RETROSPECTIVE EVALUATION OF PULMONARY LESIONS IN CATS: PREVALENCE, GROSS, AND HISTOPATHOLOGICAL FINDINGS ENCOUNTERED FROM NECROPSY CASES AT PATHOLOGY LABORATORY, VETERINARY DIAGNOSTIC CENTRE (UVDC), UNIVERSITI MALAYSIA KELANTAN (UMK) FROM 2020 TO 2025

By

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ABSTRACT

Pneumonia is the infection of lungs which is less commonly reported in cats compared to feline upper respiratory tract disease (FURD), that possibly is underdiagnosed. Despite the advancement in diagnostic tools like radiography, pneumonia remains underdiagnosed sometimes due to the inapparent radiographic findings, and the other diagnostic tests are either showing less pulmonary specific result like hematology, or it is invasive to perform like biopsy. Thus, this retrospective study was conducted to determine the prevalence and types of feline necropsy cases and to characterize the common pulmonary lesions in cats submitted to the Pathology Laboratory, University Veterinary Diagnostic Centre (UVDC), Universiti Malaysia Kelantan (UMK) from 2020 to June 2025. A total of 52 feline necropsy cases were reviewed and categorized into Infectious, Non-infectious, Trauma (wound), Trauma (motor-vehicle/high-rise), and Others based on antemortem diagnosis. The Infectious category was the most prevalent (51.9%), followed by Trauma (motor-vehicle/high-rise) (15.4%) and Non-infectious (11.5%). Domestic Shorthair (DSH) cats represented most cases (76.9%), and male cats (65.4%) were more frequently affected. Kittens constituted the largest age group (46.2%), consistent with their increased susceptibility to infectious diseases. Grossly, pulmonary congestion (84.6%), pulmonary edema (76.9%), and pulmonary atelectasis (73.1%) were the most frequent lesions. Histopathologically, pulmonary atelectasis and emphysema were most common, followed by pulmonary edema (80.0%) and interstitial pneumonia (57.5%). Interstitial pneumonia was more prevalent than suppurative bronchopneumonia, and two cases of fungal pneumonia were also recorded. This study also highlighted that interstitial pneumonia may be underdiagnosed in felines and the importance of fungal pneumonia to be included in the differential diagnosis for every patient presented with respiratory distress.

Keywords: risk factors, prevalence, retrospective, pulmonary lesion, interstitial pneumonia, fungal pneumonia, Kelantan.

ABSTRAK

Pneumonia adalah jangkitan pada paru-paru yang boleh disebabkan oleh bakteria, kulat, virus dan/atau parasit. Ia kurang sering dilaporkan dalam kucing berbanding dengan penyakit saluran pernafasan atas kucing (FURD), yang mungkin ia tidak didiagnose. Walaupun kemajuan dalam alat diagnostik seperti radiografi, pneumonia tidak didiagnosis kadang-kadang disebabkan oleh penemuan radiografi yang tidak aktif, dan ujian diagnostik lain sama ada menunjukkan keputusan yang kurang spesifik terhadap sistem pernafasan seperti hematologi, atau ia adalah prosedur yang invasif untuk dilakukan seperti biopsi. Oleh itu, kajian retrospektif ini dijalankan bagi menentukan kelaziman kes bedah bangkai kucing serta mencirikan lesi pulmonari yang lazim ditemui dalam kucing yang dihantar ke Makmal Patologi, Pusat Diagnostik Veterinar Universiti (UVDC), Universiti Malaysia Kelantan (UMK) dari tahun 2020 hingga Jun 2025. Sebanyak 52 rekod bedah bangkai kucing dianalisis dan dikelaskan kepada kategori Berjangkit, Tidak Berjangkit, Trauma (luka), Trauma (kenderaan/terjatuh dari tempat tinggi) dan Lain-lain berdasarkan diagnosis antemortem. Penyakit berjangkit merupakan penyebab kematian utama (51.9%), diikuti trauma kenderaan/terjatuh dari tempat tinggi (15.4%) dan faktor tidak berjangkit (11.5%). Kucing Domestic Shorthair (DSH) mencatatkan peratusan tertinggi (76.9%), dengan majoriti adalah jantan (65.4%). Anak kucing merupakan kumpulan umur terbesar (46.2%), konsisten dengan kerentanan mereka terhadap penyakit berjangkit. Secara gross, kongesti pulmonari (84.6%), edema pulmonari (76.9%) dan atelektasis (73.1%) merupakan lesi yang paling kerap dikesan. Secara histopatologi, atelektasis dan emfisema pulmonari adalah paling lazim, manakala edema pulmonari (80.0%) dan pneumonia interstisial (57.5%) merupakan lesi radang yang utama. Pneumonia interstisial dicatatkan lebih tinggi berbanding bronkopneumonia supuratif dan terdapat dua kes pneumonia kulat turut direkodkan. Dapatan ini menunjukkan bahawa pneumonia interstisial berkemungkinan kurang didiagnosis dalam kucing dan menekankan kepentingan memasukkan pneumonia kulat sebagai diagnosis pembezaan bagi setiap pesakit yang hadir dengan tanda gangguan pernafasan.

Kata kunci: faktor risiko, prevalens, kajian retrospektif, lesi pulmonari, pneumonia interstisial, pneumonia kulat, Kelantan.

CERTIFICATION

This is to certify that we have read this research paper entitled **'Retrospective Evaluation of Pulmonary Lesions in Cats: Prevalence, Gross, and Histopathological Findings Encountered from Necropsy Cases at Pathology Laboratory, Veterinary Diagnostic Centre (UVDC), Universiti Malaysia Kelantan (UMK) (2020-2025)'** by Ng Hooi Ean, an in our opinion, it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirements for the course DVT 55204 – Research Project.

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LIST OF ABBREVIATIONS

UVDC	Veterinary Diagnostic Centre
UMK	Universiti Malaysia Kelantan
FPV	Faculty of Veterinary Medicine
LRTI	Lower respiratory tract infection
BAL	Bronchoalveolar lavage
FNA	Fine needle aspiration
CPAM	Congenital pulmonary airway malformation
COPD	Chronic pulmonary obstructive disease
SBP	Suppurative bronchopneumonia
FHV-1	Feline herpesvirus
FBP	Fibrinous bronchopneumonia
IP	Interstitial pneumonia
EP	Embolic pneumonia
GP	Granulomatous pneumonia
FCV	Feline calicivirus
FIV	Feline immunodeficiency virus
FeLV	Feline leukemia virus
FIP	Feline infectious peritonitis
SSR	Sample submission form
HPVUMK	Hospital Pengajaran Veterinar, UMK
FURD	Feline upper respiratory tract disease
MV/HR	Motor-vehicle/high-rise

LIST OF SYMBOLS

%	Percentage
=	Equal to
>	Greater than
X	Magnification
P	Level of significant

CHAPTER 1

1.0 INTRODUCTION

1.1 INTRODUCTION

The lungs are vital component of the respiratory system, responsible for removing carbon dioxide from blood and replenishing oxygen (Singh, 2017). The lungs are anatomically divided into lobes according to branching pattern of primary bronchi. In cat, the right lung is subdivided into four lobes: cranial, middle, caudal and accessory, while the left lung has two lobes: cranial lobes (with cranial and caudal subdivisions) and caudal lobe. The lung is covered by visceral pleura, a mesothelial layer, while the parietal pleura lines the thoracic cavity and diaphragm, the space between these pleural layers is known as pleural cavity (McDonough & Southard, 2016). Grossly, the lung appears salmon-pink, dull and spongy upon palpation (Caswell, 2024). Histologically, the pleura is composed of single layer of simple squamous mesothelial cell overlying a thin connective tissue layer. Bronchi are lined by respiratory epithelium, propria-submucosa (containing glands and cartilages), muscularis and adventitia; in contrast, terminal bronchiole is lined by simple columnar or cuboidal epithelium, propria-submucosa lacking gland and cartilage, a thin layer of smooth muscle and adventitia (Eurell & Frappier, 2004). There are 2 types of pneumocyte which is type I (thin squamous epithelial cell) and type II (simple cuboidal cells) which line on a thin basement membrane adjacent to alveolar capillaries, forming blood gas barrier (Zachary, 2017).

Pulmonary injury and lesions can arise from both infectious and non-infectious causes, either as a primary condition or secondary to dysfunction in other organ systems. For example, a secondary, non-infectious cause of pulmonary lesion is cardiogenic pulmonary oedema, which is subjectively considered the most common cause of

pulmonary infiltrates in cat (Sauvé *et al*., 2005). Additionally, traumatic injuries, such as those from motor vehicle accidents, are among the leading reasons for emergency feline presentations (Mansbridge *et al*., 2024). Pulmonary lesion can be categorized into several groups including congenital anomalies, metabolic disturbances, inflation disturbances, circulatory disturbances, neoplasia and inflammatory condition (pneumonia). The common primary pulmonary lesion observed in feline necropsy cases are cranioventral consolidation as in bacterial pneumonia, whereas pulmonary lesion induced by motor-vehicle accidents is pulmonary contusions and ruptures (Stoian *et al*., 2022). Cardiogenic and diabetes mellitus, a systemic disease, will affect the lung subsequently and cause pulmonary congestion, haemorrhage and oedema.

Pneumonia is defined as an infection of the lungs affecting the alveolar epithelial lining and is potentially fatal when it is acute and fulminant, while chronic, low-grade pneumonia in cat may present non-specific clinical signs (Dear *et al*., 2024). Infectious agents vary from bacteria (*Mycoplasma felis, Bordetella bronchiseptica and Escherichia coli*), viruses (feline calicivirus and feline herpesvirus), and fungi (*Aspergillus* spp.). In fact, pneumonia in cats is less commonly reported compared to feline upper respiratory tract disease (FURD), like bacterial pneumonia in cats, which is overlooked due to similar clinical presentation and diagnostic findings as feline bronchial disease (Dear *et al.*, 2020; Slaviero *et al*., 2021). Classification of pneumonia in human medicine is not applicable in veterinary medicine. In veterinary medicine, pneumonia is classified morphologically into suppurative and fibrinous bronchopneumonia, interstitial pneumonia, embolic pneumonia, and granulomatous pneumonia, which have different gross and microscopic pulmonary lesions (Zachary, 2017).

Common clinical presentations of cat with respiratory issues include coughing, serous to mucopurulent nasal discharge, dyspnoea, tachypnoea, increased tracheal

hypersensitivity and/or systemic signs like lethargy and fever which may be observed during physical examination. However, they might not have shown these symptoms but suffer from lower respiratory issues as in a retrospective study by Macdonald *et al*. (2003), 36% of cats did not show any clinical signs related to respiratory system while about 41% of patients have no systemic manifestation. Sometimes, sudden death can be the only clinical manifestation in cat with lower respiratory tract infection (LRTI). It is also important to note that clinical signs are manifested when pathological changes and pulmonary lesions are overt.

