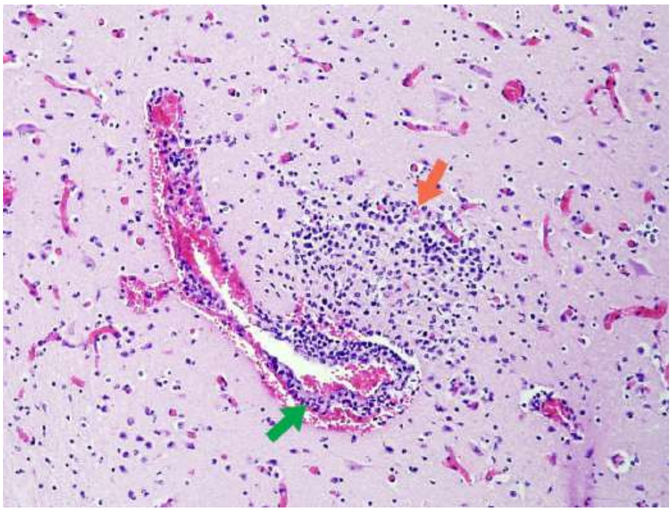

Figure 5.5: Protozoal encephalitis: non-suppurative encephalitis (orange arrow), mild vasculitis (green arrow) and congestion, associated with *Neospora caninum* in the brain of a bovine foetus. Photo: Cosme Sánchez-Miguel.

Most *N. caninum* abortions occur in mid to late gestation, but not all cows that are infected with *N. caninum* will abort. Nonetheless, infected cows are more likely to abort than uninfected. *N. caninum* abortions are more frequently seen in heifers or recently infected cows. This type of abortion follows different patterns that are dependent on level of exposure to the parasite and the predominant route of transmission within the individual herd. These patterns are:

Epidemic abortions (abortion storms): due to primary infection of naive cows that are exposed to a single source of infection such as ingestion of aborted membranes, feed or water contaminated with *N. caninum* oocysts.

Endemic abortions : chronic abortion episodes spanning several years and found within infected family lines as a result of recurrent transplacental (vertical) transmission.

Sporadic abortions : occasional occurrence of abortions within a herd

In the RVLs, diagnosis of bovine neosporosis at *post-mortem* is based on presence of lesions consistent with protozoal damage in infected tissues (brain, myocardium and placenta) and detection of specific antibodies in the dam or foetal blood or fluids. Detection of *N. caninum* by PCR or immunohistochemistry in tissues is not undertaken in routine foetal submissions and is only carried out occasionally in herd investigations. Diagnosis of *N. caninum* abortions poses a two-fold challenge: tissue lesions, though very distinctive (necrotic foci and mononuclear cell infiltrates, (Figure 5.5) are only suggestive of protozoal abortion and foetal serology depends on quality of the sample (absence of autolysis) and age of the foetus (mature enough to have produced antibodies). In addition to that, a serology positive *N. caninum* test result should be viewed with caution as calves are not always adversely affected by the protozoa and abortion could have been caused by a different abortifacient.

Control options for Neospora infection are based on biosecurity, identification of infected animals and appropriate management decisions. An integrated control programme should include measures aimed at minimising chances of horizontal (ingestion of infective oocysts) and vertical (from mother to foetus) transmission thus interrupting the parasite life-cycle.

Table 5.5: Combined frequency of detection of selected secondary abortion agents on routine foetal culture.

Organism	No of Cases
Coliforms	211
Streptococcus spp	39
Staph. spp	13
Pseudomonas spp	11
Yeasts and Fungi	9
Bacillus spp	8
Pasteurella multocida	3
Listeria spp	2
Mannheimia haemolytica	2
Histophilus somnus	1
*Salmonella spp (other than S. dublin)**	1

* Salmonella typhimurium

Prevent Neospora transmission by enhancing biosecurity

Dispose of aborted materials (foetuses and placenta) promptly and safely, as tissues infected by Neospora and other abortificient agents pose a high risk of infection.

Prevent dogs from having access to cattle areas, especially calving areas.

Prevent dogs from having access to cattle feed, pastures, fields for production of cattle forage and water sources.

Control rodents on the farm. Rodents may act as intermediate hosts for Neospora and they may pose a risk if ingested by dogs.

Secondary Pathogens

These organisms form a diverse group of bacteria associated with opportunistic infections of placenta and foetus; they are incapable of transplacental infection unless there is a damage to the placenta or the dam is immunocompromised. Since their presence is widespread in the environment, they can potentially cause maternal bacteraemia, reach the gravid uterus and trigger an opportunistic abortion. Table 5.5 summarises the number of cases in 2018, amongst them *Streptococcus spp.* (39 cases isolated), *Staphylococcus spp.* (13), *Pseudomonas spp.* (11), *Bacillus spp* (8), *Pasteurella multocida* (3), *Mannheimia haemolytica* (2) and *Histophilus somnus* (1).

Their presence in tissues of aborted foetuses should not be considered as definitive evidence of cause of abortion. For secondary pathogens to be regarded as the cause of abortion, they must be isolated from foetal material, have produced representative lesions and primary pathogens must have been excluded. Secondary pathogens usually cause sporadic abortions; multiple abortions can be a consequence of maternal health issues that facilitate haematogenous infections.

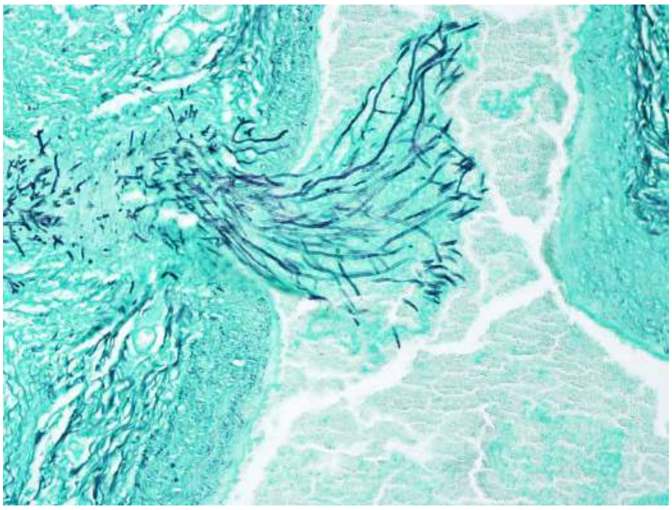

Figure 5.6: Angioinvasive *Aspergillus fumigatus* invading through the endothelial cells of a blood vessel. Grocott's methenamine silver stain. Photo: Cosme Sánchez-Miguel.

Mycotic abortions

Mycotic abortions usually occur in the third trimester of pregnancy. *Aspergillus spp.* (Figure 5.6) and *Mucor spp.* are the most common organisms isolated (9 cases in 2019). Clinical signs in dams, apart from placental retention, are infrequently observed. Diagnosis of fungal abortion is based on demonstration of fungi and presence of consistent gross and histopathological lesions. Grossly visible placental lesions include a leathery, diffusely thickened intercotyledonary membrane with necrotic haemorrhagic infarcts in cotyledons. Foetal lesions may be absent and autolysis minimal. Occasionally, locally extensive circular skin lesions may be present on foetuses. Microscopically, there is a severe suppurative placental vasculitis with intralesional fungi (Schlafer and

Miller, 2007). Inflammatory lesions associated with fungal invasion may be present in foetal respiratory and digestive systems. Direct identification of fungi using a potassium hydroxide wet-mount examination of lesion scrapings may facilitate diagnosis.

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6 Bovine Neonatal Enteritis

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The most frequently diagnosed cause of mortality in calves less than one month old in the Republic of Ireland is typically neonatal enteritis. It is generally caused by the interaction of one or more infectious enteric pathogens and several predisposing factors as stated in the text box on page 133 (Cho and Yoon, 2014).

Neonatal enteritis generally presents clinically as watery diarrhoea (occasionally containing blood) usually leading to dehydration and, in severe cases, progressing to profound weakness and death. A series of tests are performed on faecal samples collected at *post mortem* from affected calf carcases or submitted by veterinary practitioners from clinical cases as a means of identifying the enteric pathogens involved in cases of neonatal calf diarrhoea.

Approximately 1800 such faecal samples were examined in the DAFM laboratories in 2019 . This section shows the most common infectious agents diagnosed in calves less than one-month-old. The relative frequency of identification of pathogens in calf faecal samples in the Republic of Ireland in 2019 is plotted in Table 6.1 and Figure 6.4. As in previous years, Rotavirus and *Cryptosporidium spp.* were the most common pathogens identified while *E coli* K99, coronavirus and *Salmonella* Dublin were recorded relatively infrequently.

Table 6.1: Number of tests and relative frequency of enteropathogenic agents identified in faecal samples of calves up to one month of age in 2019.

Organism	No. of Tests	Positive	Percentage
Rotavirus	1260	410	32.5
Cryptosporidia	1370	205	15.0
Campylobacter Jejuni	1164	136	11.7
Giardia	820	36	4.4
Salmonella Dublin	1253	21	1.7
E.Coli K99	969	14	1.4
Coronavirus	1263	7	0.6

Factors involved in the occurrence of neonatal calf diarrhoea

Peripartum calving management: poor cow nutrition, dystocia.

Calf immunity: delayed and insufficient consumption of high-quality colostrum.

Environmental stress: Harsh weather and absence of dry, draft-free shelter, hypothermia or hyperthermia.

Contamination: pathogen load into the environment where caves are raised, mixing animals of different ages.

Rotavirus enteritis. The most frequently identified pathogen in calf faecal samples in the Republic of Ireland in recent years has consistently been rotavirus (32.54 *per cent*), its frequency ranging from 30–34 *per cent* between 2010 and 2019 (Figure **??**). Calves are most susceptible to rotavirus enteritis up to three weeks of age. Adult animals are the primary source of rotavirus infection for neonatal calves. The severity of clinical signs depends on several factors, including the age of the animal (Figure 6.3) and the immune status of the calf, the latter depends on the absorption of colostral antibodies immediately after birth. Rotavirus targets the upper small intestine causing shortening and fusion of the villi, this results

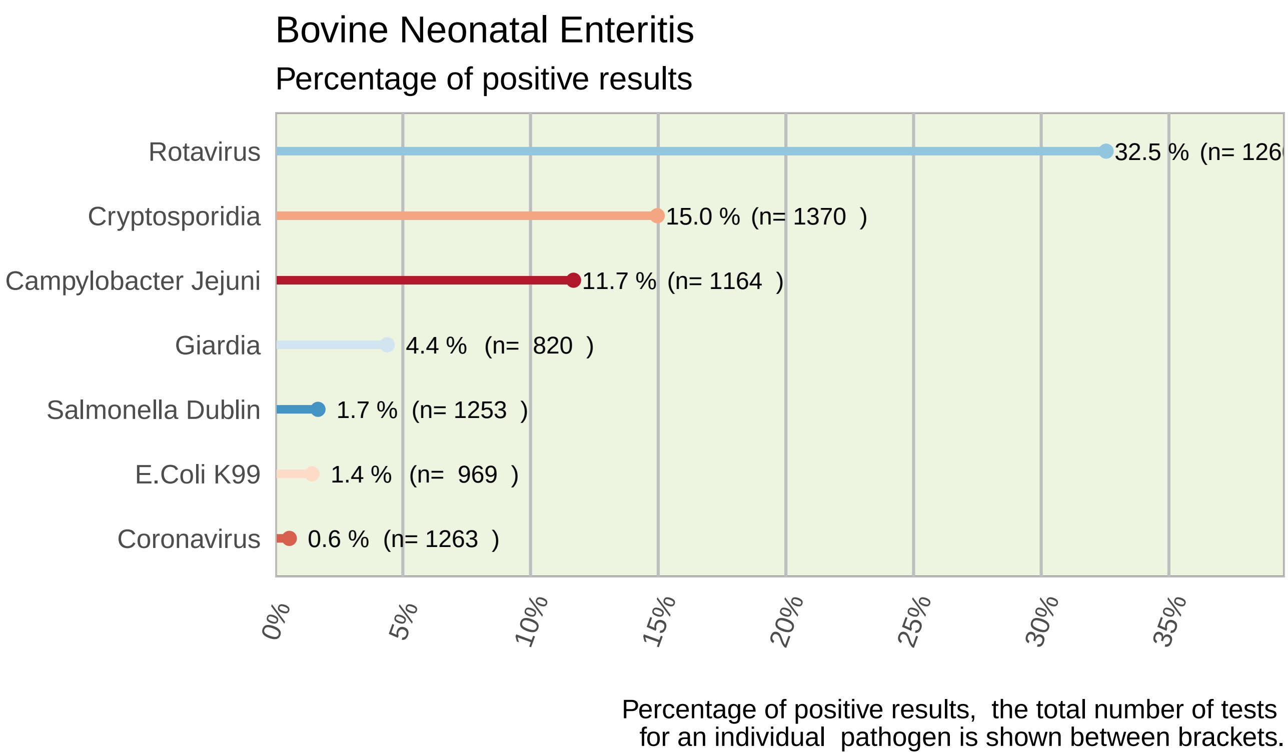

Figure 6.1: Bovine Neonatal Enteritis. Relative frequency of enteropathogenic agents identified in calf faecal samples tested in 2019.

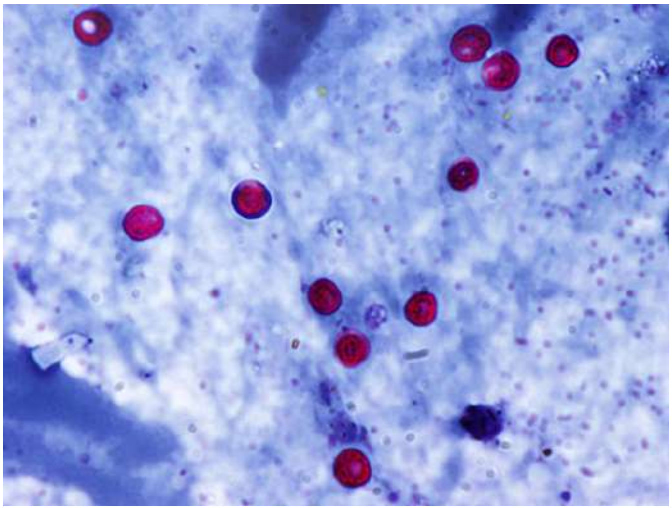

Figure 6.2: Cryptosporidial oocysts in a faecal smear, modified Ziehl-Neelsen (ZN) stain. Photo: Cosme Sanchez-Miguel.

in malabsorption and leads to diarrhoea. Death may ensue due to acidosis, dehydration and starvation

Cryptosporidiosis. *Cryptosporidium parvum* is a small single-cell parasite which causes damage to epithelial cells of the lower small intestine resulting in mild to severe enteritis, typically affecting calves during their second week of life. It is highly infectious as affected calves excrete large numbers of oocysts which are highly resistant to most of the commonly used disinfectants on Irish farms and it can survive in the environment up to several months under favourable conditions. Transmission between animals is by the faecal-oral route, often via a contaminated environment. Control of the parasite is best achieved by a strict maintenance of good calf housing hygiene practices and avoiding mixing animals of different ages. Effective disinfectants include the amine-based Keno™Cox (CIDLInes N.V., Belgium), p-chloro-m-cresol (Neopredisan (Vertriab GMBH, Germany)), hydrogen peroxide with peracetic acid (Ox-Virin, (Ox-Oxcta, Spain)), 3% hydrogen peroxide. The prophylactic use of drugs such as halofuginone lactate may also be useful. In addition to causing disease in animals, *Cryptosporidium spp.* has the potential to cause zoonotic disease, especially in immunocompromised humans; therefore, farmworkers should take appropriate hygiene precautions when handling diarrhoeic calves.

Coronavirus enteritis. Bovine coronavirus (BoCoV) belongs to the genus Betacoronavirus in the family Coronaviridae, which also includes the closely related human strains that cause respiratory infections including the common cold as well as SARS, MERS and COVID19. In addition to being an enteric pathogen, BoCoV can occasionally induce respiratory tract infections in calves. Only one serotype of BoCoV is recognised, but there is likely some antigenic variability. Calves are most susceptible to coronavirus enteritis between one and three weeks of age. Coronavirus preferentially infects enterocytes in the lower small intestines and colon, typically resulting in blunting and fusion of villi and mild enterocolitis.

Escherichia coli *K99*. *E. coli* K99 is an enterotoxigenic *E. coli* (ETEC) and an important cause of neonatal enteritis in very young calves, typically less than three days of age. These strains of *E. coli* preferentially colonise the lower small intestine and produce toxins that cause secretion of water and electrolytes from the intestinal mucosa, resulting in rapid dehydration. The percentage prevalence of *E. coli* K99 would likely be higher if testing for this enteric pathogen was restricted to animals younger than one week old.

Salmonella *Dublin*. *Salmonella enterica subsp. enterica* serovar Dublin (*Salmonella* Dublin) is the most common Salmonella serotype that affects calves in the Republic of Ireland and was isolated in 1.7 *per cent* of neonatal faecal samples cultured in 2019. The relative frequency of detection of *Salmonella* Dublin from such cases has fallen over the past decade from 3.4 *per cent* in 2011 to 1.7 *per cent* in 2019 (Figure 6.4). It is not clear why this has occurred. *Salmonella* Dublin infection has a number of clinical presentations in neonatal calves, including acute enteritis, osteomyelitis and septicaemia/systemic disease. Salmonella enteritis is characterised by watery mucoid diarrhoea with the presence of fibrin and blood. While Salmonella can cause diarrhoea in both adult cattle and calves, infection is more common and often more severe in calves from 10 days to 3 months old. In addition, calves can shed the organism for variable periods of time and/or intermittently depending on the degree of infection (carrier state).

Campylobacter jejuni. *Campylobacter jejuni* was found in almost 11.68 *per cent* of neonatal calf faecal samples tested in 2019. It is not considered pathogenic for cattle. However, it is routinely surveyed in neonatal faecal samples because it is a zoonosis and a major cause of gastroenteritis in humans. Therefore, appropriate hygiene precautions should be taken by personnel handling stock.

Giardia spp.. This organism is one of the most prevalent and widespread intestinal protozoan parasites in humans and several vertebrate animal species worldwide. The clinical significance of *Giardia spp.* as an enteric pathogen in calves is questionable. While eight strains are recognized, only two strains are thought to be transferable to humans (A&B) and thus potentially zoonotic (Thompson, 2004). Appropriate precautions should be taken by calf handlers.

Basic principles for the prevention and control of neonatal enteritis

- Enhancing host immunity
- Reducing the load of enteric pathogens in the environment.

Good colostrum management is the single most important factor in improving a calf's immunity and resistance to infection. An average 40 *Kg* calf requires 3 *litres* of colostrum within 2–4 *hours* of birth. Thereafter, appropriate nutrition of young calves, including diarrhoeic calves, is essential.

Further information regarding the appropriate prevention and care of the diarrhoeic calf can be obtained from the Animal Health Ireland-CalfCare website. High stocking densities should be avoided, and calves should be grouped according bedding to age on clean, dry. Good hygiene practices including appropriate disinfection between batches and rapid isolation and treatment of sick calves is essential. Colostral and milk antibodies against certain bacterial and viral enteric agents can be enhanced by vaccination of the cows during the dry period (passive immunisation).

***Coccidiosis*.** Coccidiosis is caused by protozoan parasites of the genus *Eimeria spp.* Only three (*Eimeria bovis*, *Eimeria alabamensis* and *Eimeria zuernii*) out of twelve bovine coocidia species are pathogenic. Some of the non-pathogenic or weakly pathogenic species are capable of producing massive numbers of oocysts; therefore faecal coccidial oocyst counts need to be interpreted in conjunction with the history and clinical

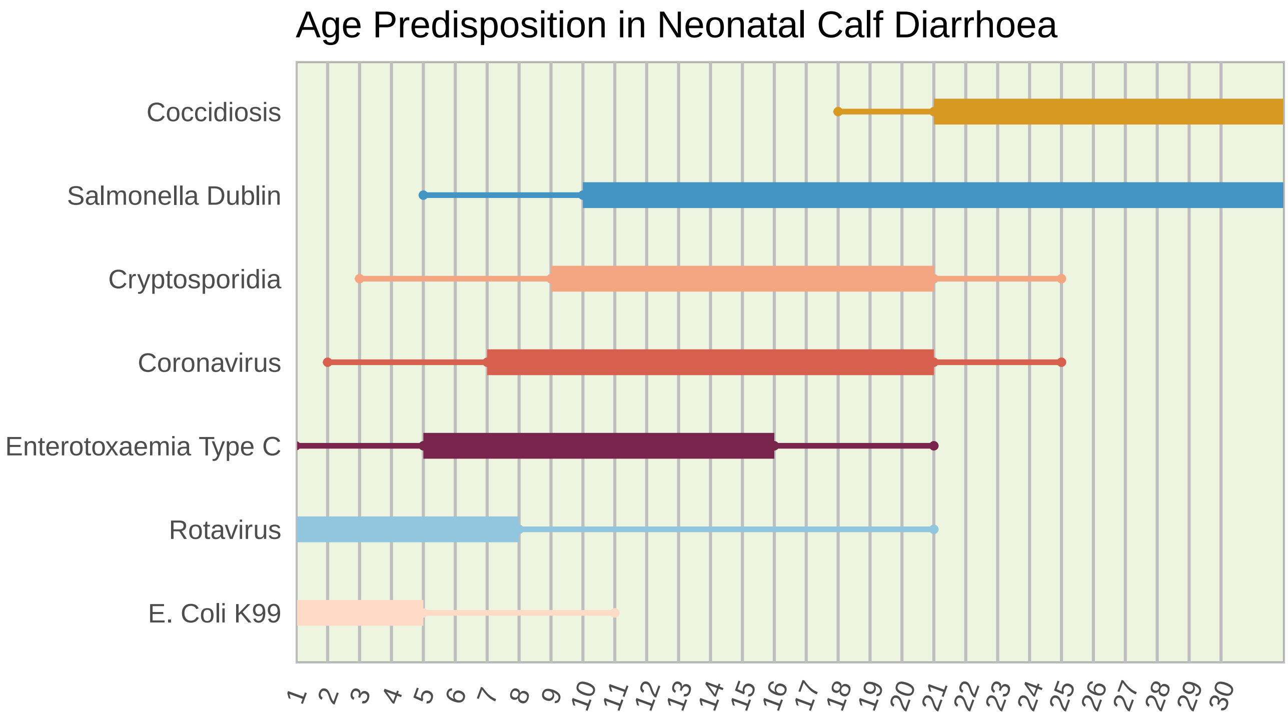

Figure 6.3: Agent and age predisposition in neonatal calf diarrhoea, the thick area represents the most likely period of disease

Table 6.2: The number of tests and relative frequency of coccidiosis in faecal samples of calves up to around one month of age in 2019.

No. of Tests	Positive	Percentage
566	96	17

findings. Coccidia damage the epithelial cell lining of the gut, causing diarrhoea and possibly dysentery and can be accompanied by tenesmus and rectal prolapse.

Coccidiosis is particularly common in calves between three weeks and six months of age, but it can occur in older animals also. Calves become infected when placed in environments contaminated by older cattle or other infected calves, e.g. indoors on wet bedding, outdoors around drinking and feeding troughs. Poor hygiene, high stocking density and poor health and nutrition will all contribute to a calf becoming infected. The frequency of detection of coccidiosis in samples from neonatal calves less than one-month-old in the Republic of Ireland in 2019 was 17 *per cent* (Table 6.2).

Often, peak coccidia oocyst-shedding does not correlate with the onset of diarrhoea in calves. Detection of *Coccidia spp.* in faecal samples is best facilitated by sampling pre-clinical comrade animals as well as those showing clinical signs.

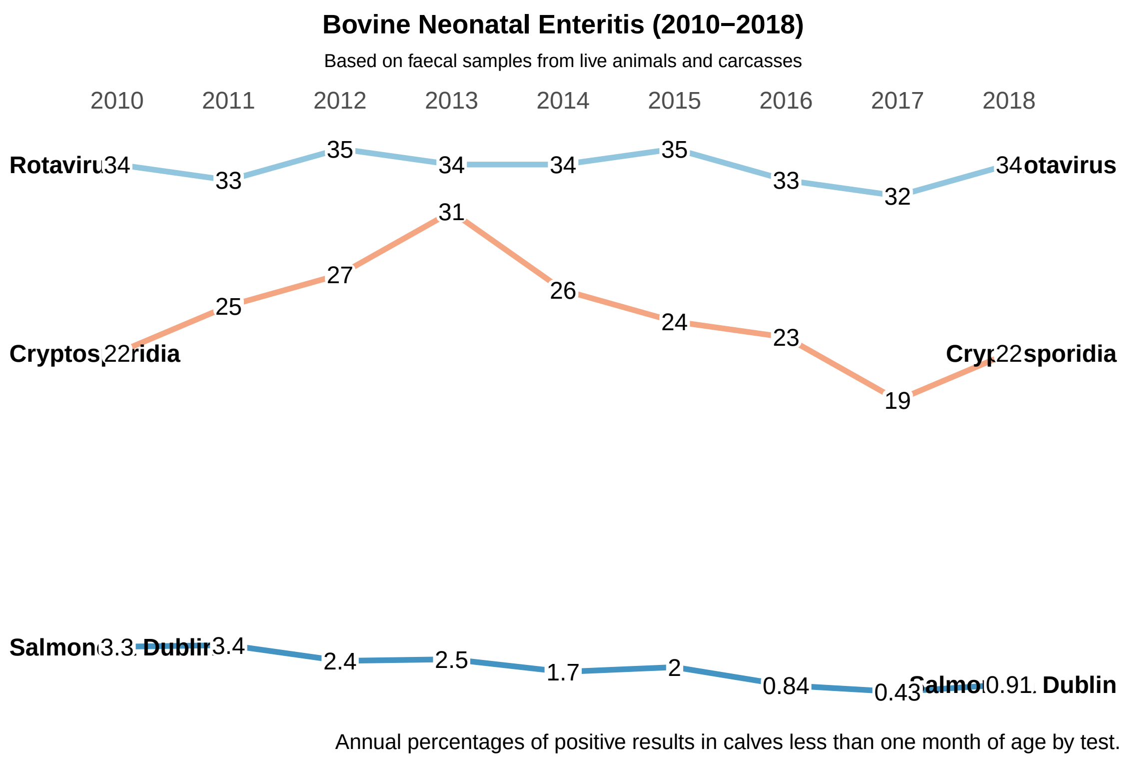

Figure 6.4: Trends in the incidence of Rotavirus, Cryptoporidia and *Salmonella* Dublin enteritis in calves less than one month.

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7 Zinc Sulphate Turbidity

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The Zinc Sulphate Turbidity (ZST) test is an indirect measurement of passive transfer of immunoglobulins via colostrum from the dam to the neonate. The adequate delivery of good quality colostrum is an essential part of calf management, as the transfer of immunity provides protection to neonates from common infectious diseases that contribute to illness and death.

ZST test and the importance of colostrum

Failure of passive transfer (FPT) is best assessed on a herd basis. It is recommended to sample several healthy calves or lambs, up to twelve animals less than a week old. Blood sampling should not be done on the first day of life as peak circulating immunoglobulin is achieved 36 hours after colostrum ingestion.

The ZST test used in the DAFM laboratory service was developed by McEwan et al. (1970), who determined that metal salts such as Zinc Sulphate would be precipitated from solution in proportion to the level of immunoglobulin present in a serum sample, once the two are combined. In recent years, to improve the quality of this test, a higher concentration of Zinc Sulphate solution has been used (Hudgens et al., 1996).

Table 7.1: Zinc Sulphate Turbidity Test Results in 2019 (n= 807).

Submission type	Status	No. of samples	Mean	Percentage
Diagnostic	Optimal	352	31.9	**65**
	Adequate	100	16.2	**18**
	Inadequate	89	6.7	**16**
Carcass	Optimal	82	28.7	**31**
	Adequate	60	15.7	**23**
	Inadequate	124	6.5	**47**

Outline of 2019 figures

In 2019, 541 blood samples were submitted for Zinc Sulphate Turbidity Test for diagnostic purposes, i.e. from live animals. Table 7.1 and Figure 7.1 show that 64 *per cent* of samples submitted for diagnostic purposes were in the optimal range, i.e. had a ZST result greater than or equal to 20 *units*; 19 *per cent* were within the adequate range, ZST results between 12.5 and 20 *units*, and the remaining 17 *per cent* were in the inadequate range, ZST results below 12.5 *units*. The distribution of ZST values is charted in Figure 7.2.

2019 figures are an improvement on just a few years ago, for example, in 2014, only 51 *per cent* of diagnostic samples returned a value greater than or equal to 20 *units*. There are two likely reasons for this improvement: information campaigns conducted by several bodies to impress upon herd-owners the importance of good colostrum management, which are likely to have led to improved colostrum feeding practices, and better-targeted testing of calves to evaluate colostrum management.

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 on-farm with a refractometer, or in veterinary clinics using an in-house biochemistry analyser (Figure 7.3) (Bielmann et al., 2010).

High levels of enzymes such as *Gamma-glutamyl transferase* (GGT) are absorbed from colostrum and measurement of GGT levels in blood samples from

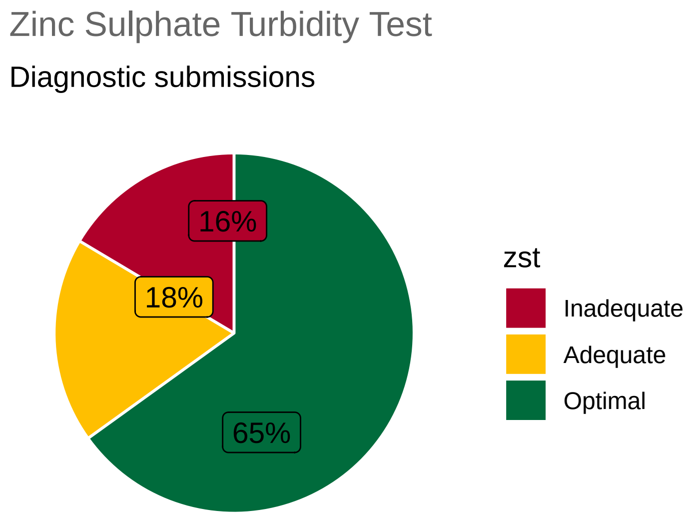

Figure 7.1: Results of ZST from submitted bovine blood samples in 2019 (n= 541).

neonatal calves may be used as a proxy for immunoglobulin absorption. These enzymes should never be used as markers for tissue damage in young calves.

Shortcomings in submission practices

Investigation of FPT

The optimum way to investigate FPT is on a herd basis. Single samples are not ideal as individual results can vary and may not be reflective of herd incidence of FPT. Colostrum management should be examined on a herd basis; when assessing a herd, the proportion of calves in the herd which have received inadequate colostral immunity is of more significance than the average serum immunoglobulin concentration.

Currently, DAFM laboratories determine the immune status of calves by ZST tests on an on-demand basis. Submissions overwhelmingly consist of a sample from a single calf; in 2019, just under 50 *per cent* of submissions for ZST testing contained one single sample and only 25 *per cent* of submissions contained five or more samples. This is an improvement on the situation several years previously, for example in 2014 single samples made up 79 *per cent* of submissions while only 7 *per cent* of submissions contained five or more samples. Awareness of the importance of colostrum in herd health, and the need for planned investigations into the efficacy of colostrum feeding, has increased.

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.

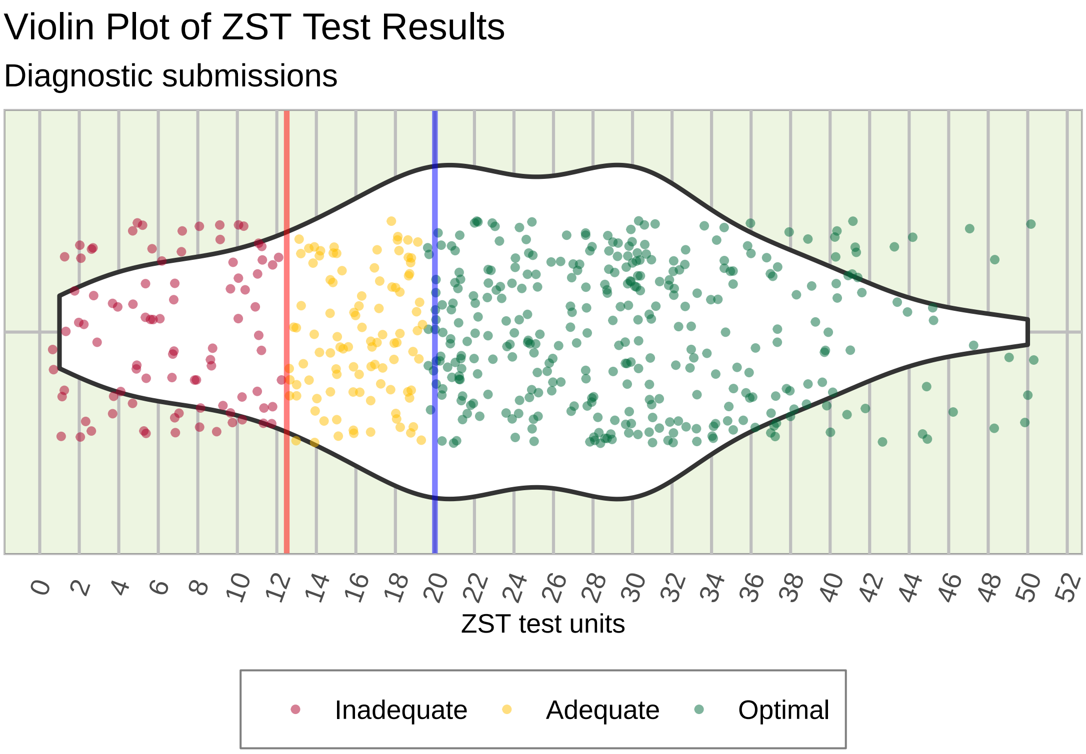

Figure 7.2: Distribution of ZST test results during 2019. Optimal colostral immunity is defined as greater than 20 units (orange line), adequated between 12.5 and 20 units and inadequated less than 12.5 units (red line). The width of the white area at each point of the x-axis is proportional to the number of samples returning a ZST result of that value. Outliers with values greater than 52 units (8 samples) were removed from the plot (n= 517).

ZST and immunoglobulin classes

ZST tests give results which correlate well with levels of total immunoglobulin and with *IgG*, which is understandable as *IgG* comprises the largest proportion of immunoglobulin in both colostrum and in bovine blood. Results from the ZST test do not give as good a measure of circulating immunoglobulin M (*IgM*), which composes a smaller proportion of the immunoglobulin in colostrum and is important in the prevention of septicaemia. To complicate matters, *IgM* molecules are commonly much larger than those of *IgG* and closure of the intestine to *IgM*, in other words the point at which the intestinal mucosa ceases to absorb *IgM* intact into the blood stream, occurs much earlier than it does for *IgG*.

The upshot of this is that a calf receiving colostrum after a slight delay may have adequate, or even optimal, levels of *IgG* and total immunoglobulin, yet have absorbed inadequate levels of *IgM*. This inadequacy will not be reflected in ZST results or results from any of the alternative indirect tests for FPT, such as total protein or *Gamma-Glutamyl Transferase* (GGT) levels. Only a direct test for *IgM*, such as an ELISA or radial immunodiffusion (RID), will pick up this deficiency.

Figure 7.3: A colourimeter, used to measure the turbidity of the solution in the Zinc Sulphate Turbidity Test. Photo: Ian Hogan.

Post mortem samples

Another source of samples for ZST testing in DAFM laboratories is blood harvested from calves at necropsy, which by definition are not from healthy calves. ZST results from calves sampled at necropsy, except in the case of very acute deaths, may give misleading results due to the course of illness that preceded death. However, RVL staff may use ZST results from these calves to flag possible cases of FPT in a herd, if results suggestive of FPT are returned this can prompt a potential need to investigate further the performance of colostrum management in that herd. When ZST testing was carried out on 266 samples taken from calf carcasses during post mortem examinations in the laboratory service, 47 *per cent* of samples had results indicating a failure of passive transfer and a further 23 *per cent* of samples were in the suboptimal range.

Ovine submissions

Submissions from ovine neonates for ZST testing are low, especially diagnostic submissions of which only four were received from two flocks in 2019; such a small sample size does not make it possible to draw conclusions.

Failure of passive transfer

While lambs and calves from beef breeds will usually receive adequate colostrum by suckling, dairy calves require herdowner intervention in order to consume enough colostrum to give sufficient protection. This is due to a dilution effect on colostrum quality caused by the higher volumes of milk produced by modern dairy cows. Ideally, the first feed of colostrum should be given to the calf within two hours of birth and certainly no later than six hours after birth. The quantity required should be based on weight, with the typical 35—45 *Kg* dairy calf needing 3 *l* and smaller cross-bred calves needing less.

Samples collected from lamb carcasses dropped to 57 samples from 148 the previous year. Of these 22 samples (39 *per cent*) gave results in the inadequate range and a further 14 (25 *per cent*) were classed as suboptimal. We must again bear in mind the possible limitations of this test when performed on samples taken from dead animals. It is likely that failure of passive transfer in lambs is most commonly due to mis-mothering; the risk may also be high for lambs born as triplets.

Failure of passive transfer (continued)

Inadequate transfer of colostral immunity may be due to poor quality colostrum, low colostral intake, poor colostrum absorption or a combination of these three factors. Supplementary feeding using a stomach tube or oesophageal feeder may be necessary. Frozen colostrum may be used when needed. Artificial colostrum is less effective but may be used as a last resort.

It should always be remembered that improved colostrum feeding practices will not completely compensate for inadequate hygiene.

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8 Bovine Mastitis

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Cellcheck, the National Mastitis Control Programme, co-ordinated by Animal Health Ireland, encourages the use of milk culture and antimicrobial sensitivity testing as part of farm mastitis control plans, aimed at reducing somatic cell counts and encouraging the appropriate use of antimicrobials on dairy farms. A number of private, milk processor and Department of Agriculture, Food and the Marine operated laboratories in Ireland offer milk culture and sensitivity testing.

Bacterial infection is responsible for the vast majority of cases of mastitis (clinical and subclinical), and identifying the agent responsible gives important information about the possible source of infection (contagious or environmental) and where to focus control measures to achieve success in improving milk quality.

Milk Culture in RVLs

The RVLs tested 3,477 milk samples in 2019, a similar figure to the 3,413 tested in 2018 (Table 8.1). Ideally, each milk sample submission should be accompanied by a submission form detailing the herd number, animal number and date of sampling. Samples are initially tested for inhibitory substances, such as antibiotics, which can interfere with bacterial growth in the laboratory. At least four different types of agar plate are used to culture each milk sample (Figure 8.3).

If following incubation at 37 °C, bacterial growth is seen on plates, further tests are carried out to identify the organisms growing before proceeding to carry out antimicrobial sensitivity testing. If the milk sample has been contaminated, cultures usually yield a mixed bacterial growth (Figure 8.1); in these cases, it can be challenging to identify the significant bacterial species, and the result is entered as mixed bacterial growth. Contamination usually occurs when bacteria from sources other than milk inside the udder enter the sample. This could be from the skin of the udder, the sampler's hands or from inside of the container itself if the latter is not sterile. It will also occur if the milk sample submitted is taken from the bulk tank and not directly from the cow.