The common diagnostic tests used in clinical setting are complete blood count and serum biochemistry, radiography, bronchoalveolar lavage (BAL), and to a lesser extent lung fine needle aspiration (FNA). Samples are taken accordingly and checked under cytology, microbiology, histopathology and parasitology. Complete blood count is often offering a little help in diagnosing pneumonia, as the most common hematologic abnormalities shown will be leukocytosis and the study by Macdonald *et al.* (2003), surprisingly, there are 4/18 cats suffering from deadly disease, despite the leukocyte counts are within normal reference range. There is no parameter specific to the respiratory system in serum biochemistry, which limitedly contributes to the diagnosis of pneumonia, and although different types of pneumonia may present with various radiographic changes and patterns, there are reported cases of cryptococcal LRTI that do not show radiographic abnormalities (Foster & Martin, 2011). Despite thoracic radiography remains an important tool in diagnosing lower airway and lung parenchymal disease (Dear *et al*., 2020). Bronchoalveolar lavage (BAL) is a gold standard for lower airway sampling via bronchoscopy; however, due to financial constraints of the client and availability of equipment, it is not always possible to carry out. Fine needle aspiration (FNA) bears a higher risk compared to BAL, but this procedure is easy to perform with the guidance of

ultrasound and there is no clinical complication reported in the study of DeBerry *et al*. (2002).

Common treatment of infectious lung diseases includes antibiotics (doxycycline, amoxicillin-clavulanic acid, enrofloxacin, clindamycin), which can be given in monotherapy or dual therapy but should ideally be guided by culture and sensitivity testing, anthelmintics (ivermectin and moxidectin) and antifungal (itraconazole) (Traversa & Di Cesare, 2016). According to Church (2004), management of non-infectious causes of primary respiratory disease is done with bronchodilators (terbutaline sulphate, theophylline), antitussives (dextromethorphan hydrobromide, codeine phosphate) and mucolytics (bromhexine hydrochloride, acetylcysteine), either alone or in combination as needed. While oral prednisolone and dexamethasone are effective in managing asthma and chronic bronchitis, they are not used in treating infectious respiratory diseases as they suppress the immune system, non-steroidal anti-inflammatories may be considered (Reinero, 2019).

Feline pulmonary lesions encompass a wide spectrum of infectious and non-infectious conditions, despite advancements in diagnostic techniques such as radiography, BAL, and cytology, early detection persists as challenges due to nonspecific clinical signs and the limitations in routine tests like complete blood count and serum biochemistry. Treatment strategies vary based on aetiology, emphasizing the need for targeted antimicrobial therapy for infectious causes and bronchodilators, corticosteroids, etc., for non-infectious conditions. However, there are gaps remain in understanding the prevalence, pathological patterns and clinicopathological correlations of pulmonary lesions in cats, particularly in the underrepresented population.

1.2 PROBLEM STATEMENT

Pulmonary lesions in cats present significant diagnostic and therapeutic challenges due to diverse aetiologies and variable clinical manifestations. For example, pneumonia is less commonly diagnosed in cats, unlike FURD, with the highly variable clinical signs, pneumonia tends to be underdiagnosed, and sudden death in cats with LRTI may be the only manifestation. There remains a scarcity of detailed studies, particularly in Southeast Asia, specifically Malaysia, that systematically document their prevalence, pathological features and regional trends. Other current knowledge gaps include inadequate retrospective studies in which comprehensive analyses of pathology lab case records are lacking which could otherwise reveal emerging trends in lesion patterns and uncharacterized conditions in which both common and rare pulmonary diseases in cats remain understudied, then limiting the ability to correlate pathological findings with clinical outcomes. Therefore, this study is needed as it highlights the critical role of gross and histopathological analysis and is used to characterize the nature and extent of pulmonary lesions, ultimately providing veterinarians with evidence-based insights to refine their diagnostic approaches and therapeutic decision-making, ensuring better management of feline respiratory diseases in clinical practice.

1.3 RESEARCH QUESTIONS

I. What is the common prevalence category of feline necropsy cases encountered in the Pathology Laboratory, UVDC, UMK from 2020 to June 2025?

II. What are the common pulmonary lesions observed in feline necropsy cases encountered in the Pathology Laboratory, UVDC, UMK from 2020 to June 2025?

1.4 RESEARCH OBJECTIVES

I. To determine the common prevalence category of feline necropsy cases encountered in the Pathology Laboratory, UVDC, UMK from 2020 to June 2025.

II. To identify the common pulmonary lesions observed in feline necropsy cases encountered in the Pathology Laboratory, UVDC, UMK from 2020 to June 2025.

1.5 RESEARCH HYPOTHESIS

I. The common prevalence feline necropsy category encountered in the Pathology Laboratory, UVDC, UMK from 2020 to June 2025 is the infectious category.

II. The common pulmonary lesion observed in feline necropsy cases in the Pathology Laboratory, UVDC, UMK from 2020 to June 2025 is suppurative bronchopneumonia, pulmonary emphysema, pulmonary congestion and pulmonary consolidation.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 PULMONARY LESION AND PNEUMONIA IN CATS

There are a variety of pulmonary lesions that happen in cats and are grouped into congenital anomalies, metabolic disturbances, inflation disturbances, circulatory disturbances, and neoplasia and inflammation. Congenital anomalies of lower respiratory tract are rare in cat (Chong *et al*., 2024; Nebel *et al*., 2024). One of the lesions is cystic pulmonary lesions consistent with congenital pulmonary airway malformation (CPAM) which histopathologically characterized by randomly distributed, well demarcated cysts like structure of size in lung parenchyma (Chong *et al*., 2024). Another is developmental lung disease with individual alveolar diameter is equal or larger than that of adjacent terminal bronchioles, as well as the bronchioles and bronchi have prominent smooth muscle bundle; (Nebel *et al*., 2024). The next pulmonary lesion in cats is pulmonary calcification which can be classified as dystrophic and metabolic. It can be seen secondary to necrotized area of lung in cat; affected lung fails to collapse and have "gritty" texture, its histopathological lesion ranges from calcified alveolar basement membrane to heterotopic ossification. Other than that, pulmonary emphysema, which is defined as an abnormal permanent enlargement of airspaces distal to terminal bronchioles with destruction of alveolar walls. Pulmonary emphysema can happen in end-stage asthma conditions, chronic pulmonary obstructive disease (COPD) and other situations (Mcmichael, 2024). While pulmonary atelectasis that are classified into congenital and acquired can be seen in cats who have accidentally aspirated amniotic fluid and have space occupying mass in the pleural cavity or air passages, respectively. Circulatory disturbances

of lungs include pulmonary lesion like hyperaemia, congestion, haemorrhage, oedema, embolism and infarcts. From the study of Aarsvold *et al*. (2015), primary pulmonary neoplasia in feline species is not common in cats, and among all the reported case, adenocarcinoma occupies more than 50%. Secondary or metastatic tumour are generally diagnosed more often than primary pulmonary tumour. Lastly, one of the main pulmonary lesions, pneumonia. Apparently, pneumonia is less often reported compared to FURD, it is more commonly seen in kittens due to infection or perhaps in adults who suffering from immunosuppressive conditions (Slaviero *et al*., 2021).

2.2 CLASSIFICATION OF PNEUMONIA

There are scarce resources published to specifically classify pneumonia in feline patients. Based on Zachary (2017), a universal classification of pneumonia is developed relying on morphological changes of the lung in which texture, distribution, appearance and exudation are the 4 main characteristics. Thus, pneumonia is classified into 4 morphologically distinct types, which are bronchopneumonia, interstitial pneumonia, embolic pneumonia and granulomatous pneumonia. Bronchopneumonia is then further divided into suppurative and fibrinous pneumonia, depending on the type of inflammatory exudate. The types of pneumonia may overlap, with at least 2 types can happen simultaneously in a cat. For example, a study by Slaviero *et al*. (2021), bronchointerstitial pneumonia occurs in cats with feline herpesvirus 1 (FHV-1).

2.1.1 Suppurative Bronchopneumonia (SBP)

Suppurative bronchopneumonia, also known as lobular bronchopneumonia, is characterized by grossly multifocal, cranioventral consolidation of the lung; it may

spread irregularly to other lobes (Slaviero *et al*., 2021). In acute suppurative bronchopneumonia, there is presence of purulent exudate in bronchi and the red hepatization while in chronic or advanced cases, inflammatory exudation has found in bronchi, bronchioles, alveoli, and the presence of exudates lead to distension of bronchi, and bronchiole, resulting in bronchiectasis, as well as grey hepatization and microscopically; histopathologically, numerous neutrophils, macrophages, fibrin and cellular debris present in the pulmonary parenchyma and occasionally aggregates of bacteria may be found (Zachary, 2017, Bolt *et al*., 2024).

2.1.2 Fibrinous Bronchopneumonia (FBP)

Lobar pneumonia or pleuropneumonia has same pattern of consolidation as suppurative bronchopneumonia, but it appears harder and rubbery during palpation. The lungs are intensely dark red due to severe congestion and haemorrhage, and the pleural surface has ground glass appearance due to deposition of fibrin. Fibrin originates from fibrinogen which leaks into interstitial space due to increased permeability of blood vessels which cause presence of yellowish or serosanguineous fluid in thoracic cage. Adhesion of lungs to structures like diaphragm, pericardium, parietal pleura by plaque of fibrin is also evident in chronic cases, and degree of adhesion is dependent on severity of disease (Zachary, 2017). The interlobular septa are markedly thickened due to massive exudation and inflammatory cell infiltration. Histopathologically, fibrinous to fibrinonecrotic pleuropneumonia can be seen at the adhesion site, other than that, neutrophils, macrophages, fibrin and microthrombi may present in the alveolar with the alveolar septa being thickened (Balboni *et al*., 2014).

2.1.3 Interstitial pneumonia (IP)

Interstitial pneumonia is usually caused by damage that totally compromises the lung parenchyma with little tissue left normal. The general appearance of lung includes failure of collapse, wet, heavy and meaty diffusely, and/or presence of rib imprints; upon palpation the lung is elastic (Carvallo & Stevenson, 2022). The microscopic lesion seen follow the stage of disease progress, during acute exudative phase, hyaline membranes are observed at the alveolar basement membrane and bronchiolar wall and thickening of alveolar septa caused by inflammatory oedema and neutrophils happens. In acute proliferative phase, type II pneumocytes undergo hyperplasia, which further leads to thickening of alveolar septa. In chronic stage, alveolar wall undergoes fibrosis and lymphocytes, macrophages, fibroblasts and myofibroblast will be seen in the alveolar interstitium, sometimes squamous metaplasia of alveolar epithelium and smooth muscle hyperplasia in bronchioles and pulmonary arterioles might be seen (Zachary, 2017). Interstitial pneumonia is usually caused by viral agents, with intranuclear or intracytoplasmic inclusion bodies might be identified during microscopic examination (Slaviero *et al*., 2024).