Figure 8.1: Mixed bacterial growth on a blood agar plate following culture of a contaminated milk sample. Photo: Alan Johnson.

Table 8.1: Number of milk samples submitted to the RVLs from 2010 to 2019.

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
5355	3469	2899	3329	2288	2315	2849	2416	3413	3477

The milk culture results for 2019 are summarised in Table 8.2 and Figure 8.2 . The number of contaminated samples was very high at 31.4 *per cent*, significantly up on the 13.7 *per cent* obtained in 2018. The results stress the importance of collecting milk

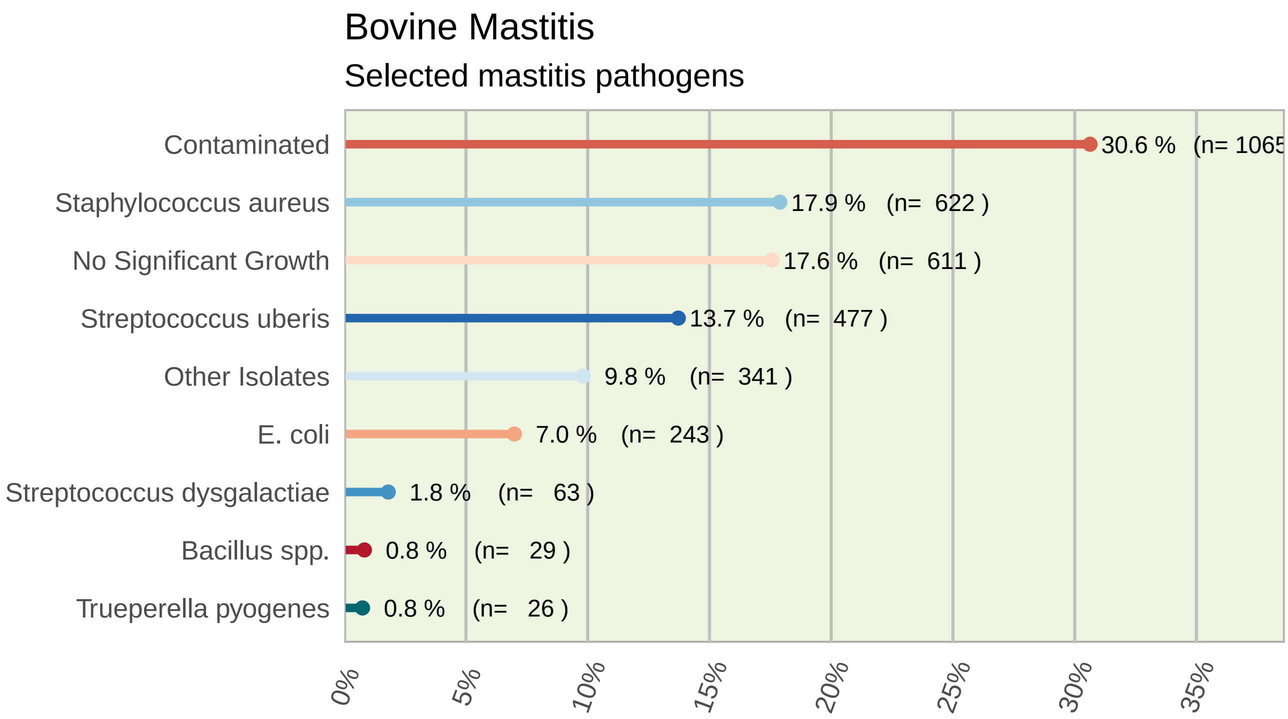

Figure 8.2: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2019 (n= 3477).

Table 8.2: Relative frequency of mastitis isolates in milk samples submitted to RVLs in 2019 (n= 3477).

Result	No. of cases	Percentage
Contaminated	1065	30.6
Staphylococcus aureus	622	17.9
No Significant Growth	611	17.6
Streptococcus uberis	477	13.7
Other Isolates	341	9.8
E. coli	243	7.0
Streptococcus dysgalactiae	63	1.8
Bacillus spp.	29	0.8
Trueperella pyogenes	26	0.8

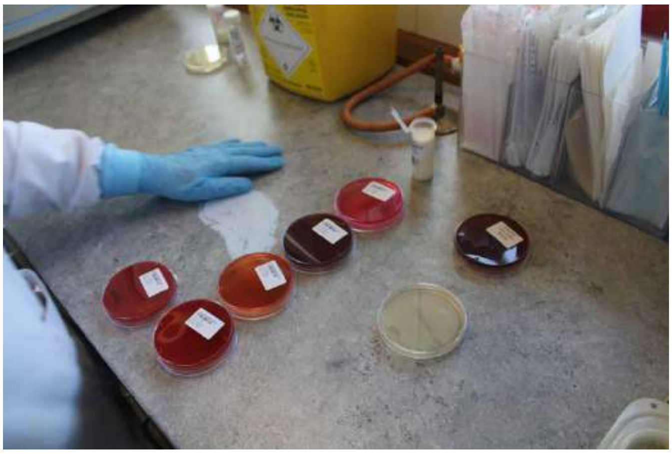

Figure 8.3: Agar plates used in the culture of milk samples in Limerick RVL. Photo: Alan Johnson

samples in a sterile manner. (See the two boxes regarding *Milk Sample Collection for Bacteriology* in page 46 and page 47).

Staphylococcus aureus

This organism continued to be the most commonly pathogen isolated in cases of mastitis by RVLs in 2019. It was isolated from 622, 18.4 *per cent*, of samples submitted. There continues to be downward trend for the isolation rate of Staph. aureus year-on-year (Figure 8.5).

Staph. aureus is the main cause of contagious mastitis and typically, though not always, 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.

Other *Staphylococcus spp.* isolates, mostly coagulase-negative, were cultured from 155, 4.6 *per cent*, of the milk samples.

Streptococcus uberis

This organism is often described as an environmental mastitis pathogen. It is usually due to faecal contamination of surfaces. Sub-optimal housing and poor udder hygiene can increase the risk of infection (Barrett et al., 2005).

In addition, *Strep. uberis* also has some characteristics of a contagious pathogen and can be spread from cow-to-cow at milking time. *Strep. uberis* was isolated from 477, 14.1 *per cent*, of milk samples cultured during 2019. In contrast to Staph. aureus, the trend for the isolation rate of *Strep. uberis* is rising (Figure 8.5). In many countries it is the most commonly isolated mastitis pathogen.

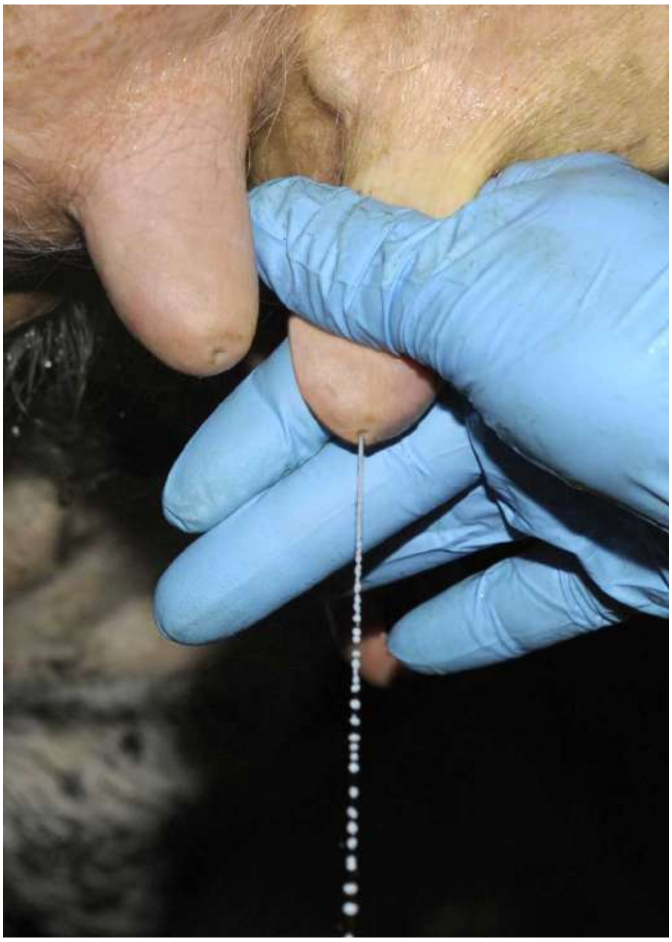

Figure 8.4: Collecting a milk sample for culture. Photo: Animal Health Ireland.

Streptococcus dysgalactiae

A common cause of mastitis in cows and heifers, *Streptococcus dysgalactiae* is considered to be a contagious mastitis pathogen. Still, it can also survive quite well in the environment and can cause infections from that source. Infected teat lesions can be a significant source of infection. *Streptococcus dysgalactiae* was isolated from 63 (1.9 *per cent*) milk samples during 2019, a drop from 3.2 *per cent* in 2018.

Truperella pyogenes

This is the most commonly isolated pathogen in cases of summer mastitis. It is associated with a suppurative foul-smelling secretion and loss of the quarter for milk production. Insect vectors are considered central to its spread, hence its association with the summer months. A similar syndrome can be found during the indoor (in-house) season following a teat injury. *T. pyogenes* was isolated from 26, 0.8 *per cent*, milk submissions.

Milk Sample Collection for Bacteriology:
Materials for Sampling

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; it is vital that proper procedures are followed.

Materials for sampling:

Disposable latex gloves
Sterile screw-top plastic tubes (20 ml capacity approximately)
Cotton wool balls soaked in 70 % alcohol or medicated wipes.
Paper towels

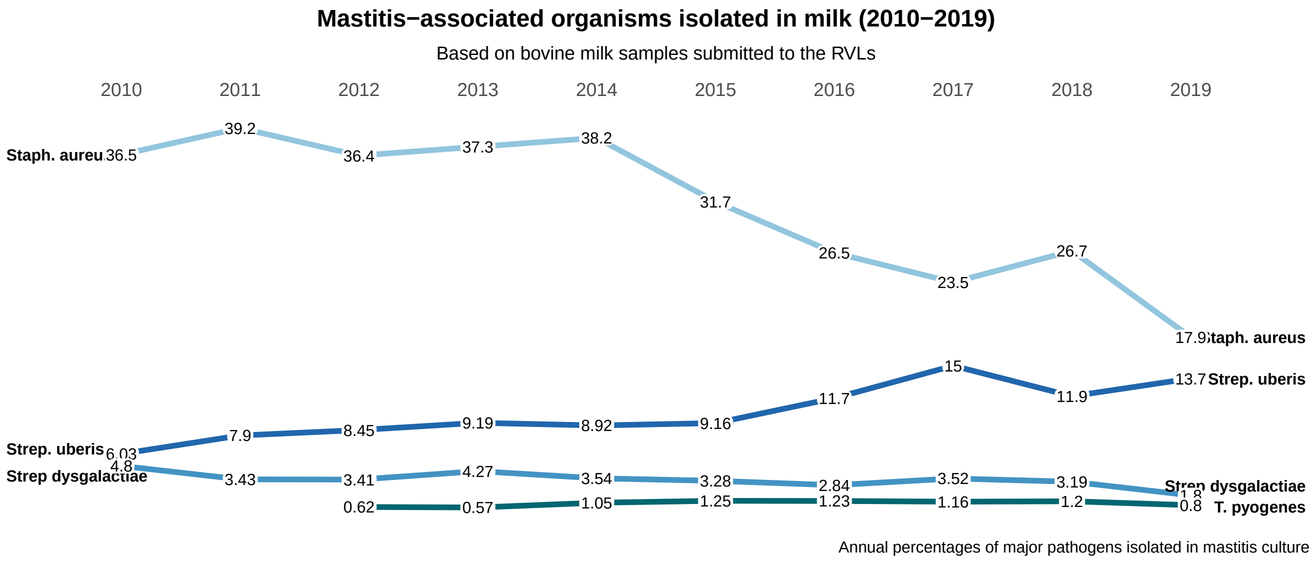

Figure 8.5: Mastitis-associated Organisms Isolated in Milk (2010-2019).

Milk Sample Collection for Bacteriology: **Sampling Technique**

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

For additonal information on mastitis control, visit the Animal Health Ireland webpage (Animal Health Ireland, 2020).

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9 Bovine Parasites

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Naturally, diseases caused by parasites are an important aspect in livestock and therefore investigated by DAFM laboratories. The management of parasitic disease is a crucial part in herd health management. Treatment should be based on regular investigation of the parasitic burden of a herd. In general, cattle develop some immunity to parasites; however, this immunity does not prevent infection but halts development of clinical disease.

Typical samples for internal parasites include faeces which has been either harvested during *post mortem* examinations in the laboratories or collected by PVPs from living animals. The most common and important internal parasites in bovines in Ireland are *Trichostrongylidae*, *Nematodirus spp.*, *Coccidia spp.* as well as *Fasciola hepatica* and *Calicophoron daubneyi*.

Faecal samples for investigation of parasitic burdens in cattle were received throughout the year with peaks from May to August and in November. The peak during summer months covers the traditional grazing season and is most likely due to monitoring efforts. The high number of submissions in November coincides with the beginning of housing, which is commonly associated with antiparasitic treatment. The highest number of samples yielding positive results occurred in spring, late autumn and early winter .

Table 9.1: Charateristic comparison of the two most prevalent nematodes affecting cattle in the Republic of Ireland.

Cooperia oncophora	Ostertagia ostertagi
Small intestine	Glands of abomasum
Adult stage 15-18 days PI*	Adult stage 18-21 days PI
Immunity develops after first grazing season	Immunity develops after second grazing season

* Post-Infection

Trichostrongylidae

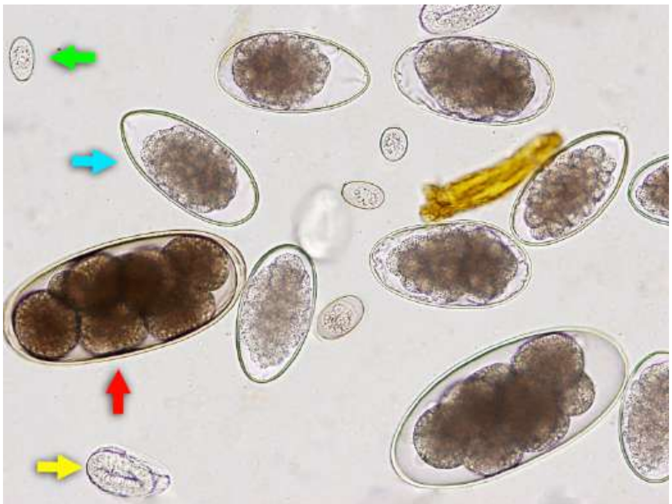

Figure 9.1: Modified McMaster fecal egg counting. Microscopic appearance of parasitic eggs and oocysts in a faecal smear: *Trichostrongyles* (blue arrow), *Nematodirus* (red arrow), Larvated *strongyloid* egg (yellow arrow) and *coccidial oocysts* (green arrow). Photo: Cosme Sánchez-Miguel.

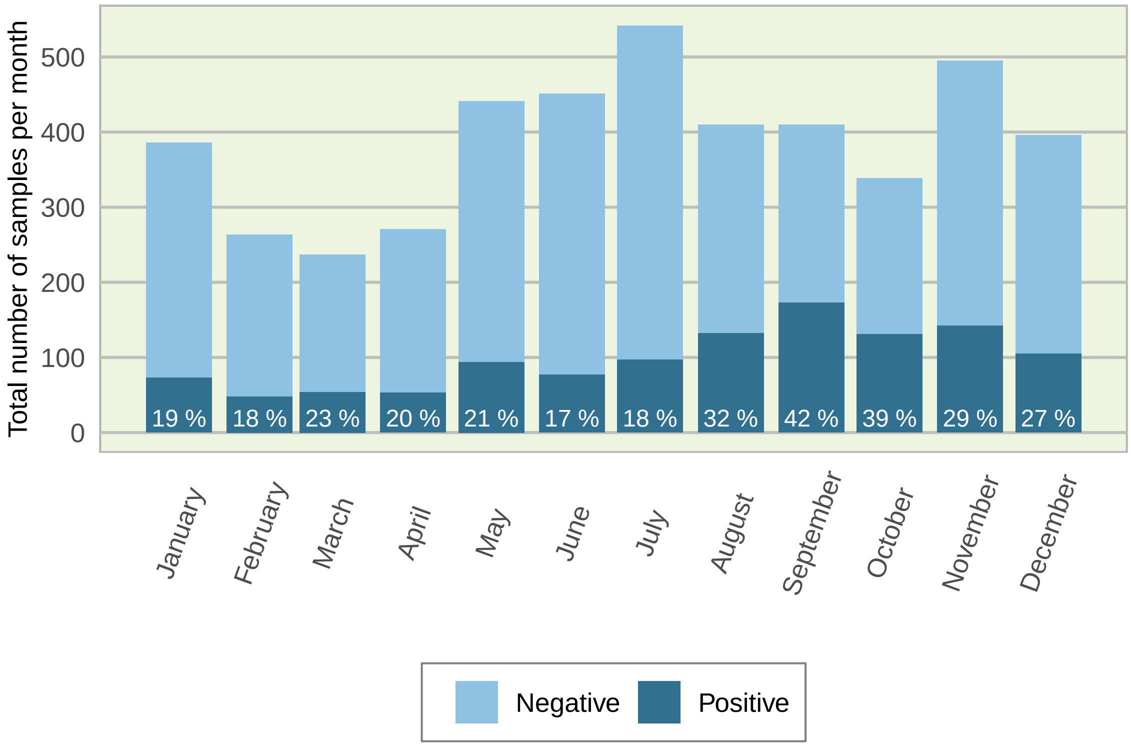

Figure 9.2: Stacked count of bovine faecal samples (all ages) tested per month for *Trichostrongylidae* during 2019. The percentage in each bar represents positive samples (n= 4647).

Table 9.2: Number of bovine faecal samples tested for Trichostrongylidae eggs in 2019 and results by percentage (n= 4647).

Result	No. of samples	Percentage
Negative	3467	75
Low (50-500 epg)	854	18
Medium (500-1200 epg)	188	4
High (>1200 epg)	138	3

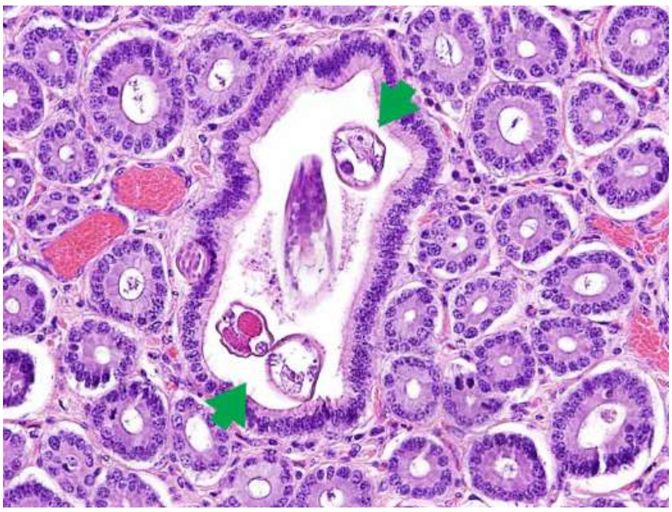

Figure 9.3: Fragments of Ostertagia spp. (arrows) in the abomasal gastric glands. Photo: Cosme Sánchez-Miguel.

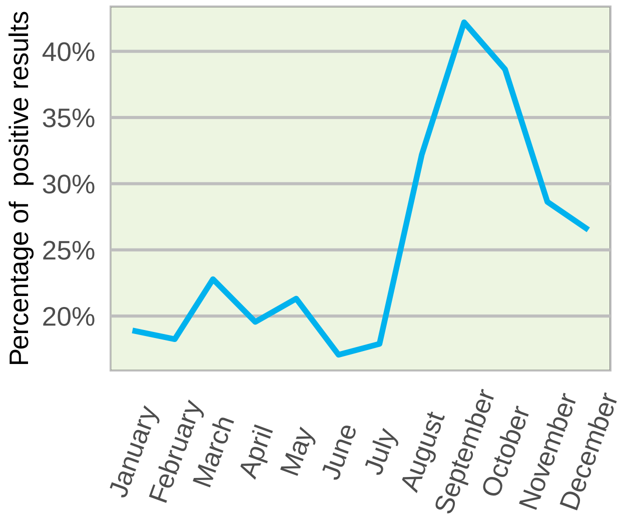

Figure 9.4: Percentage of positive bovine faecal samples for *Trichostrongylidae* eggs in 2019 (n= 4647).

The most prevalent round worms causing parasitic disease in bovines in the Republic of Ireland are *Ostertagia ostertagi* and *Cooperia oncophora* (Murphy et al., 2006). These parasites can cause parasitic gastro-enteritis with acute clinical disease significantly reducing the productivity of affected animals.

Table 9.3: Number of bovine faecal samples tested for *Nematodirus* eggs in 2019 and results by percentage (n= (n= 4647).

Result	No. of samples	Percentage
Negative	4582	98.6
Low (50-500 epg)	56	1.2
Medium (500-1200 epg)	6	0.1
High (>1200 epg)	3	0.1

O. ostertagi has also been described as causing two different syndromes in weanlings: Ostertagiosis *Type 1* which typically occurs in late summer or autumn after a mass emergence of larvae on fields; and Ostertagiosis *Type 2*, observed mainly in late winter and early spring. *Ostertagiosis Type 2* is caused by larvae which experienced a delayed development in the abomasal mucosa (hypobiosis). Prevention by appropriate treatment at the time of housing is vital for *Ostertagiosis type 2* as treatment response is usually very poor.

In the last decade, it has been shown that cows can develop a subclinical parasitic infection with *O. ostertagi* which can lead to significant production losses linked to reduced milk yields, weight loss, non-specific immune suppression and mortality (Delafosse, 2013).

Nematodirus spp.. *Nematodirus spp.* also known as thread necked worms are a species of nematodes which mainly affect small ruminants, but have been reported to cause disease in cattle. Nematodirus battus is the most significant species in Ireland and affects primarily naive young lambs. N. helvetianus, which is more likely to infect cattle, has been noted across Europe but appears to be more common across Australia and Asia (McMahon et al., 2017).

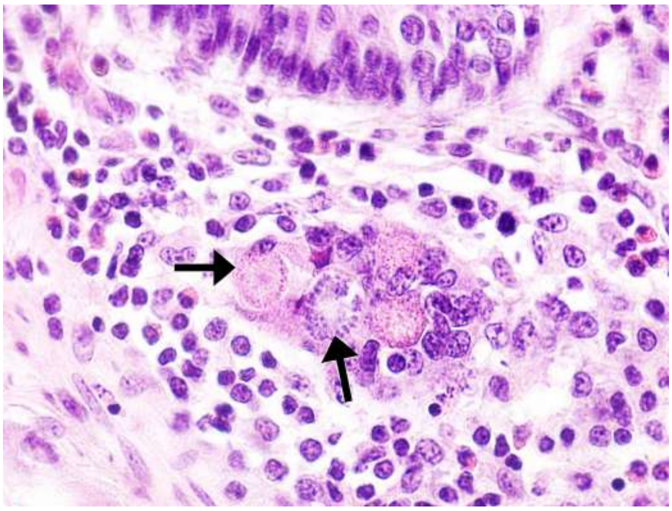

Figure 9.5: Different coccidial development stages in the small intestinal mucosa of a calf. Photo: Rebecca Froehlich-Kelly

Coccidia

Table 9.4: Comparison of the pre-patent periods of *Eimeria spp*.

Eimeria	Pre-patent period*
Eimeria bovis	21 days
Eimeria zuerni	21 days
Eimeria alabamensis	8-12 days

Note:
* Time between infection of the animal and the first appearance of oocysts in faeces

Coccidia (*Eimeria spp.*) belong to the group of protozoa and are host specific. *Eimeria bovis*, *Eimeria zuerni* and *Eimeria alabamensis* are the only three species considered pathogenic in cattle. Coccidia causes significant clinical disease in calves and lambs from 3 *weeks* to 9 *months* of age. Clinical disease in adults is rather uncommon as immunity to the disease can develop quickly. Diarrhoea and dysentery are the most common signs of clinical coccidiosis.

The disease is usually self-limiting and lasts 3—4 weeks, the time frame for parasites to complete their life cycle in host.

Infection occurs after ingestion of sporulated oocysts; these release sporozoites that penetrate the epithelial cells of the small and large intestine. Further development continues within epithelial cells where coccidia mature and produces oocysts for

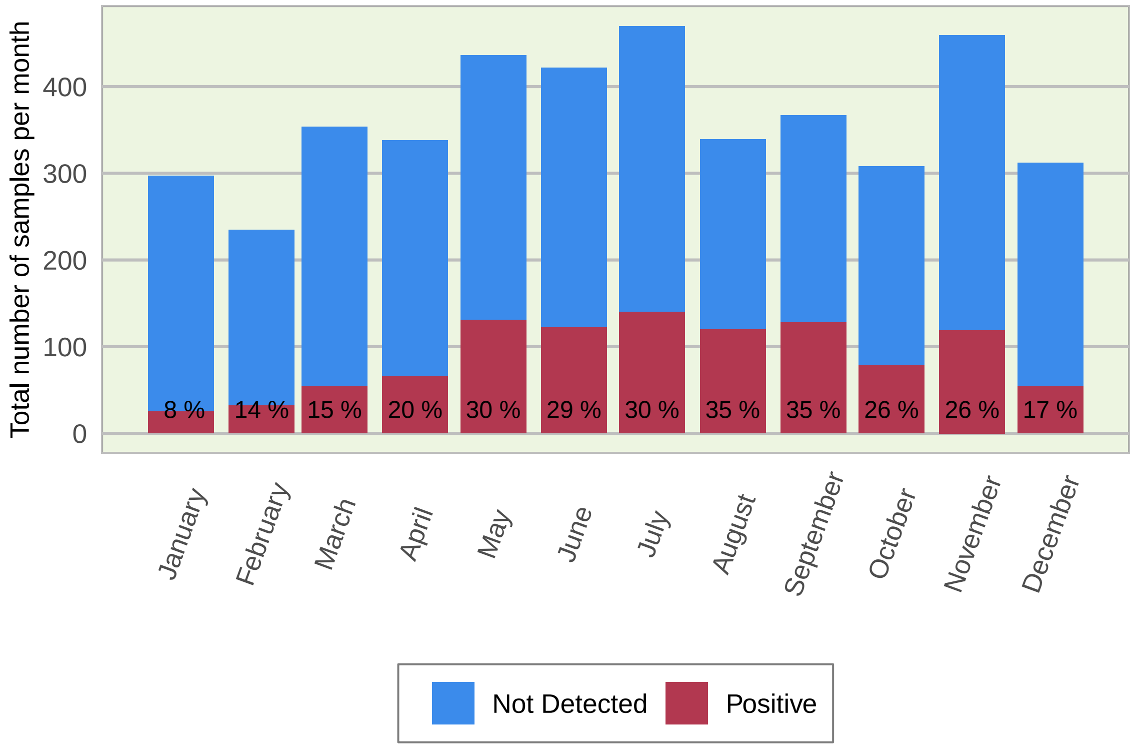

Figure 9.6: Stacked number of bovine faecal samples (all ages) tested for coccidial oocysts in 2019. The percentage in each bar represents the number of positives (n= 4657).

Table 9.5: Number of bovine faecal samples submitted in 2019 (all ages) for detection of coccidial oocysts and results by percentage, (n= 4657).

Result	No. of samples	Percentage
Not Detected	3493	**75**
Light Infection	842	**18**
Moderate Infection	199	**4**
Heavy Infection	88	**2**
Severe Infection	35	**1**

excretion in faeces; affected epithelial cells are destroyed, leading to rapid and severe damage of intestinal epithelium.

As in previous years, in 2019 the majority of positive samples contained low numbers of oocysts. (Table 9.5). The clinical significance is unclear. There is a strong likelihood that the submitted samples are mostly collected in the post-acute phase and therefore, not reflecting the real coccidial burden and may even lead to false negatives.

Treatment and control. Anti-protozoal treatment at the occurrence of clinical signs is usually unrewarding as diarrrhoea indicates the end of coccidia life cycle in the host and that severe intestinal damage is already present.

Consequently, where high environmental contamination is present, control is best achieved by hygiene and prophylactic treatment.

Currently, there are three anticoccidials registered for the use in bovine in the Republic of Ireland:

Decoquinate: 60.6 *g/kg* premix for medicated feeding stuff
Diclazuril: 2.5 *mg/ml* oral suspension
Toltrazuril: 50 *mg/ml* oral suspension

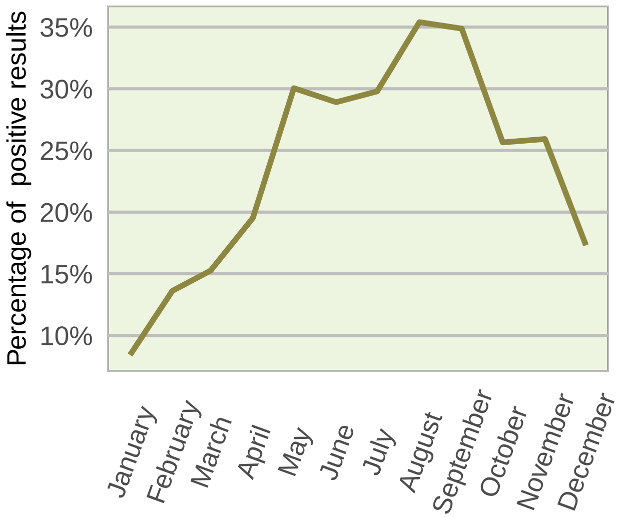

Figure 9.7: Percentage of bovine faecal samples testing positive for coccidial oocysts in 2019 (n= 4657).

Rumen and Liver Fluke

The most economically important trematodes in Ireland are the liver fluke species *Fasciola hepatica* and the rumen fluke species *Calicophoron daubneyi*. If measured by the detection of eggs in faecal samples, in recent years the prevalence of *Fasciola hepatica* appears to have declined, whereas rumen fluke appears to have stayed static. Infection rates with rumen fluke appear to be significantly higher in cattle compared to sheep. Moreover, there is a seasonal pattern for rumen fluke in cattle. Co-infection with both parasites seems to be very common in cattle (Naranjo-Lucena et al., 2018).

Figure 9.8: Liver fluke in the liver hepatic bile ducts. Photo: Cosme Sánchez-Miguel.

Fasciolosis. Fasciolosis caused by *Fasciola hepatica* presents both as an acute disease, caused by larvae migrating through hepatic tissue, or a chronic disease, caused by adult trematodes in the liver. In bovines chronic fasciolosis is the most common cause of clinical disease. Clinical signs include weight loss, diarrhoea and hypoproteinaemia due to liver damage and epithelial loss in the intestine.

Figure 9.9: Microscopic section of bovine ruminal wall with two rumen fluke attached to the mucosal surface. Photo: Cosme Sánchez-Miguel.

Table 9.6: Number of bovine faecal samples submitted in 2019 (all ages) for detection of liver fluke eggs and breakdown of positive and negative results (n= 3913).

Result	No. of samples	Percentage
Liver fluke eggs not detected	3831	**98**
Positive liver fluke eggs	82	**2**

Paramphistomosis. Rumen fluke is mainly described to cause disease during the juvenile phase of the parasite, when it inhabits the duodenum from several weeks to months, attaching to the duodenal wall. Severe disease outbreaks have been described when young animals were exposed to a large number of metacercariae in the field (O'Shaughnessy et al., 2018). However, cases of clinical disease are sporadic with only 3–4 cases being reported annually in Ireland (Toolan et al., 2015).

To date, adult rumen fluke living in the rumen and attaching to ruminal mucosa are not thought to cause significant disease; however, there is some evidence

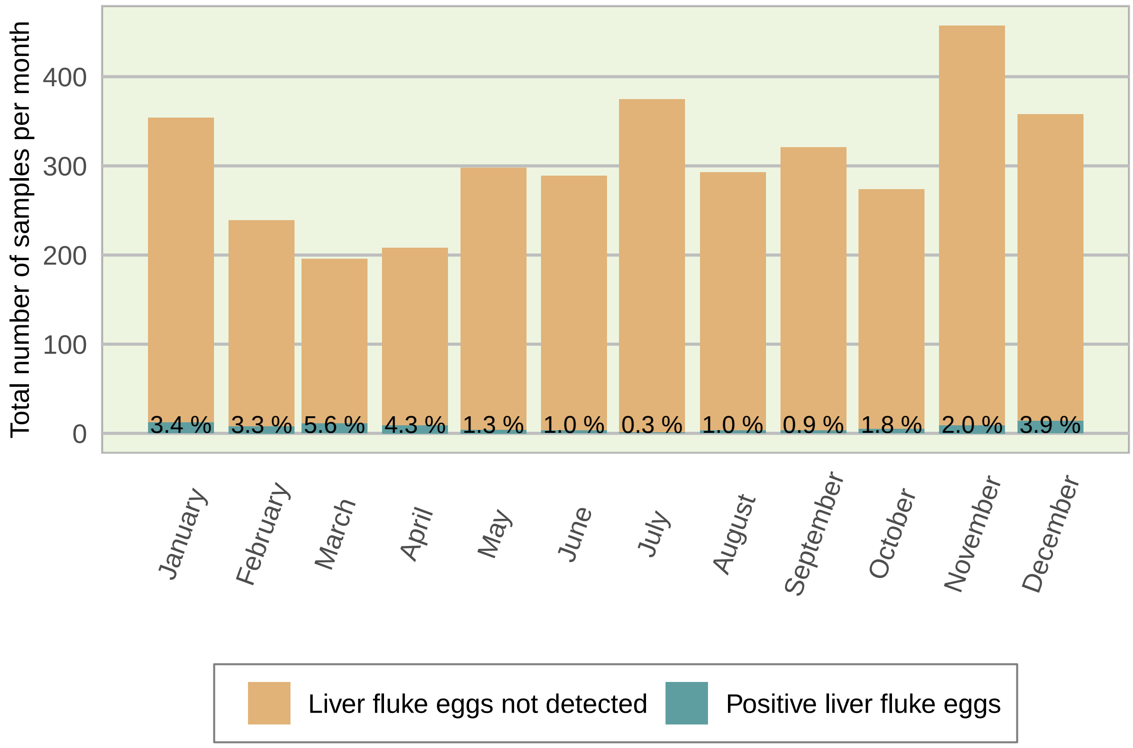

Figure 9.10: Stacked number of bovine faecal samples (all ages) tested for liver fluke in 2019. The percentage in each bar represents the number of positive samples per month (n= 3913).

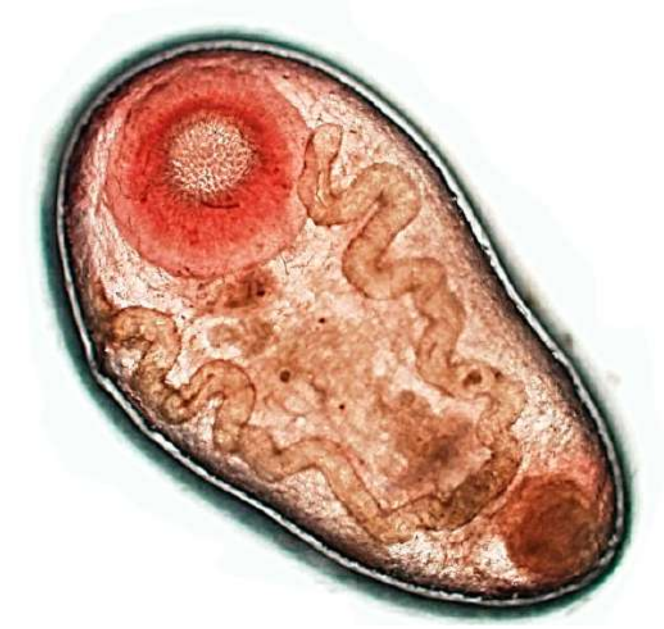

Figure 9.11: Rumen fluke (*Calicophoron daubneyi*) at low magnification showing the oral sucker (top-left), the bilobulated intestine and the excretory pore (bottom-right). Photo: Cosme Sánchez-Miguel.

Table 9.7: Number of bovine faecal samples submitted in 2019 (all ages) for detection of rumen fluke eggs and breakdown of positive and negative results (n= 3913).

Result	No. of samples	Percentage
Rumen fluke eggs not detected	2708	**69**
Positive rumen fluke eggs	1205	**31**

of inflammatory changes occurring in the reticulum and the rumen during and infestation.

Risk of infection with both parasites varies from year to year depending on climatic conditions, especially rainfall and surface moisture. Wet ground conditions at moderate temperatures, as occurring in Ireland during spring and summer, particularly favour reproduction and spread of the mollusc intermediary host (*Galba trunculata*), development of fluke in the intermediary host and shedding of the metacercaria on pasture.

Both liver and rumen fluke use the same molluscan intermediary host, the mud snail (*Galba trunculata*).

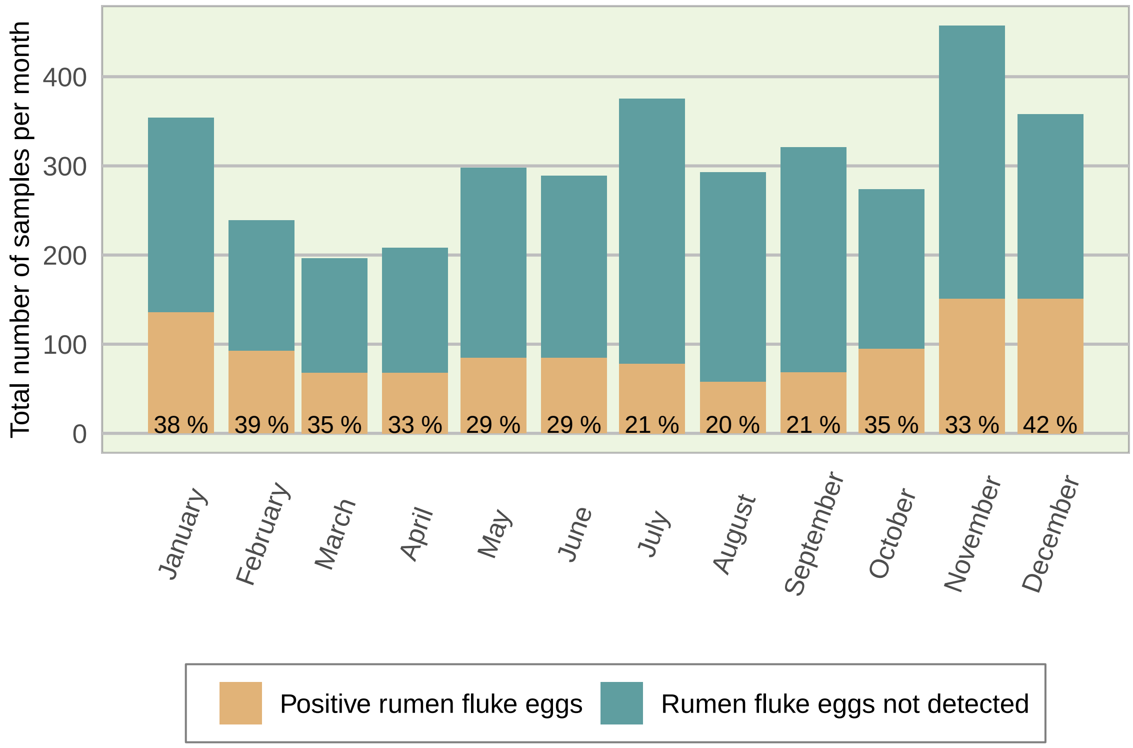

Figure 9.12: Stacked count of bovine faecal samples (all ages) tested for rumen fluke. The percentage in each bar represents positive samples (n= 3913).

This might lead to an interspecific competition between larval stages of the two species; however, further research will be needed to support this. Current research indicates that infection with both parasites can occur concurrently and even make infection with the other parasite more likely (Naranjo-Lucena et al., 2018; Deplazes et al., 2016).

Every autumn, to assist farmers and private veterinary practitioners, DAFM issues a fluke forecast based on analysis of meteorological data for the preceding 6 *months*. In 2019, as in previous years, rumen fluke eggs were more often detected in bovine faecal samples than liver fluke eggs.

Treatment and Control. There is a variety of flukicides available for treatment and control of *Fasciola hepatica*. However, due to regulatory changes in recent years, restrictions apply for use in dairy cattle depending on the active ingredient and the reproductive stage of the animals. Further, when choosing a suitable treatment, consideration of the developmental stage of the parasite is needed as only some products affect juvenile stages (e.g. Triclabendazole, Closantel, Nitroxinyl). In contrast, some products only affect the adult stage (greater than 12 *weeks*) of the parasite. Depending on the product and the time of application (e.g. at housing) a repeat or delay in treatment might be appropriate.

Finally, there is also evidence that there is emerging resistance against some flukicides , in particular, Triclabendazole; consequently, the choice of appropriate flukicide, needs to be prudent and circumspect .A comprehensive list of available flukicides, including restrictions, is available from the Irish Health Products Regulatory Authority. To date, there is no registered treatment for rumen fluke (C. daubneyi) available. However, there has been evidence that some products like oxyclozanide and closantel show good activity against adult rumen fluke infestation and lead to a reduction in faecal egg count. Dose rates and related side effects, as well as the route of administration, appear to have an impact on treatment success (Arias et al., 2013; Malrait et al., 2015).

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Diseases of Sheep, DAFM

10 Overview of Sheep Diseases

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The Regional Veterinary Laboratories (RVLs) of the Department of Agriculture, Food and the Marine (DAFM) are engaged 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 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.

Figure 10.1: *Pieris* leaves recovered from the ruminal contents of a sheep. Photo: Colm Ó Muíreagaín.

Table 10.1: Conditions most frequently diagnosed on post-mortem examinations of lambs in 2019 (n= 553). Only diagnoses greater than ten cases are shown.

Disease	No. of Cases	Percentage
GIT Infections	139	25.1
Systemic Infections	81	14.7
Clostridial disease	59	10.7
Respiratory Infections	50	9.0
GIT torsion/obstruction	47	8.5
Nutritional/metabolic conditions	32	5.8
Diagnosis not reached	27	4.9
CNS	21	3.8
Liver disease	18	3.2
Trauma	18	3.2
Cardiac/circulatory conditions	14	2.5
Urinary Tract conditions	10	1.8
Navel Ill/Joint Ill	9	1.6

In 2019, approximately 1029 ovine carcases were submitted for *post mortem* examination. This comprised 553 lambs (from birth to one year of age) and 476 adult sheep (over one year of age). The range of diagnoses varies according to age of the animal. Thus results in this section are presented by age category. In order to facilitate presentation and comparison, conditions which affect given systems have been grouped together.

Diseases of the gastrointestinal tract accounted for 25 *per cent* of diagnoses in young lambs while a further 14 *per cent* was due to related conditions of GIT torsions/obstructions and nutritional/metabolic conditions. Within the category of GIT infections 48 *per cent* were due to parasitic gastroenteritis while 46 *per cent* were due to enteritis. These figures demonstrate the importance of parasitic disease in young animals during their first season on pasture. Trichostrongyles including (*Ostertagia spp.*/ *Trichostrongylus spp.* /

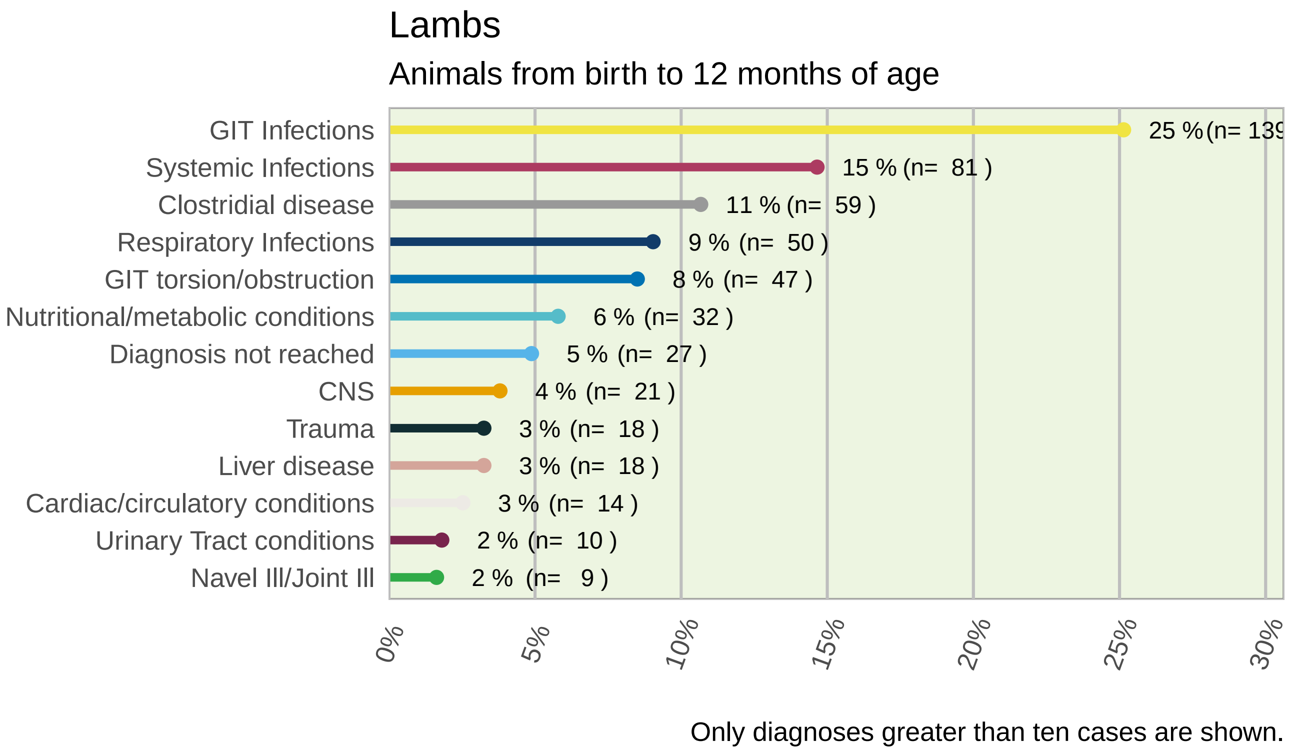

Figure 10.2: Conditions most frequently diagnosed on post-mortem examinations of lambs in 2019 (n= 553). Only categories with n greater than 8 are shown.

Figure 10.3: Pieris japonica, an ornamental plant widely available in Irish garden centres. Photo: Colm Ó Muíreagaín.

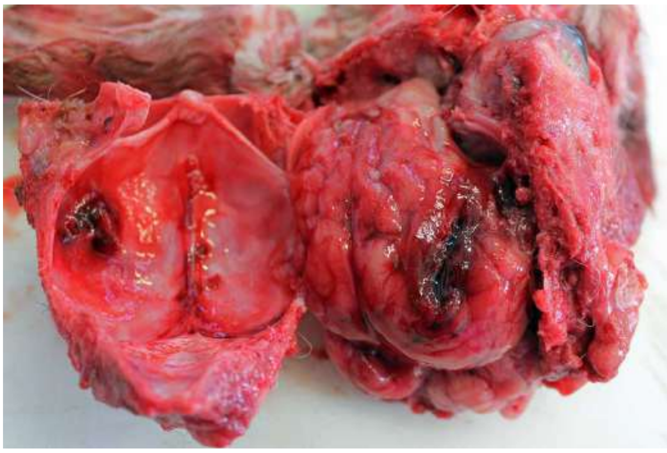

Figure 10.4: Lamb's head with skin removed and skull partially reflected to show puncture wound in bone and damage to underlying brain tissue due to predation. Photo: Shane McGettrick

Cooperia spp.) and Nematodirus battus were the predominant parasites identified. The importance of sustainable endoparasite control in sheep flocks is highlighted by DAFM on a regular basis, however effective control strategies must be based on and adapted to individual farm factors such as pasture/flock management and choice of treatments. The high incidence of enteritis in young sheep reflects the relative severity of intestinal infections with agents such as *Escherechia coli*, Rotavirus, *Cryptosporidium spp.* in early life.

Clostridial disease is a very important cause of death in young sheep, accounting for 11 *per cent* of the total diagnoses in this group. Pulpy kidney disease caused by *Clostridium perfringens type D* was confirmed as cause of death in 36 lambs submitted

Table 10.2: Conditions most frequently diagnosed on post-mortem examinations of adult sheep (over one year of age) in 2019 (n= 476). Only diagnoses with greater than ten cases are shown.

Disease	No. of Cases	Percentage
Respiratory Infections	83	17.4
Nutritional/metabolic conditions	56	11.8
GIT Infections	47	9.9
Systemic Infections	42	8.8
CNS	39	8.2
Diagnosis not reached	31	6.5
Liver disease	29	6.1
Poisoning	22	4.6
Cardiac/circulatory conditions	18	3.8
Trauma	18	3.8
Reproductive Tract Conditions	17	3.6
GIT torsion/obstruction	15	3.1
Clostridial disease	12	2.5
Abscessation	10	2.1

Figure 10.5: Renal infarcts in a case of endocarditis in a lamb. Photo: Denise Murphy.

in 2019. This condition is frequently associated with stress and a change of diet in unvaccinated sheep. The confirmation of the disease requires presence of the clostridial toxins and associated pathology (Figure 10.8). The disease will often occur in a peracute presentation in a group of animals and owners may not always submit further cases once the diagnosis has been confirmed, especially if vaccination has not occurred. Systemic disease caused a further 15 *per cent* of deaths in this age group and includes deaths due to toxaemia and septicaemia. The most common agents identified in systemic infections were: *E. coli*, *Bibersteinia trehalosi* and *Mannheimia haemolytica*.

Respiratory infections accounted for 9 *per cent* of total diagnoses in this age group with the vast majority of these diagnosed as pneumonia due to a bacterial aetiology.

Tick pyaemia

Tick pyaemia is a condition of young lambs where the tick inoculates *Staphylococcus aureus* into affected lambs. This gives rise to septicaemia (bacteria and toxins in the blood), resulting in dullness, depression, inappetence, etc. The bacteria can then seed out in internal organs such as the kidneys and liver and joints and can also cause spinal abscesses.

Control of tick-borne diseases necessitates controlling tick populations through the removal of vegetation suitable for tick survival. External long-acting parasiticides specifically aimed at ticks can be used to kill ticks during periods of greatest risk. Specific treatment of tick pyaemia involves antibiotic treatment of the *Staphylococcus aureus* bacterial infection.

Respiratory infections accounted for 17 *per cent* of the diagnoses made in adult sheep. Of these diagnoses bacterial pneumonia was the most frequent cause of death. The most commonly detected pneumonic agents were *Mannheimia haemolytica*, *Pasteurella multocida* and *Bibersteinia trehalosi*.

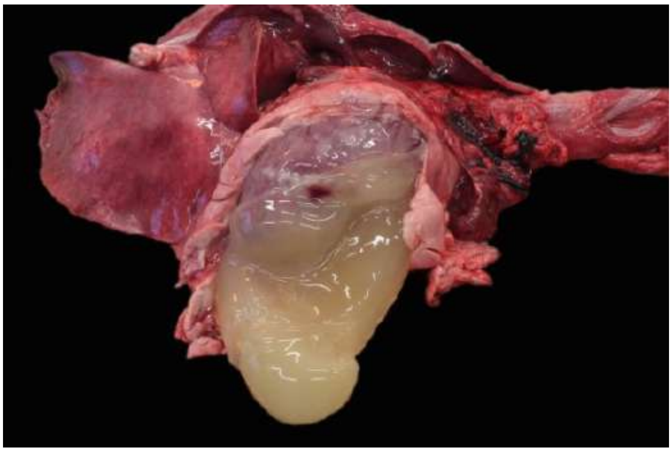

Figure 10.8: Fibrinous pericardial effusion in a lamb due to toxins associated with *Clostridium perfringens type D*. Photo: Colm Ó Muireagáin.

Nutritional and metabolic conditions accounted for 12 *per cent* of diagnoses in older sheep. 71 *per*

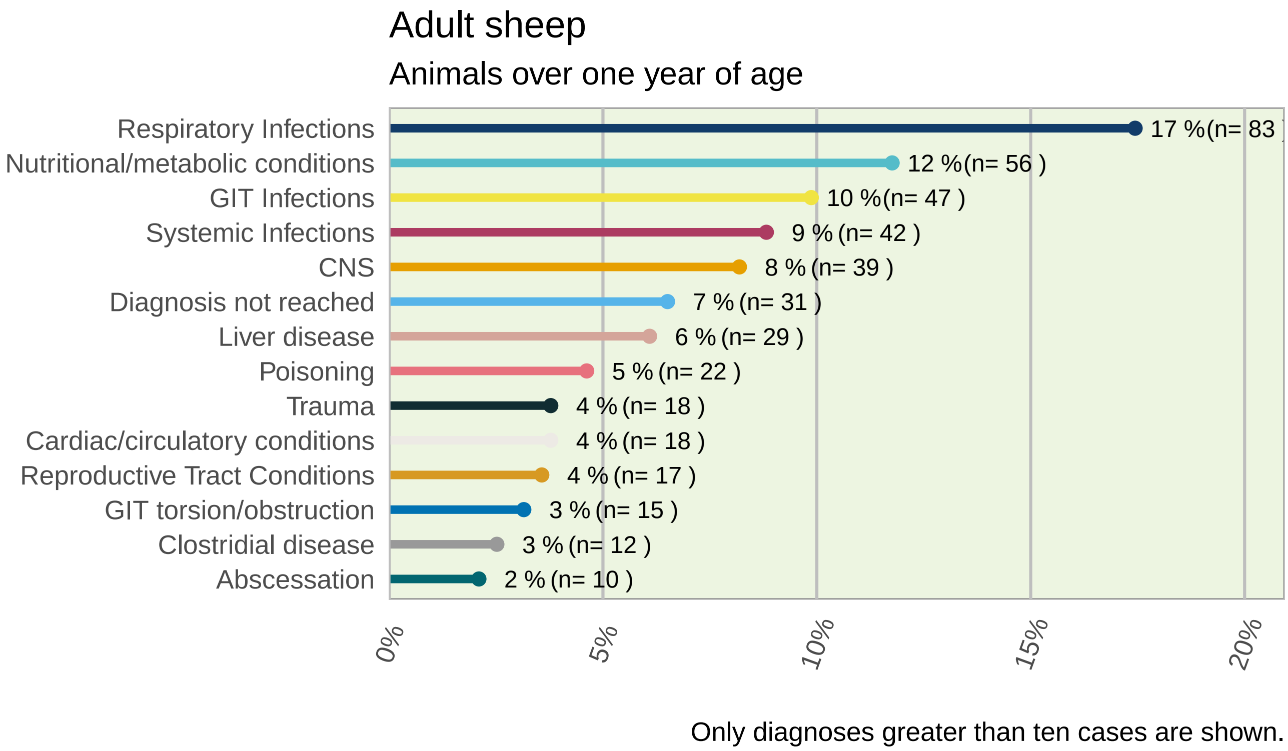

Figure 10.6: Conditions most frequently diagnosed on post-mortem examinations of adult sheep (over one year of age) in 2019 (n= 476). Only categories with n greater than 8 are shown.

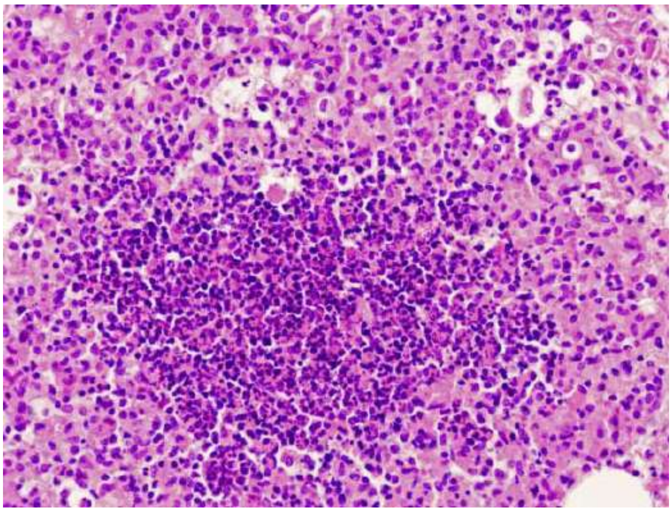

Figure 10.7: Micro-abscessation in the midbrain of a ewe with Listeriosis. Photo: Rebecca Froehlich-Kelly.

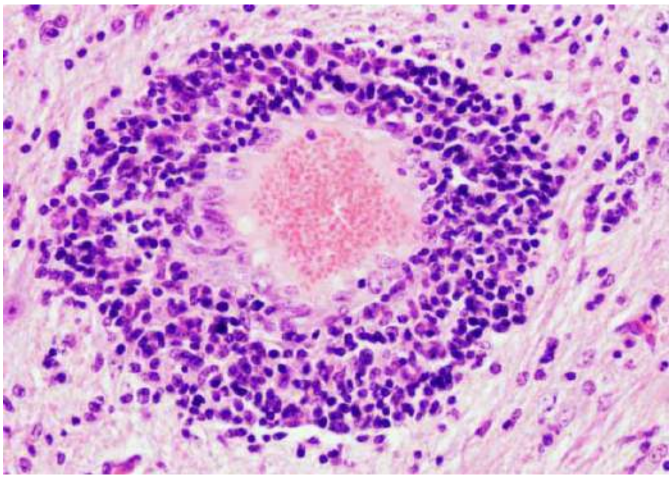

Figure 10.9: Vascular cuffing in the midbrain in a case of Listeriosis

cent of these cases occurred in peripaturient animals consisting of metabolic illnesses such as pregnancy toxaemia, hypocalcaemia and hypomagnesaemia. 26 *per cent* of the remaining cases were in animals diagnosed with acidosis.

CNS disease occurred in 8 *per cent* of cases submitted to RVLs. Such cases often present non specifically or as sudden death and are therefore frequently submitted by a farmer or vet seeking a diagnosis. Listeriosis due to *Listeria monocytogenes* was a frequent finding. This disease is associated with silage feeding and usually present with nervous signs such as depression, circling, ataxia and blindness. Diagnosis is based on identification of the agent by culture or presence of the typical histopathology.

Pregnancy toxaemia

Pregnancy toxaemia affects ewes during late gestation. Clinical signs include listlessness, aimless walking, muscle twitching, opisthotonos, and teeth grinding. Over a number of days this can progress to blindness, ataxia, and finally recumbency and death. Ewes in poor body condition score (BCS ≤ 2) or that are overfat (BCS ≥ 4) and carrying multiple foetuses are most at risk of developing pregnancy toxaemia. The primary predisposing cause is inadequate nutrition usually because of inadequate energy density of the ration and/or decreased rumen capacity as a result of compression from a gravid uterus and growing foetuses. In late gestation, gluconeogenesis in the liver increases to facilitate glucose availability to the foetuses. Mobilization of fat stores is increased to facilitate adequate energy for the increased demands of the developing foetuses and the approaching lactation. However, in a negative energy balance, this increased mobilisation may overwhelm the liver's capacity and result in hepatic lipidosis, with subsequent impairment of function.

Both fat and thin ewes are susceptible. Ewes in poor body condition develop ketosis because inadequate nutrition is offered or because other diseases limit intake (e.g. lameness, dental disease). Overfat ewes may have depressed appetites (or decreased capacity of the rumen due to foetuses taking up space), and adipose mobilisation quickly overwhelms the liver's capacity, resulting again in hepatic lipidosis.

Sub-clinically affected animals can become clinical under stressful situations such as adverse weather, transport, handling for shearing or dosing, or other concomitant disease (footrot, pneumonia, etc). The condition usually occurs 1-–3 weeks before parturition. Onset of clinical signs earlier than day 140 of gestation is associated with a higher risk of mortality.

Post mortem changes can include a pale *fatty* liver and often include multiple foetuses in a state of decomposition indicating *pre-mortem* death. These signs alone are not pathognomonic. *Post mortem* samples of ocular fluid can be analyzed for*BHB*. Concentrations >2.5 are consistent with a diagnosis of pregnancy toxaemia; however, samples need to be fresh. Histology of the liver is also of benefit.

Ante mortem diagnostics include urinary ketone levels and increased serum *BHB* levels. Hypoglycemia is not a consistent finding. Non-esterified fatty acids (*NEFA*) can also be increased.

11 Ovine Parasites

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Trichostrongyles

Although grazing ruminants are commonly exposed to nematode challenge at pasture, on occasion, this may lead to the development of a condition known as parasitic gastroenteritis (PGE) (Figure 11.1) (Craig, 2018). This is as a result of grazing pasture heavily contaminated with infective nematode larvae and is compounded if the host animal has little or no prior exposure to these larvae. The disease is most often seen in the first grazing season and is characterised by a range of clinical signs such as diarrhoea, anorexia and sudden weight loss (Urquhart et al., 1996). In some cases, death may also occur. In subclinical infections, animal performance is impacted and can result in reduced live weight gain and milk yields (Charlier et al., 2007; Stromberg et al., 2012).

Although a number of different nematodes such as *Haemonchus contortus, Nematodirus battus, T. circumcincta, Trichostrongylus spp.* and *Cooperia spp.* can give rise to PGE in lambs (Craig, 2018), *Haemonchus spp.* infections are not commonly reported in Ireland (Rinaldi et al., 2015) and *T. circumcincta* appears to be the main species found in the abomasum in lambs in Ireland (Good et al., 2006). In contrast to *N. battus*, where clinical disease is typically observed in late spring or early summer, disease due to the *T. circumcincta* and *Trichostrongylus spp.* is mainly seen from mid-summer onwards.

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

Table 11.1: Number of ovine faecal samples tested for *Trichostrongylidae* eggs in 2019 and results by percentage (n= 1541).

Result	No. of samples	Percentage
Negative	662	43
Low (50-500 epg)	438	28
High (>1200 epg)	268	17
Medium (500-1200 epg)	173	11

The number of faecal samples that were categorised as either medium or high burden (28 *per cent*) was marginally less than last year's combined figure of 32 *per cent*. Those in the high burden category for this year (17 *per cent*) are similar to previous year's value (18 *per cent*). Although it is beyond the scope of this report to fully interrogate these figures, it may merely 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 essential that producers regularly faecal sample those at-risk categories throughout the grazing season so that anthelmintic treatments can be used in a more targeted and sustainable fashion.

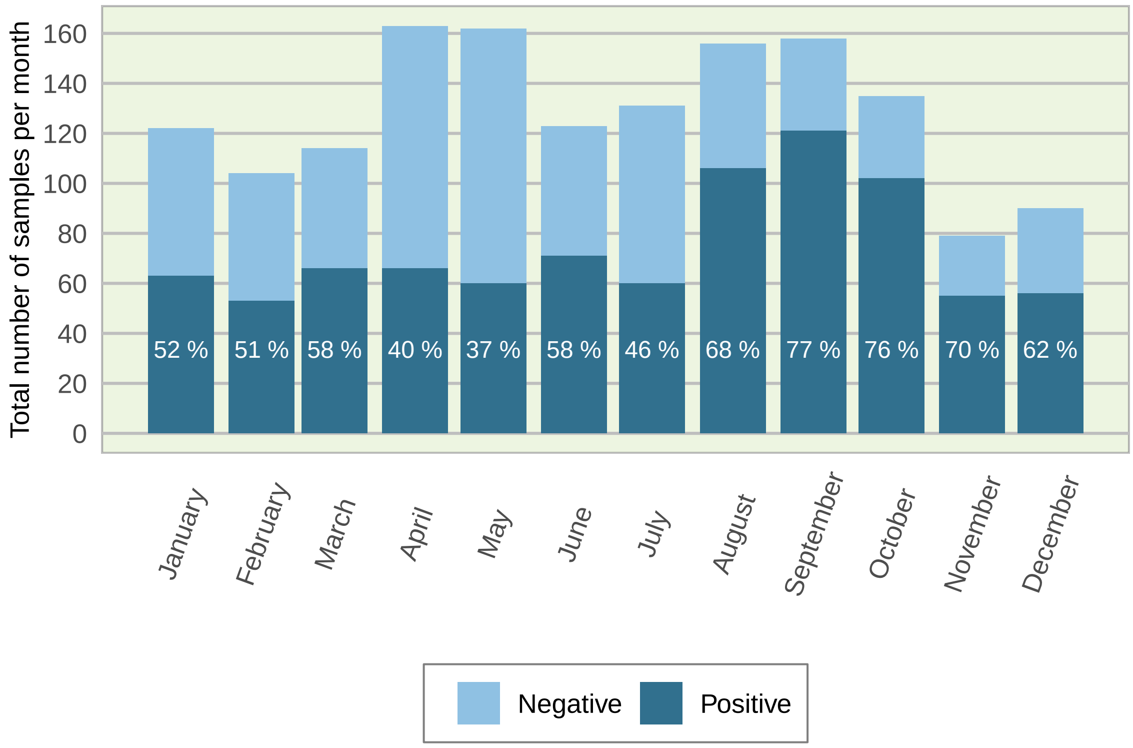

Figure 11.2: Stacked count of ovine faecal samples (all ages) tested per month for *Trichostrongylidae* during 2019. The percentage in each bar represents positive samples per month (n= 1541).

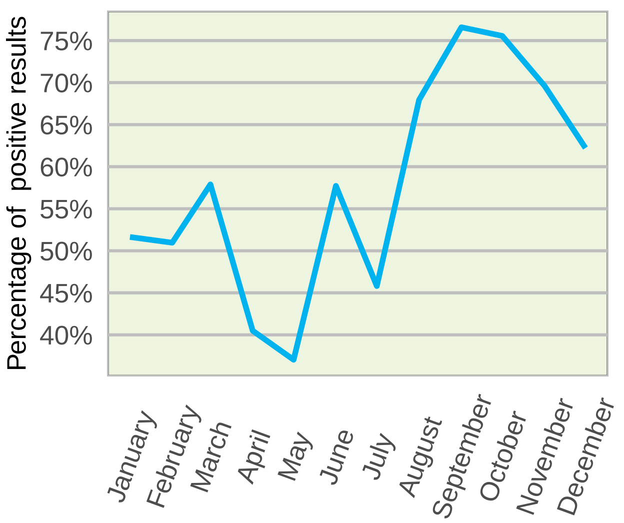

Figure 11.3: Percentage of positive ovine faecal samples for *Trichostrongylidae* eggs in 2019 (n= 1541).

Nematodirus

Although there are several *Nematodirus* species which can potentially affect sheep (e.g. *Nematodirus filicollis*, *N. spathiger* and *N. battus*), by far the most important of these is the highly pathogenic *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, 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.

Typically there is a mass hatch of eggs in late spring or early summer (April-June) leading to a build-up of infective larvae on pasture, although hatching can also occur at other times of the year (e.g. autumn) (Urquhart et al., 1996). There is usually only one generation of infective larvae present on pasture each year. Infection is characterised by profuse diarrhoea, dehydration and weight loss.

Based on this year's data, the highest 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 89 *per cent* of samples, it still does not preclude this roundworm from being responsible for disease in some instances given that the pathology attributed to this roundworm is primarily due to the larval stages as outlined below.

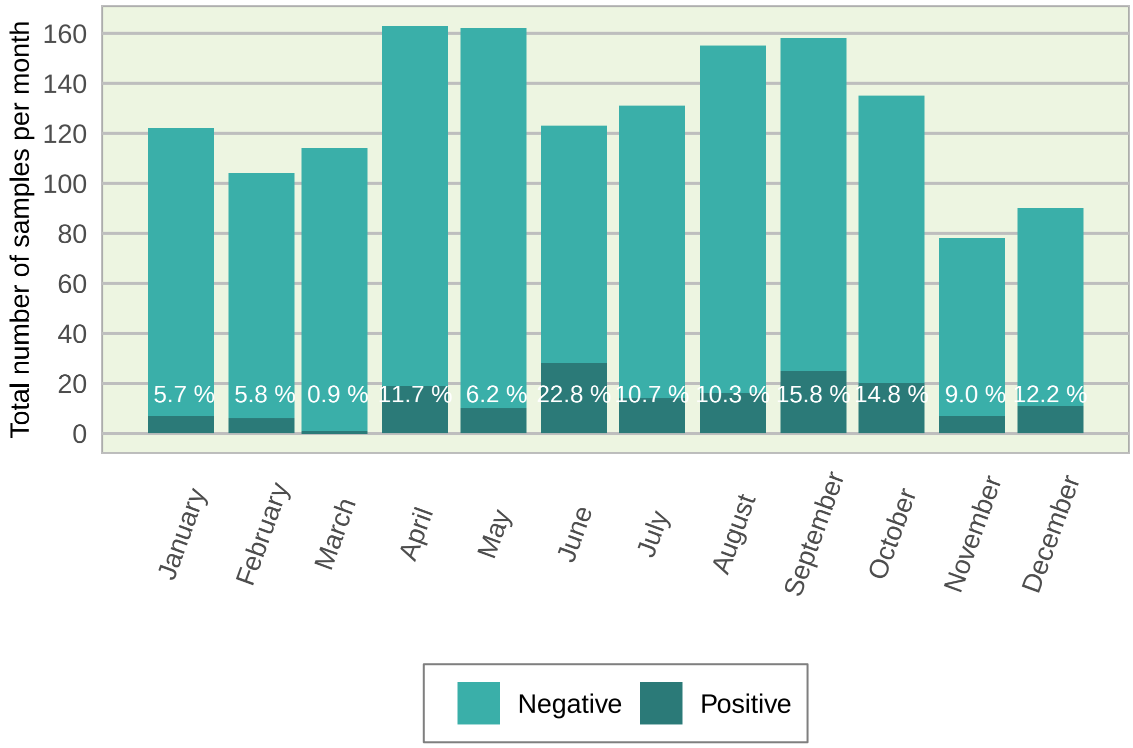

Figure 11.4: Count of ovine faecal samples exmined for *Nematodirus* eggs in 2019. The percentage in each bar represents the number of positive samples per month (n= 1539).

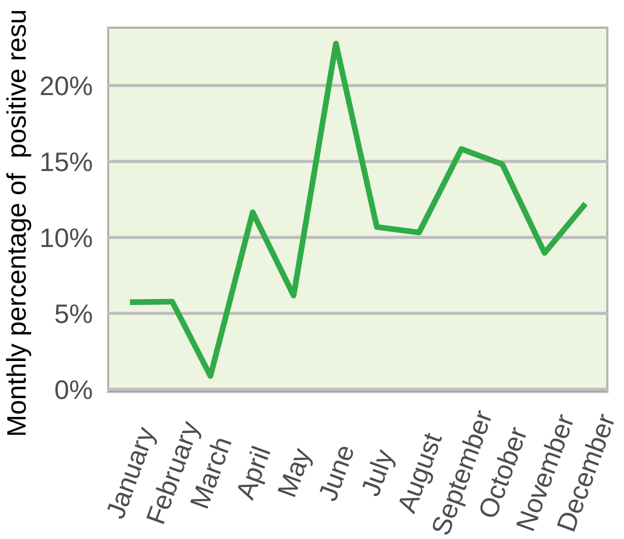

Figure 11.5: Percentage of ovine faecal samples which tested positive for *Nematodirus* eggs in 2019 (n= 1541).

Table 11.2: Number of *Nematodirus* eggs detected in ovine faecal samples in 2019 and results by percentage (n= 1539).

Result	No. of samples	Percentage
Negative	1375	89.3
Low (50-500 epg)	144	9.4
Medium (500-1200 epg)	13	0.8
High (>1200 epg)	7	0.5

Faecal Egg Count

It is important to recognise that many factors can ultimately affect faecal egg output in an individual animal. Examples of some of these are described in the text. With this in mind, it is advised to always sample multiple animals with the same group where parasitism is suspected.

Table 11.3: Number of ovine faecal samples submitted in 2019 (all ages) for detection of coccidial oocysts and results by percentage, (n= 1515).

Result	No. of samples	Percentage
Not Detected	909	60
Light Infection	392	26
Moderate Infection	115	8
Heavy Infection	66	4
Severe Infection	33	2

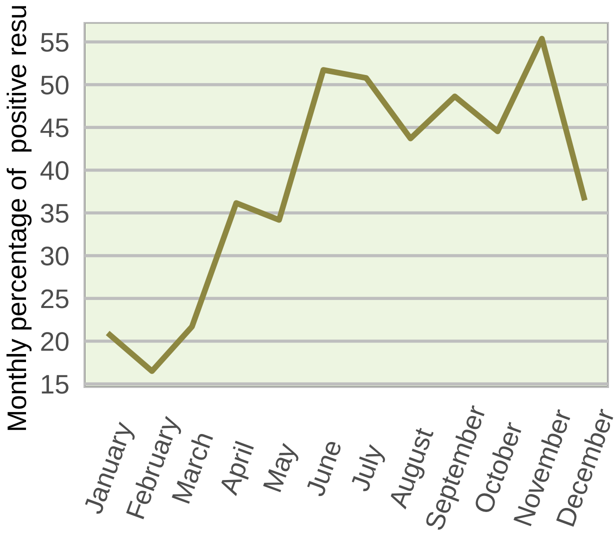

Figure 11.8: Count of ovine faecal samples examined for coccidial oocysts in 2019 (n= 1515).

Coccidiosis

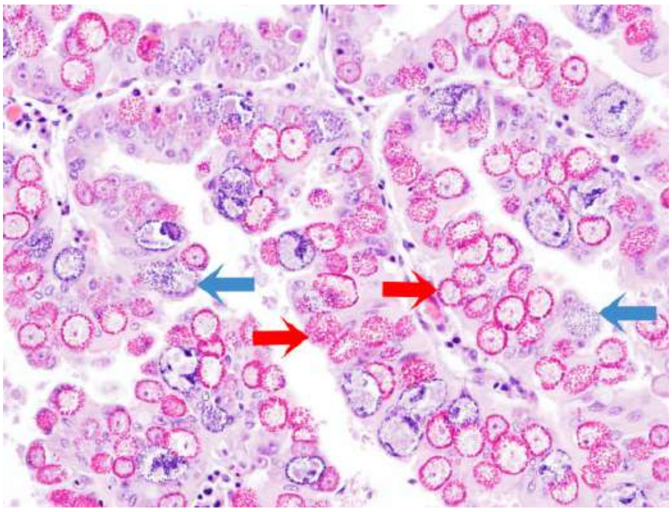

Figure 11.6: Microscopic photography if the intestinal villi of a sheep with coccidiosis showing the merozoites diferenciated into gametes, the red arrows show the macrogametes and the blue arrows the microgametes. Photo: Cosme Sánchez-Miguel.

Eimeria is a genus of ubiquitous protozoans that give rise to the condition commonly known as coccidiosis (Keeton and Navarre, 2018). Although there are a number of *Eimeria spp.* that may affect 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, subclinical disease also commonly occurs and is characterised by reduced 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).

Although a large majority of this year's samples (86 *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 regard 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

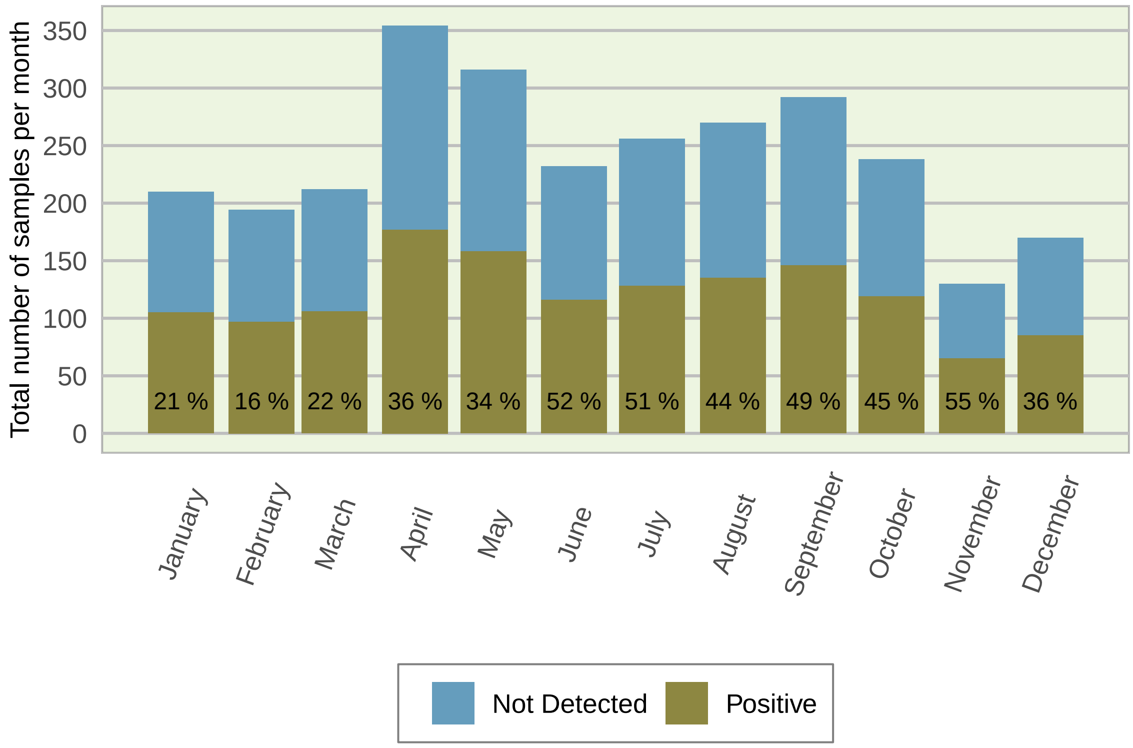

Figure 11.7: Stacked number of ovine faecal samples (all ages) tested for coccidial oocysts in 2019. The percentage in each bar represents the number of positives per month (n= 1515).

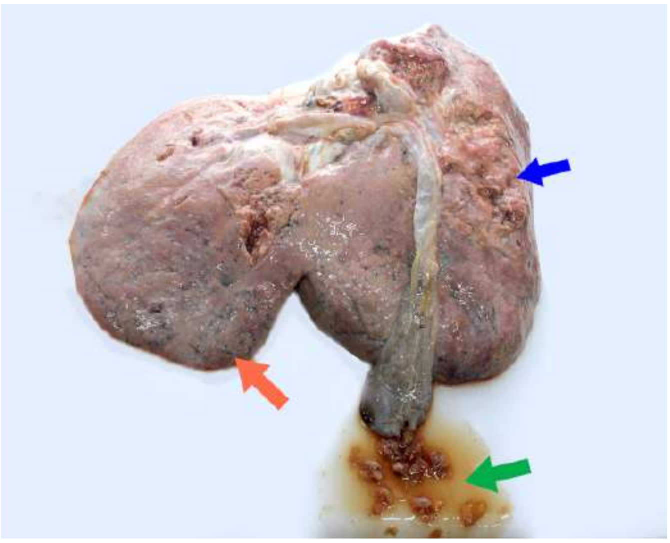

Figure 11.9: Acute fluke in the liver of a sheep. Photo: Cosme Sánchez-Miguel.

relation to the diagnosis of coccidiosis, it is advised to sample multiple animals within the same group.