2.1.4 Embolic pneumonia (EP)

Embolic pneumonia has multifocal, to coalescent multiple nodular lesions in the lung parenchyma. In early stages, the nodule might be very small and appear white surrounded by discrete haemorrhagic halo which will progress into pulmonary abscess later (Zachary, 2017). Histopathologically, the larvae and eggs might be seen inside the alveoli and cause granulomatous reaction and the worm which is space occupying results in pulmonary emphysema (Pennisi *et al*., 2015).

2.1.5 Granulomatous pneumonia (GP)

Granulomatous pneumonia has the same pattern of lesion distribution as embolic pneumonia too, but the nodule can be either caseous or non-caseous granuloma which is well circumscribed, and it is firm particularly when calcification happens. Microscopically, the predominant inflammatory cells are macrophages, giant cells and lymphocytes (Zachary, 2017).

2.2 PREDISPOSING FACTORS ASSOCIATED WITH LUNG INJURIES IN CATS

Previous literature has described that pneumonia can happen at any age in cats (Akçakavak *et al*., 2024). In the study of Slaviero et al. (2021), of the 78 cats that died due to pneumonia, 17.9% kittens, 24.4% juniors, 17.9% matures, 16.7% primes, 10.3% seniors and 6.4% geriatrics. However, young age increases the risk for feline pulmonary disease (Foster *et al*., 2004; Rodriguez *et al*., 2018). Besides, male cats are at higher rate of having LRTI compared to female and no breed predilection reported for LRTI in cats (Foster *et al*., 2004; Foster & Martin, 2011; Akçakavak *et al*., 2024). Pneumonia can be secondary to factors that result in systemic immunosuppression like FIV, FeLV and chemotherapy or corticosteroid therapy (Slaviero *et al*., 2021).

2.3 ETIOLOGICAL AGENT ASSOCIATED WITH LUNG INJURIES IN CATS

Etiological agents that lead to lung injuries in cats can be classified into several groups, which include bacterial, viral, fungal, verminous, and environmental causes. Viral agents reported to cause pneumonia in cats are feline calicivirus (FCV) and FHV-1

(Rodriguez *et al*., 2018; Slaviero *et al*., 2021). Other than these primary agents, feline immunodeficiency virus (FIV) and feline leukaemia virus (FeLV) are known to cause immunosuppressive conditions and lead to secondary pneumonia (Slaviero *et al*., 2021; De Mello *et al*., 2023). Feline infectious pneumonia (FIP) is reported to cause secondary pneumonia too (De Mello *et al*., 2023; Murphy *et al*., 2024). A variety of bacteria species can cause pneumonia, including *Mycoplasma felis*, *Bordetella bronchiseptica, Streptococcus* spp., extraintestinal pathogenic *E.coli*, *Pasteurella* spp., *Salmonella* spp., *Mycobacterium* spp., *Staphylococcus* spp., *Arcanobacterium pyogenes*, *Pseudomonas aerogunosa*, and *Klebsiella pneumoniae* (Bart *et al*., 2000; Foster *et al*., 2004). Foster & Martin (2011) stated that verminous pneumonias are known to be caused by *Aelurostrongylus abstrusus*, *Toxoplama gondii*, *Eucoleus aerophilius*, *Paragonimus* spp., *Cytauzoon felis* and *Dirofilaria immitis*. *Cryptococcus* spp. and *Sporothrix schenckii* are reported to cause mycotic pneumonia worldwide while *Aspergillus* spp., *Mucor* spp., and *Candida* spp. are ubiquitous, causing opportunistic infection meanwhile aspiration pneumonia is reported due to inadvertent inhalation of foreign material, with the potential causes including neurological disease, iatrogenic cause, forced feeding, oesophageal disease, gastrointestinal disease and decubitus vomiting (Bart *et al*., 2000; Dear *et al*., 2020).

2.4 GROSS AND HISTOPATHOLOGICAL LESIONS OBSERVED IN CAT PRESENTED WITH RESPIRATORY CONDITIONS

Bacterial pneumonia remains a leading infectious cause, presents grossly with cranioventral consolidation, while microscopically, abundant neutrophilic infiltration at the bronchoalveolar junction and will extend to adjacent bronchi and alveoli (Slaviero *et*

al., 2021). Pulmonary lesions can also be caused by vehicle-animal collisions, with main gross lesions including pulmonary rupture, contusion and herniation of lung lobes may be observed (Stoian *et al*., 2022). Next, cat with diabetes mellitus concurrent with heart failure have presence of free fluid in thoracic cavities with the lung containing air indicated by floating in the formalin, microscopically, pulmonary oedema, congestion and haemorrhage (Dobromylskyj & Little, 2021).

CHAPTER 3

3.0 METHODOLOGY

3.1 STUDY AREA

This research was conducted in the Postmortem and Histopathology Laboratory of Veterinary Diagnostic Centre (UVDC), UMK. The case records, including history, gross pathological findings, tentative diagnosis and other related information were obtained from the laboratory usage logbook, while analysis of case and histopathology slide observations were conducted in the histopathology laboratory. Histopathology slides of selected missing cases were obtained by re-sectioning preserved tissue samples by histopathology lab technician in the histopathology lab.

3.2 STUDY DESIGN

This research followed a retrospective cohort design, analysing necropsy records from the Postmortem and Histopathology Laboratories at UVDC, UMK. Cases or samples were collected from 2020 to June 2025.

3.3 STUDY POPULATION

The study population in this research comprised all feline necropsy cases that had been carried out in the Postmortem Laboratory, UVDC, UMK, from 2020 to June 2025.

3.4 SELECTION CRITERIA

I. INCLUSION CRITERIA

All the feline necropsy cases that had been carried out in the Postmortem Laboratory, UVDC, UMK, from 2020 to June 2025 were selected.

II. XCLUSION CRITERIA

Non-feline necropsy cases and cases that were outside the specified timeframe are excluded.

3.5 SAMPLING METHOD AND PROCEDURE

A Convenient sampling method was used as the study population consisted of all available feline necropsy cases from 2020 to June 2025 at UVDC, UMK, which meant the population was inherently limited to submitted cases only. Data like laboratory reference number, clinical history, patient signalment, management, given treatment, tentative diagnosis and postmortem findings were collected from the postmortem laboratory usage logbook, as well as the total number of necropsy cases per year. The sample submission form was also screened for postmortem findings; tentative diagnosis and the data were recorded.

The next step was collecting histopathology specimens from the Histopathology Laboratory. The slides in the collection cabinet from 2020 to June 2025 were screened to obtain desired slides for the research. Missing slides of selected samples had been informed to the laboratory technician so that re-sectioning of the remaining tissue block was done.

Re-sectioning of the tissue block was done by using a microtome, the tissue block was placed on an ice plate to prevent tissue twitching or artifacts. Once it has been chilled, the block was carefully sectioned with a blade to remove any ice droplets. The embedded

tissue was then carefully placed onto the microtome stage and sectioned using rotary microtome (Leica RM2245, Germany). A tissue sample of 2.5 to 3 µm thickness was sliced and transferred to warm water bath (40 ℃) to be floated so that it would flatten and stretch, resulting in a histopathology specimen that was uniformly thick. The floated tissue slide was fished by a clean glass slide and left to dry.

All the histopathological specimens were observed under a ZEISS digital microscope and scanned by using a Panoramic MIDI II scanner to retrieve high-quality image.

3.6 DATA COLLECTION TOOLS

Primary data was retrieved through a comprehensive review of available records and physical files in the UVDC, UMK, which includes the postmortem laboratory logbook, sample submission form (SSR), and histopathological specimens kept in postmortem and histopathological laboratories. The records are carefully screened to avoid missing information and the extracted information was collected and kept in a created data sheet for organization and easier identification. All the data remained confidential and the records of UVDC, UMK were returned in their original state after review.

3.7 DATA ANALYSIS

The collected data were categorized according to antemortem diagnosis, sex, age and breeds, and summarized in a table, then a chart was constructed by using data sheets

so that the relationships of each category with the pulmonary lesion can be illustrated clearly. The prevalence was calculated according to each category.

According to Platt & Olby (2013), samples were classified into degenerative, anomalous, metabolic, miscellaneous, neoplastic, infectious, inflammatory, immune-mediated, toxic, traumatic, or vascular disease based on the antemortem findings. In this research, they were categorized into infectious, non-infectious, trauma and others. All suspected cases of bacterial, viral, or parasitic infection were grouped into the 'infectious' category, regardless of the body system being affected. Meanwhile 'non-infectious' category included cardiovascular problems, anomaly, diabetes mellitus, endocrine, chronic kidney disease and other non-infectious conditions. 'Trauma' category generally referred to cases with break in skin and bone continuity and was subdivided into 'trauma (wound)' for bite wound, maggot-infected wound and other traumatic wounds that was at high risk of developing infection, as well as 'trauma (motor-vehicle/high-rise)' which included vehicle-animal collision and falling from a height. 'Other' category included those sudden death, unclear antemortem diagnosis, and other causes.

Samples were categorized into 4 groups of feline life stages, including kitten (birth up to 1 year), young adult (1-6 years old), mature adult (7-10 years old) and senior (more than 10 years old) (Quimby *et al*., 2021). The samples were also categorized according to breed, which includes domestic shorthair (DSH), domestic longhair (DLH), British Shorthair (BSH) and others.

The prevalent category of feline necropsy cases encountered in the Postmortem Laboratory, UVDC, UMK was calculated by using the number of feline necropsy cases divided by total number of necropsy cases over the same period. The formula used was:

$$Prevalence = \frac{The\ number\ of\ feline\ necropsy\ cases\ over\ a\ period\ of\ time}{Total\ number\ of\ necropsy\ cases\ over\ the\ same\ period\ of\ time}\ x\ 100\%$$

(Tenny & Hoffman, 2023)

The common pulmonary lesions presented in feline necropsy cases were listed down and the prevalence of each pulmonary lesion was calculated and constructed into a table and chart.

The data was then entered into the SPSS system, where Fisher's Exact test was used to determine the association between some histopathological lesions and 3 case categories which were infectious, non-infectious and trauma (motor-vehicle/high-rise). The findings were then presented in a table.