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 (Figure 11.9), causing sudden death in cases of heavy challenge. Please note that control of liver fluke must always be given precedence as detection of its presence is always significant.

Table 11.4: Number of ovine faecal samples submitted in 2019 (all ages) for detection of liver fluke eggs and results by the percentage (n= 1262).

Result	No. of samples	Percentage
Liver fluke eggs not detected	1167	92
Positive liver fluke eggs	95	8

Although there has been a substantial 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 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 which attach themselves to the intestinal mucosa by their blind-ended posterior-placed

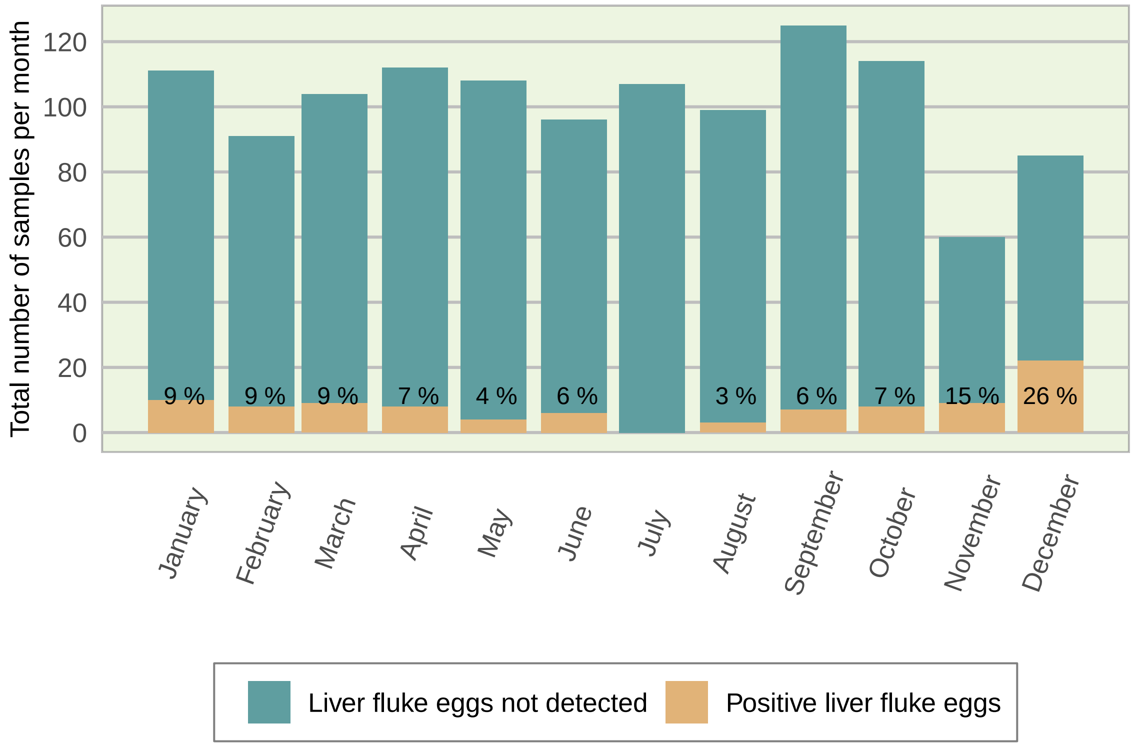

Figure 11.10: Stacked number of ovine faecal samples (all ages) tested for liver fluke in 2018. The percentage in each bar represents the number of positive samples per month (n= 1262).

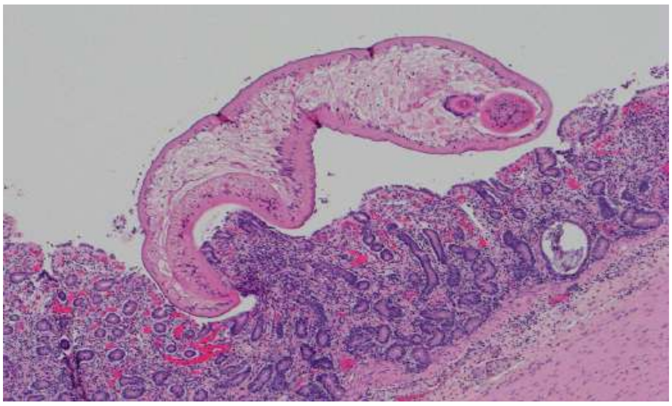

Figure 11.11: Juvenile Rumen Fluke Attaching to the Intestinal Mucosa by the Acetabulum. Photo: James O'Shaughnessy

Table 11.5: Presence of rumen fluke eggs in ovine faecal samples in 2019 (n= 1262).

Result	No. of samples	Percentage
Rumen fluke eggs not detected	937	74
Positive rumen fluke eggs	325	26

suckers(known as the acetabulum) and draw plugs of mucosa into these suckers leading to haemorrhage and enteritis (Figure 11.11) .

The number of samples positive for liver fluke (8 *per cent*) is similar to last years' data, where 10 *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 still a significant result.

The figure for this year's rumen fluke-positive samples (20 *per cent*) is again broadly similar to last year's data, where 26 *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 acute disease remain very uncommon.

Some Comments on Faecal Egg Counting

Faecal egg counts (FEC) of stomach/gut worms such as *Teladorsagia circumcincta*, and *Trichostrongylus spp.* are expressed as *eggs per gram* (EPG) of faeces.

As the FEC value is expressed as a ratio, anything that changes the volume of faeces produced will alter its value. For example, in cases of inappetence, the volume of faeces produced will be reduced. As a result, the FEC value will be increased. Conversely, animals with diarrhoea may have a reduced FEC as a result of the dilution effect from the increased faecal volume.

It is also important to recognise that there is not a direct relationship between the total worm burden of an individual animal and their FEC value.

Nematodirus. Given that most of the pathogenic effects of this parasite are caused by the larval stages, coupled with the fact that the female worm is a poor egg producer, faecal egg counts alone do not provide a reliable basis for deciding on when to treat lambs.

Liver fluke. Liver fluke eggs are not consistently shed in faeces. In addition, despite a substantial burden of liver fluke in an individual animal, some animals will only shed a small number of eggs. Therefore, it is advised that more than one animal in a group should be sampled to determine whether liver fluke infection is present on the farm.

Rumen fluke. As adult rumen fluke is not associated with clinical disease, the detection of rumen fluke eggs in the faeces of animals that appear healthy does not indicate that treatment for rumen fluke is necessary.

On rare occasions, acute rumen fluke disease may occur. This is due to the presence of large numbers of juvenile rumen fluke in the small intestine. If only immature stages are present in the animal at that time, no eggs will be detected in submitted faecal samples.

Please note that if juvenile rumen fluke infection is suspected, it is important to state on laboratory submission forms that faecal samples are to be tested for the presence of juvenile rumen fluke as well as for routine egg analysis.

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Diseases of Pigs and Poultry, DAFM

12 Diseases of Pigs,

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In 2019, DAFM laboratories carried out necropsy examinations on 384 pig carcases, while 3073 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. Pigs submitted for necropsy examination were predominantly from piglet (140) and weaner (132) stages of growth and almost exclusively from intensive, large scale pig farming units.

Porcine Respiratory Disease Complex

- **Bacterial:**
  - *Bordetella bronchiseptica*
  - *Pasteurella multocida*
  - *Actinobacillus pleuropneumoniae*
  - *Haemophilus parasuis*
  - *Mycoplasma hyopneumoniae*
- **Viral:**
  - PRRSV
  - PCV2
  - Swine Influenza
  - Porcine Respiratory Coronavirus

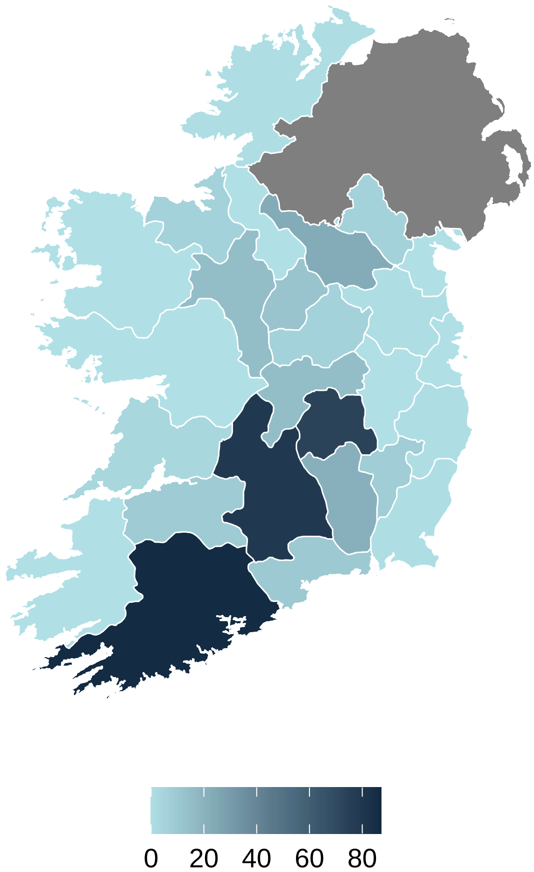

Figure 12.1: Number of carcass per county submitted to the RVLs for *post-mortem* examination during 2019.

Post mortem diagnoses

The most frequent diagnoses in pig necropsy submissions during 2019 are detailed in Table 12.1 and Figure 12.3. This dataset is inherently limited and 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.

Globally respiratory disease is considered one of the most serious disease problems in intensive pig

Table 12.1: Diseases diagnosed in pigs submitted for *post-mortem* examination to the RVLs in 2019 (n= 246).

Diagnosis	No. of cases	Percentage
Respiratory Infections	54	22.0
GIT Infections	34	13.8
Integument/Musculoskeletal	31	12.6
Systemic Infections	25	10.2
Reproductive Tract Conditions	23	9.3
CNS	19	7.7
Perinatal Mortality	6	2.4
GIT torsion/obstruction	5	2.0
Cardiac/circulatory conditions	4	1.6
Peritonitis	4	1.6
Liver disease	2	0.8
Urinary Tract conditions	2	0.8
Abscessation	1	0.4

production and a large driver for vaccination and antibiotic usage in pig production.

Pneumonia and pleuropneumonia were the most frequent diagnoses in pig necropsy cases received in 2019, with respiratory disease accounting for 22 *per cent* of all diagnoses reached. All porcine respiratory disease investigations at DAFM labs undergo both bacterial and viral testing, to try to determine the pathogens present.

It is well recognised that pneumonia in pigs typically is a result of many interacting factors including; infectious agents (viral and bacterial), environmental conditions, management factors and genetic factors. As pneumonia in pigs is rarely exclusively due to infection with a single pathogen, 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 the farm level and at meat factory level for the pig producers (as *pleurisy* is the most common cause of pig carcases being detained or condemned at slaughter).

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

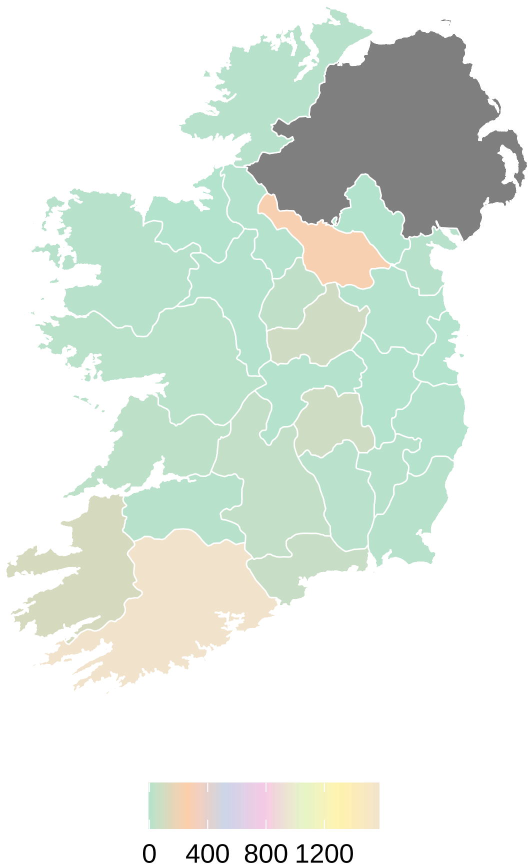

Figure 12.2: Number of non-carcass diagnostic samples per county submitted to the RVLs during 2019.

Actinobacillus pleuropneumoniae is one of the most prevalent bacterial pulmonary pathogens in pigs worldwide. In its most virulent form, *Actinobacillus pleuropneumoniae* causes severe diffuse fibrinohaemorrhagic necrotizing pleuropneumonia (Figure 12.4), which is rapidly fatal in all ages of pigs.

DAFM labs investigated a number of *Actinobacillus pleuropneumoniae* outbreaks associated with increased sudden death in finisher stage pigs often with associated high levels of pleurisy in cohorts at slaughter examination.

In 2019 seven *Actinobacillus pleuropneumoniae* isolates were serotyped from various submitting farms and serotypes 8, 2 & 12 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 or less prevalent in Ireland at this time.

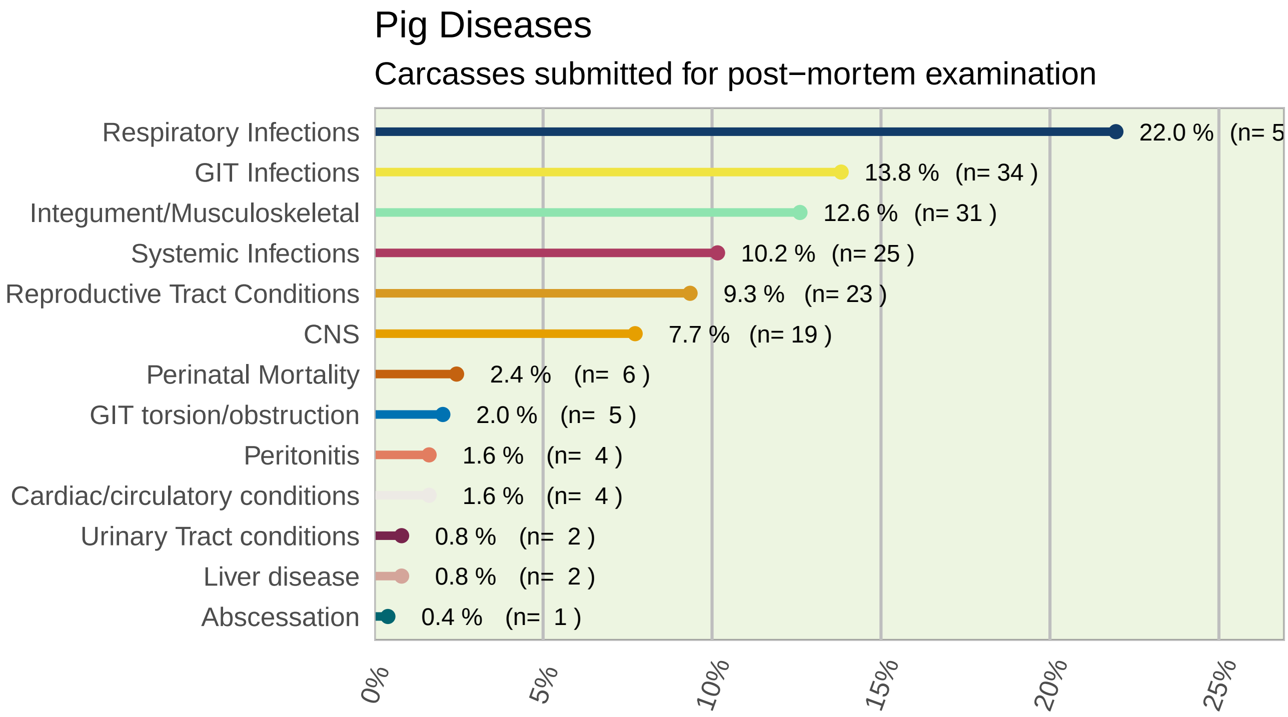

Figure 12.3: Diseases diagnosed in pigs submitted for *post-mortem* examination to the RVLs in 2019 (n= 246).

In 2019 the most frequently detected porcine viral respiratory pathogen was PRRSV.

Figure 12.4: Porcine pleuroneumonia. Severe diffuse fibrinosuppurative pleurisy and bronchopneumonia with marked pulmonary consolidation. Actinobacillus pleuropneumoniae was isolated. Photo: Aoife Coleman.

Gastrointestinal disease

In 2019 GIT infections represented the second most common disease diagnosed in pig carcases submitted. The majority of these cases were neonatal enteritis investigations, as DAFM Labs in recognizing neonatal enteritis as a significant cause of morbidity and economic loss on Irish farms which can lead to increased use of antibiotics, continues to operate a proactive service in investigating neonatal diarrhoea outbreaks in affected herds. Similar to neonatal enteritis in many farmed animal species, 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 Laboratories were; *E. coli*, Rotavirus, *Clostridium difficile*, *Salmonella spp.* and enteroadherent bacteria.

Reaching a conclusive diagnosis in these cases is often challenging due to; multi-pathogen infections, the paucity of diagnostic tests, presence of novel agents and the complex interaction between gut microbiome and environmental factors. Therefore DAFM Labs have developed a comprehensive post mortem and clinical microbiology sampling and testing protocol for neonatal enteritis cases, which affords us a good opportunity to investigate these cases. All enteritis cases are routinely tested for Porcine Epidemic Diarrhoea (PED), a devastating newly emerging porcine disease, which has caused significant losses in the recent past in USA and continental Europe, but has not been detected here.

Musculoskeletal Disease

Lameness and joint diseases are common presentations in intensive pig rearing systems. DAFM labs assisted with the investigation several outbreaks of increased incidence of lameness/joint disease on pig farms in 2019. In investigating these outbreaks, submission of acutely affected pigs affords the best opportunity for an accurate diagnosis. The most commonly isolated pathogen was *Trueperella pyogenes* however, this is typically a secondary opportunistic pathogen and unlikely to have been the primary agent. Also isolated from joints in affected outbreaks were; *Actinobacillus pleuropneumoniae*, *Pasteurella multocida*, *Streptococcus suis* and *Staphylococcus aureus*. Additionally one case where no agent was isolated, had Mycoplasma hyosynoviae detected by PCR testing on joint fluid. It is also noteworthy that one case where *Staphylococcus aureus* was detected, methicillin resistance, ie. MRSA was detected, the case history indicated that the arthritis outbreak was not responding to antibiotics. While pig carriage of MRSA is well documented in Europe and Ireland, this was a rare clinical isolation of MRSA from a pig in Ireland. Published European literature indicates when associated with clinical disease in pigs, MRSA is most commonly detected from arthritis lesions.

Systemic disease

A number of pig cases were submitted where the diagnosis reached was of systemic disease. *Streptococcus suis* or systemic Salmonellosis were the most common agents identified in cases where systemic disease was diagnosed.

A systemic disease is one where multiple organs are infected by an agent and show inflammatory changes, so while this is one of the more common diagnoses, reaching it is hampered in the many cases where pigs have been treated with antibiotics prior to post mortem examination. Typically pigs affected by a systemic infection will present as sick and may be moved to hospital pens within an intensive piggery unit, where individual antibiotic treatment is more likely to occur.

Streptococcus suis, is a common worldwide pathogen of pigs, which causes bacteriaemia and attendant; polyserositis, meningitis, arthritis or pneumonia (Figure 12.5). Streptococcus suis carriage in pigs is very common and is typically acquired at or around the time of birth from the sow. However, carriage alone is not responsible for the disease, as only virulent strains are considered capable of causing disease.Once disease emerges within a herd, the long bacteraemia facilitates shedding and spread of virulent strains within the cohort group of pigs and beyond, as delays in reaching target weight gains in affected pigs can result in them falling back to younger age groups. Without an available commercial vaccine, treatment is usually via group administration of in-feed antibiotics, with autogenous vaccines possibly introduced to try to control the situation.

Figure 12.5: Pericardium: Severe diffuse fibrinosuppurative pericarditis in a weaner pig. Streptococcus suis isolated. Photo: Aoife Coleman

Salmonella. Routine culture of porcine tissues from post mortem samples includes Salmonella culture; from these samples, eight animals were identified with *Salmonella typhimurium* infection. As this is a bacterium capable of causing severe zoonotic disease in people, all confirmed *Salmonella typhimurium* isolates are notified to the local 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.

Porcine Abortion

DAFM labs routinely conduct abortion investigations on submitted batches of aborted piglets. Ten *per cent* of all submissions received in 2019 were abortion investigations, and no significant infectious abortifacients were identified in any cases examined. All abortion cases are routinely screened for PRRSV, Parvovirus, bacterial agents and ASF and examined histologically.

Notifiable disease

African Swine Fever awareness. The ongoing outbreak of African Swine Fever (ASF) in multiple European countries poses a risk to the Irish pig industry. In 2019 the disease increased its reach in wild boar and commercial pig farms in Eastern Europe and continued its westerly spread having been identified in wild boar populations in western Poland in 2019. The most significant potential risk factor for entry into Ireland is feeding illegally imported infected pork products to pigs. During 2019, DAFM veterinary laboratory service continued its focus on preparation and contingency planning to mitigate risk from a potential incursion of exotic disease such as ASF to the pig population, through practical training of staff on outbreak investigations and pig sampling techniques (Sánchez-Cordón et al., 2018).(Beltran-Alcrudo et al., 2017)

ASF is a notifiable disease, and PVPs are reminded to notify DAFM if they the suspect presence of the disease by contacting their local RVO or the National Disease Emergency Hotline at 1850 200 456. An ASF factsheet for vets detailing the clinical signs of ASF is available on the African swine fever page on the DAFM website. DAFM also produced a biosecurity leaflet specifically aimed at non-intensive pig farms and an ASF factsheet for farmers; both are available to download from the African swine fever page on the Department 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. During 2019, as part of a surveillance program on culled sows undertaken by the Blood Test Laboratory, 1195 samples were tested for Aujeszky disease. All these samples were also tested for Classical Swine Fever (CSF) and African Swine Fever (ASF). Any samples that produced a reaction for ASF were forwarded to Virology Division in the Central Veterinary Research Laboratory (CRVL) for further testing. All the samples tested were negative for the three diseases.

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

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13 Poultry Diseases

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Avian Influenza Surveillance

Avian influenza type A is a contagious disease caused by viruses which are naturally found in, and which are adapted to, populations of wild birds. Avian influenza viruses can also affect poultry and mammalian species 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 reduced egg quality has been reported.

Avian Influenza viruses are classified into subtypes based on two surface proteins: the haemagglutinin (HA) and neuraminidase (NA). H5 and H7 subtypes have been associated with acute clinical disease in chickens, turkeys and other birds of economic importance.

Table 13.1: Avian influenza surveillance testing during 2019 in Ireland.

2019	Animals tested	Positive
National Poultry Health Programme Poultry – AI AGID test (a)	12921	0
EU - H5 and H7 Surveillance Poultry (AI-HI test) (b)	8976	0
Wild birds –AI PCR	78	0
Poultry – AI PCR	634	0
Captive birds – AI PCR	27	1 (c)

[a] AGID: Agar Gel Immunodiffusion test;
[b] HI: Haemagglutination Inhibition test for H5 and H7;
[c] Low positive. Non- H5, H7,N1.

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

a) **Avian influenza serology testing in poultry for the national Poultry Health Programme (PHP).** The Poultry Health Programme is a DAFM surveillance programme to support trade in poultry, and to comply with EU regulations and *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*. The PHP also includes testing for Mycoplasma and Salmonella arizonae. Last year, 12921 poultry species were tested for AI through this programme (Table 13.1).

b) **Avian influenza H5 and H7 serology testing of poultry under the EU Poultry Surveillance Scheme.** Ireland uses the representative sampling method described in the *Commission Implementing Decision 2010/367/EU of 25 June 2010 on* *the implementation by the Member States of surveillance programmes for avian influenza in poultry and wild birds.*

In 2019, 8976 samples were tested by H5 and H7 HAI. Up to 2018, the results have been reported to the European Commission (EC), and from 2019 onwards results are submitted to EFSA, which is mandated to analyse and report the data by the EC. 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.

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). 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 PCR 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.

Until 2018 results of the wild bird surveillance were submitted to the European Commission, and from 2019 onwards results will be forwarded to EFSA. In 2019, 78 wild birds were tested and none of them were positive by AI PCR (Table 13.1).

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.

Poultry/captive bird samples and carcasses are submitted routinely to the RVLs and CVRLs by the PVP and backyard flocks for PCR testing for diagnosis, screening and exports/imports.

Farmers/owners are encouraged to report suspicions of avian influenza to their local Regional Veterinary Office and to make use of their local Regional Veterinary Laboratory to aid with diagnosis of disease conditions.

Last year 634 poultry and 27 captive birds were submitted and tested for AI PCR. Only one macaw tested low positive for AI PCR but was negative for H5, H7 or N1 (Table 13.1). All data on Avian Influenza surveillance is provided to the European Reference Laboratory (EURL) every year.

Avian Mycoplasma Surveillance

Active Surveillance. The Poultry Health Programme 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

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

Mycoplasma Meleagridis

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

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

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

In 2019, 31124 and 1899 serum samples were screened for *M. gallisepticum* and *M. meleagridis*, respectively, at the CVRL as part of DAFM official sampling (Table 13.2).

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

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

Table 13.2: Official Sampling for Poultry Health Programme and EU AI surveillance during 2019 in Ireland

Type of submissions	Test	No. Tests	Positive
National-Poultry Health Programme	M. gallisepticum SPAT	31124	0
National-Poultry Health Programme	Avian Influenza AGID	12921	0
National-Poultry Health Programme	M. meleagridis SPAT	1899	0
National-Poultry Health Programme	Salmonella arizonae 'H' SAT	1190	0
EU-H5 H7 HI -Surveillance	Avian Influenza H5	8976	0
EU-H5 H7 HI -Surveillance	Avian Influenza H7	8976	0

Avian Salmonella Surveillance

As part of the national Poultry Health Programme, serological testing for screening of *S. arizonae* is carried out in turkey flocks in addition to testing for Avian influenza and *M. Meleagridis* (Table 13.2). Last year, 1190 serum samples were screened for *S. arizonae*.

In parallel, DAFM carries out the EU Salmonella Surveillance by collecting samples on-farm and confirming detected serotypes by culture (Table 13.3). Programme is as follows:

Table 13.3: Number of Salmonella culture Tests from on-farm samples during 2019 in Ireland

Avian Production Type	No. Samples	No. Positive Flocks
Broiler Breeder	921	2 (a)
Layer	474	2 (b)
Broiler	111	0
Turkey Fattener	59	2 (c)
Broiler Grandparent	6	0
Turkey Breeder	12	0
Layer Breeder	4	0
Hatchery	12	0

[a] Salmonella Typhimurium;
[b] Salmonella Schwarzengrund and Salmonella Typhimurium;
[c] Salmonella Derby.

- 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 2019, 1599 samples from farms and hatcheries were analysed; of these, Salmonella was detected in 2 broiler breeder flocks, 2 layer flocks and 2 turkey fattener flocks (Table 13.3).

Newcastle Disease and Pigeon PMV1

Newcastle Disease 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 of the strain virulence, from lethargy and mild respiratory signs, to egg drop production, neurological sings and sudden death.

Table 13.4: Paramixovirus- 1 (PMV-1) testing during 2019 in Ireland.

PMV1 PCR testing 2019	No birds	PCR	Positive	Strain virulence
wild birds (a)	49	107	4	2 high virulent, and 2 low positive (not characterised)
captive/racing	36	89	5	All high virulent
poultry (b)	437	543	1	avirulent-vaccine

[a] Rook, hen harrier, 2 wild pigeons;
[b] Vaccine strain.

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

In 2019, a total of 49 wild birds, 36 captive birds, and 437 poultry were tested. From the wild birds, 2 wild pigeons, 1 rook and 1 hen-harrier tested positive and from the captive birds 5 cases/events (including pets/ racing/rescue/fancy pigeons) tested positives. The pigeon cases were all high virulent strains. In addition, 1 poultry case was detected by PMV1 PCR but confirmed as vaccine-avirulent strain (Table 13.4).

Disease Diagnostics

Beyond the active and passive surveillance of important notifiable diseases, DAFM carries out testing of other notifiable and non-notifiable diseases that have significant economic impact. Samples from suspect and healthy animals -for monitoring purposes- are submitted directly to the CVRL (Table 13.5) and carcasses of animals are submitted to the RVLs (Figures 13.1, 13.2 and 13.4).

Last year, 7 cases were confirmed positive for *C. psittaci*, 49 for Infectious Bronchitis, 115 for *M. synoviae*, 16 for *M. gallisepticum*, 2 for *A. pneumovirus*, 8 for Infectious laryngotracheitis and 2 by *Marek's Disease* (Table 13.5). Some of them are notifiable diseases and when suspected, samples or carcasses should be submitted to the CVRL or RVLs, respectively. In addition, some agents such as *C. psittaci* have zoonotic potential.

Table 13.5: PCR testing of submitted samples

Pathogen	PCR	Animals tested	Positive
Avian pneumovirus	26	13	2
Chlamydia psittaci *	374	187	7
Infectious Bronchitis	1059	529	49
Infectious laryngotracheitis *	260	120	8
Mycoplasma synoviae *	1300	646	115
Marek's Disease	3	3	2
Mycoplasma gallisepticum *	1332	661	16
Mycoplasma Meleagridis *	16	16	0

* Notifiable diseases.

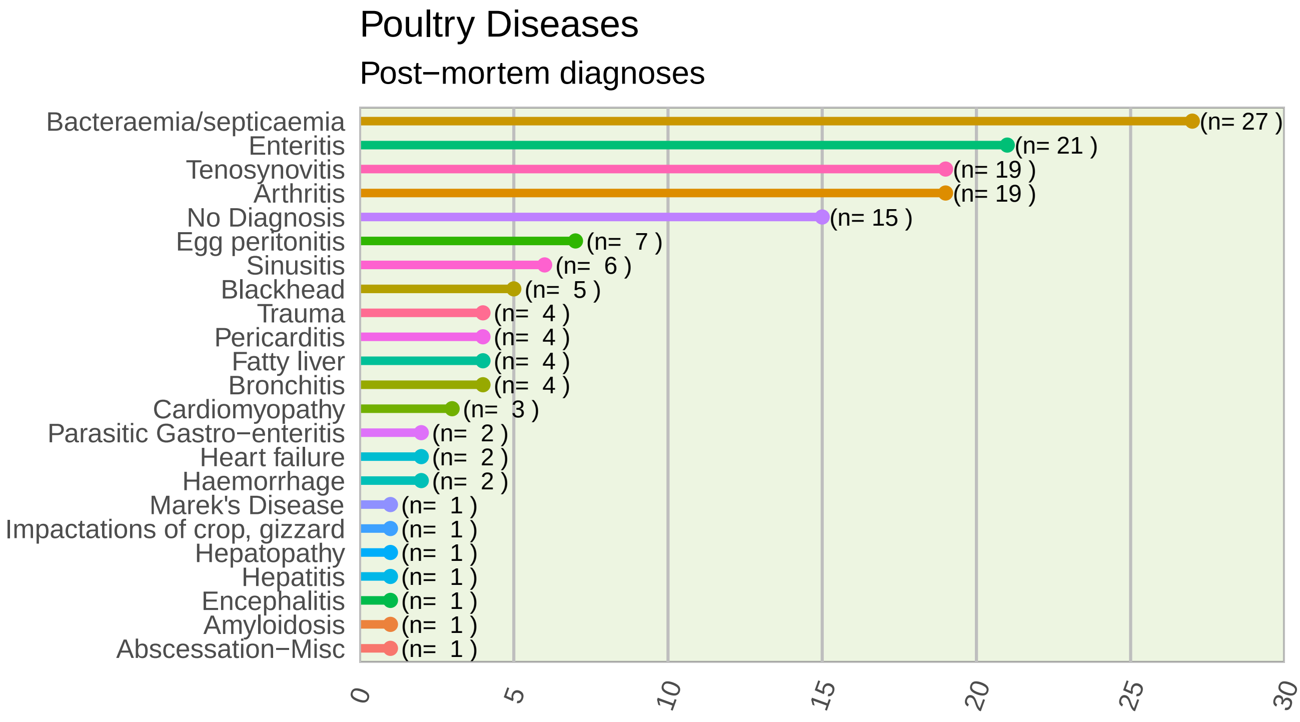

Figure 13.1: Disease diagnosed in poultry carcasses in 2019.

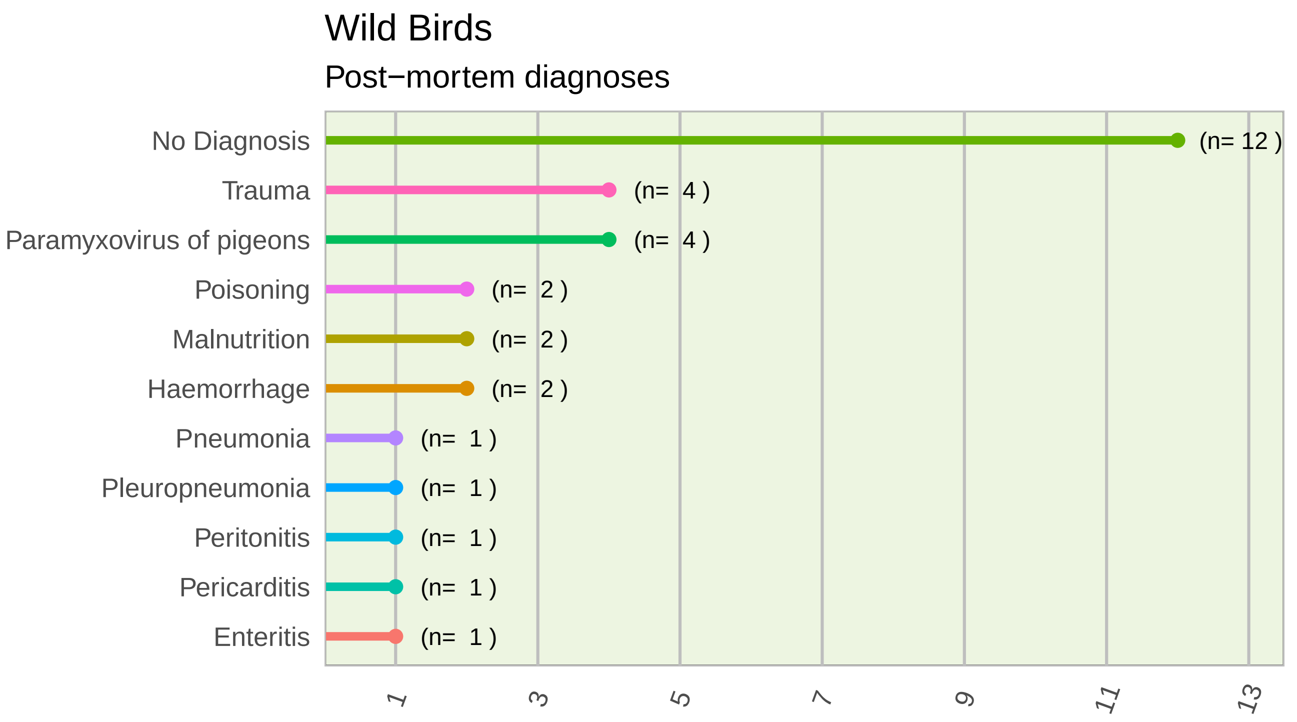

Figure 13.2: Diseases diagnosed in wild bird carcasses in 2019.

Figure 13.3: Cutaneous Marek's disease affecting the feather folicles and also the skin around the eye, comb and wattles. Photo: Cosme Sánchez-Miguel.

In 2019, the most common diagnosis in poultry carcasses was bacteraemia/septicemia (27 cases) followed by enteritis, arthritis and tenosynovitis (Figure 13.1). In wild birds and captive birds- including pigeons-, PPMV1 infection was the most common diagnosis in carcasses followed by trauma in wild birds and enteritis in captive birds (Figure 13.2 and Figure 13.4). In a number of carcasses the cause of death was not determined.

Case Reports in Poultry

In 2019, respiratory disease was a common diagnosis in poultry. Respiratory diseases diagnosed in backyard flocks included infectious bronchitis (coronavirus), *Mycoplasma gallisepticum* infection, fowl cholera (*Pasteurella multocida*) and *Infectious Laryngotracheitis* (ILT).

Infectious bronchitis. This a common endemic viral infection of chickens causing respiratory and urogenital tract disease. Young birds are more susceptible than older ones and the disease can be exacerbated by the presence of other pathogens (e.g. *Escherichia coli*, *Mycoplasma gallisepticum*, *Ornithobacterium rhinotracheale*) or adverse environmental conditions (e.g. high levels of ammonia, dust or in house temperatures that are too high or too low). Infection may also cause failure to reach peak egg production, a drop in egg production or misshapen eggs. Although live and attenuated vaccines have been used for many decades to prevent infectious bronchitis, the condition persists worldwide and results in enormous economic losses. The challenge posed by the virus appears to be related to its ability to mutate or form recombinants that are less recognised by a host's immune system. Thus, new strains of infectious bronchitis virus emerge from time to time.

Infectious Laryngotracheitis. ILT was diagnosed in 72-week-old FR HyLine layers. Clinical signs included coughing, dullness and the birds huddled together. At postmortem examination, caseous material was present in the lumen of the trachea. ILT was confirmed by PCR. Virus sequencing results indicated that the virus was wild type. *Mycoplasma gallisepticum* and *Mycoplasma synoviae* were also detected by PCR in this ILT outbreak. The flock was culled. Contiguous testing for ILT was carried out in epidemiologically linked sites and these flocks were negative for ILT virus.

Marek's Disease. The cutaneous form of Marek's disease was detected in free range commercial broilers at slaughter. Due to the longer finishing time required for free range birds, Marek's disease is seen more often in free range broilers (Figure 13.3.

Figure 13.6: Torticollis in a pheasant due to Marek's disease in its neurological form. Photo: Cosme Sánchez-Miguel.

Other conditions. Less commonly diagnosed conditions in poultry included predation, vent pecking, lice infestation, staphylococcal tenosynovitis, fatty liver haemorrhagic syndrome of layers and cardiohepatic syndrome in turkeys.

Staphylococcal arthritis and tenosynovitis may occur in birds of any age. In broiler breeders stress caused by uneven feed distribution or aggression may predispose to infection. *Staphylococcus aureus* is

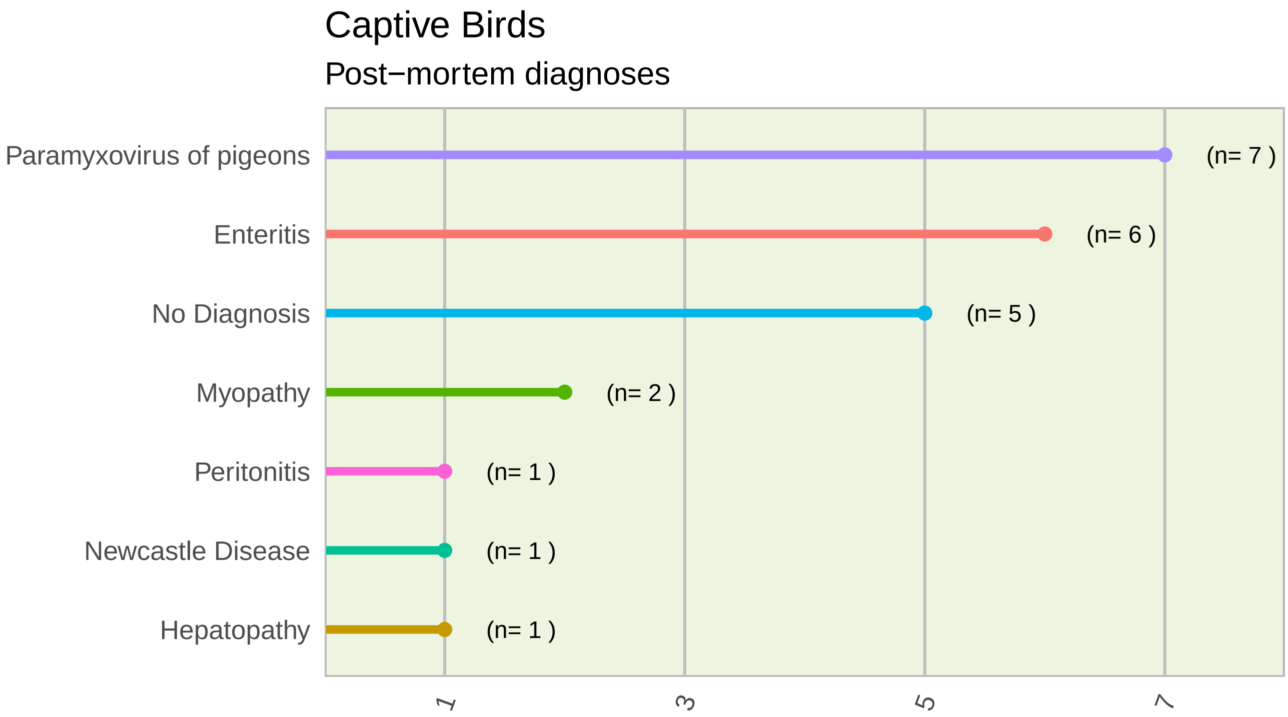

Figure 13.4: Diseases diagnosed in captive bird carcasses in 2019.

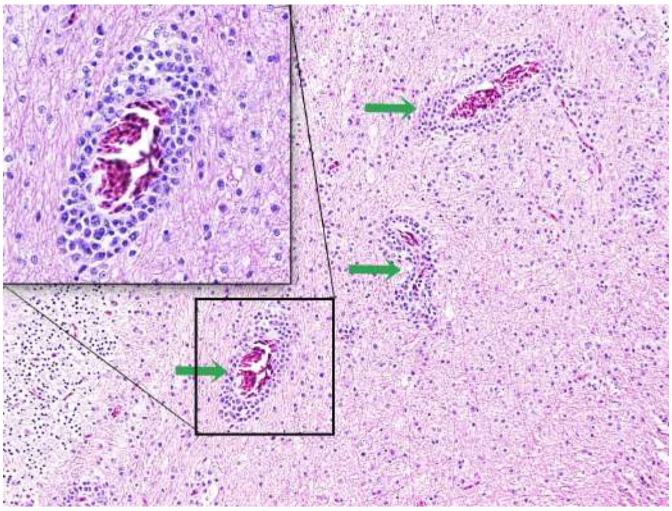

Figure 13.5: non-suppurative perivascular cuffs, vasculitis and endothelial hypertrophy in the cerebrum of a bird with Marek's disease. Photo: Cosme Sánchez-Miguel.

the most common isolate but other staphylococcal species have been recovered.

Cardiohepatic syndrome is a fatal condition of unknown cause affecting young turkeys between 2 and 3 weeks of age. It has been suggested that the condition may be linked to stress and/or the rapid growth rates seen at this age. Typically, deaths due to cardiohepatic syndrome cease after the birds reach four weeks of age. Mortality in outbreaks of cardiohepatic syndrome can be up to 50 *per cent*.

Addendum: Update on the H6N1 Epizootic in Ireland in 2020

Avian influenza viruses are classified as either low pathogenic (LPAI) or highly pathogenic (HPAI) depending on the severity of the disease. Up to now only H5 or H7 hemagglutinin types are found in HPAI viruses in nature, with rare exceptions. HPAI or LPAI of the subtypes H5 or H7 (or any other HPAI if found) are notifiable under the EU and OIE legislation.

Index case. On the 20th of February 2020, the first confirmed case of Low Pathogenic Avian Influenza (LPAI) H6N1 in the Republic of Ireland in 2020 was in a flock located right on the Monaghan Fermanagh border. This farm was situated less than 1km from a known LPAI H6N1 positive flock in Northern Ireland. The first signs of the disease noted were:

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

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

- Twenty oropharyngeal swabs, twenty cloacal swabs and
- Twenty bloods were collected per house.
- Five bird carcases were collected per house.

At *post-mortem* examination, intestine, lungs and brain tissue were collected from each bird, in order to carry out further analysis.

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

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

Table 13.6: Sampling and testing protocol for suspect H6N1 cases

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

Subsequent cases. The second case appeared in a commercial Turkey unit where animals showed lethargy and some mortalities. In addition, four cases were identified in confined layers, 7 cases in layers with outdoor access and three cases in turkey farms.

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

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

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

- Twenty oropharyngeal swabs, pooled in 4 or 5
- Twenty cloacal swabs, pooled in 4 or 5
- Blood from twenty birds
- Brain tissue from five carcasses
- Lung tissue from five carcasses
- Intestine tissue from five carcases

Next, the oropharyngeal & cloacal swabs and tissues were tested using molecular methods, and the blood serum, by serological methods (Table 13.6).

Overall results. Oropharyngeal/cloacal swabs, intestine and lung tissue, tested positive for AI MP, H6N1 PCR with low tropism for brain tissue in all cases. Samples tested all negative for H5, and H7 PCR . Serum tested positive for AI ELISA and AI AGID.

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

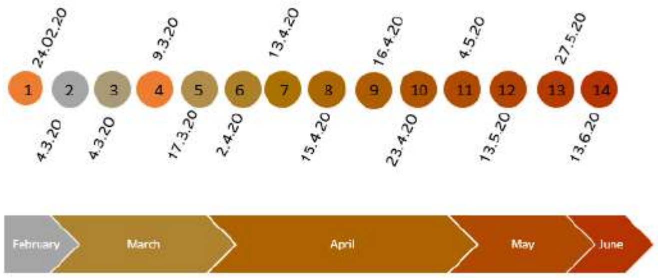

Figure 13.7: Timeline of the confirmed cases of LPAI H6N1 in commercial poultry flocks in Ireland in 2020

In conjunction with clinical signs, LPAI H6N1 was confirmed in the 14 commercial poultry flocks in County Monaghan between 24/02/2020 and 17/06/2020 (Figure 13.7). All flocks were treated as an HPAI or LPAI H5 or H7 avian influenza suspect case (as per the EU Directive) until confirmation of LPAI H6N1 ruled it out.

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

Initial phylogenetic analysis of the first index case, based on the HA (haemagglutinin) fragment sequence, indicated that the virus structure was consistent with circulating strains. Further phylogenetic analyses on the later cases are underway by collaborators in the OIE/FAO Reference Laboratory for AI, APHA (UK) and the OIE/FAO/European Reference Laboratory for AI, IZSVe (Italy).

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

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

A full epidemiological investigation is ongoing, which aims to elucidate some of the ways of infection spread.

For further updates see the Avian Influenza Alert of the National Disease Control Centre

14 Gamma Interferon Test for Tuberculosis

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Gamma Interferon (GIF) Introduction

The gamma interferon diagnostic test was first developed in the late 1980s during the latter stages of the bovine tuberculosis (*bTB*) programme in Australia. The principle of the assay is to use ELISA methodology to detect and quantify release of the IFN-γ cytokine when heparinised whole blood is cultured with bovine and avian (PPD) tuberculin (Rothel et al., 1990**Wood1991**). Results from experimental and natural infections of cattle with *Mycobacterium bovis* (the infectious cause of *bTB*) indicate that the assay can detect a cell-mediated immunological (CMI) response to infection as early as two weeks post-infection, and earlier than the single intradermal comparative tuberculin test (SICTT) (Buddle et al., 1995; Waters et al., 2010; Pollock, Welsh, and McNair, 2005).

In Ireland, the sensitivity of the GIF has been found to be 88 *per cent* (Clegg et al., 2011). This test is most often used as an ancillary diagnostic test in parallel with the SICTT to detect the maximum number of infected animals in *Mycobacterium bovis* exposed herds, and as a quality control check on SICTT reactors. Using it in infected herds allows for the detection of additional infected animals that have tested false-negative to the SICTT.

GIF functionality

The Animal Health Computer System (AHCS) was developed for DAFM to support its animal health activities and a major function of AHCS is the management of the TB eradication scheme.

In May 2019, the work to adapt AHCS to GIF testing through the scheduling and recording of GIF tests and then the incorporation of GIF results into a variety of system generated reports was complete. Twelve months after this GIF functionality came into being, an analysis of the AHCS data relating to GIF has been undertaken and some of the results of this review are included in Tables 14.1, 14.2 & 14.3. The GIF test is used in the eradication scheme in three ways:

GIF 8Hr Diagnostic Test: Described as GIF8D on AHCS, this test is used for detecting additional TB positive animals from the cohorts of reactor animals. This is the only GIF test where animals may be declared reactors based on the results of the test.

GIF 24Hr QC Test: Described as GIF24QC on AHCS this test is used as a quality control tool for surveying SICTT reactor animals.

GIF 8Hr QC Test: Described as GIF8QC on AHCS, this test is used for retesting reactor animals where there is poor correlation between skin test reactors and the GIF24QC. It may be used to gather further evidence regarding the true TB status of skin test reactor animals.

Comment on tables 1–3

In Table 14.1, with increasing skin test group size, the proportion of animals which are GIF tested tends to reduce. This may be a reflection of finite resources both in terms of the practicalities of bleeding very large numbers of animals and limitations to laboratory capacity. Also in Table 14.1, the percentage

Table 14.1: Analysis of the SICTTs carried out in Ireland between May 2019 and May 2020 where the eight hour GIF diagnostic test (GIF8D) was also used.

SICTT size (no. of animals involved)	No. of SICTTs (Skin tests)	Average no. animals per SICTT	Average no. of animals GIF tested	% Animals GIF tested	% GIF positive
<100	472	53	24	45	9.5
100–200	316	146	54	37	8.3
200–300	125	240	94	39	8.6
300–400	44	334	77	23	6.5
400–500	19	452	126	28	3.6
500–600	29	516	159	30	5.2
>600	18	813	145	18	8.7

Note:
SICTT: single intradermal comparative tuberculin test

Table 14.2: Analysis of GIF24QC, 8QC and 8D testing in Ireland between May 2019 and May 2020.

Type	Total tested	G +	% G+	G -	%G-	GNR	% GNR
24QC	7313	4789	65	2087	28	437	7
8QC	2236	1245	56	932	41	59	3
8D	53528	4329	8	48997	91	400	1

Note:
G: GIF, PM: Post-mortem, GNR: GIF no result

of GIF positive animals was highest in the smallest group size (less than 100). With smaller groups it may be easier to identify potentially affected cohorts resulting in more focussed GIF testing. The rate of GIF positives did trend downward with increasing group size though the group with greater than 600 skin test animals was an outlier in this regard. Perhaps this was due to the fact that this group had the lowest number of tests making for less robust statistical analysis.

In the case of the SICTT reactors it is expected that there is normally approximately 65 *per cent* correlation between the SICTT and the GIF24QC results which as it transpires is consistent with the overall correlation between GIF24QC and SICTT reactors in Table 14.2. Undoubtedly however there would be variation around this figure with some tests disclosing a greater than 65 *per cent* correlation and some less. In the case of poor GIF24QC/skin correlation the Veterinary Inspector concerned must assess the case and this assessment may include the use of GIF8QC which would have a higher sensitivity. It is not surprising therefore that at 56 *per cent*, correlation between GIF8QC and skin reactors is lower than that for 24 hour QC, test sensitivity differences not withstanding.

Table 14.3: Relationship between GIF 24QC, 8QC and post mortem results.

Type	G+/ PM+	%G+/ PM+	G+/ PM -	%G+/ PM -	G-/ PM -	%G-/ PM-	G-/ PM+	%G-/ PM+
24QC	2241	48	2445	52	1612	88	215	12
8QC	587	48	632	52	537	88	76	12

Note:
G: GIF, PM: \textit{Post-mortem}, GNR: GIF no result

A small percentage of GIF samples had no result. This may be due to insufficient sample, clotted sample, or a delay in sample arrival to the laboratory. The higher figure for GIF 24QC under this heading may be due to postal delay.

In relation to Table 14.3, the high lesion rate of 48 *per cent* for both GIF 24QC and 8QC is unsurprising given that the animals in question would have been positive both on SICTT and GIF giving a very strong indication of infection. Though not tabulated, the lesion rate for GIF 8D positives was 22 *per cent*. The GIF8D is applied to cohorts of skin reactors so the lower lesion rate of 22 *per cent* with this test is not unexpected.

TB in Deer

Wildlife reservoirs have been implicated as a source of infection for grazing cattle. Infected badgers are considered a maintenance host and are directly implicated in the transmission of *Mycobacterium bovis* to cattle in Ireland (Griffin et al., 2005). With respect to deer, their role in acting as a maintenance host for *Mycobacterium bovis* is considerably less clear, in most areas of Ireland there is no evidence in support of deer acting as maintenance host for TB (More, 2019). In certain areas of County Wicklow, a higher prevalence of TB in deer has been found. Recently, DAFM, in cooperation with the NPWS and local stakeholders groups, has been carrying out research into the prevalence of TB in deer populations. The findings of this work to date for 2019 are that of 87 carcasses tested, *Mycobacterium bovis* has been isolated from nine. Whole genome sequencing has been carried out on isolates of *Mycobacterium bovis* from deer, badgers and cattle in that area of Wicklow, with the results published in the scientific literature (Crispell et al., 2020). These results suggest transmission of *Mycobacterium bovis* between cattle and deer in the Wicklow area.

The Wicklow investigation is one of several DAFM studies into TB prevalence in deer. During the period 2014 – 2016, Drumshanbo RVO as part of its response to a bovine TB outbreak in North Sligo, 17 culled wild deer were submitted to the laboratory service for testing and none were found to have TB (Doyle et al., 2018). Between 2018 and 2019 Tralee RVO lead an investigation into TB in deer within is management region. Out of 184 wild deer carcasses examined TB was confirmed in one. Quigley et al. (1997) describes the largest *post mortem* survey of TB in deer in Ireland.The study found a 0.28 *per cent* prevalence for TB among 14842 slaughtered farmed deer while the same study found a 2.8 *per cent* TB prevalence among 340 wild deer culled from Glenveagh National Park Co. Donegal. In 2019, outside of the ongoing Wicklow investigation, 152 deer carcasses or part carcasses were submitted to the regional veterinary laboratory service and of these TB was confirmed in four or 2.6 *per cent* of submitted carcasses.

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15 Wildlife Disease Surveillance

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During 2019 the Veterinary Laboratory Service participated in a number of disease surveillance exercises. A number of the more high profile surveillance programmes are discussed.

RHD2 in wild rabbits and hares

Rabbit Viral Haemorrhagic Disease 2 (RHD2) (Figure 15.1) was first identified in France in 2010 (Le Gall-Reculé et al., 2011) and has subsequently spread worldwide. It was initially diagnosed in Irish (both domestic and wild) rabbits in Co Cork in 2016, and subsequently had been frequently reported within the domestic rabbit population.

In summer 2019, officers from the National Parks and Wildlife Service received reports of notable fatality events in a wild rabbit colony in Co Clare and an Irish hare,found dead, was submitted from Co Wexford. RHD2 was detected in both animals from both locations. Subsequent to this a number of positive identifications were made across Ireland amongst both wild rabbit and Irish hare populations. Rabbits are the primary host of this virus, and hares are believed to be a *spillover* host (Velarde et al., 2017).

Pigeon paramyxovirus in racing pigeons

Pigeon Paramyxovirus (PPMV1) is a notifiable disease of pigeons and poultry. PPMV1 can be spread by pigeons and is associated with Newcastle Disease in poultry. PPMV1 may cause sudden death in affected animals but may also present causing the following clinical signs:

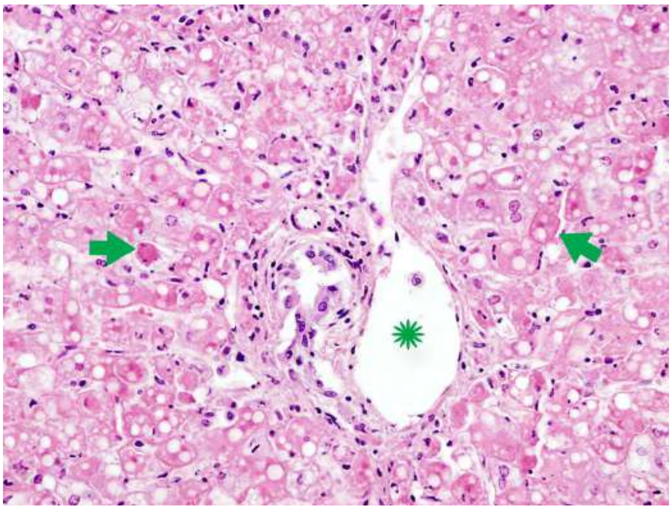

Figure 15.1: Microphotograph demonstrating diffuse cytoplasmic vacuolation and necrosis of hepatocytes characterised by hepatocellular hypereosinophilia (green arrows), karyopyknosis and karyolysis in the liver of a rabbit with RHD2 (the prominent cavity with * is a portal vein). Photo: Cosme Sánchez-Miguel.

- Diarrhoea that is often watery and green in colour
- Dullness, inappetence, drop in egg production, pale or misshapen eggs
- Respiratory symptoms such as conjunctivitis, gaping beak, coughing and sneezing
- Nervous signs such as tremors, drooping wing, twisted necks and paralysis

Following a number of reports of mortality events in Pigeon racing lofts countrywide, several pigeon carcases were submitted to the Veterinary Laboratory service for examination. From these submissions, 10 cases of Pigeon *paramyxovirus* were detected. Anecdotally, younger birds in affected racing lofts were most severely affected. Of the cases identified within the Veterinary Laboratory Service, many of the flocks were vaccinated against this disease. Cases were found in Meath, Kerry, Clare, Cork and Dublin indicating a strong probability, given the nature of the disease, that it was widespread. A vaccine is available, and pigeon owners are legally obliged to annually vaccinate all pigeons intended for training, racing or showing. Race and show organisers are required to ensure that all participating birds have been vaccinated in accordance with legislation (S.I. No. 57 of 2012). PPMV1 can occasionally spread to humans, causing conjunctivitis and mild flu-like symptoms.

Mycobacterium bovis in the red fox

Following the publication of a French report where the authors had detected *Mycobacterium bovis* from red foxes (*Vulpes vulpes*) in Southern France (Michelet et al., 2018), a survey of Irish foxes was devised and undertaken in late 2018 and early 2019. Within this survey, tissues from 170 foxes were sampled and dispatched for mycobacterial culture. At the time of writing, tissues from 120 foxes have been examined, and to date, Mycobacterium bovis has not been isolated. However, non-tuberculous mycobacteria, which are not deemed to be significant, have been isolated from 11 foxes.

RAPTOR protocol

Since 2011, in conjunction with the National Parks and Wildlife Service (NPWS), the Regional Veterinary Laboratories have been running the RAPTOR (Recording and Addressing Persecution and Threats to Our Raptors) Programme. An 'incident' under the RAPTOR protocol, is classed as the occurrence of a non-habitat related anthropogenic impact on a bird of prey or the use of poisoned bait (which could possibly lead to raptor injury or death). All incidents are then examined as follows:

- Injured Birds, Carcases and any evidence are collected from their location
- X-rays are taken on any dead birds
- Dead birds are then examined by *post mortem* at the RVLs
- Toxicological testing is undertaken at the State Laboratory
- Data is subsequently analysed, interpreted and reported.

In 2019, 39 incidents were examined under the *RAPTOR* programme and of these, 22 cases were confirmed as poisoning, with 3 cases of poisoned bait found. In addition to this, there were 3 cases of shooting and 11 cases classified as *other* (these included incidents of road casualties, wind turbine strike and birds caught in netting as some of the causes). More detail can be found on the National Parks & Wildlife Service

Figure 15.2: Falcon (*Falco peregrinus*) submitted for *post mortem* examination to the Regional Veterinary Laoratory as part of the *RAPTOR* programme. Photo: Cosme Sánchez-Miguel.

Echinococcus multilocularis in the red fox

Echinococcus multilocularis is a zoonotic tapeworm that infects the red fox as a definitive host; other definitive hosts include cats and dogs. There several forms of human echinococcosis but alveolar echinococcosis is more frequently caused by *Echincoccus multilocularis* and is a serious parasitic zoonosis. 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 adult tapeworm passes eggs into the intestine, which are passed out in the faeces and ingested by intermediate hosts (typically mice, voles and shrews), which in turn infect the definitive hosts. Zoonosis occurs when the human is the intermediate host.

Every year as part of an EU-wide assessment, DAFM undertakes a survey of red foxes from across the country to assess the prevalence of this parasite. In 2018/2019, 400 foxes were examined, and none returned evidence of infection with this parasite.

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Animal Health Ireland

16 Bovine Viral Diarrhoea (BVD) Eradication Programme and Infectious Bovine Rhinotracheitis

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Bovine Viral Diarrhoea (BVD) is a highly contagious disease in cattle that can spread directly from infected animals or indirectly (e.g. via slurry, equipment, farm workers/visitors). Most BVD infections are Transient Infections (*TI*) without clinical signs. BVD affects fertility, calf health and causes foetal losses (Figure 16.1). Infection with BVD virus within the first 120 days of pregnancy may result in a persistently infected foetus. Persistently Infected (*PI*) animals will shed high levels of BVD virus for life; they are, therefore, the most significant source of virus.

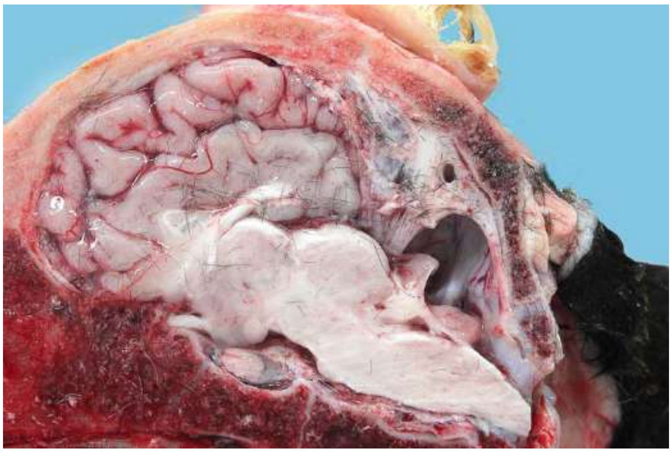

Figure 16.1: Cerebellar hypoplasia resulting from vascular impairment secondary to vasculitis of the cerebellum during organogenesis in a calf infected in utero with BVD virus. Photo: Cosme Sánchez-Miguel.

Bovine viral diarrhoea (BVD) Eradication Programme

A compulsory National Eradication Programme for BVD has been in place in Ireland since 2013. The programme is based on 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 a farm (Animal Health Ireland, 2020b).

Table 16.1: Animal-level prevalence of PI calves born during each year of the programme by herd type.

Year	Total	Beef	Dairy
2013	0.66	0.78	0.55
2014	0.46	0.54	0.37
2015	0.33	0.39	0.26
2016	0.16	0.21	0.12
2017	0.10	0.12	0.08
2018	0.06	0.07	0.04
2019	0.04	0.05	0.03

In 2019, just over 2.3 million calves were born and, as in previous years, there was a high level of compliance with the requirements to tissue tag test (99,6 *per cent*). The prevalence of *PI* births in 2019 is on the

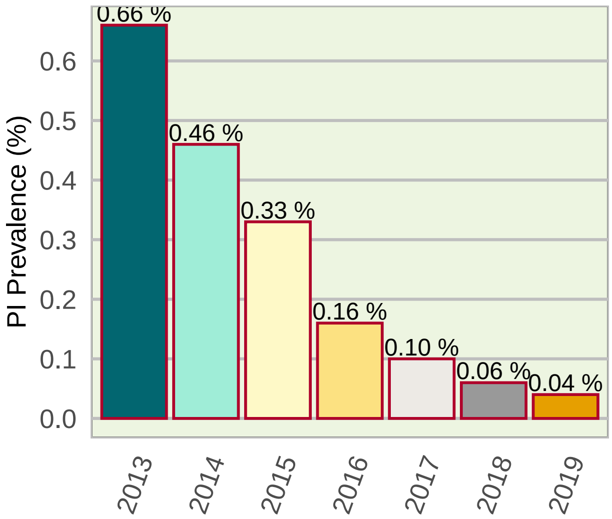

Figure 16.2: Animal-level prevalence of PI calves born during each year of the programme.

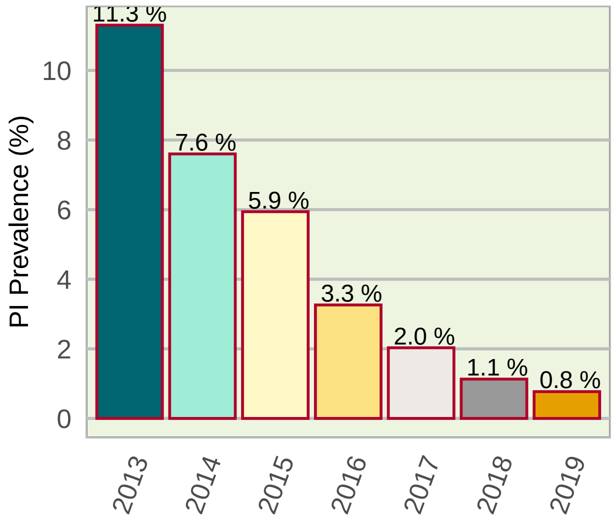

Figure 16.3: Herd-level prevalence of PI calves born during each year of the programme.

Table 16.2: Herd-level prevalence of PI calves born during each year of the BVD eradication programme.

Year	Dual...2	Total	Beef	Dairy	Dual...6
2013	0.8	11.3	8.8	20.3	14.1
2014	0.6	7.6	5.9	13.2	11.0
2015	0.5	5.9	4.4	10.4	9.3
2016	0.2	3.3	2.4	5.7	5.1
2017	0.2	2.0	1.4	3.9	3.7
2018	0.1	1.1	0.7	2.2	1.9
2019	0.1	0.8	0.5	1.4	1.5

decline, with 0.04 *per cent* of calves (978) being considered persistently infected with BVD (Table 16.1 and Figure 16.2) . In 2018 this figure was of 0.06 *per cent*, and when compared with the prevalence in 2013, the first year of the compulsory programme, it represents over a sixteen-fold decrease. The prevalence of breeding herds in which one or more calves had a positive or inconclusive result also decreased by from 1.13 *per cent* (820) in 2018 to 0.77 *per cent* (552) in 2019 (Table 16.2 and Figure 16.3).

Each year the programme is reviewed by the BVD Implementation Group (BVDIG) and enhancements introduced to drive the programme towards eradication. In 2019 these enhancements included increased levels of financial support for removal of *PIs* within a reduced period of time (from 3 weeks to 10 days), the automation of the imposition of restrictions of herds retaining *PI* calves for more than three weeks after the date of their first test (five weeks in 2018) and the introduction of enhanced sampling of positive herds through the mandatory herd investigations (funded through the Rural Development Plan under the Targeted Advisory Service on Animal Health [*TASAH*]) that must be completed within three months of the initial positive result.

Programme enhancements have not only contributed to the reduction in the overall number of *PIs* but also to good progress in reducing the number of *PIs* retained, with only six herds retaining *PIs* at the end of 2019 (no registered date of death within three weeks of the date of initial test). While this clearly demonstrates good progress, it is critical that the incidence of retention is reduced to zero with all calves being tested as soon as possible after birth and *PIs* removed as rapidly as possible thereafter.

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 (based on either 'direct' or 'indirect' results).

(2) Absence of any animal(s) deemed to be persistently infected with BVD virus from the herd in the 12 months preceding the acquisition of NHS.

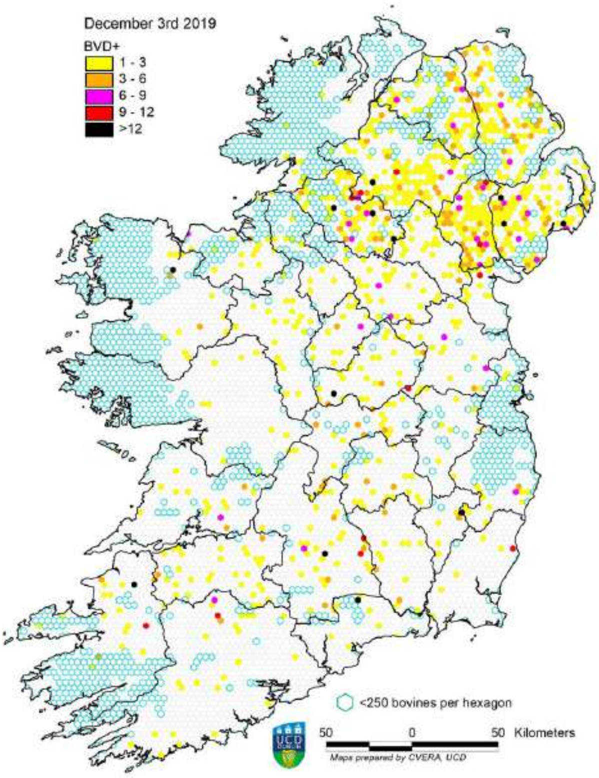

Figure 16.4: Distribution of calves born persistently infected (PI) with BVD virus in 2019. Each hexagon covers an area of approximately 10 km^2. Hexagons in which there are fewer than 250 cattle (e.g. mountainous/urban areas and lakes) are shown with blue border.

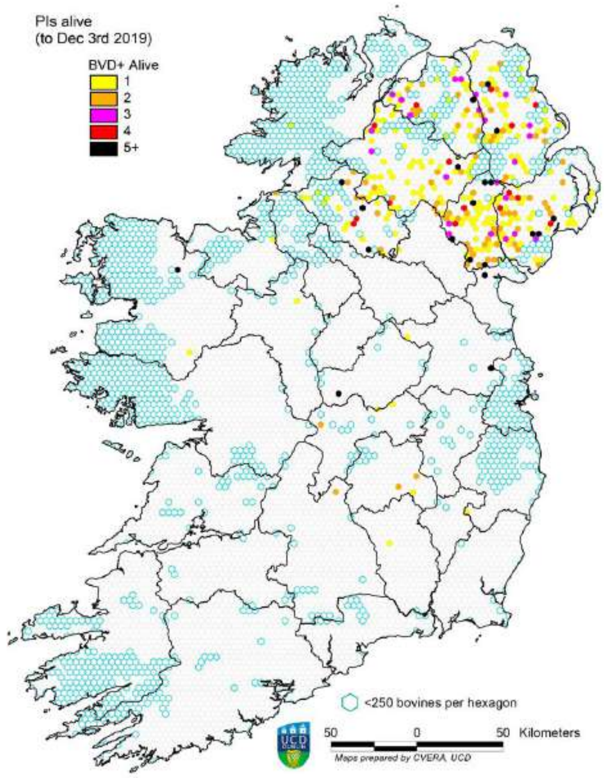

Figure 16.5: Distribution of persistently infected (PI) calves alive in 2019. Each hexagon covers an area of approximately 10 km^2. Hexagons in which there are fewer than 250 cattle (e.g. mountainous/urban areas and lakes) are shown with blue border.

At the end of 2019, close to 77,000 (93.5 *per cent*) of some 83,000 breeding herds had achieved NHS. A further 4,900 were only ineligible due to the presence of a small number of untested animals. While an important programme milestone for any herd, NHS also brings with it an economic benefit, with the number of laboratories that use the *RTPCR* test method offering testing at reduced costs to herds with NHS.

The status of almost all animals (99.5 *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 January 2013 that have neither been tested nor produced a calf. At the end of 2019 the number of these animals was approximately 4,500 (Figure 16.4 and 16.5). The majority of these animals are in beef herds, and the majority are also male or have not had a calf registered to them. These animals are not required to be tested under the legislation and may currently be sold untested. However, from May 2020, there is be a legal requirement to test these pre-2013 born animals.

The number of animals born since January 2013 that do not have a valid test result and are therefore not compliant with the requirements of the legislation has also reduced to approximately 11,000 at the end of 2019. The majority of these have never been tested, while a small number have had an initial empty result and not been retested. Most of these animals are 2019-born (88 *per cent*), with smaller numbers from preceding years. During 2019 DAFM has issued letters to these herds, informing them of the need to test these animals. Collectively, these measures contributed to the increased number of herds with NHS.

Targeted Advisory Service on Animal Health (TASAH). Since 2017 all herds with positive results are required to undergo an RDP-funded *TASAH* herd investigation by a trained veterinary practitioner within three months of the initial positive result. These investigations, conducted through the Targeted Advisory Service on Animal Health

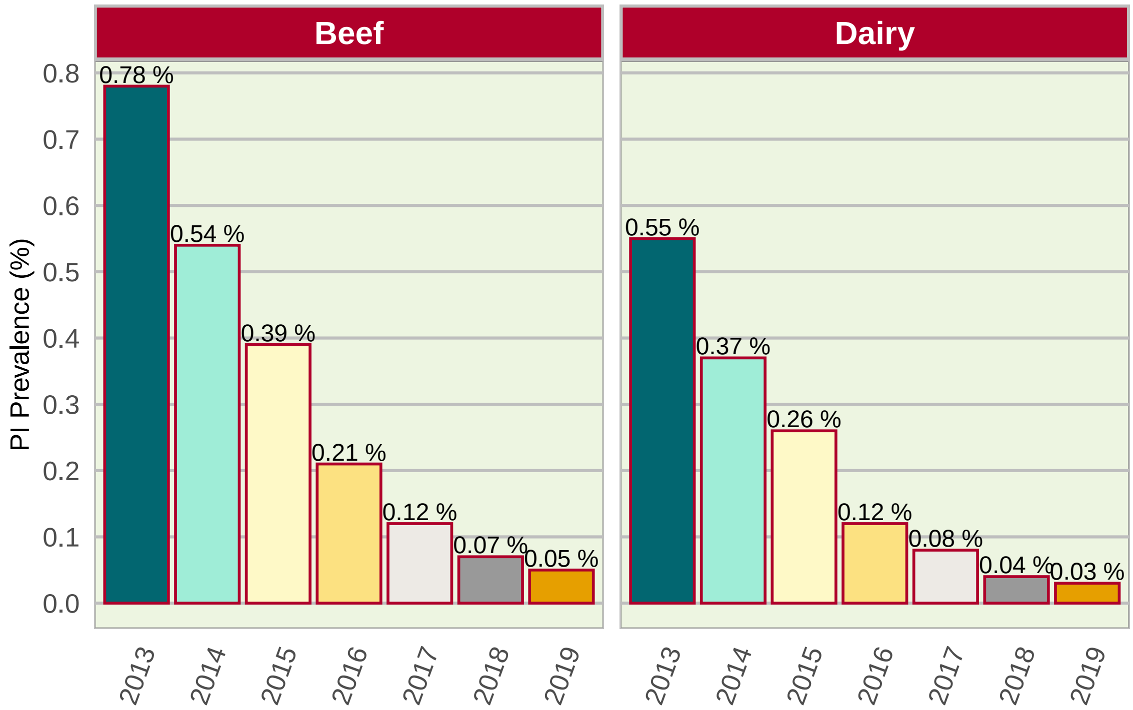

Figure 16.6: Animal-level prevalence of BVDv PI calves born during each year of the programme by beef and dairy herds.

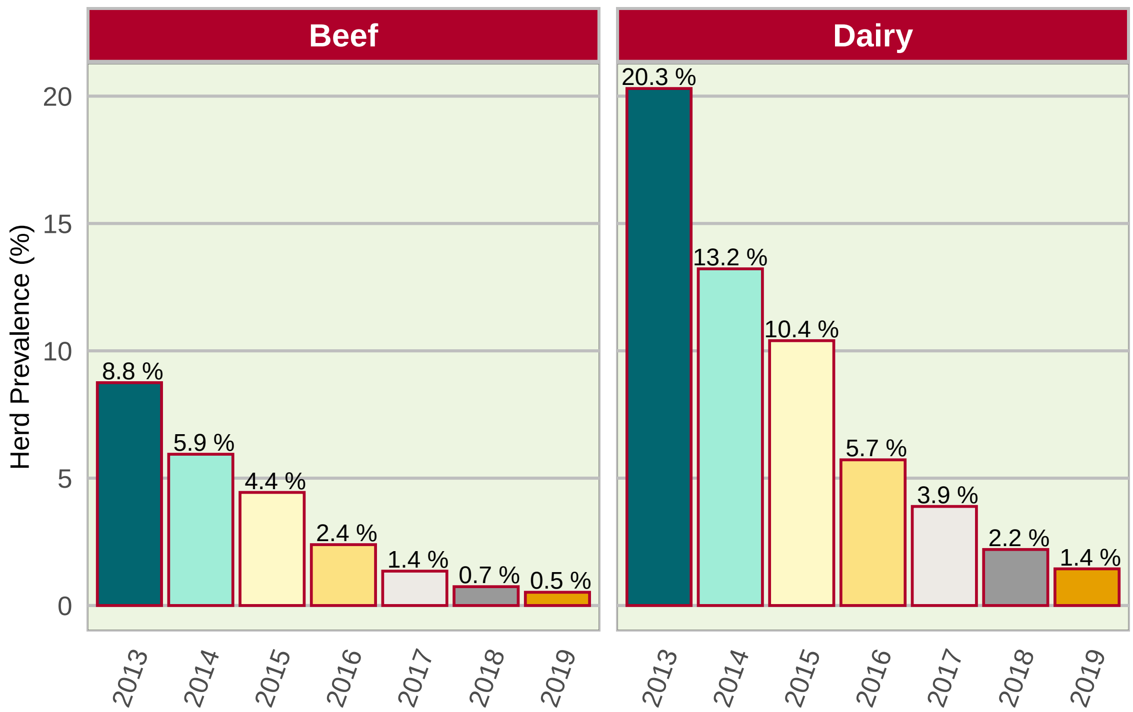

Figure 16.7: Herd-level prevalence of BVDv PI calves born during each year of the programme by beef and dairy herds.

(*TASAH*) and funded through the Rural Development Plan (2014–2020), seek to review herd biosecurity, identify a plausible source or sources of infection, ensure that the herd is left free from BVDV and agree with farm-specific measures to prevent its reintroduction. By the end of 2018, 699 investigations had been completed, biosecurity recommendations provided to herd owners and the results reported to AHI.