CHAPTER 4

4.0 RESULT

4.1 YEARLY DISTRIBUTION OF NECROPSY CASES AND FELINE NECROPSY CASES IN UVDC, UMK

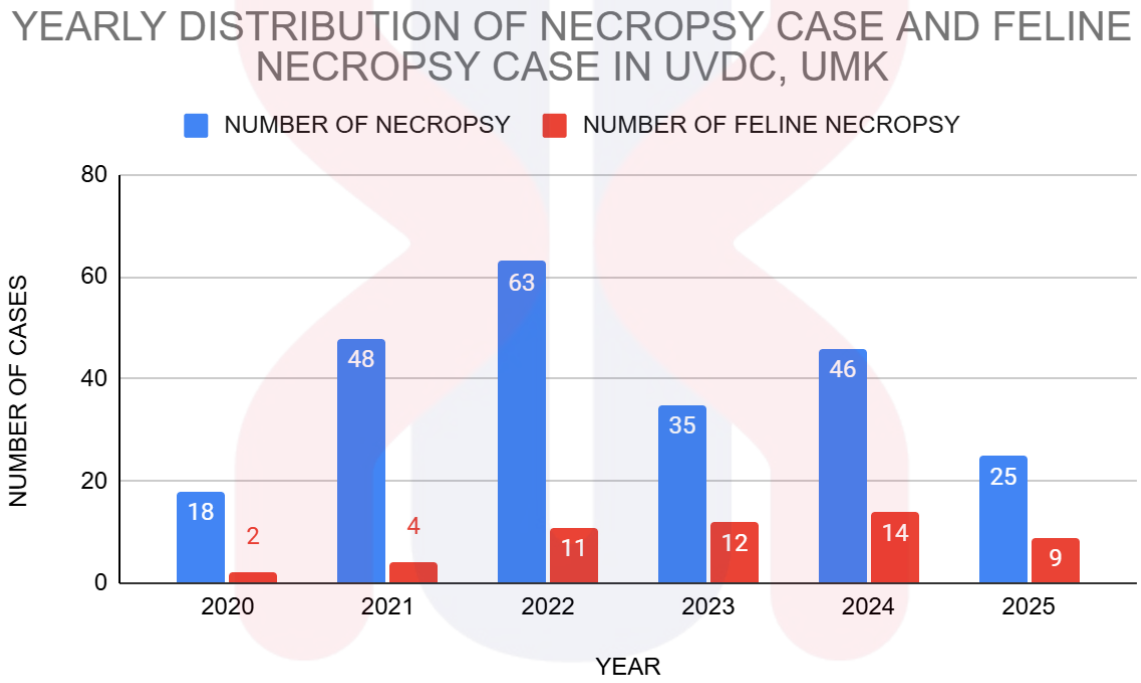

Figure 4.1: Total number of necropsy and feline necropsy cases in UVDC, UMK from 2020 to 2025

Figure 4.1 illustrates the yearly distribution of total necropsy cases and feline necropsy cases recorded at UVDC, UMK from 2020 to 2025. The blue color bar depicts the total necropsy cases encountered which include goat, cattle, horses, cats, chicken and others. Overall, the number of necropsy cases varied throughout the five years, with the highest number recorded in 2022 (63 cases), followed by 2021 (48 cases) and 2024 (46 cases). For feline necropsy cases, the numbers also showed an increasing trend, peaking in 2024 (14 cases), followed by 2023 (12 cases) and 2022 (11 cases). The lowest counts were recorded in 2020, with only 2 feline necropsy cases.

4.2 YEARLY DISTRIBUTION OF PULMONARY NECROPSY CASES IN UVDC, UMK

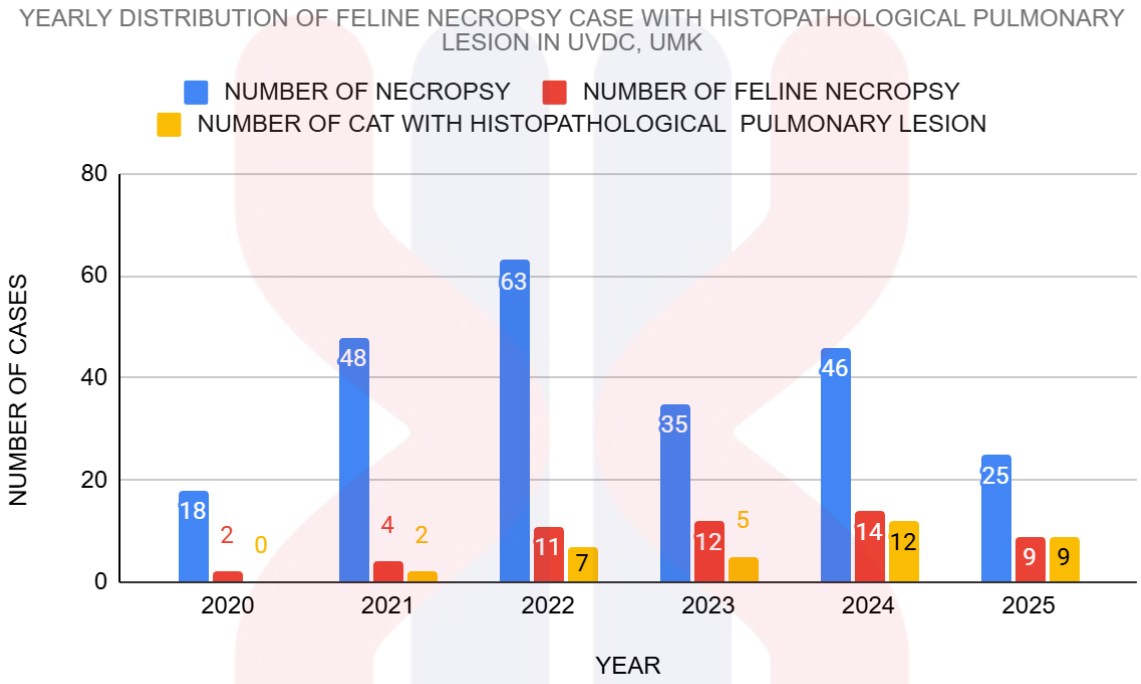

Figure 4.2: Total number of necropsy, feline necropsy cases and feline necropsy case with histopathological pulmonary lesion in UVDC, UMK from 2020 to 2025.

Figure 4.2 shows the yearly distribution of feline necropsy cases, feline necropsy case and feline necropsy cases with histopathological pulmonary lesions submitted to UVDC, UMK from 2020 to 2025. Overall, the total number of feline necropsy cases fluctuated over the years, with a noticeable increase from 2020 to 2022, peaking in 2022 (63 cases). This was followed by a decline in 2023, a slight increase in 2024, and a reduction again in 2025. The number of feline necropsy cases with histopathological pulmonary lesions demonstrated an overall increasing trend, particularly from 2021 onwards. No pulmonary lesions were recorded in 2020, while the highest numbers were observed in 2024 and 2025 (9 cases each).

4.3 CATEGORICAL DISTRIBUTION AND PREVALENCE OF FELINE NECROPSY CASE ENCOUNTERED IN UVDC, UMK

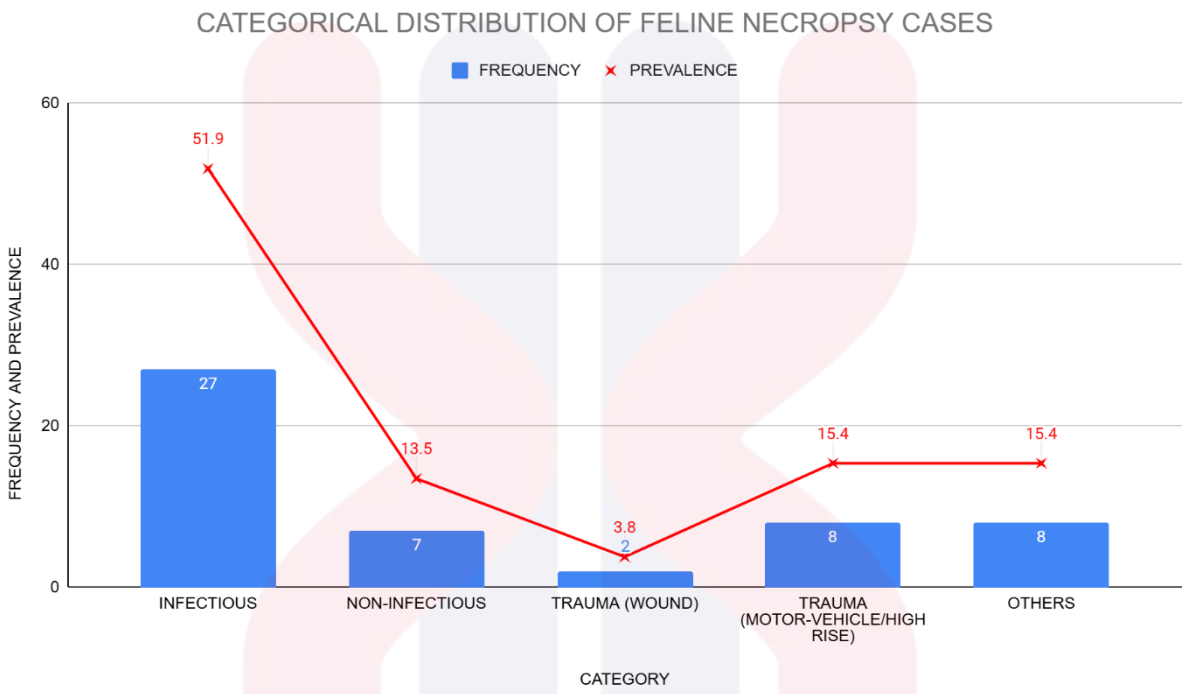

Figure 4.3: Categorical distribution and prevalence of feline necropsy cases in UVDC, UMK

Figure 4.3 illustrates the categorical distribution and prevalence of feline necropsy cases in UVDC, UMK. The data show that infectious diseases were the most common cause, accounting for 27 cases (51.9%), making it the predominant category among all necropsy findings. The next most frequent categories were non-infectious causes and others, both representing 8 cases (15.4%) each. Meanwhile, trauma-related cases were less frequent, with motor-vehicle injuries accounting for 7 cases (13.5%) and wound-related trauma contributing only 2 cases (3.8%).