Preliminary analysis of these results indicated that the majority (92 *per cent*) of herd owners were provided with three biosecurity recommendations, with these most commonly relating to the risks of introduction of virus associated with personnel (including the farmer), the purchase of cattle, contact with neighbouring cattle at pasture and the role of vaccination. One or more plausible sources of infection were identified in 72 *per cent* of herds, with a single plausible source identified in 43 *per cent* of herds. In 43 *per cent* of cases, the source was considered to be within the herd, while in 57 *per cent* of cases it was outside the herd. The most commonly identified plausible sources of infection were contact at boundaries, the introduction of transiently infected animals without adequate quarantine, retained *PI* animals, personnel (including the farmer) in the absence of appropriate hygiene measures and trojan dams. These data provide a basis for targeted biosecurity advice to prevent accidental introduction of BVD virus to herds that are currently free of infection.

Infectious bovine rhinotracheitis-BETTER Farm Pilot

Infectious Bovine Rhinotracheitis (IBR) is caused by a virus called Bovine Herpes Virus-1 (BoHV-1) that spreads between cattle and usually causes inflammation in nose and upper airways. Only primary infections are commonly associated with any clinical signs and severity can vary from inapparent to very severe. Latent infection refers to a carrier state where virus survives in an infected animal, though not causing disease or spreading). All animals that have ever had a primary infection are considered to be latently infected. Reactivation of latent infections provides a source of virus for new primary infections.

A pilot IBR eradication programme was developed by the IBR Technical Working Group for herds participating in Phase Three of the Teagasc/Irish Farmers

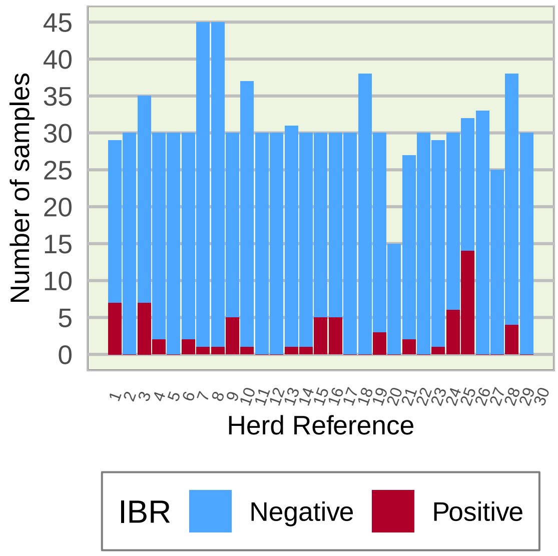

Figure 16.8: Total numbers of animals tested for IBR in each herd, and the number positive

journal BETTER Farm Beef Programme. Herds were tested by applying a *snapshot* which requires the sampling of 30 randomly selected animals over 9 months-old that are used or intended for breeding and testing of the samples at DAFM's Blood Testing Laboratory in Cork with an IBR *gE* (marker) ELISA. This sampling allows a statistically based estimation of the within herd seroprevalence and the formulation of the most appropriate biosecurity recommendations to the farm in terms of IBR-control (Animal Health Ireland, 2020a).

In addition, trained veterinary practitioners applied an on-farm veterinary risk assessment and management plan (*VIBRAMP*) to participating herds. The *VIBRAMP* consists of a questionnaire that captures details of the farm structure, animal movements, biosecurity and vaccination history, with the vet and herd owner agreeing up to three changes to improve biosecurity.

Results. Between 15 and 44 samples were submitted per herd, totalling 909 samples. A large proportion of the seropositive results were from older, non-homebred animals. 59 *per cent* (17) of the herds had a negative 'snapshot' test (0 or 1 seropositive animals), with 11 herds having no positives and 6 having one. 41 *per cent* (12) had a positive (2 or more seropositive animals) *snapshot* test, of which 3 herds had two positives, 8 had between 3 and 7 seropositive animals and one herd had 14 positives.

Table 16.3: Characteristics of participating herds according to results. Results given as average (minimum-maximum).

	Negative*	Positive*	**Overall**
No. animals in herd	164 (68–325)	200 (40–423)	**180 (40–423)**
No. cows in herd	49 (15–102)	65 (15–109)	**56 (15–109)**
No. births in 2017	54 (18–111)	68 (19–111)	**60 (18–111)**
Degree of expansion	1.2 (0.73–2)	2.8 (0.75–15.7)	**1.9 (0.73–15.7)**
Moves from mart	11 (0–52)	12 (0–47)	**12 (0–52)**
Moves from farm	26 (2–111)	54 (3–196)	**38 (2–196)**
IBR vaccination	24 % (4/17)	67 % (8/12)	**41 % (12/29)**

* snapshot

Analysis of results show that on average, positive *snapshot* herds were larger than negative herds and had a higher number of animals introduced directly from other herds (moves from farm) than negative *snapshot* herds (Table 16.3). The degree of expansion was calculated by dividing the average of births in the herds in 2017 with the average births in 2013/14. Positive herds experienced a higher degree of expansion (herds were, on average, 180 *per cent* larger) than negative herds, which were 25 *per cent* larger than in 2013/14.

BETTER Farm IBR Pilot Programme 2019/20. Herds participating in the initial 2018 IBR Pilot phase, were offered to continue in the 2019/21 phase. The new phase consists of three components: sampling, risk assessment and biosecurity. Herds will carry out a whole herd test which involves sampling and testing of all the animals over 9 months-old in the herd. Samples will be tested with an IBR *gE* (marker) test. This testing will give a clear picture of the IBR status of the herd. The IBR-trained PVPs, will apply a second on-farm veterinary risk assessment and management plan (*VIBRAMP*). The vet and herd owner will review progress against previously agreed biosecurity recommendations and will agree up to three changes to improve biosecurity.

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Agri-Food & Biosciences Institute

Agri-Food & Biosciences Institute

17 Cattle Diseases, AFBI

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Neonatal Calves (0–1 months)

As in previous years enteric infections were the most frequently diagnosed cause of death in the neonatal calf group up to one month of age accounting for 40 *per cent* of cases. Common infectious causes of diarrhoea recorded included *E. coli*, *Salmonella* Dublin, rotavirus, coronavirus and *Cryptosporidium* (Table 17.1 and Figure 17.3).

Figure 17.1: Calf diarrhoea and dehydration in a 36 hour old calf. Photo: AFBI

Inadequate colostrum intake, stress and poor hygiene contribute to the severity of scour outbreaks. Pathogenic *E. coli* infections usually cause watery diarrhoea in very young calves from about 15 hours to three days of age. Rotavirus is a common cause of diarrhoea in both dairy and beef suckler herds and it usually affects calves from about 4 days to 2 weeks (Figure 17.1). Transit of calves through markets increases the likelihood of exposure to *Salmonella* Dublin.

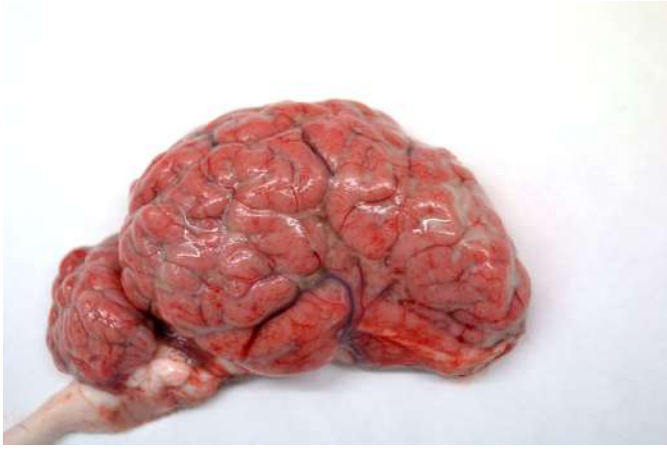

Figure 17.2: Meningitis as part of colisepticaemia in a 3 day old calf. The meninges overlying the brain are both congested and cloudy. Photo: AFBI

Table 17.1: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for *post mortem* in 2019 (n=498)

Category	No. of cases	Percentage
Enteric infections	198	**39.8**
Respiratory infections	63	**12.7**
Septicaemia / toxaemia	61	**12.2**
Nutritional / metabolic conditions	55	**11.0**
Navel ill /Joint ill	39	**7.8**
Other diagnoses	26	**5.2**
GIT torsion / obstruction	14	**2.8**
Central nervous system	11	**2.2**
Peritonitis	8	**1.6**
Diagnosis not reached	6	**1.2**
Gastrointestinal ulcers or perforations	6	**1.2**
Heart / circulatory system	6	**1.2**
Hereditary and developmental abnormality	5	**1.0**

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 14 of the 63 cases (22 *per cent*) of respiratory infection. *Mannheimia haemolytica* and *Pasteurella multocida* were diagnosed in 9 and 7 cases of respiratory infection, followed by *Arcanobacterium pyogenes* in 4 cases and

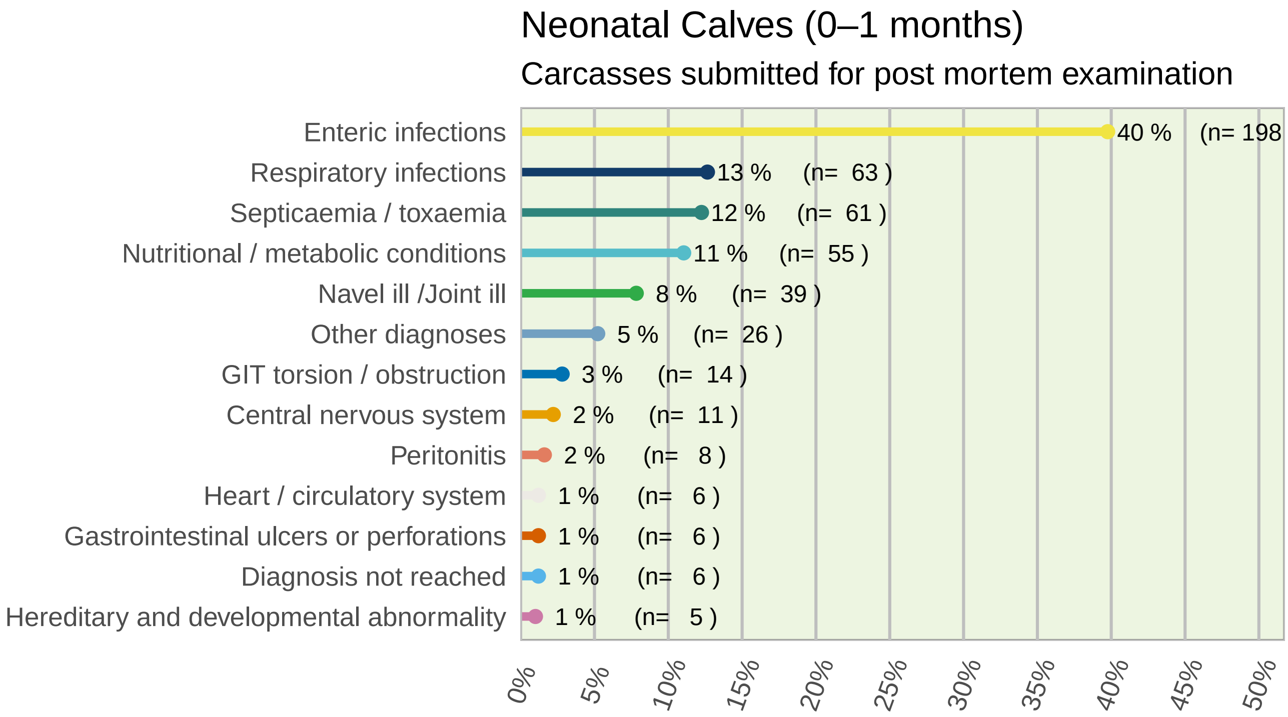

Figure 17.3: Conditions most frequently diagnosed in calves less than one month old submitted to AFBI for *post mortem* in 2019 (n=498).

Figure 17.4: Bloated abomasum with a thickened congested wall in a neonatal calf. Photo: AFBI

Haemophilus somni (3 cases or 5 *per cent* of respiratory infections). RSV was the most frequently diagnosed viral respiratory pathogen diagnosed (3 cases) followed by PI3 (one case).

Death due to septicaemic or toxaemic conditions represented 12 *per cent* (61 cases) of deaths in neonatal to one-month-old calves. Unsurprisingly colisepticaemia (Figure 17.2) was the major cause of death in this group accounting for 42 cases (69 *per cent* of the septicaemic/toxaemic conditions) and emphasising the need for good hygiene in calving pens and neonatal calf areas, adequate disinfection of the umbilicus of new-born calves and of course adequate feeding of good quality colostrum to new-born calves in the first six hours of life. Septicaemia due to *Salmonella* Dublin was the second most frequent cause of neonatal septicaemia with five cases recorded (8 *per cent* of the septicaemic/toxaemic cases).

Hypogammaglobulinaemia was the most frequently recorded nutritional/metabolic condition (31 cases of the 55 cases of the nutritional/metabolic conditions recorded, 56 *per cent*). Ruminal feeder (6 cases), ruminal acidosis (6 cases) and bloat (6 cases) were also frequently recorded diagnoses in this grouping (Figure 17.4).

Calves 1-5 months old

Respiratory tract infections and pneumonia were by far the most commonly recorded cause of death in calves from one to five months of age and were recorded in more than 50 *per cent* of cases (Table 17.2 and Figure 17.6). Bacterial respiratory infections

Table 17.2: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for *post mortem* in 2019 (n=271).

Category	No. of cases	Percentage
Respiratory infections	141	**52.0**
Enteric infections	22	**8.1**
Other diagnoses	22	**8.1**
GIT ulcer / perforation	15	**5.5**
Nutritional / metabolic conditions	14	**5.2**
GIT torsion / obstruction	11	**4.1**
Diagnosis not reached	9	**3.3**
Clostridial disease	8	**3.0**
Cardiovascular conditions	7	**2.6**
Septicaemia / toxaemia	7	**2.6**
Nervous disease	6	**2.2**
Peritonitis	5	**1.8**
Urinary tract conditions	4	**1.5**

(Figure 17.5) were most frequently diagnosed. *Mycoplasma bovis* (Figure 17.7) was the most frequently detected pathogen and was recorded in 26 cases (representing 18 *per cent* of the 141 recorded respiratory infections), *Pasteurella multocida* was detected in 24 cases (17 *per cent*) and *Mannheimia haemolytica* was detected in 17 cases (12 *per cent*). *Haemophilus somni* and *Arcanobacterium pyogenes* were both recorded in nine cases (6 *per cent* of respiratory diagnoses). Parasitic pneumonia due to lungworm was recorded in 13 cases. BRSV was the most commonly recorded viral respiratory infection (13 cases) followed by IBRV in two cases.

Enteric infections were the second most commonly recorded disease category in calves from one to five months of age (22 cases or 8 *per cent* of diagnoses in this age group). Coccidiosis was the most frequently recorded enteric infection (seven cases or 32 *per cent* of the enteric infections recorded) followed by *Cryptosporidium* (two cases). Coccidiosis may occur in contaminated conditions such as damp, dirty straw bedding indoors or around feeding and drinking troughs contaminated with faeces outdoors. Diarrhoea is sometimes accompanied by straining and blood may frequently be observed in the faeces. Veterinary advice on treatment should be sought and attention should be paid to the hygiene of calf pens and the cleanliness and positioning of feeding troughs.

Gastrointestinal ulcers and perforations were the next most common category of disease in this age

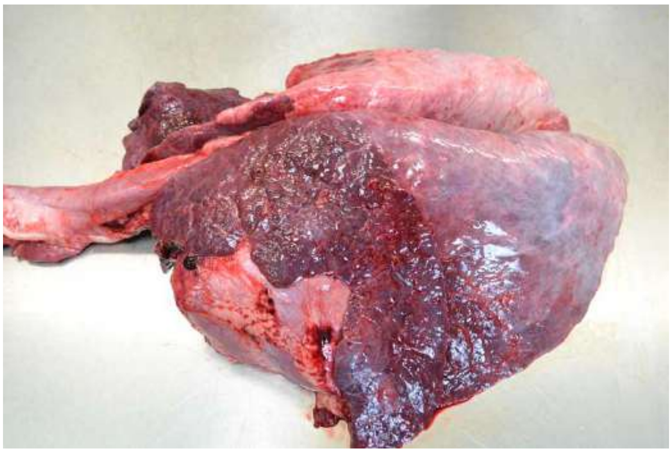

Figure 17.5: Bacterial pneumonia. Severely affected pneumonic lung (to left of picture) appears purple. Photo: AFBI

group. Six cases of perforation of the abomasum were recorded and a further four 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. Of the nutritional and metabolic conditions recorded ruminal acidosis was most frequent (5 cases) and there were four cases of bloat. There were 11 cases of gastrointestinal torsion. Gastrointestinal torsion may occur subsequent to increased or decreased gastrointestinal motility which in turn is affected by nutritional changes and upsets, gas accumulation and bloat, carbohydrate overload and acidosis.

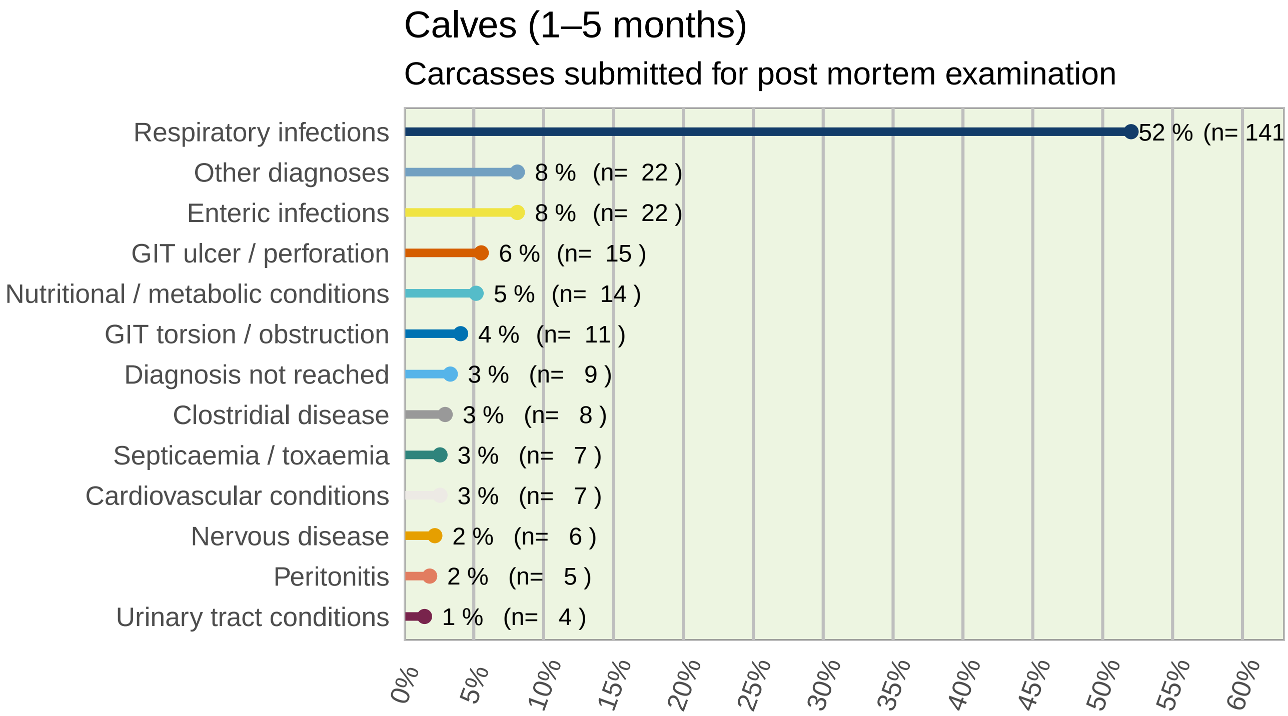

Figure 17.6: Conditions most frequently diagnosed in calves one to five months old submitted to AFBI for *post mortem* in 2019 (n=271).

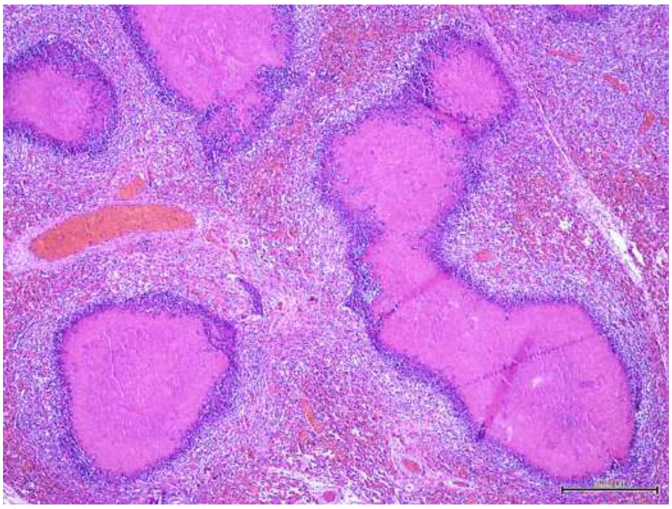

Figure 17.7: Microscopic appearance of pneumonia caused by *Mycoplasma bovis*. Photo: AFBI

Weanlings 6–12 months old

Respiratory tract infections were the main cause of death in older calves (from six to 12 months old) followed by deaths caused by clostridial infections with these two groups combined representing 68 *per cent* of the diagnoses in this age range (Table 17.3 and Figure 17.8). Bacterial infections were again the most frequent recorded cause of respiratory infections. *Mycoplasma bovis* was detected in 12 cases representing 19 *per cent* of respiratory diagnoses, *Pasteurella multocida* was detected in nine cases (14 *per cent* of respiratory diagnoses), *Histophilus somni* in five cases and *Mannheimia haemolytica* in three cases. Parasitic pneumonia due to lungworm infection was recorded in 15 cases meaning that lungworm was the individual infectious agent causing respiratory disease most frequently detected in this age group. Respiratory infections caused by viruses were detected in 12 cases (19 *per cent* of respiratory infections) with BRSV most frequently recorded (10 cases) with single cases of PI3 infection and IBR also detected.

Twenty five cases of clostridial disease were recorded (19 *per cent* of diagnoses in this age group) and blackleg (Figure17.9) was the most important clostridial disease diagnosed (19 cases or 76 *per cent* of the clostridial infections recorded). Three diagnoses of botulism were recorded, two cases of clostridial enterotoxaemia and a case of black disease were also recorded. Clostridial disease often results in sudden death and vaccination is an important feature of control programs.

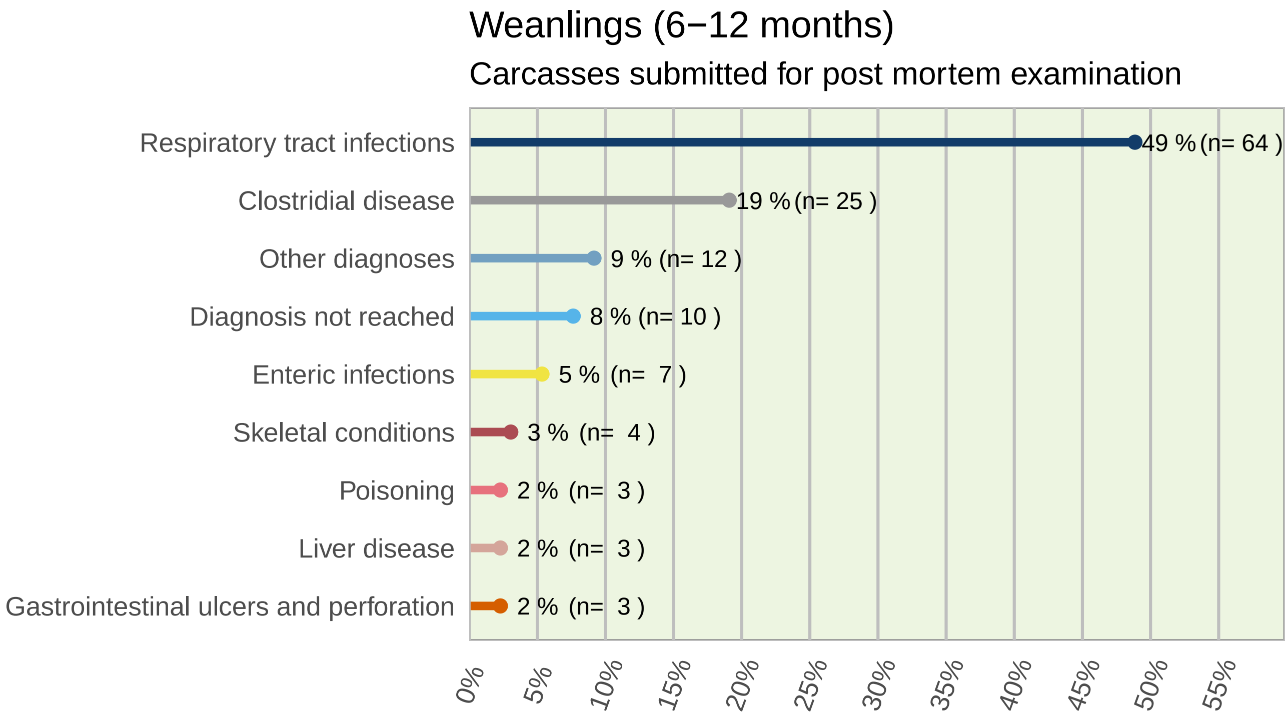

Figure 17.8: Conditions most frequently diagnosed in calves six to twelve months old submitted to AFBI for *post mortem* in 2019 (n=131).

Table 17.3: Conditions most frequently diagnosed in calves six to twelve months old submitted to AFBI for *post mortem* in 2019 (n=131).

Category	No. of cases	Percentage
Respiratory tract infections	64	**48.9**
Clostridial disease	25	**19.1**
Other diagnoses	12	**9.2**
Diagnosis not reached	10	**7.6**
Enteric infections	7	**5.3**
Skeletal conditions	4	**3.1**
Gastrointestinal ulcers and perforation	3	**2.3**
Liver disease	3	**2.3**
Poisoning	3	**2.3**

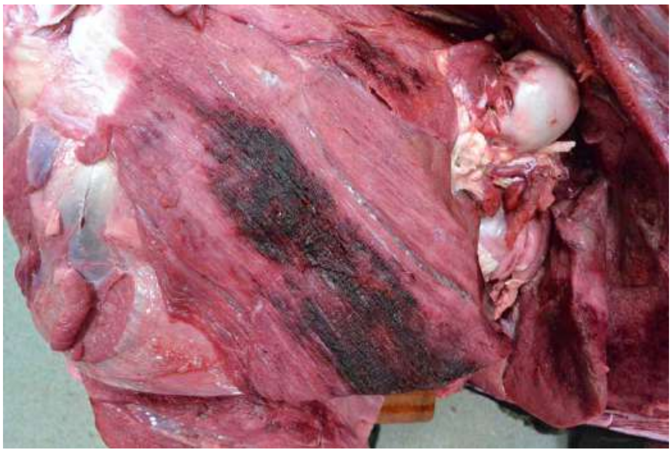

Figure 17.9: Blackleg lesion in hindquarter muscles. Photo: AFBI

Enteric infections represented 5 *per cent* of cases (seven cases) in weanlings. Parasitic gastroenteritis was recorded in five cases and it accounted for 71 *per cent* of the enteric infections.

Figure 17.10: Fractured femur in a ten-month-old heifer (on left). The femur on the right is normal. Thinning of cortical bone is evident in the femur on the left. Rickets due to mineral imbalance/insufficiency was diagnosed on histological examination. Photo: AFBI

Figure 17.11: Thickening and corrugation of the ileal mucosa in a cow affected by Johne's disease. Photo: AFBI

Adult Cattle (older than 12 months)

Respiratory infections were the most frequently diagnosed cause of death in adult cattle (older than 12 months) (Table 17.4 and Figure 17.12). *Mycoplasma bovis* was the most common respiratory pathogen recorded with 17 cases recorded (being detected in 25 *per cent* of the 69 respiratory infections recorded). *Mannheimia haemolytica* is an important cause of pneumonia particularly in adult cows and 15 cases of this infection were recorded (22 *per cent* of respiratory infections in adult bovines). Other bacterial respiratory infections recorded were *Trueperella pyogenes* (four cases), *Histophilus somni* (three cases) and *Pasteurella multocida* (two cases). Seven cases of viral respiratory infection were detected comprising five cases of IBR and a single case each of BRSV and of BVDV infection. Parasitic pneumonia (hoose) remains an important cause of death in adult cattle with six cases detected on *post-mortem* examination. Hoose may occur in older cattle grazing contaminated pasture where anthelmintic regimes or grazing practices are not conducive to acquiring protective immunity at a younger age.

Diseases of the heart and circulatory system (45 cases) accounted for 12 *per cent* of the conditions recorded in cattle older than 12 *months*. Thrombosis of the caudal vena cava was recorded in 13 cases. 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 11 cases of valvular endocarditis (Figure 17.13)and there were three cases of pericarditis and also three cases of cardiac abscessation.

Table 17.4: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for *post mortem* in 2019 (n=386).

Category	No. of cases	Percentage
Respiratory infections	69	**17.9**
Other diagnoses	50	**13.0**
Cardiac/circulatory system	45	**11.7**
Diagnosis not reached	39	**10.1**
Nutritional / metabolic conditions	25	**6.5**
Clostridial disease	22	**5.7**
Liver disease	22	**5.7**
Skeletal conditions	22	**5.7**
Enteric infections	17	**4.4**
Reproductive tract infections/Mastitis	15	**3.9**
Intestinal or gastric torsion /obstruction	14	**3.6**
Peritonitis	13	**3.4**
GIT ulceration / perforation / foreign body	12	**3.1**
Nervous system conditions	8	**2.1**
Poisoning	8	**2.1**
Urinary tract conditions	5	**1.3**

Nutritional and metabolic conditions accounted for 25 cases (6 *per cent* of the cases in adult cattle). The main conditions encountered included hypocalcaemia (nine cases), hypomagnesaemia (six cases) and acidosis (six cases).

Clostridial disease was responsible for 6 *per cent* of deaths in adult cattle in Northern Ireland. Blackleg was the most commonly diagnosed clostridial disease in adult cattle in Northern Ireland (9 cases) and

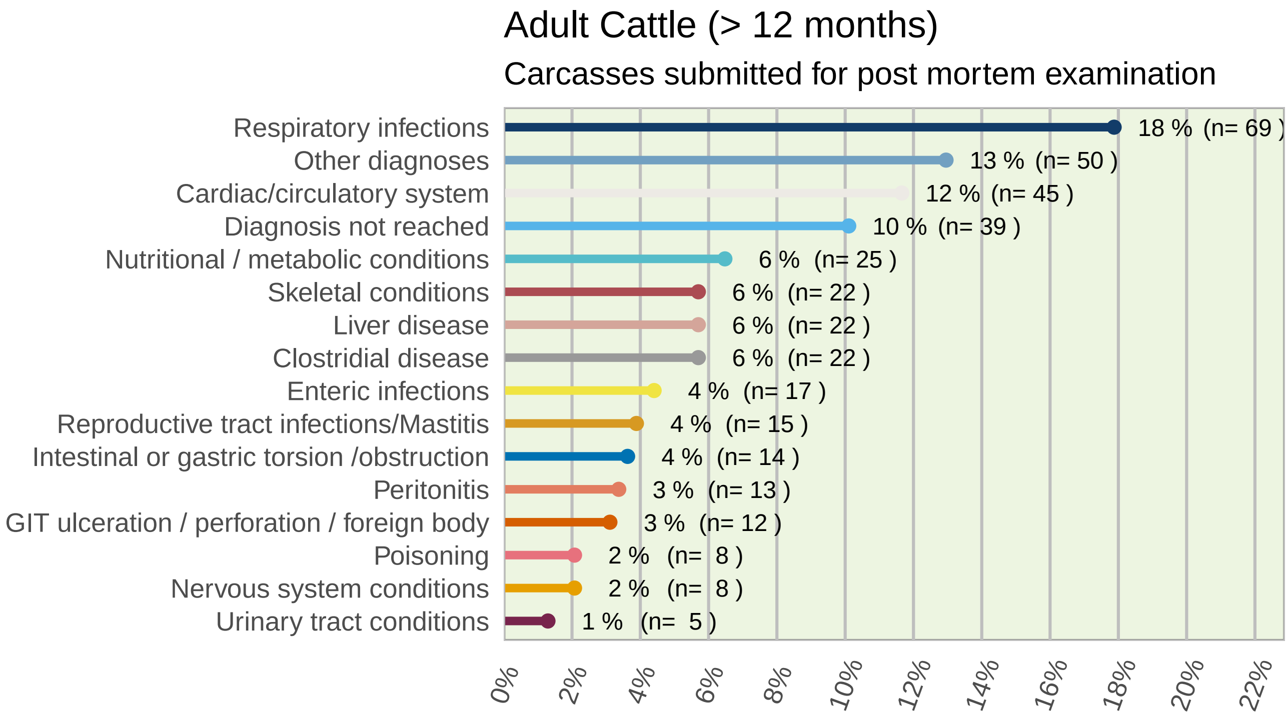

Figure 17.12: Conditions most frequently diagnosed in adult cattle (older than 12 months) submitted to AFBI for extitpost mortem in 2019 (n=386).

Figure 17.13: Endocarditis of the pulmonary valve in a three-year-old cow. Photo: AFBI

black disease was diagnosed in 7 cases . Five cases of botulism were recorded.

Case Report: *Atypical cases of Cerebrocortical Necrosis in adult cattle, AFBI*

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Cerebrocortical necrosis (CCN) is most frequently seen in young sheep up to 18 months old and young cattle up to 2 years of age, which show signs of blindness, muscle tremors, head-pressing against objects and opisthotonus, also known as *star gazing*, teeth grinding, and the signs may progress to recumbency and convulsions (Figure 17.14) CCN is a degenerative condition in the brain of cattle, sheep and goats where degeneration and necrosis target mid and deep layers of neurones in the grey matter of the forebrain, and the damaged regions can often be visualised at *post mortem* by the autofluorescence of the necrotic tissue under UV illumination (Figure 17.15). CCN is not a single disease as several underlying conditions can lead to the laminar necrosis in the brains of affected animals, and while thiamine deficiency is the most frequently attributed cause in Europe and associated with a low roughage diet and concentrate feeding; high sulphur intake, water deprivation, lead toxicosis and hypoxia or hypoglycaemia can also result in similar brain damage.

Figure 17.14: Lamb affected by CCN showing opistotonus or *stargazing*. Photo: AFBI

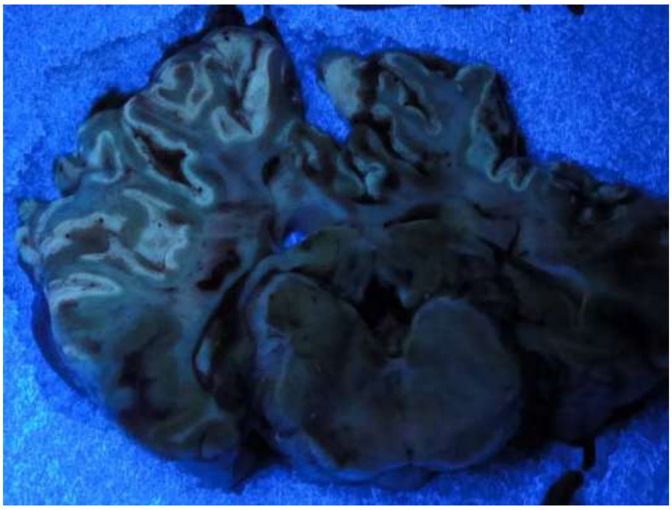

Figure 17.15: Bovine brain under UV illumination showing autoflorescence of the cerebral grey matter. Photo: AFBI

CCN is most frequently recognised in young animals, with a peak incidence between 6–18 months, however during the summer of 2019 a small cluster of CCN cases were diagnosed in older cattle. Two cases affected 4 year old cows, these animals had been at pasture and had been receiving a small amount of supplementary concentrate feeding, and there was a history of previous similar cases on the farms during the summer. The third case was a 2 year old dairy heifer at pasture, but not receiving any concentrate feeding and she was the only animal affected on this farm. Presenting signs in the cases ranged from loss of power, staggering, through teeth grinding and blindness to recumbency and convulsions. Hypomagnesaemia is a major differential diagnosis in adult cattle presenting with staggering or convulsion while on lush pasture, but the eye fluid levels of calcium and magnesium were within normal ranges in all cases, nor was lead detected in tissues of any of the cases. At *post mortem* examination the cow which had developed convulsions had haemorrhages and bruising over the soft tissues of the head, but no other lesions were detected in any of the cattle. Brain tissue was examined histologically from each case and a laminar pattern of necrosis was detected in neurones of the forebrain (Figure 17.16). Unusually the damaged layers of brain cells in these cases were often superficial within the brain cortex rather than the deeper layers typically affected in CCN.

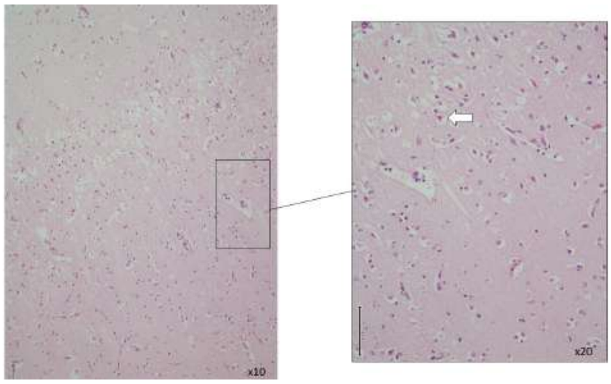

Figure 17.16: Brain histology from a four year old cow, showing a layer of oedema and neuronal necrosis. Necrotic neurone highlighted by white arrow. Photo: AFBI

Apart from animals at pasture no further common management factors were identified between the cases, and no similar cases were identified in previous years from the archive. Due to the similarity of signs in these cases to hypomagnesaemia, cases of CCN may be missed in adult cattle without *post mortem* and brain histology, so in future seasons identification of further cases may provide more information on potential risk factors leading to disease in older cattle. The diagnosis of CCN on one of the affected farms meant that a subsequent case was treated with vitamin B1 and survived the episode but retained some neurological deficits.

18 Bovine Abortion, AFBI

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Economically abortion remains a significant cost to the cattle industry, with the loss of a pregnancy leading to the loss of income from a beef cow for the year, to decreased milk yield from a dairy cow as lactation period may be extended, or the cow prematurely culled. Studies have estimated the cost per abortion to range from $555 to $900 in dairy cattle, and the cost per abortion being greater the later in pregnancy the loss occurs.

Many herds have an abortion rate of 1–2 *per cent* and concern is usually raised for intervention if a number of abortions occur within a short period of time, or if the incidence of abortion becomes greater than 3–5 *per cent*. While many abortions are sporadic, abortion storms (>10 *per cent* of cows in a herd aborting) can occur when a new pathogen is introduced into a naïve herd, such as *Neospora caninum* or Salmonella infections.

Infections of dam or foetus are not the only causes of abortions, some of the non-infectious causes include:

- genetic anomalies in the foetus, although these often result in early embryonic loss and an early return to service,
- conditions in the mother such as dehydration, malnutrition, nutrient deficiency,
- toxins, for instance plant, fungal or chemical.

Systemic infection in the dam often with pyrexia and endotoxaemia, can be associated with pregnancy loss, and the abortion may occur before an infectious agent can invade the foetus, for instance clinical mastitis cases are associated with a two fold increase in the risk of pregnancy loss than unaffected cows. Placental damage or infection may occur without spread of the infectious agent to the foetus, particularly with fungal placentitis and *Ureaplasma* infections.