4.4 AGE GROUP DISTRIBUTION AND PREVALENCE OF FELINE NECROPSY CASE IN UVDC, UMK

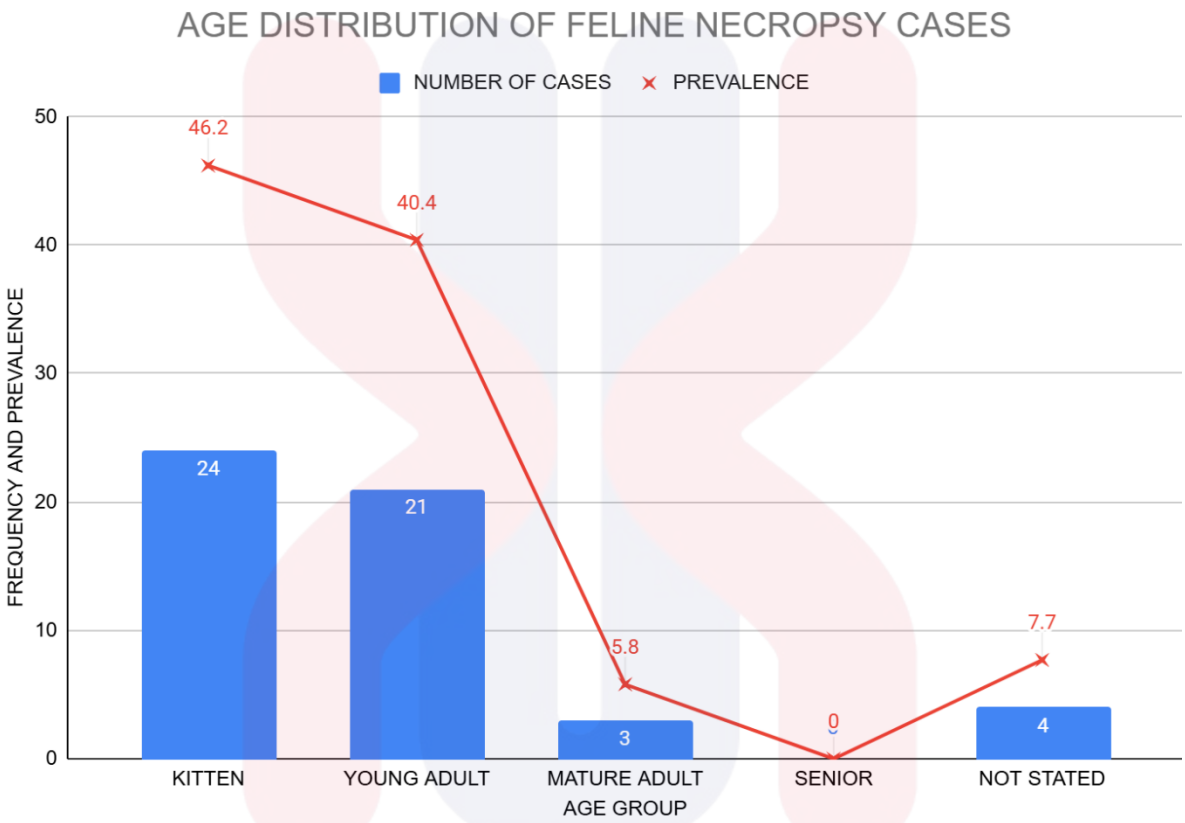

Figure 4.4: Categorical distribution and prevalence of feline necropsy cases in UVDC, UMK

Figure 4.4 presents the age distribution and prevalence of feline necropsy cases in UVDC, UMK. The data show that kittens represented the highest proportion of cases, with 24 cases (46.2%), followed by young adults with 21 cases (40.4%). The third most common group was the mature adults, comprising 3 cases (5.8%), while senior cats recorded no cases. Additionally, 4 cases (7.7%) were categorized as not stated due to incomplete age data.

4.5 BREED DISTRIBUTION AND PREVALENCE OF FELINE NECROPSY CASE IN UVDC, UMK

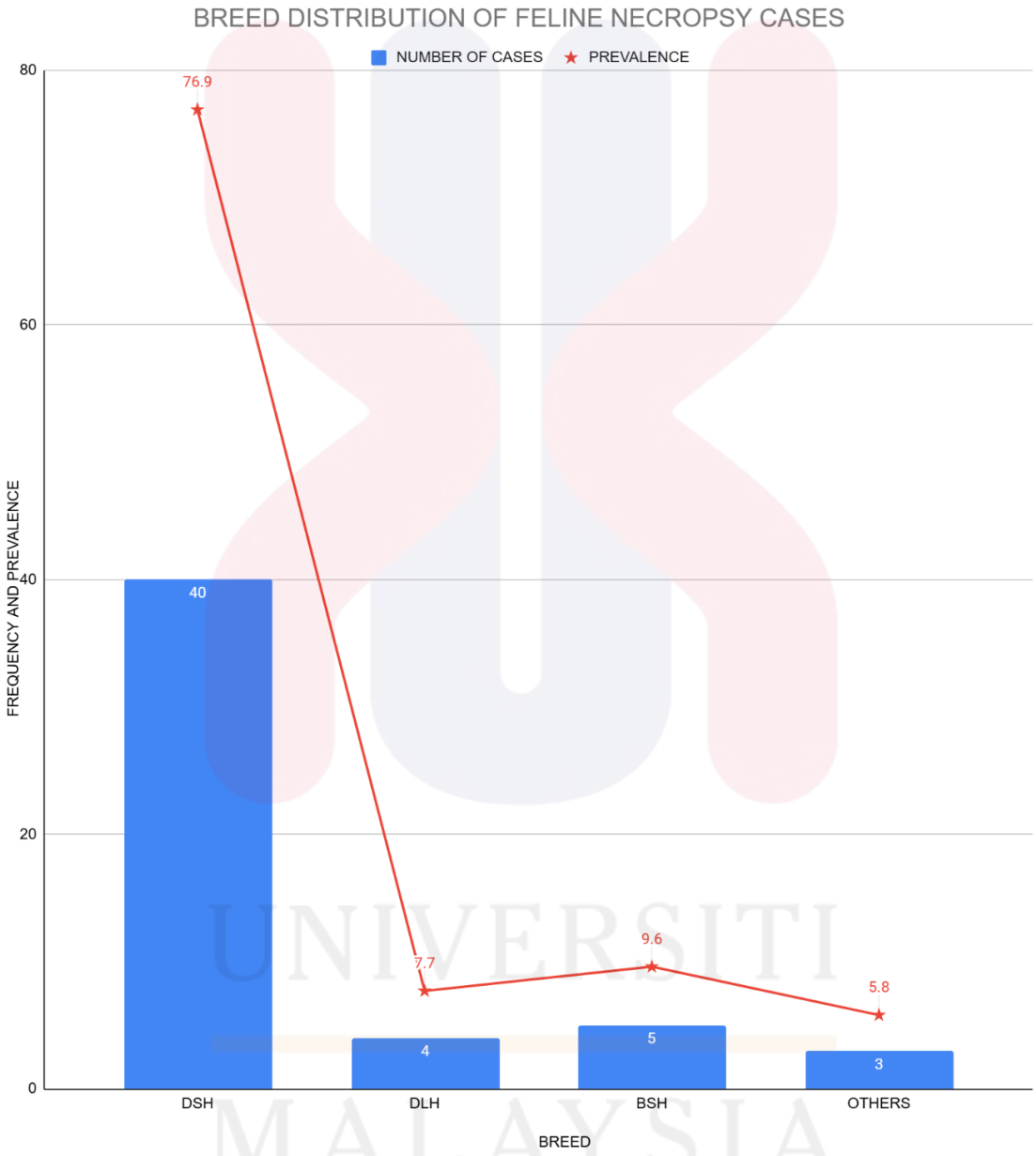

Figure 4.5: Breed distribution and its prevalence of feline necropsy cases in UVDC, UMK

Figure 4.5 illustrates the breed distribution and prevalence of feline necropsy cases in UVDC, UMK. The data show that DSH had the highest proportion of cases, with 40

cases (76.9%), followed by BSH with 5 cases (9.6%). The third most common breed was DLH, comprising 4 cases (7.7%), while other breeds had 3 cases (5.8%).

4.6 SEX DISTRIBUTION AND PREVALENCE OF FELINE NECROPSY CASES IN UVDC, UMK

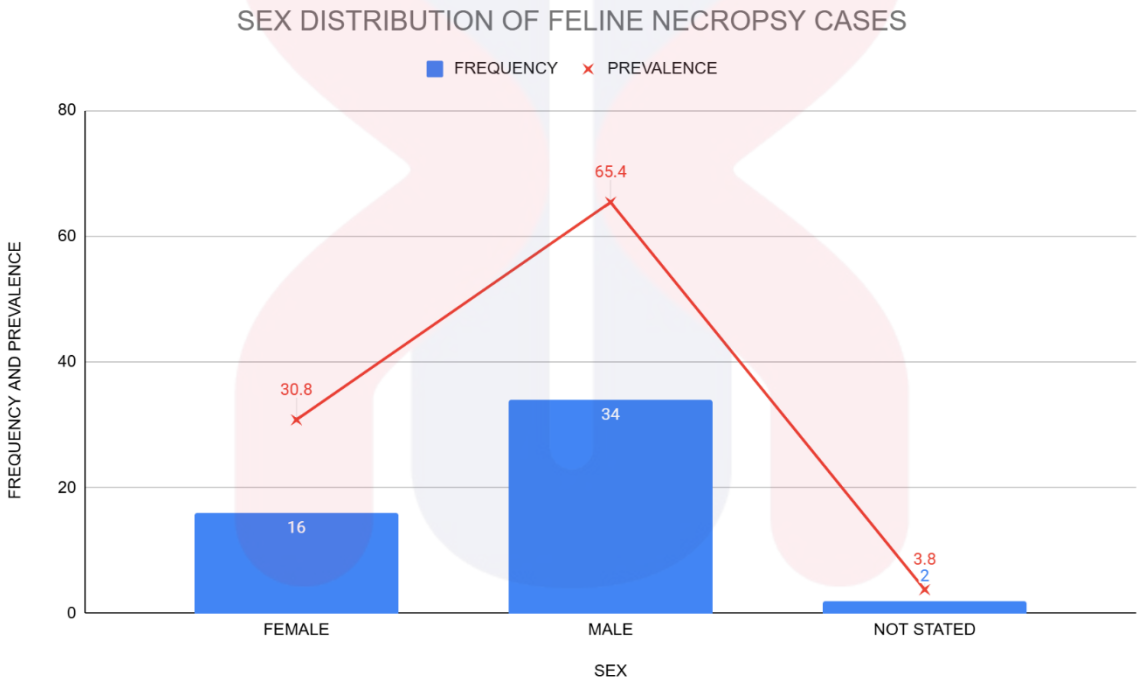

Figure 4.6: Sex distribution and prevalence of feline necropsy cases in UVDC, UMK

Figure 4.6 illustrates the sex distribution and prevalence of feline necropsy cases in UVDC, UMK. The data show that male was the most predominant sex, accounting for 34 cases (65.4%), followed by females, comprising 16 cases (30.8%). Non-stated cases have 2 cases (3.8%).

4.7 OSS PULMONARY LESION DISTRIBUTION OBSERVED IN FELINE NECROPSY CASE IN UVDC, UMK AND THE PREVALENCE

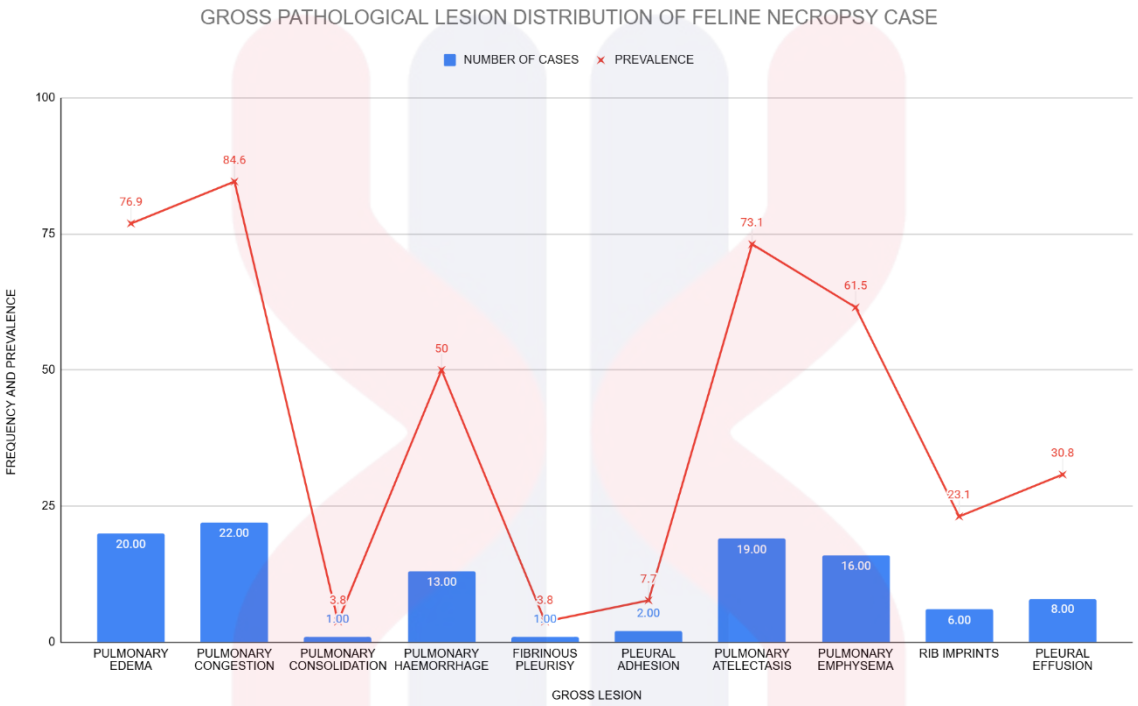

Figure 4.7: Gross pathological lesion distribution and prevalence of feline necropsy cases in UVDC, UMK

Figure 4.7 illustrates the gross pathological lesion distribution and prevalence of feline necropsy cases in UVDC, UMK. The data show that pulmonary congestion had the highest proportion of cases, with 22 cases (84.6%), followed by pulmonary edema with 20 cases (76.9%). The third most common gross lesion was pulmonary atelectasis, comprising 19 cases (73.1%).

4.8 HISTOPATHOLOGICAL PULMONARY LESION OBSERVED IN FELINE NECROPSY CASE IN UVDC, UMK AND THE PREVALENCE

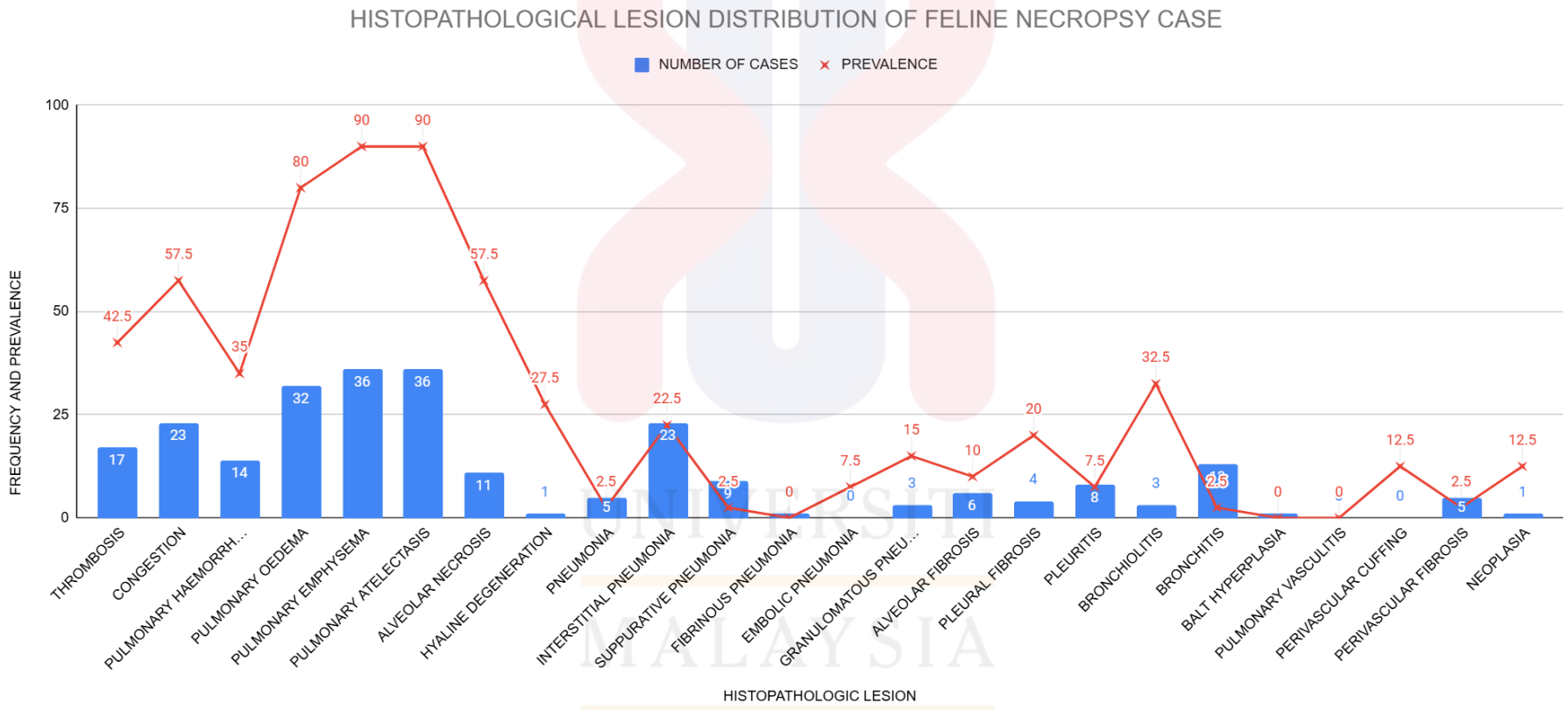

Figure 4.8: Histopathological lesions distribution and its prevalence of feline necropsy cases in UVDC, UMK

Figure 4.8 presents the histopathological lesion distribution and prevalence of feline necropsy cases in UVDC, UMK. The data show that both pulmonary emphysema and atelectasis had the highest proportion of cases, with 36 cases (90.0%) each, followed by pulmonary edema with 32 cases (80.0%). The third most common gross lesion was pulmonary congestion and interstitial pneumonia, each comprising 23 cases (57.5%).

4.9 ASSOCIATION BETWEEN COMMON PULMONARY LESIONS AND CATEGORIES OF FELINE NECROPSY CASES

Lesion	Category	Positive	Negative	P-value
Bronchitis	Infectious	6 (22.2%)	21(77.8%)	0.214
	Non-infectious	1 (14.3%)	6 (85.7%)	
	Trauma (MV/HR)	4 (50.0%)	4 (50.0%)	
Interstitial pneumonia	Infectious	9 (33.3%)	18 (66.7%)	0.017
	Non-infectious	2 (28.6%)	5 (71.4%)	
	Trauma (MV/HR)	7 (87.5%)	1 (12.5%)	
Suppurative pneumonia	Infectious	4 (14.8%)	23 (85.2%)	0.781
	Non-infectious	1 (14.3%)	6 (85.7%)	

	Trauma (MV/HR)	2 (25.0%)	6 (75.0%)	
Pulmonary oedema	Infectious	14 (51.9%)	13 (48.1%)	0.181
	Non-infectious	6 (85.7%)	1 (14.3%)	
	Trauma (MV/HR)	6 (75.0%)	2 (25.0%)	
Pulmonary atelectasis	Infectious	18 (66.7%)	9 (33.3%)	0.052
	Non-infectious	3 (42.9%)	4 (57.1%)	
	Trauma (MV/HR)	8 (100%)	0 (0%)	
Pulmonary emphysema	Infectious	18 (66.7%)	9 (33.3%)	0.122
	Non-infectious	4 (57.1%)	3 (42.9%)	
	Trauma (MV/HR)	8 (100%)	0 (0%)	
Pulmonary haemorrhage	Infectious	6 (22.2%)	21 (77.8%)	0.868
	Non-infectious	1 (14.3%)	6 (85.7%)	
	Trauma (MV/HR)	2 (25.0%)	6 (75.0%)	
Pulmonary thrombosis	Infectious	6 (22.2%)	21 (77.8%)	0.057
	Non-infectious	1 (14.3%)	6 (85.7%)	

	Trauma (MV/HR)	5 (62.5%)	3 (37.5%)	

Table 4.9: Association between common pulmonary lesions and categories of feline necropsy cases

Table 4.9 presents the statistical analysis of the association between case categories (non-infectious, infectious and trauma (MV/HR)) and various pulmonary histopathological lesions using Fisher's Exact Test. The results indicate that most of the p-values obtained were greater than 0.05 ($P > 0.05$), suggesting that there is no significant association between the category and respective histopathological lesions, except for interstitial pneumonia ($P = 0.017$). Therefore, interstitial pneumonia is suggested associated with infectious condition due to the highest number of cases in infectious category.