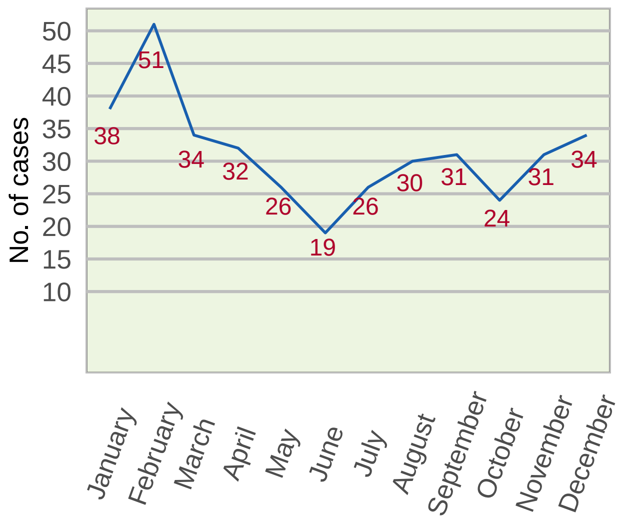

Figure 18.1: Abortion submissions to AFBI per month during 2019.

Therefore to increase the likelihood of diagnosing the cause of an abortion it is important to examine and sample the dam, the placenta and the foetus. As many placental lesions are focal, a large portion of placenta should be examined, with the tip of the pregnant horn being a frequent site for placental lesions in cattle. Retained placenta is also useful as there will be less environmental contamination present. While a freshly dead foetus significantly increases the opportunities to recover a pathogen, many foetuses have been dead for a period of time before they are expelled and in these circumstances serum from the dam and any available placenta are of value, as are further abortion cases from the same farm.

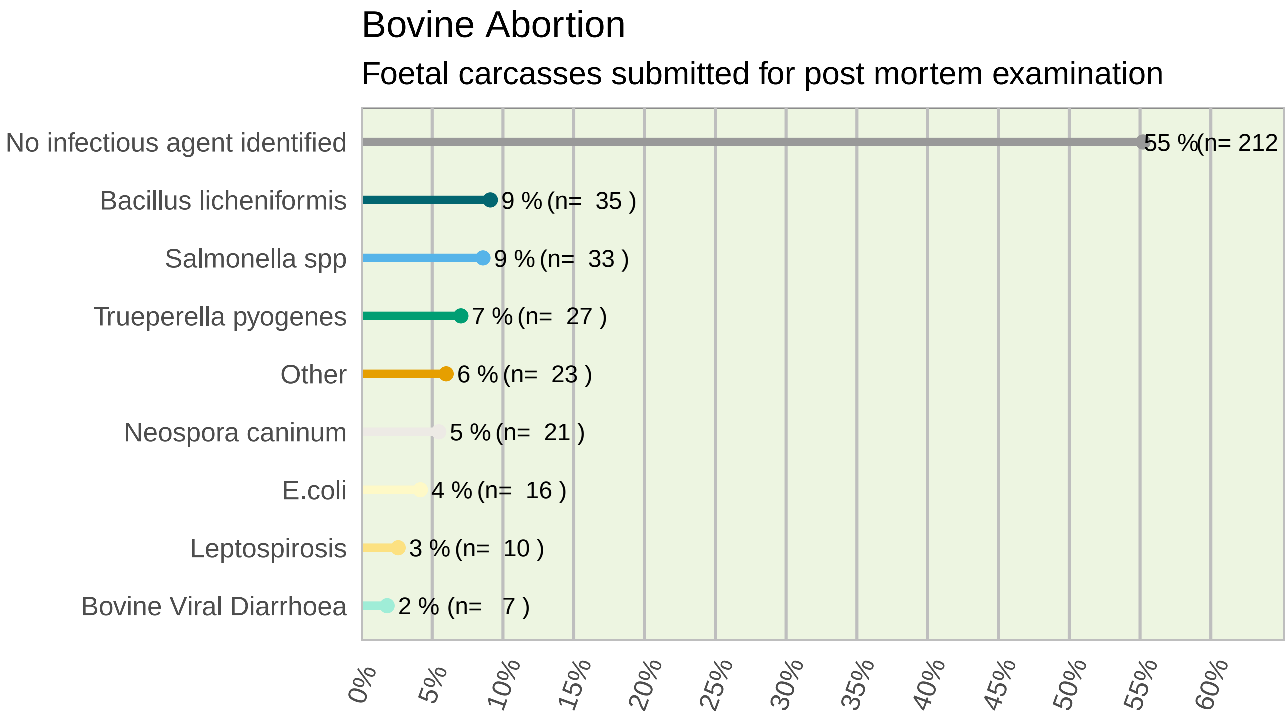

Figure 18.2: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2019.

Table 18.1: Relative frequency of the identified infectious agents of bovine abortion from submitted foetal *post mortems* in 2019, (n= 384).

Category	No. of cases	Percentage
No infectious agent identified	212	**55.2**
Bacillus licheniformis	35	**9.1**
Salmonella spp	33	**8.6**
Trueperella pyogenes	27	**7.0**
Other	23	**6.0**
Neospora caninum	21	**5.5**
E.coli	16	**4.2**
Leptospirosis	10	**2.6**
Bovine Viral Diarrhoea	7	**1.8**

In 2019, AFBI investigated 384 bovine abortion submissions (Table 18.1 and Figure 18.2), with a moderate peak in submissions in February. Infectious agents were identified in 45 *per cent* of abortion cases (Figure 18) and of these bacterial agents comprised 80 *per cent* of diagnoses. Both jurisdictions in Ireland are officially free of Brucella abortus and all bovine abortions submitted to AFBI are cultured for B abortus to assist confirming that disease free status is maintained. *Bacillus licheniformis* and *Trueperella pyogenes* were the most commonly diagnosed bacterial agents (21 *per cent* and 17 *per cent* respectively of infectious abortions), with *Salmonella* Dublin and *Escherichia coli* each causing 11 *per cent*. *Leptospira sp* accounted for 6 *per cent* of agents and there were several abortion cases associated with *Salmonella Montevideo* and *Salmonella Mbandaka* during the year.

There were seasonal trends associated with different pathogens (18.6), with *Bacillus licheniformis* and *Trueperella pyogenes* most frequently diagnosed in the first quarter, *E. coli* in the first two quarters, while *Salmonella* Dublin and Neospora were most frequently detected in the last quarter of the year and Leptospira was most common during the spring and summer. *Salmonella* Dublin and Neospora infections are considered to be more prevalent in dairy herds, the peaks associated with these pathogens would correspond to late gestation in many of the autumn calving dairy herds.

Bacillus licheniformis. This is a primary abortifacient, not requiring prior compromise of the dam or placenta to infect and cause abortion, and is mostly frequently recovered from abortions during winter. In 2019 *B. licheniformis* was recovered from 9 *per* *cent* of bovine abortion submissions to AFBI (Figure 18.2). The dam becomes bacteraemic with *B. licheniformis*, which invades the placenta and causes placental necrosis and inflammation, and then invades the foetus causing a multifocal suppurative pneumonia. Fibrin coating the foetal lungs is sometimes seen at *post mortem*. Abortion associated with *B.licheniformis* is often sporadic, however outbreaks on farm can occur. *B. licheniformis* abortions have been associated with periods when levels of the organism in the farm environment are high, with high levels detected in pit silage and water troughs, particularly when water troughs have been soiled by silage or faeces. Control measures include ensuring rapid drops in pH in silage during ensiling, feeding good quality silage to pregnant animals, removal of stale or spoiled silage from feed passages before replenishing and regular cleaning of drinkers and water troughs.

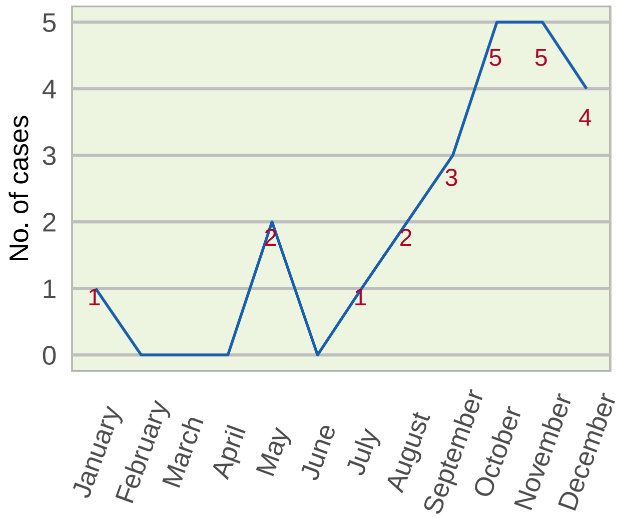

Figure 18.3: Number of cases per month were *S.* Dublin was identified as a causative agent in 2019

Salmonella *Dublin*. *S.* Dublin was associated with 8 *per cent* of the bovine abortion submissions to AFBI in 2019, with diagnoses peaking in the last quarter of the year (Figure 18.3), a trend described by other laboratories and noted in both spring and autumn calving dairy herds. *S.* Dublin, a cattle adapted serotype of *Salmonella enterica* subspecies *enterica*, can also cause disease in humans, with endemic infections in a cattle herd persisting for many years in carrier animals and manifesting in a wide range of clinical signs from abortion, diarrhoea, ill thrift, sudden death to bone infections and gangrene. Cattle can be infected via the feed, water, bedding or equipment, or introduction of carrier animals into the herd, with abortions being sporadic or epizootic and often preceded by a stressful event such as transport or change of feed, usually occurring in late gestation. The abortion follows a bacteraemia in the dam and the cow may appear well or show signs of ill-health in the previous week such as enteritis. The bacteraemia leads to destruction of the foetal placental villi and the placenta may appear thickened, with exudate of the cotyledons, and possibly there may be portions of caruncle still attached, but it is often retained after the abortion. The foetus may not be invaded by the Salmonella organism at the time of abortion and samples such as placenta and maternal serum would be necessary to confirm the diagnosis.

During 2019 serotypes *Salmonella Montevideo* and *Salmonella Mbandaka* were also recovered from several cases of bovine abortion, including an outbreak with S Montevideo on a dairy farm. These serotypes have rarely been recovered from bovine abortion cases by AFBI, while they are not uncommon causes of bovine disease in GB, Europe and North America. *S. Montevideo* is occasionally isolated from sheep in Ireland, however no contact with sheep was identified in the AFBI cases. Other putative sources for *S. Montevideo* infections include scavenging seagulls, poultry and soya meal, but recent work in North America suggests a subset of *S. Montevideo* isolates are specific to cattle and distinct from human or poultry isolates which may suggest maintenance of the serotype within the cattle population, although no evidence of carrier status for *S. Montevideo* in cattle has been reported. *S. Mbandaka* infections have previously been associated with feed contamination, in particular soya bean meal, maize meal and rapeseed products.

Trueperella pyogenes. This bacterium is a commensal organism of bovine skin and mucous membranes, but is also an important opportunistic pathogen and often recovered from suppurative infections. Apart from uterine infection isolates, few differences in virulence factors have been detected in commensal strains of *T. pyogenes* compared with strains isolated from sites of infection supporting an opportunistic mode of action, and as endometrial stromal cells are particularly sensitive to the pyolysin toxin of *T. pyogenes*, the uterus is a vulnerable site during a *T. pyogenes* bacteraemia or from ascending infection from the vagina should the barrier of the

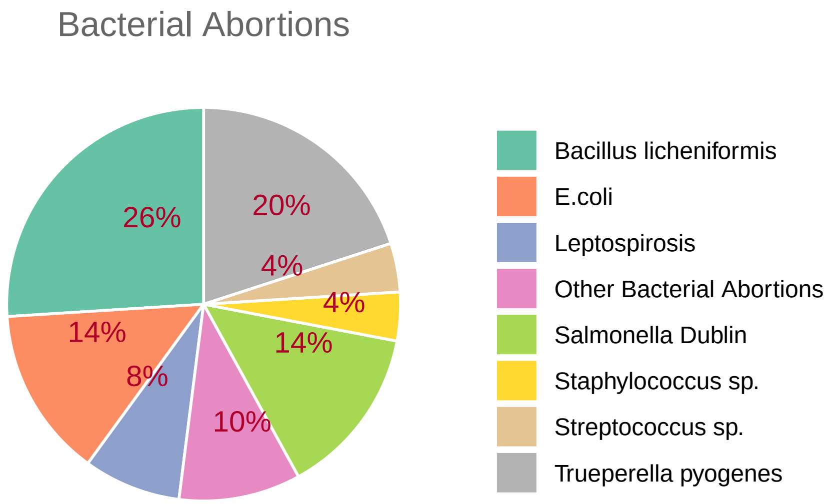

Figure 18.4: Bacterial agents identified in bovine abortions during 2019 as a percentage of all bacteria associated abortions.

cervix be incomplete. *T. pyogenes* associated abortions are typically sporadic, with a suppurative placentitis, oedematous cotyledons and congested foetal lungs, while histologically there may be numerous bacteria with a limited inflammatory response. In 2019 *T. pyogenes* was recovered in 7 *per cent* of the bovine abortions submitted to AFBI.

Figure 18.5: Neospora caninum in the brain of a bovine foetus, stained by immunohistochemistry. Photo: AFBI

Neospora caninum. The protozooa *N. caninum* was detected by AFBI in 5.5 *per cent* of bovine abortions during 2019. *N. caninum* is associated with abortions late in gestation, although it may also have a role in early embryonic loss and increased rate of return to service. A cow can be infected by ingesting oocysts shed by recently infected dogs (horizontal transmission) or from the dam before birth as the parasite crosses over the placenta and into the foetus. Placental and foetal infection may result in abortion, birth of weak calves, or birth of viable calves which are infected for life by the parasite and subsequently an infected heifer may pass the parasite to her offspring, perpetuating the infection down the generations. The risk of an infected cow aborting is greatest in the first pregnancy after infection, and other risk factors include, a previous abortion, a purebred pregnancy, poor quality fodder particularly mouldy feed and natural water sources such as ponds.

Leptospira sp.. This organism was diagnosed in 2.6 *per cent* of all bovine abortions, predominantly from submissions in the summer months which is a recognised risk period for transmission, from urine contaminated water sources or pasture. Carrier animals are also more likely to shed Leptospira organisms in their urine while at pasture and judicious use of vaccination will provide protection to herd mates and farm staff alike from this zoonotic pathogen.

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

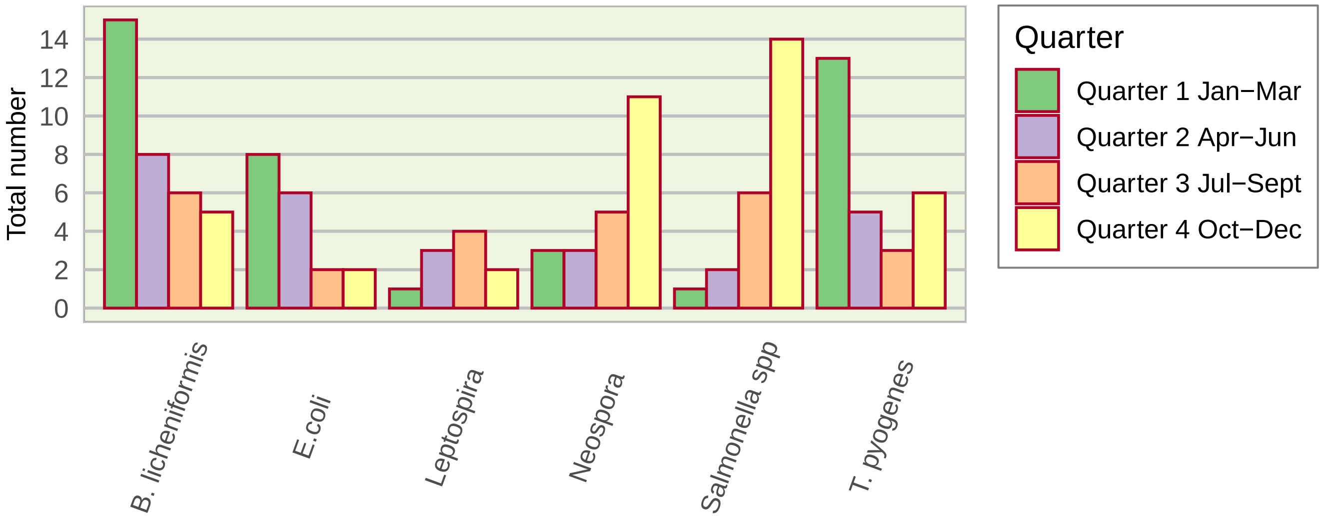

Figure 18.6: Bacterial abortions by agent during each quarter of 2019

A range of bacterial agents were recovered from sporadic cases of bovine abortion, including *Streptococcus sp*, *Staphylococcus sp*, while *Escherichia coli* was diagnosed in 4 *per cent* of abortion submissions. In many instances these bacteria, normal gut and mucosal commensal organisms may have been opportunistic infections when the dam's innate defences were lowered.

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19 Bovine Respiratory Diseases, AFBI

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Bovine respiratory disease (BRD) is a hugely significant cause of morbidity and mortality in cattle with the condition responsible for 31 *per cent* of bovine carcasses submitted to the lab at AFBI during 2019 in cattle over one month old. It is most prevalent in bovines aged between 1 and 5 months old where approximately 50 *per cent* of bovine carcasses submitted within this age group were diagnosed with a respiratory condition (Table 17.2 and Figure 17.6).

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

Table 19.1: Relative frequency of the different aetiological agents identified in cases of pneumonia diagnosed during *post mortem* by AFBI in 2019 (n=210).

Category	No. of cases	Percentage
Mycoplasma bovis	58	**27.6**
Pasteurella haemolytica	40	**19.1**
Pasteurella multocida	35	**16.7**
Dictyocaulus viviparus	25	**11.9**
Bovine Respiratory synthical virus BRSV	21	**10.0**
Histophilus somnus	12	**5.7**
Trueperella pyogenes	12	**5.7**
Infectious Bovine Rhinotracheitis (IBR)	6	**2.9**
Bovine Viral Diarrhoea (BVD)	1	**0.5**

The financial implication of an animal or a group of animals affected with the condition is not to be ignored with costs mounting due to loss and disposal of carcasses, veterinary treatment, time invested by a farmer in treating animals and of course loss of production with a prolonged interval to slaughter.

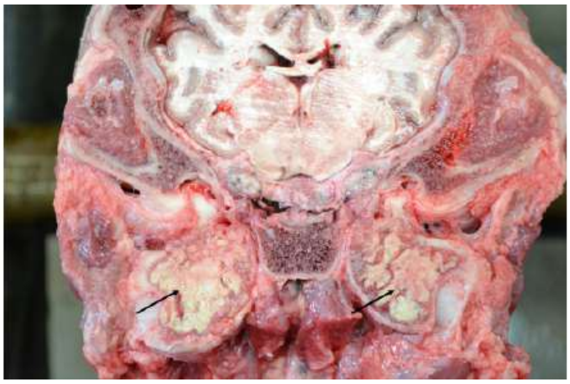

Figure 19.1: Otitis media due to *Mycoplasma bovis*. Photo: AFBI

Infectious agents are by far the most frequently diagnosed cause of pneumonia. Animals on every farm inevitably will be carrying some infectious agents within the respiratory tract however disease tends to occur when natural defences are low or when there is an extremely high burden of infection in the environment.

Bacterial causes are particularly important accounting for nearly 75 *per cent* of the identified causes of pneumonia. Vaccines are available and offer a level of protection in some instances however good husbandry and management of the herd combined are necessary to reduce loses.

Mycoplasma bovis was identified with the greatest frequency on *post-mortem* examination of cattle diagnosed with bovine respiratory disease during 2019 in Northern Ireland. The condition provides veterinary practitioners with a challenge as the bacteria is well equipped to evade the animal's immune system. It can be present and shed from mucous membranes within the respiratory tract, genital tract and mammary gland without clinical signs. The result should be interpreted in conjunction with the clinical picture and findings of PM examination. The infection

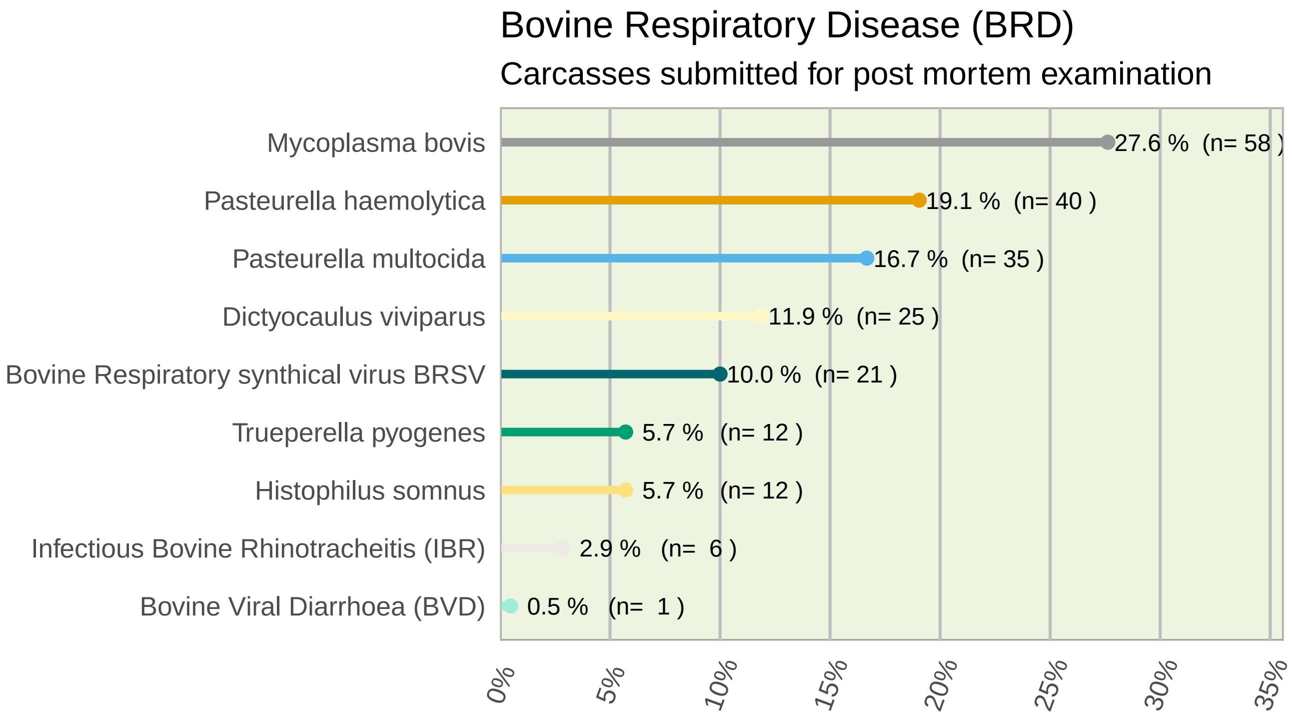

Figure 19.2: Relative frequency of the different agents identified in cases of pneumonia diagnosed during *post mortem* examination by AFBI in 2019 (n=210).

usually causes a chronic caseonecrotic bronchopneumonia with a cranioventral distribution. A bacteraemia with subsequent infection in other tissues can result. Calves can become infected through contact with genital secretions but more so from ingestion of infected milk. Currently no commercial vaccines are available for the condition although some commercial companies are licensed to produce autogenous vaccines.

Figure 19.3: Chronic suppurative bronchopneumonia. Photo: AFBI

Respiratory Syncytial Virus (RSV) was the commonest cause of viral bovine respiratory disease. Spread by aerosol it causes a cranioventral pattern of pneumonia. Grossly, the lung is often atelectic and deep red in colour with a rubbery texture. Subpleural and interlobular emphysema with the formation of bullae is often a feature. Secondary bacterial infection can at times obscure RSV diagnosis.

For the most successful diagnosis of respiratory disease the full fresh carcase should be submitted were possible. When in the field the best samples taken should include a sample of diseased tissue both fresh tissue for culture, immunofluorescence and PCR and a section of tissue in formalin for histopathology. It is vital that the sections harvested for testing are representative of the affected tissue. A detailed history including clinical signs, duration, number of animals affected and treatment administered will all add value when interpreting test results and histopathology.

Dictyocaulus viviparus causing parasitic bronchitis was a significant bovine respiratory disease aetiology during summer and autumn months accounting for nearly 12 *per cent* of pneumonia cases with a peak

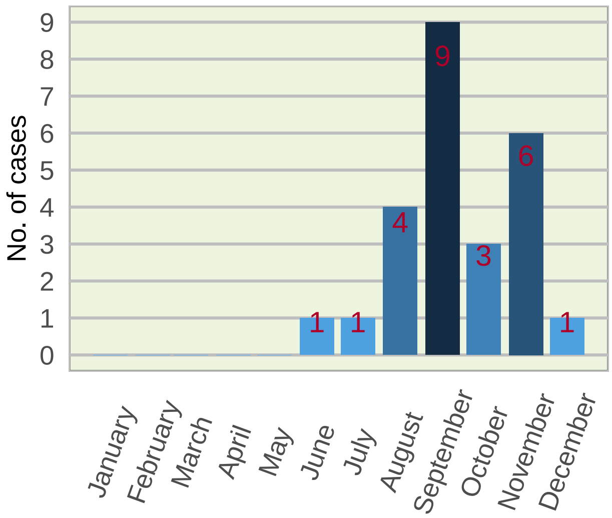

Figure 19.4: Number of lungworm cases diagnosed during *post mortem* by AFBI per month in 2019.

Figure 19.5: Lungworm in a trachea. Photo: AFBI

during the month of September (Figure 19.4)). Repeated challenge each year is necessary to maintain an immune response. Circumstances including animals being housed all year round along with administration of anthelmintics with an extended period of action can provide an opportunity for infection in older animals who have not had adequate exposure.

20 Bovine Mastitis, AFBI

Table 20.1: Bacterial isolated in milk submitted to AFBI in 2019 (n=903).

Category	No. of cases
E.coli	303
Streptococcus uberis	196
Staphylococcus aureus	110
Streptococcus dysgalactiae	63
Bacillus licheniformis	29
Bacillus cereus	17
Trueperella pyogenes	16
Yeast	12
Other bacteria	10
Fungi	9
No organism isolated	138

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Mastitis is one of the most important production diseases of dairy cows. It has significant financial costs as it depresses milk yield, leads to milk quality penalties, can have high treatment and veterinary costs, causes discarding of milk during antibiotic therapy and increases culling rates. Knowledge of the causative organism responsible for mastitis allows mastitis control programs to be tailored to meet specific needs on farm and to this end culturing of milk in cases of clinical or subclinical mastitis is important.

Pathogens which can cause mastitis are regularly classified as contagious organisms or environmental organisms according to whether spread from cow to cow in the milking parlour or via the milking machine is the principle means of spread or whether most new infections arise from contaminated non-hygienic environments such as cow accommodation and calving pens.

There were 765 microbial isolates from milk samples submitted to AFBI to investigate cases of clinical mastitis or suspected subclinical mastitis in 2019 (Table 20.1 and Figure 20.1). Isolation of multiple organisms from a milk sample is strongly suggestive of contamination during sampling and interpretation of these results requires care. Proper procedures should be followed when collecting a milk sample for bacterial culture with attention to optimal preparation and disinfection of the teat before the sample is collected to minimise risk of contamination by dirt, dust and faecal material from the udder skin.

The environmental mastitis causing organisms *E. coli* and *S. uberis* were the most frequently isolated bacteria. *E. coli* was the most frequently isolated organism from submitted milk sampling which bacteria were detected in 2019 and was recovered in almost 40% (303 *E. coli* isolates) of cases. *S. uberis* was recovered in 196 cases (26 *per cent* of cases where a micro-organism was cultured). *S. aureus* was the third most frequently cultured mastitis associated bacterium. *S. aureus* is recognised as the most important cause of contagious mastitis typically spread from cow to cow via the milking equipment or milker's hands. 110 cases of *S. aureus* were isolated (13 *per cent* of cases where a micro-organism was isolated). *S. dysgalactiae* was isolated in 63 cases (8 *per cent* of cases where microbes were isolated). Transmission of *S. dysgalactiae* on farms is by both environmental contamination and by contagious cow to cow transmission.

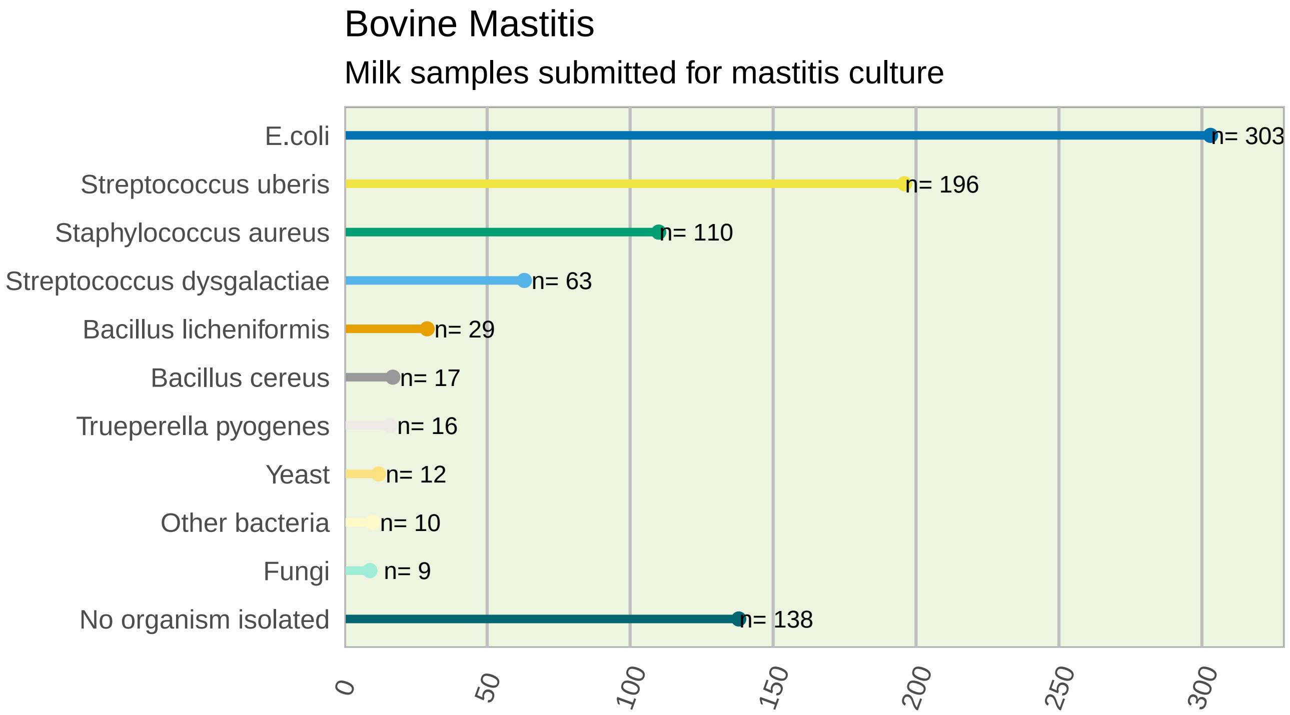

Figure 20.1: Bacteria isolated in milk samples submitted to AFBI in 2019 (n=903)

21 Zinc Sulphate Turbidity Testing, AFBI

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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.

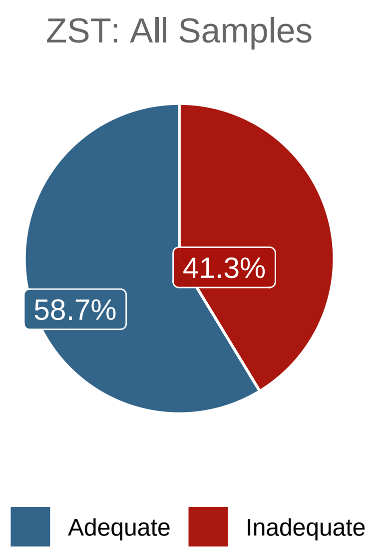

Figure 21.1: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2019 from bovine calf serum samples (n=954). Adequate colostral immunity is defined as greater than or equal to 20 units.

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

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

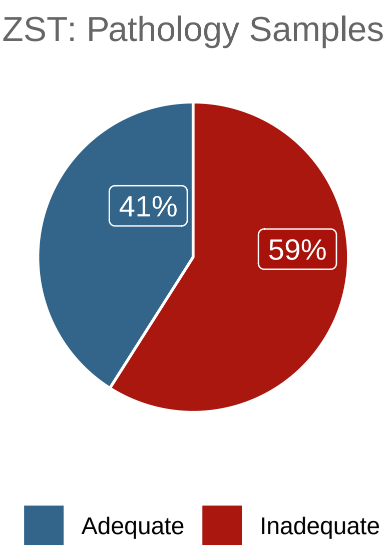

Figure 21.2: Results of Zinc Sulphate Turbidity tests performed by AFBI in 2019 from bovine calf serum samples taken at *post mortem*(n=198). Adequate colostral immunity is defined as greater than or equal to 20 units.

Figure 21.3: Brix refractometer. Colostrum quality can be assessed by placing a drop of colostrum on the stage and looking through the eyepiece. Photo: Cosme Sánchez-Miguel.

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

In 2019, a total of 954 serum samples were tested; of these 756 were diagnostic samples submitted from live calves, and 198 were obtained at *post mortem* examination. The results are shown in Figures 21.1 and 21.2 where it can be seen that of all the samples tested, 41.3 *per cent* were inadequate while 58.7 *per cent* were adequate, whereas the results of those obtained at *post mortem* showed that only 41 *per cent* of samples were adequate and 59 *per cent* were inadequate. This frequent finding of inadequate ZST levels in neonatal calves submitted for *post mortem* would suggest a link between failure of passive transfer and neonatal mortality.

These results indicate that failure of passive transfer of immunity to neonates continues to be a problem in herds, and so highlight the need to continue to reiterate the importance of good colostrum management. It is recommended that every calf receives 3 *litres* of good quality colostrum within the first 2 hours of life. A useful on farm tool for measuring the concentration of immunoglobulins in colostrum is a Brix refractometer (Figure 21.3 and so can aid in the overall picture of colostrum management in the herd.

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22 Bovine Neonatal Enteritis, AFBI

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

AFBI tested a total of (720) faecal samples in 2019 (Table 22.1 and Figure 22.1), and similarly to the previous two years, *Cryptosporidium spp* was detected most frequently (35 *per cent* of samples positive). Rotavirus was detected second most commonly, but in a change from previous years, the proportion of positive samples was only slightly lower than that of *Cryptosporidium spp.* at 32.3 *per cent*. There was an increase in the relative frequency of the detection of *E. coli* expressing the *K99* fimbriae from 2.7 *per cent* in 2018 to 6.8 *per cent* in 2019. Coronavirus was detected in 3.9 *per cent* of samples tested. Frequently more than one pathogen is detected in a single sample, or from different samples from the same outbreak, and often where mixed infections are present the disease severity and mortality rate is greater than where single infections are present.

Table 22.1: Most frequently isolated bacteria from milk samples submitted to AFBI in 2019 (n=720).

Organism	No. Tested	Positive	Percentage
Cryptosporidium species	704	**246**	34.9
Rotavirus	703	**227**	32.3
Coronavirus	720	**28**	3.9
Escherichia coli K99	470	**32**	6.8

Cryptosporidiosis, most commonly caused by *Cryptosporidium parvum*, a single-celled parasite, produces a watery diarrhoea in calves between 7 and 13 days of age. The organism infects cells of the small intestine and heavy colonisation occurs quickly through rapid replication. Animals are infected through ingestion of oocysts produced in large numbers by other infected calves. The oocysts have a tough outer shell and can survive for long periods in the environment, being resistant to many commonly used disinfectants and able to withstand a wide range of temperatures, thus are difficult to remove from the environment.

In addition, only a small number of oocysts are required for infection to occur. 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

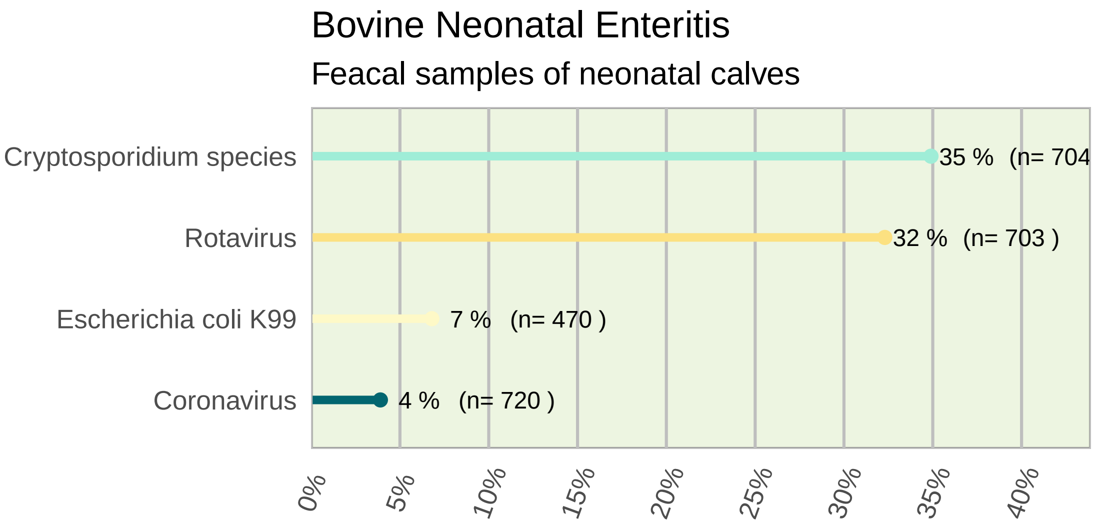

Figure 22.1: Frequency of common enteropathogenic agents identified in calf faecal samples tested by AFBI in 2019.

strict hygiene measures, separating infected and non-infected calves and proper cleaning and disinfection of calf accommodation using an ammonia based substance, followed by drying out and ideally leaving empty for a prolonged period.

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

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

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

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23 Bovine Parasites, AFBI

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Gastrointestinal nematodes

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

In 2019, 3.9 *per cent* (number of samples examined, n=2307) of bovine faeces samples submitted to AFBI for parasitological examination had a *FEC* $\geq$ 500 *epg* (Figure 23.1), compared to 4.9 *per cent* of samples submitted in 2018. As in 2018, the peak months for clinically significant gastrointestinal nematode infection were September (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), with a lower peak occurring in the May and June (presumably corresponding with *Type 2* PGE in yearlings; see Figure 23.2.

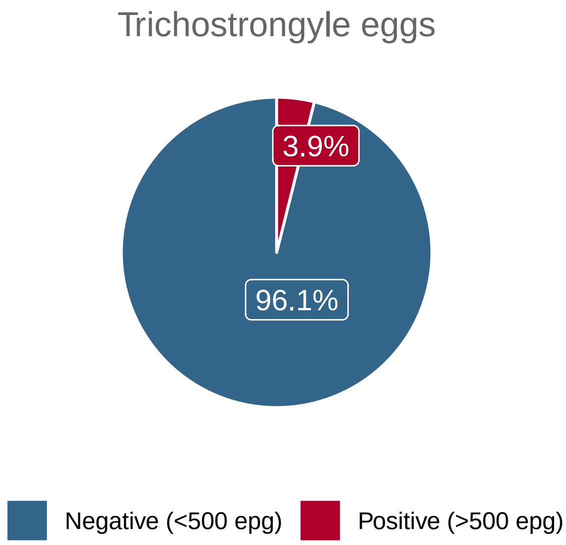

Figure 23.1: Relative frequency of detection of trichostrongyle eggs in bovine faecal samples examined by AFBI in 2019 (n=2307).