4.10 EXAMPLE OF THE HISTOPATHOLOGICAL LESIONS OBSERVED IN FELINE NECROPSY CASES

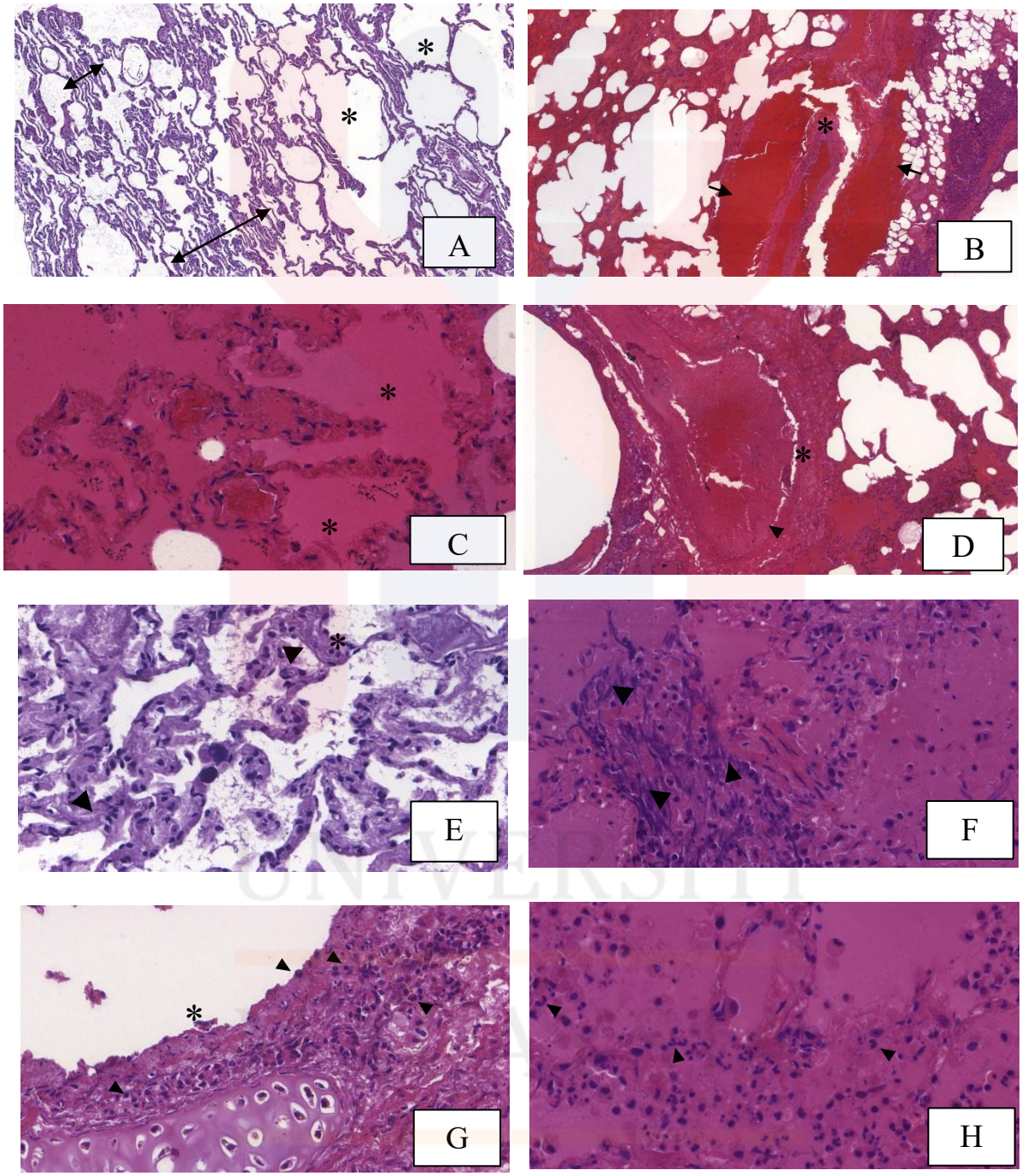

Figure 4.10(A): Slit-like appearance of the alveolar septa (double arrows) indicated pulmonary atelectasis and enlargement of alveolar spaces (asterisk) demonstrating pulmonary emphysema (H&E, 7.7X). **Figure 4.10(B):** Large clumps of erythrocytes (arrow) observed outside the

blood vessels (asterisk) indicating severe pulmonary haemorrhage (H&E, 7.2X). **Figure 4.10(C)**: Homogenous, eosinophilic material (asterisk) present within the alveolar space indicating pulmonary edema (H&E, 37.7X). **Figure 4.10 (D)**: Homogenous clumps of erythrocytes with no observable features noticed attached (arrowhead) to the endothelium of pulmonary capillary (asterisk), indicating pulmonary thrombosis (H&E, 10.2X). **Figure 4.10(E)**: Thickening of alveolar septa due to infiltration of mononuclear and polymorphonuclear inflammatory cells (asterisk) and collagen fiber (arrowhead) consistent with interstitial pneumonia (H&E, 30.8X). **Figure 4.10(F)**: Presence of long filamentous, basophilic stained septate hyphae (arrowhead) indicating fungal pneumonia (H&E, 62.4X). **Figure 4.10(G)**: Sloughing of bronchial mucosa (asterisk) and infiltration of inflammatory cells (arrowhead) in the mucosa and submucosal layers indicating bronchitis (H&E, 41.1X). **Figure 4.10(H)**: Infiltration of polymorphonuclear inflammatory cells (arrowhead) within the alveolar septa, indicative of suppurative pneumonia (H&E, 51.2X).

CHAPTER 5

5.0 DISCUSSION

Necropsy carried out UVDC, UMK was evidently the highest in 2022, with a total of 63 cases, while the lowest number recorded was 18 cases in 2020. It is hypothesized that the low number of necropsy cases in 2020 was due to the COVID-19 pandemic, resulting in lockdowns that restricted case submission. In 2025, there were only 25 necropsy cases recorded, as the data collected was up to June 2025 only. In general, the number of feline necropsy cases shows increasing trends, which could be attributed to growing recognition of necropsy services provided by UVDC, UMK, increased public willingness to surrender their deceased pets for educational purposes and a higher number of cases referred from Hospital Pengajaran Veterinar, UMK (HPVUMK). Additionally, the increase could also reflect a genuine rise in feline mortality associated with infectious diseases, trauma, and potentially underdiagnosed conditions in Kelantan.

The total number of feline necropsy cases with histopathological pulmonary lesion shows similar trends with the number of feline necropsy cases. This may be attributed to the lungs being the vital organ responsible for oxygen exchange and supply to the body. Therefore, any systemic disturbance can significantly affect pulmonary function and causes lesion. Other than that, lungs are a vital organ that are constantly exposed to external environment through respiration, and any destruction in anatomical and physiological immune barriers makes them susceptible to infectious agents. Lung is highly vascularized that systemic spread of infection, could affect the lung and cause death acutely due to hypoxia and hypoxemia.

The feline necropsy cases were grouped into several categories: Infectious, Non-infectious, Trauma (wound), Trauma (motor-vehicle/high-rise) and Others, based on antemortem diagnosis. Among these 5 categories, Infectious has the highest record, which are

27 cases (51.9%), while trauma (wound) has the lowest number of cases, which is 2 cases (3.8%). According to research carried out by Kent et al. (2022), infectious causes are the second common cause of death, following cancer, which may relate to this research that has the Infectious category as the most prevalent category. The high number of cases in the Infectious category could be due to the clear observable symptoms of infection, and clinicians would like to know the causative pathogen and actual cause of death. Trauma (wound) was the least presented, possibly due to wound condition is not severe and deadly, and it resolves with treatment. Furthermore, trauma (motor-vehicle/high-rise) accounted for 8 cases (15.4%) in which 5 were recorded in 2025, and 3 in 2024. Some of these cases involved cat carcasses collected from the faculty area and then sent to post-mortem examination for this study, which may contribute to the observed data distribution. No cases were recorded in 2020 and 2021, likely due to the COVID-19 pandemic, which may have led to underreporting and reduced incidence of road traffic accidents because of nationwide lockdowns and movement restrictions. It is proposed that the active behavior of cats and unorganized road design contribute to the high incidence of motor-vehicle accidents as well. Rural areas have a higher rate of road traffic accidents in cats compared to town and urban areas; and Kota Bahru, though the capital of Kelantan, is less urbanized compared to major Malaysian cities like Kuala Lumpur and Penang (Wilson *et al*., 2017). Additionally, the poor city planning of Kota Bharu, Kelantan possibly contributes to this data as well.

DSH was the most prevalent breed in this study (76.9%), followed by BSH (9.6%) and DLH (7.7%). This distribution likely reflects the demographic composition of the feline population in Kelantan, where most cats owned are DSH. A study conducted in Johor Bahru to determine the composition of stray cats reported that DSH is the most prevalent breed (Yusof *et al.,* 2022). Although similar studies on the feline population in Kelantan are limited, it is reasonable that the overpopulation of stray cats, predominantly DSH, also contributes to this

finding, as several necropsy submissions involved stray animals. Additionally, it is possible that owners of pedigree cats are more reluctant to submit their pets for necropsy, as the breed is costly. It could also be due to the emotional attachment or limited pedigree cat owners in Kelantan, leading to an underrepresentation of purebred cases in the dataset. A total of 5 cases of BSH were recorded. Of these, 1 case involved anaesthetic-associated death with necropsy revealing a congenital heart anomaly, 1 case presented with a hindlimb abscess and was diagnosed post-mortem with septicaemia, 1 case of unexplained death revealed a congenital diaphragmatic hernia, while the remaining 2 cases had incomplete clinical history. Among the 3 confirmed cases, there appears to be a possible association between the BSH breed and congenital anomalies contributing to mortality. This observation highlights the need for further research into breed predispositions and congenital disorders in BSH cats within the local population.

Kittens represented the highest proportion of cases, with 24 cases (46.2%), followed by young adults with 21 cases (40.4%). The third most common group was the mature adults, comprising 3 cases (5.8%). These findings are consistent with the distribution observed in the Infectious category, as kittens are generally more susceptible to infectious diseases and inflammatory conditions due to their immature immune systems (Taylor *et al*., 2025). The pulmonary lesion that presents in kitten in this study are pulmonary emphysema, pulmonary atelectasis, and pulmonary congestion. A study conducted by Grieco et al. (2021) reported that inflammation was a significant cause of death among kittens, followed by young and adult cats, with pneumonia and feline infectious diseases being the most frequently observed pathological findings. The same study also demonstrated a statistically significant association between cause of death and age group. In the present study, among the three mature adult cases, two were classified under the Infectious category, while one case involved Trauma (motor-vehicle/high-rise), which also showed comparable trend findings. However, a statistical analysis was not

conducted in this study to demonstrate the relationship between age group and antemortem diagnosis category.