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

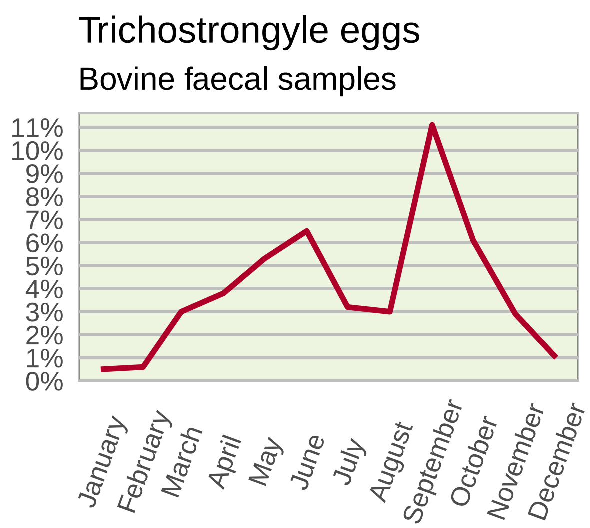

Figure 23.2: Percentage of bovine faecal samples positive for trichostrongyle eggs per month during 2019 (positive samples have equal or greater to 500 eggs *per gram*).

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

Liver fluke.

In 2019, *Fasciola hepatica* incidence dropped to 6.6 *per cent* (n = 2074) of bovine faecal samples submitted to AFBI (Figure 23.4), compared to 12.5 *per cent* in 2018.

It is likely that this reflects the availability of the infective metacercarial cysts on pasture in the late autumn and early winter of 2018. 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 23.3), and the development of the fluke infective stages within it.

The risk of fluke infection each year, based on climatic data, is predicted by AFBI staff and published in the farming press in October. Pathogenesis of liver fluke depends on the number of metacercariae ingested and the stage of parasite development within the liver. The acute phase of infection, which is rarely symptomatic in cattle, occurs while parasites migrate through the hepatic parenchyma. Fluke eggs are not

Figure 23.3: Galba truncatula, the snail host of Fasciola hepatica and *Calicophoron daubneyi*. Photo: AFBI

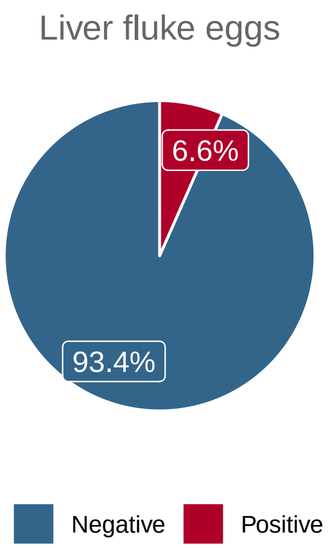

Figure 23.4: Relative frequency of detection of liver fluke eggs in bovine faecal samples examined in AFBI in 2019 (n=2074).

present in faecal samples during this phase, and diagnosis of infection rests on blood testing for evidence of liver damage.

The chronic phase of infection corresponds to the presence of adult parasites residing in the bile ducts, leading to characteristic calcification of ducts and the pipe-stem liver appearance visible on *post-mortem* (Taylor, Coop, and Wall, 2015). Fluke eggs are present in faecal samples at this stage, and diagnosis is often confirmed by ELISA testing to demonstrate fluke coproantigens in the faeces. Liver fluke infection, fasciolosis, has major economic implications for livestock productivity due to the resulting morbidity and mortality (McCann, Baylis, and Williams, 2010). Carcases

Figure 23.5: Adult *Calicophoron daubneyi* in the rumen of a dairy cow. Photo: AFBI

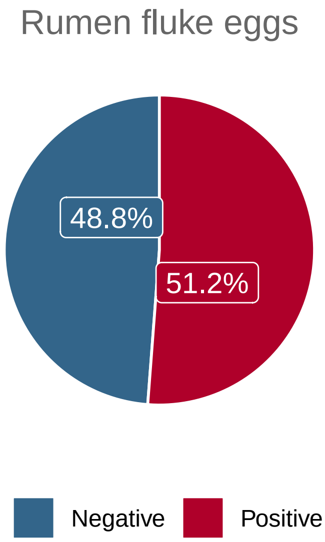

Figure 23.6: Relative frequency of detection of rumen fluke eggs in bovine faecal samples examined in AFBI in 2019 (n=2079).

Figure 23.7: Liver fluke and rumen fluke eggs in a faecal sample. Photo: AFBI

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 23.5) are found in the reticulum and rumen and are generally well tolerated, even with heavy burdens.

Any pathogenic effect is usually associated with the intestinal phase of infection, where immature flukes, hatched from ingested metacercariae, attach to the duodenal mucosa before migrating to the forestomachs; diarrhoea, anorexia and rectal haemorrhage may be noted. Young animals at pasture in late summer or autumn may be affected if the climatic conditions earlier in the year, or localised flooding, have favoured population build-up of the snail intermediate host, *Galba truncatula* (the same as for *F. hepatica*). However, a large number of animals with rumen fluke eggs detected in their faeces show few, if indeed any, clinical signs of disease. Incidence of positive bovine faecal samples at 51.2 *per cent* (n = 2079) (Figure 23.6) remains similar to that in 2018 (55 *per cent*).

In faecal examinations, the eggs of *C. daubneyi* can be distinguished from those of *F. hepatica* by their characteristic clear appearance (Figure 23.7).

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.

Coccidia spp.

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 2019, coccidian oocysts were seen in 21.3 *per cent* (n=2310) of bovine faecal samples examined in AFBI (Figure 23.8).

This level is similar to that recorded in 2018 (22 *per cent*), and indeed in most recent years, but it should be noted that in many samples a low level of oocysts was recorded, with only 2.7 *per cent* in the moderate or high categories. This may be because the peak of oocyst shedding from the infected animals had passed before the samples were collected.

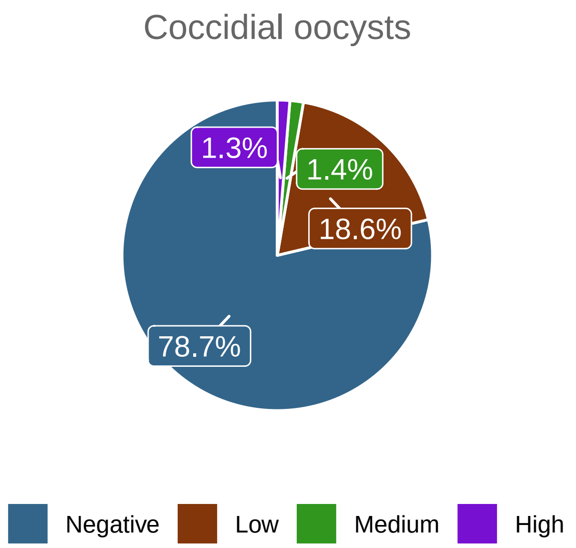

Figure 23.8: Results for bovine faecal samples tested for coccidial oocysts during 2019 (n=2310)

Examination of the faeces for oocysts of coccidians is an important element of diagnosis, and it may be significant to distinguish the species of parasite present (usually on the basis of the dimensions of the oocysts), and thus predict the likely pathogenicity of the infection. In cattle, coccidiosis caused by *Eimeria zuernii*, *E. bovis* and *E. alabamensis* usually affects calves under 1 year old, but occasionally yearlings and adults are infected if they have not experienced infection in early life. Disease occurs following a massive intake of oocysts from the environment, and this would be associated with large numbers of animals sharing unhygienic yards, or where animals congregate at pasture round water troughs and feeders.

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

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

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

Lungworm

Bovine lungworm *Dictyocaulus viviparus* is the cause of parasitic bronchitis (husk/hoose) in cattle. The disease is characterised by coughing and respiratory distress, and typically affects young cattle during their first grazing season, following which the surviving animals usually develop a strong immunity. Occasionally, if an older animal with acquired immunity is suddenly exposed to a massive larval challenge from a heavily contaminated field, severe clinical signs may result. In 2019, AFBI tested 231 bovine faecal samples for the presence of lungworm larvae, and of these 40 (17.3 *per cent*) were positive. Amongst 210 *post-mortem* diagnoses of pneumonia where the aetiological cause was identified, 25 cases (11.9 *per cent*) involved *D. viviparus* infection. The peak incidence of lungworm infection was in September. In recent years there has been a tendency for lungworm infection to occur in older cattle because treatment with long-acting anthelmintics during the first grazing season has prevented calves from being sufficiently exposed to lungworm infection to develop immunity.

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24 Ovine Diseases, AFBI

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The number of sheep submissions in Northern Ireland increased slightly in 2019 compared to 2018 with 558 submissions being received compared to 510. However it should be noted that a high number of these 2019 submissions were abortions (177) with other categories showing a diminishment. In 2019, 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 24.1: Most frequent causes of death in sheep submitted to AFBI for *post mortem* in 2019, data from 504 diagnoses excluding abortion.

Category	Percentage
Septicaemia	4.1
Poisoning	2.7
Metabolic disease	3.4
Clostridial disease	6.3
Enteric diseases	15.4
Neurological diseases	6.6
Respiratory diseases	10.8
Parasitic diseases	14.7
Other diseases	28.6
Diagnosis not reached	7.4

Mannheimia haemolytica was the most common cause of bacterial pneumonia in sheep in Northern Ireland in 2019. *Jaagsiekte* (ovine pulmonary adenocarcinoma) is also commonly diagnosed in Northern Ireland. In 2019 this disease accounted for 30 *per cent* of all diagnoses of respiratory disease in sheep and this proportion has been more or less constant since 2015.

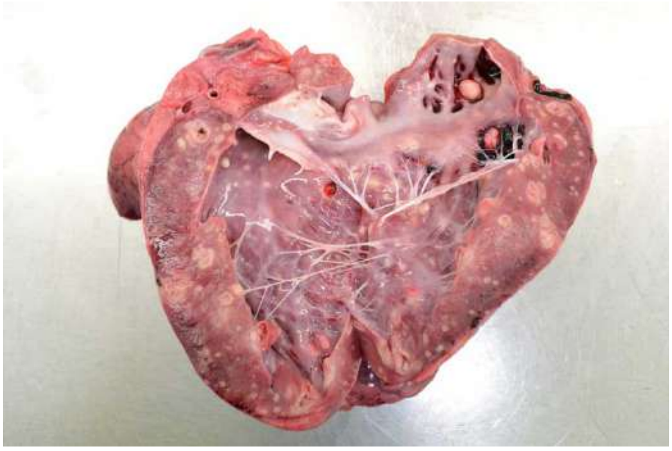

Figure 24.1: Suppurative foci in the heart due to *S. aureus* septicaemia in a lamb, likely to be caused by tick pyaemia. Photo: AFBI

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.

Case report: Tick pyaemia

Tick pyaemia (*S. aureus* septicaemia) was suspected in a ten-week-old lamb with severe multifocal to coalescing suppurative myocarditis and endocarditis, suppurative foci throughout the lungs, kidneys and skeletal musculature. *S. aureus* was recovered in septicaemic distribution (Figure 24.1).

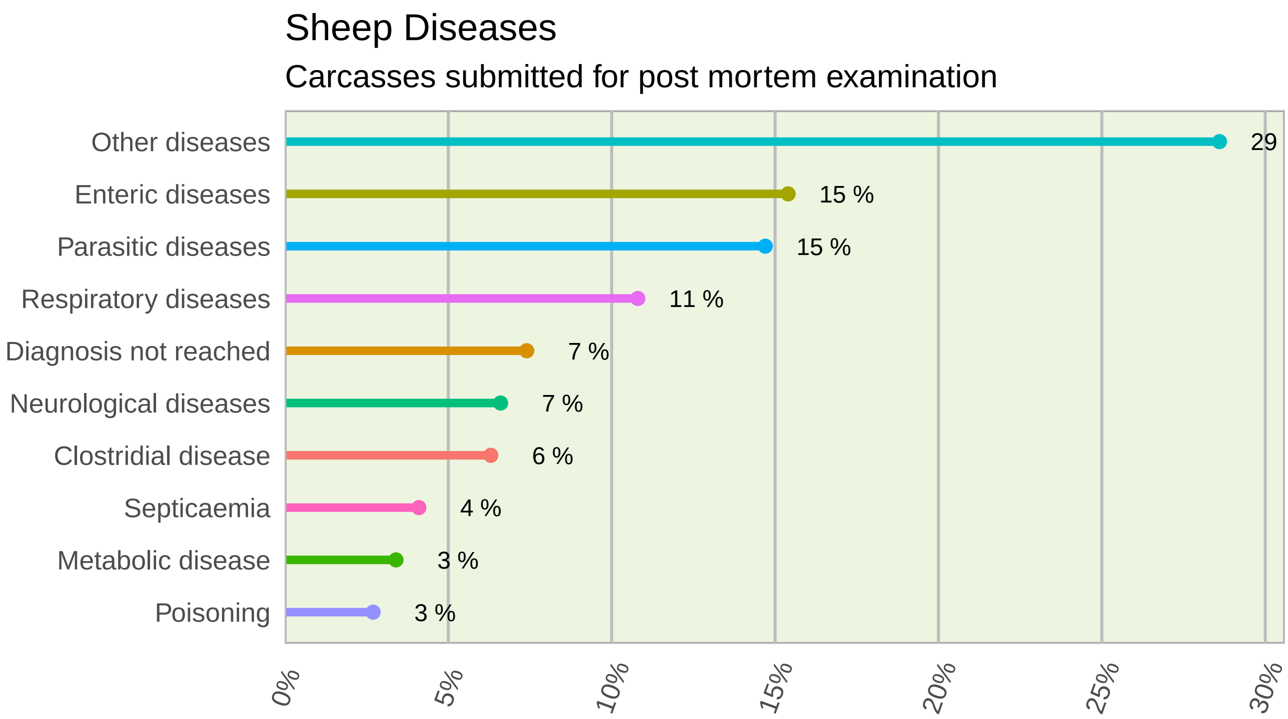

Figure 24.2: Relative frequency of the different agents identified in cases of pneumonia diagnosed during *post mortem* examination by AFBI in 2019 (n=210).

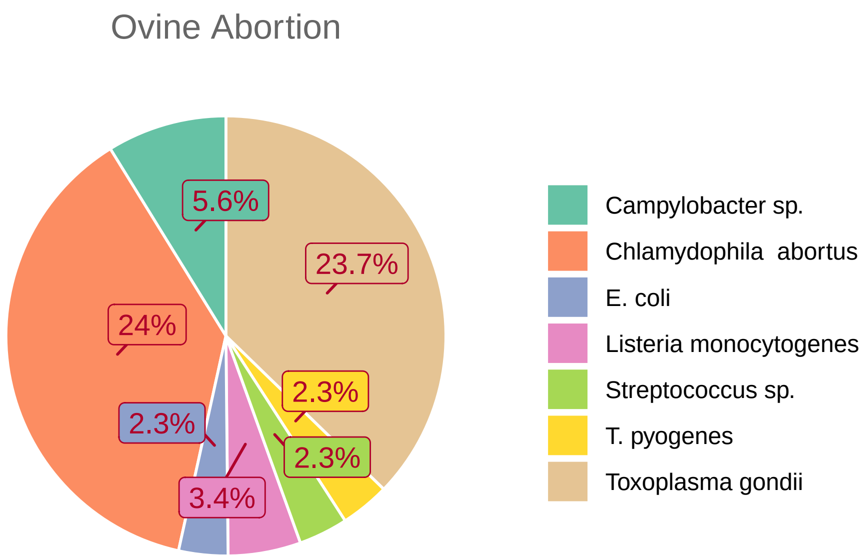

Figure 24.3: Ovine abortion cases in Northern Ireland 2019: Data from 108 cases from which significant pathogens were recovered.

Ovine Abortion

Specimens from 177 ovine abortions and stillbirths were examined during 2019. Significant pathogens were detected in 108 cases (61.2 *per cent*). Pathogens identified included *Chlamydophila abortus* (44 cases, 24.9 *per cent*), *Toxoplasma gondii* (42 cases, 23.7 *per cent*), *Campylobacter sp.* (10 cases 5.6 *per cent*), *Listeria monocytogenes* (6 cases, 3.4 *per cent*), *T. pyogenes* (4 cases, 2.3 *per cent*), *Streptococcus sp* (4 cases, 2.3 *per cent*) and *E. coli* (4 cases, 2.3 *per cent*) (Figure 24.3).

25 Ovine Parasites, AFBI

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Gastrointestinal nematodes

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 25.1).

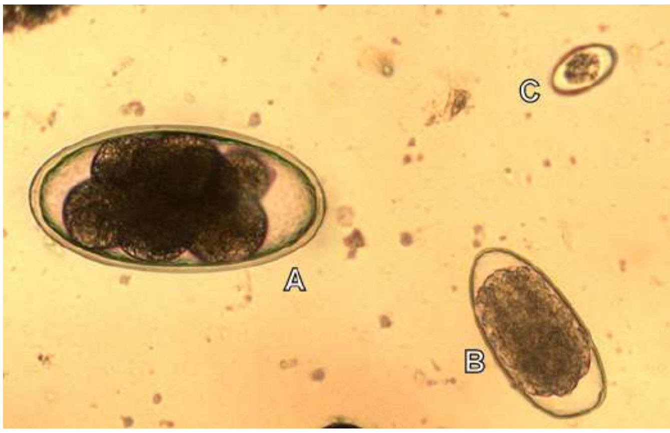

Figure 25.1: Nematodirus egg (A), trichostrongyle egg (B), and coccidian oocyst (C) in a faecal sample. Photo: AFBI

The number of trichostrongyle eggs detected is consistently higher in sheep when compared to cattle (Figures 25.2 and Figure 23.1 respectively).

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

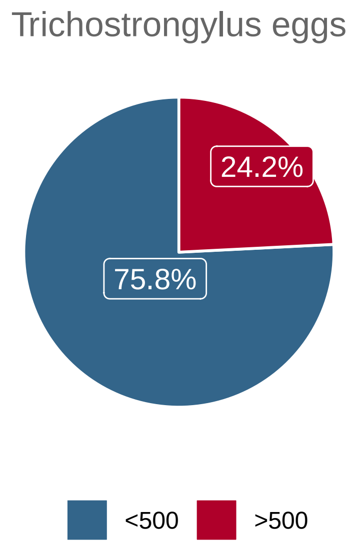

Figure 25.2: Relative frequency of detection of trichostrongyle eggs in ovine faecal samples examined by AFBI in 2019 (n=766)

The percentage of ovine samples containing ≥ 500 trichostrongyle eggs per gram dropped from 30.5 *per cent* in 2018 to 24.2 *per cent* in 2019 (number of samples examined, n =766; Figure 25.2), with peak *FECs* occurring in December-January (perhaps corresponding to late pregnancy in the ewes) and in August-September (parasitic gastroenteritis in lambs at pasture) Figure 25.3.

However, the rates of diagnosis for *Teladorsagia* and *Trichostrongylus* are tending towards a uniform year-round distribution, suggesting consistent levels of

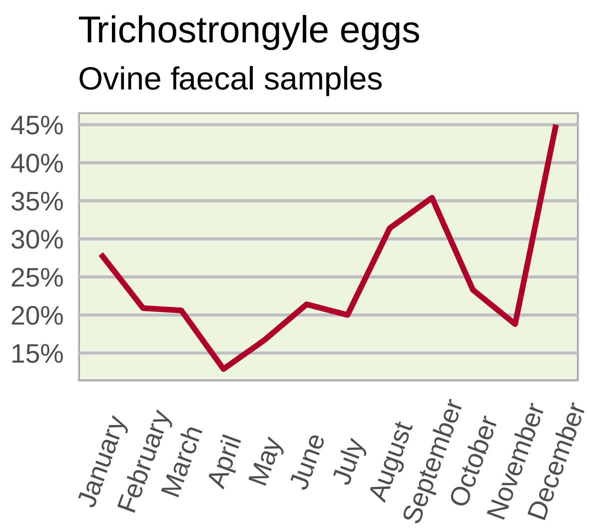

Figure 25.3: Percentage of ovine faecal samples positive for trichostrongyle eggs per month during 2019 (positive samples have equal or greater to 500 eggs *eggs per gram*).

larval survival throughout the year, with extension of the traditionally-expected seasonal windows of transmission. Changes in the temporal and spatial distribution pattern of nematode parasites that cause parasitic gastroenteritis in sheep can be related to recent changes in local temperature and rainfall, with year-on-year prolongation of conditions suitable for worm egg and larval development and enhanced over-winter survival of infective larvae (McMahon et al., 2012).

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

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

Nematodirus

Nematodirosis can be a significant cause of diarrhoea in sheep, particularly in young lambs. Development to the *L3* larval stage takes place within the egg, and in the case of *Nematodirus battus* (the most significant species seen in Ireland), a prolonged cold period is usually required before hatching from the egg occurs. It is common therefore that large numbers of *L3* larvae appear in April, May and June on those pastures where lambs have grazed the previous year. When lambs are weaned and are beginning to eat more grass, these *L3* larvae are ingested. If enough larvae are taken in, severe clinical disease can result. Faecal egg counts of more than 200 characteristic *Nematodirus eggs per gram* (Figure 25.4) 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 AFBI 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 734 faecal samples examined for *Nematodirus eggs* in 2019, 4.6 *per cent* were found to contain $\geq$ 200 *epg* (Figure 25.4), a reduction from the level recorded in 2018 (8 *per cent*).

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

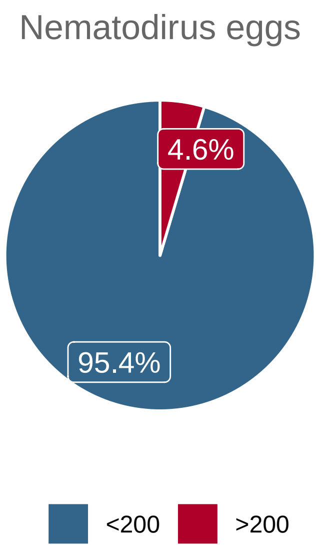

Figure 25.4: Relative frequency of detection of extit-Nematodirus eggs in ovine faecal samples examined by AFBI in 2019 (n=734)

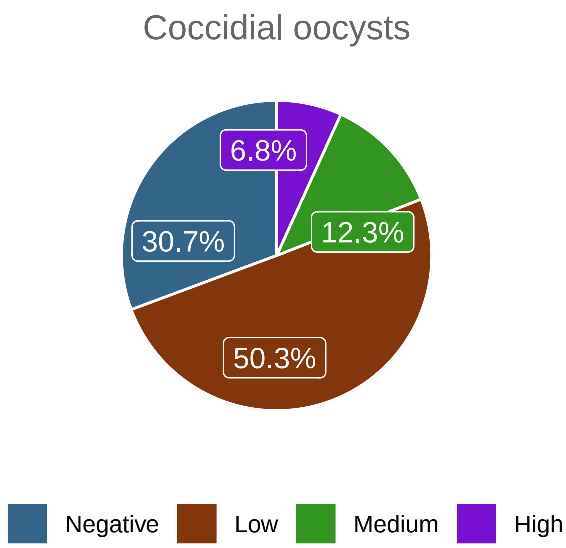

Figure 25.5: Relative frequency of detection of coccidial oocysts in ovine faecal samples during 2019 (n=766)

the peak egg hatching period, calculated by AFBI parasitologists using climatic data.

In recent years, a trend seems to be emerging for a second autumnal peak in *Nematodirus battus* infection in sheep. The reason for this appears to be flexibility in the hatching behaviour of the eggs, with a significant proportion hatching in autumn, in response to climatic change (McMahon et al., 2017).

Coccidiosis

In 2019, as in previous years, coccidial oocysts were detected more frequently in sheep than in cattle faeces samples. Of the sheep samples examined in 2019, 69.4 *per cent* (n=766) were positive for oocysts (compared to 66.5 *per cent* in 2018), but only 19.1 *per cent* exhibited moderate or high levels (Figure 25.5).

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

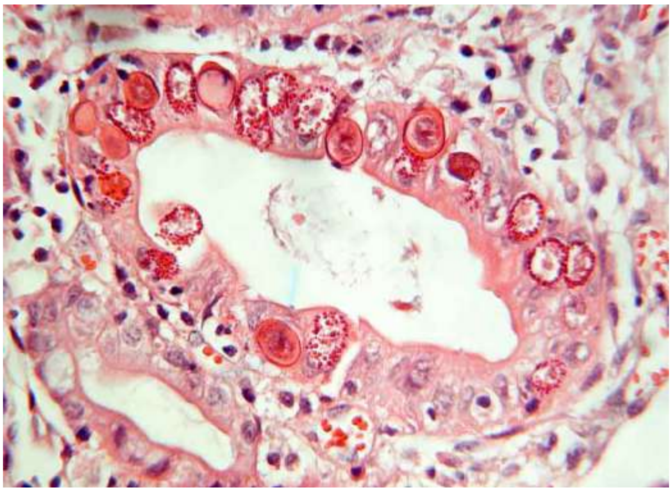

Figure 25.6: Histopathology section of coccidiosis in the gut wall of a lamb. Photo: AFBI

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 naïve 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 2019, rumen fluke eggs were more frequently detected than liver fluke eggs (positive FECs were recorded in 25 *per cent* and 8.3 *per cent* of 677 faecal samples respectively; Figures 25.10 and Figure 25.7).

The percentage with liver fluke eggs detected showed a marked decrease from 2018, when 29.5

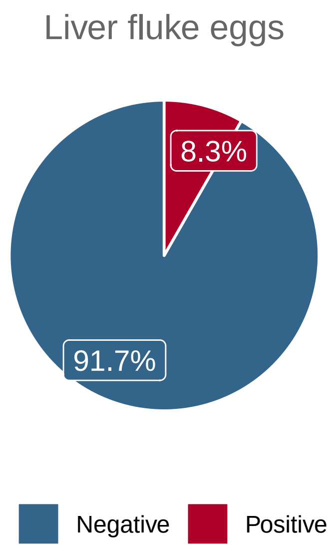

Figure 25.7: Relative frequency of detection of liver fluke eggs in ovine faecal samples examined by AFBI in 2019 (n=677).

per cent of samples examined yielded positive results, whereas in 2019 there was a slight increase in numbers of samples testing positive for rumen fluke eggs (up from 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 in 2019 as compared to 2018 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 (McMahon et al., 2013a; 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 2019. The possibility of intra-molluscan competitive effects between liver fluke and rumen fluke larval stages has yet to be fully researched.

Liver fluke disease can occur in either acute or chronic forms. The acute form occurs in sheep in the autumn and early winter of those years when the climatic conditions from April to September have favoured the breeding and resulting population expansion of the intermediate host. Disease is caused by the migration of large numbers of immature flukes through the liver, frequently resulting in fatal haemorrhage (Figure 25.8).

Figure 25.8: Liver haemorrhage in acute fasciolosis. Photo: AFBI

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 25.9).

Figure 25.9: Adult liver flukes in the main bile duct of a sheep. Photo: AFBI

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

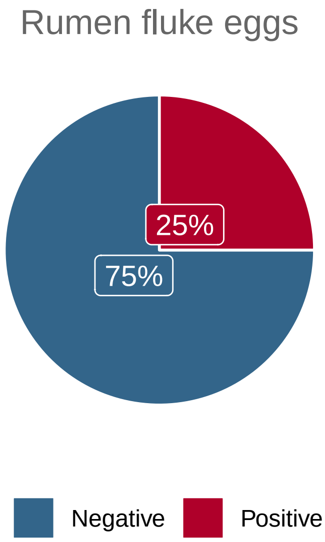

Figure 25.10: Relative frequency of detection of rumen fluke eggs in ovine faecal samples examined by AFBI in 2019 (n=677).

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 early spring is important to help reduce pasture contamination with fluke eggs, and this is particularly relevant if triclabendazole is no longer effective in controlling fasciolosis on the premises (Fairweather et al., 2020). Use of an anthelmintic with activity mainly against adult flukes (closantel, nitroxynil, albendazole, oxyclozanide) is likely to be appropriate in these circumstances. However the flukicide programme used has to be on a 'know-your-farm' basis and no one set of recommendations will cover all flocks or herds.

Adult rumen flukes are less damaging to sheep and cattle than liver flukes, but heavy infections of immature 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.

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26 Disease of Pigs, AFBI

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The pig industry in Northern Ireland is steadily increasing with a total of 674300 pigs on Northern Irish pig farms in June 2019, the highest since 1998. A small number of highly productive businesses make up a large proportion of the Northern Ireland pig industry. In the last census conducted in 2017 93 *per cent* of the total number of pigs were on farms with 1000 pigs or more. Whilst the majority of pig medicine is carried out by a few specialist pig veterinarians there are also a large number of pigs kept as backyard pigs farm pigs or even as pets and these animals may be seen by any veterinary practice.

Table 26.1: Conditions most frequently diagnosed in pigs submitted for exitpost mortem by AFBI in 2019 (n=114).

Category	No. of cases	Percentage
Respiratory diseases	23	**20.2**
Neurological diseases *	23	**20.2**
Others	18	**15.8**
Torsions	12	**10.5**
No diagnosis recorded	9	**7.9**
Cardiovascular diseases	9	**7.9**
Gastric ulceration	8	**7.0**
E.coli infections **	7	**6.1**
Salmonellosis	5	**4.4**

Note:
* Including Streptococcal infection;
** including oedema disease and colisepticaemia.

In 2019 AFBI laboratories carried out *post mortems* on 114 submissions (Table 26.1 and Figure 26.4). A submission could be for a single animal or a batch of up to 3 animals.

In previous years respiratory conditions have been the most frequently diagnosed conditions. In 2019 neurological conditions and respiratory conditions both accounted for approximately 20 *per cent* of submitted cases (Table 26.1 and Figure 26.4).

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

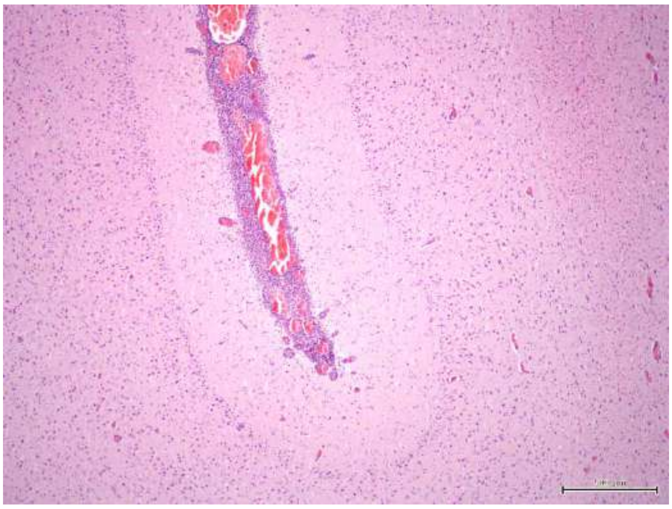

Figure 26.1: : Histology of a case of bacterial meningitis from which *Steptococcus suis* was isolated. The sulcus is filled with neutrophils, other mononuclear cells, cell debris, fibrin and oedema fluid. Photo: AFBI

Twelve cases of torsion of the abdominal organs were recorded by AFBI during 2019 (10.6 *per cent* of total submissions), mainly of the small intestines (Figure 26.1). Eight cases (7 *per cent* of total submissions) of gastric ulceration were recorded. Abdominal torsions and gastric ulceration are due to multifactorial causes but management factors including feed type and feeding frequency are thought to be implicated in both events (Gottardo et al., 2017; VukmiroviC et al., 2017).

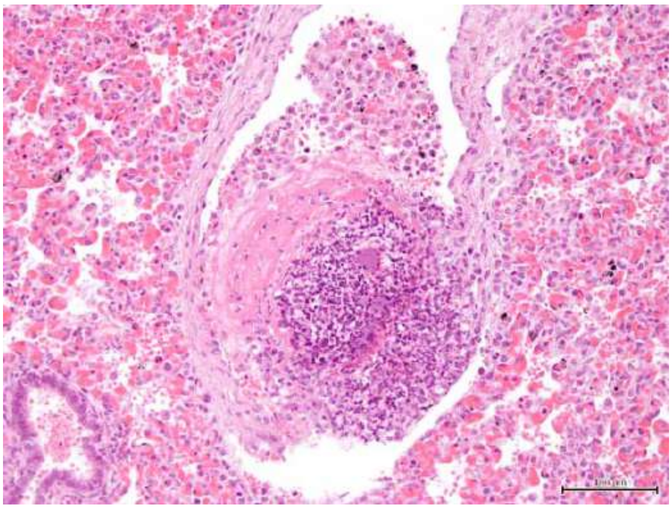

Figure 26.2: Bacterial embolus in a pulmonary blood vessel in a five-day-old piglet with Actinobacillus suis septicaemia. Photo: AFBI

Septicaemia due to *Actinobacillus suis* was diagnosed in four five-day-old piglets. The piglets presented weak at birth and faded by four to five days. On gross examination there were pronounced epicardial haemorrhages, purulent pericarditis, ecchymotic haemorrhages in lungs and thickened joint capsules and tendon sheaths. Histologically there was severe necrotising epicarditis, myocarditis, meningoencephalitis with abundant intralesional bacteria and there was severe septic pulmonary thromboembolism (Figure 26.2). *A. suis* was cultured in septicaemic distribution from all four piglets. *A. suis* is a bacterium which resides in the tonsils and upper respiratory tract.

Historically it has been associated with cases of septicaemia in very young piglets, suckling piglets and weaned piglets. Disease is observed when stresses such as weaning, transportation and parturition enable the bacteria to overcome the natural immune defence. *A. suis* is associated with a wide range of diseases including sudden death, septicaemia, arthritis, endocarditis, pneumonia, meningitis and skin lesions. Disease due to *A. suis* has been associated with high health status pigs of all ages.

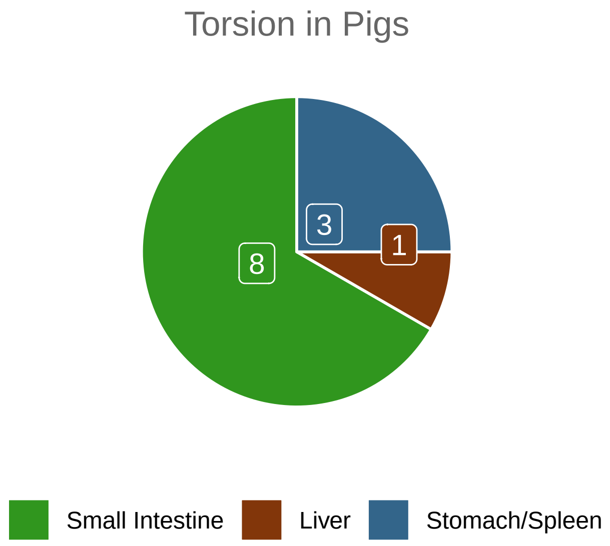

Figure 26.3: A breakdown of torsions in pigs diagnosed by AFBI in 2019

African Swine Fever. 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). For additional information, visit Agricultural Census in Northern Ireland 2019.

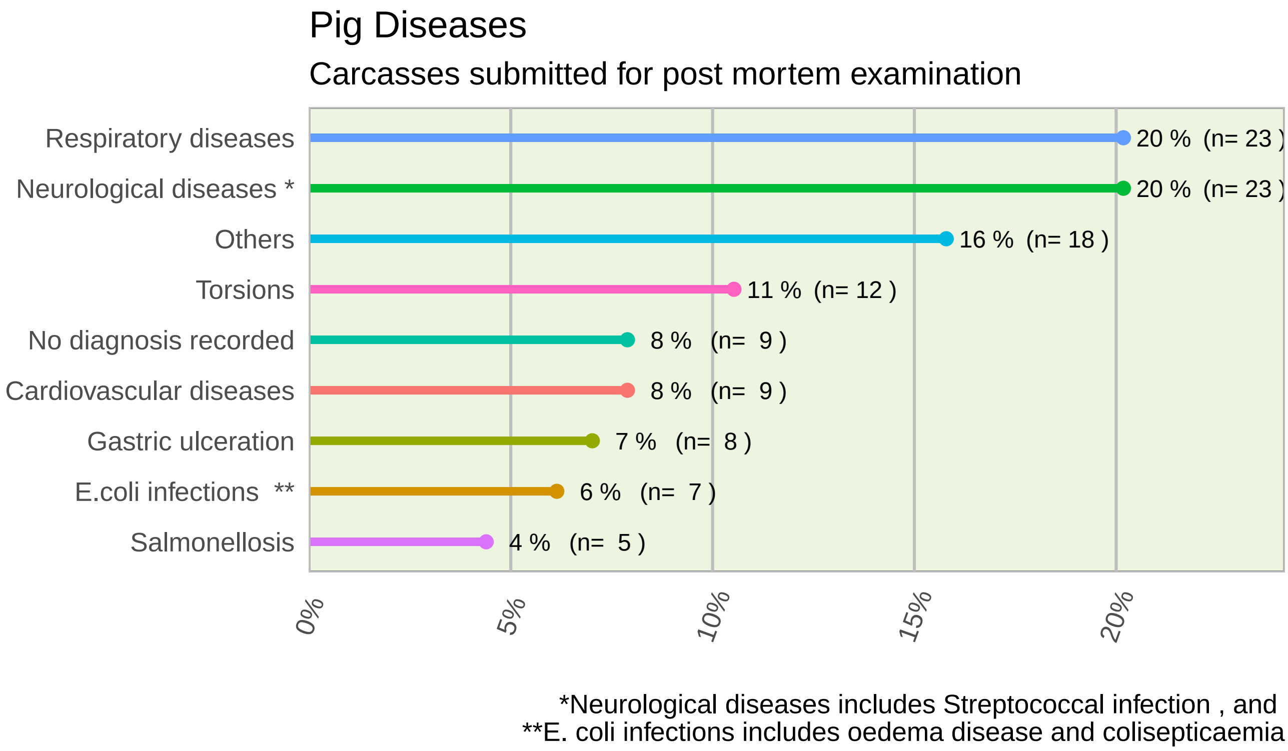

Figure 26.4: Conditions most frequently diagnosed in pigs submitted for *post mortem* by AFBI in 2019 (n= 114).

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R packages and LaTeX

27 R packages and LaTeX

The analysis, construction of graphics and visualisation of data from the Veterinary Laboratory Service, Animal Health Ireland and the Agri-Food & Biosciences Institute for this 2019 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, 2013), and the RStudio integrated development environment. An adaptation of the package MonashEBSTemplates of Rod Hyndman (Hyndman, 2018) has provided the template for this report.

Extensive use of the package bookdown (Xie, 2018a) and rmarkdow (Allaire et al., 2018) and LaTeX languages were utilised in this report for formatting and typesetting the final LaTeX bookdown document.

Most of the charts were plotted with the package *ggplot2* (Wickham et al., 2018a) and the tables constructed with *kableExtra* (Zhu, 2018) and *finalfit* (Harrison, Drake, and Ots, 2019).

Many other packages were also used in the preparation of this report, for further information refer to the references below.

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List of Tables