Male cats were the most common sex represented in this study (65.4%), followed by females (30.8%) and cases with unspecified sex (not stated) (3.8%). Based on a study by Childs & Ross (1986), 63% of cats involved in motor-vehicle accidents are male and 90% of them are intact, it is supported by the study conducted by Rochlitz (2003), that tomcats are at higher risk of being in road accident as they roam to search for oestrous females. Due to incomplete case histories of this study, the neutering status of the cats was unknown. However, the predominance of intact males may be attributed to their territorial and roaming behaviours, which increase the risk of exposure to infectious agents, traumatic injuries, and intraspecific aggression. Previous studies have reported that neutering status is significantly associated with mortality risk, with neutered cats demonstrating a longer life expectancy compared to intact individuals (De Gennaro *et al*., 2023).

Among the gross lesions, pulmonary congestion had the highest proportion of cases (84.6%) followed by pulmonary edema (76.9%) and pulmonary atelectasis (73.1%). These findings are consistent with the histopathological findings in which pulmonary atelectasis (and pulmonary emphysema) being is the most prevalent histopathological lesion, followed by pulmonary edema (80.0%) and pulmonary congestion (and interstitial pneumonia) (57.5%). Pulmonary oedema develops when injury to alveolar epithelial and/or capillary endothelial cells occurs, leading to inflammation that causes increased vascular permeability. As a result, proteinaceous fluid leaks from the vascular compartment into the interstitial and alveolar spaces. Pulmonary oedema is the consequence of injury and inflammation, and it is not agent specific. Simultaneously, disruption of capillary walls triggers the formation of clots or thrombi as part of the haemostatic response, causing blood pooling within pulmonary vessels and resulting in pulmonary congestion. Congestion may also arise secondary to right-sided

congestive heart failure, which leads to blood backflow into the lungs. Although pulmonary congestion and oedema are common findings, they are non-specific indicators of pneumonia. Similarly, pulmonary atelectasis and emphysema are not pathognomonic of pneumonia but may occur secondary to inflammatory or infectious processes that disrupt normal alveolar airflow. In such cases, rupture of alveolar septa allows air to be displaced into adjacent intact alveoli, causing overdistension and enlargement of alveolar spaces, characteristic of pulmonary emphysema. The compression of surrounding collapsed alveoli gives rise to slit-like appearances microscopically which is pulmonary atelectasis. Overall, pulmonary congestion, atelectasis, and emphysema are frequent lesions that likely occur secondary to inflammatory injury of the lung tissue, regardless of the primary aetiology.

A statistically significant association ($p = 0.017$) was observed between interstitial pneumonia and the categories tested. Most interstitial pneumonia cases occurred in the infectious group (66.7%), followed by non-infectious (71.4%) and trauma (motor-vehicle/high-rise) (12.5%) cases. This finding suggests that interstitial pneumonia was predominantly associated with infectious etiologies. It is believed that the cats had FURD initially, possibly a mixed-pathogen infection, which the upper airway is disrupted, then infection is spread to the lower airway, leading to pneumonia in this study. According to Slaviero et al. (2021), viral pneumonia in cats is associated with interstitial and broncho-interstitial patterns, primarily caused by FCV (15/28 cases), FHV-1 (10/28), or mixed infection (3/28); their study also emphasized that FCV and FHV-1, which are well-known agents of FURD, may contribute to pneumonia that may be underdiagnosed in clinical practice. Secondary bacterial infections such as *Pasteurella multocida*, *Streptococcus canis*, and *Bordetella bronchiceptica* happen following viral-induced immune compromise, facilitating bacterial colonization (Dear *et al.,* 2024). In this study, molecular diagnostic methods were not performed to confirm viral infections in any of the cases, indicating a likely underestimation of viral pneumonia in the

local feline population. This may be due to the clinical management of pneumonia, where viral pneumonia is usually symptomatically treated with antibiotics to treat or to prevent secondary bacterial infection, as there is no antiviral for specific viral infection. There is antiviral (Famciclovir) for feline herpesvirus infection; however, it may not be widely available in Malaysia, and the owner may not afford it. Thus, these make the viral component clinically overlooked. It was demonstrated that FCV and FVR can be isolated from clinically healthy cats, with most positive individuals acting as asymptomatic carriers—FCV carriers shedding virus continuously, while FHV-1 carriers shed intermittently, especially after stressful episodes (Wardley *et al*., 1974; Kang & Park, 2008; Berger *et al*., 2015). This poses a concern in multi-cat environments or cats with more social contacts. FCV infection is reported to be more common in kittens, and although recovered cats are less likely to be re-infected, they may continue shedding viruses before they eliminate the virus. Meanwhile, FHV-1 remains latent and may recrudesce under stress (Acar *et al*., 2025). All three groups of cats were presented without primary complaints of respiratory distress, and interstitial pneumonia was an incidental finding during histopathological examination. Due to incomplete history and stray status of some cats, only the vaccination status of some patients is known, with most of them not vaccinated. Clinically, no respiratory signs were seen in those cats who were presented alive to the veterinary clinic, while only one cat was presented with open-mouth breathing. Reported radiographic features of interstitial pneumonia typically show an interstitial pattern, which may be structured or unstructured. According to Norris et al. (2002), restrictive lung disease often presents with pulmonary hypo-inflation, while Macdonald et al. (2003) observed that mixed radiographic patterns were most common, followed by interstitial and alveolar patterns. In this study, radiographs from 2 cats later diagnosed with interstitial pneumonia revealed increased radiopacity in the caudodistal lung region, while another 1 case showed diffuse thoracic soft tissue opacity consistent with pleural effusion. Grossly, rib impressions were absent in all

cases. These findings highlight the subtle and often incidental nature of interstitial pneumonia in feline cases, emphasizing the need for more research to identify specific clinical indicators and develop more sensitive diagnostic tools.

Additionally, two cases of pyogranulomatous pneumonia were identified, both associated with fungal infection. Notably, no specific clinical signs indicative of fungal pneumonia was documented in these cases. Due to limitations in case record management, complete clinical histories were unavailable, with only one case providing sufficient information for review. In the present study, the cat had a history of chronic sneezing accompanied by greenish nasal discharge and was diagnosed with chronic FURD. The cat received treatment consisting of enrofloxacin, bromhexine, meloxicam, nebulization with acetylcysteine, and fluid therapy; however, it succumbed the following day and was diagnosed with aspergillosis through necropsy and fungal isolation and identification. Aspergillosis is prevalent in Malaysia is primarily due to hot and humid climate that provides favourable environmental condition for *Aspergillus* spp. to grow and disseminate, increasing the risk of opportunistic infections in both animals and humans, particularly in immunocompromised individuals. Based on a study by Slaviero et al. (2021), 3 cases of cryptococcal pneumonia and 2 cases of aspergillus pneumonia were recorded out of 5 cases of fungal pneumonia, and the study highlighted the uncommon status of cryptococcal pneumonia in feline patients. Aspergillosis in this case may also align with the findings from Velayuthan et al. (2023) which reported allergic bronchopulmonary aspergillosis is the second most common respiratory mycoses noticed in Malaysian; by which the study also concluded 1.93% of Malaysian population is annually affected by serious fungal infections. Therefore, the current study underscores the likelihood that fungal pneumonia is often underdiagnosed, though possibly because this cat present at an advanced stage of disease with poor prognosis and lack of response to standard therapy before diagnosis of fungal pneumonia was made. Importantly, a study conducted in Brazil by Pavelski et al. (2018)

emphasized the significance of considering fungal pneumonia as a differential diagnosis in patients presenting with respiratory signs; and highlighted the absence of a characteristic radiographic pattern in fungal pneumonia cases, and although bronchoalveolar lavage (BAL) has limited sensitivity, it remains a valuable diagnostic tool. Moreover, fungal pneumonia is considered an opportunistic infection, and both humans and animals may be exposed to the same environmental fungal sources. Given the scarcity of local data in Kelantan, this study highlights the need for further investigation into the predominant etiological agents; and diagnostic approaches for feline fungal pneumonia in Malaysia, to improve early detection and clinical outcomes.

The main limitation of this study was the small sample size, which may restrict the generalizability of the findings. Additionally, improper documentation led to the loss of many case histories and incompatibility between necropsy and histopathological records, posing challenges during data collection and analysis. Furthermore, several archived tissues block from previous years were stored under suboptimal conditions, resulting in poor-quality new sections and some of the blocks required for this study were lost. Some previously prepared histopathological slides have also faded over time, making microscopic evaluation and interpretation difficult.

CHAPTER 6

6.0 CONCLUSIONS AND RECOMMENDATIONS

The findings of this study generally support the initial hypothesis that infectious diseases represent the most prevalent category among feline necropsy cases submitted to the Pathology Laboratory, UVDC, UMK, from 2020 to June 2025. However, contrary to the initial expectation that suppurative bronchopneumonia would be the most common pulmonary lesion, the results revealed that interstitial pneumonia, pulmonary edema, pulmonary congestion, pulmonary atelectasis and emphysema were more frequently observed. This is likely because many of these lesions are non-specific secondary changes that develop following generalized pulmonary inflammation and tissue injury, regardless of the primary etiology. Meanwhile, the higher occurrence of interstitial pneumonia may be linked to underdiagnosed viral infections such as FCV and FHV-1 and are significantly linked to infectious etiology.

This research contributes to the field of small animal medicine by providing valuable baseline data on the prevalence and histopathological patterns of feline pulmonary lesions in Kelantan and contributes to a better understanding of regional trends in feline respiratory pathology. This study also found significant relationships between interstitial pneumonia and infectious groups, and its state of being underdiagnosed. Furthermore, it also highlighted the importance of including fungal infection as a differential diagnosis in cats presenting with respiratory distress, especially in those with chronic unresolved respiratory distress. BAL could be used to diagnose LRTI, other than imaging modalities, which provides information of inflammatory cells involved in the pneumonia and perhaps etiological agent though its sensitivity is not as high as histopathological evaluation. Next, the research also indirectly highlights the need to strengthen awareness of vaccination among cat owners to reduce the risk

of viral infection like FCV and FHV-1, as well as neutering to reduce roaming, territorial aggression, and subsequent risk of trauma or infectious disease exposure.

To address the limitations of this study, future research should include larger sample sizes and more comprehensive clinical data collection to achieve more accurate and unbiased findings. Investigating the prevalence of mycoplasmosis in the feline population is also recommended, as this underdiagnosed bacterial disease was not covered in the present study. Proper record management is crucial to ensure complete documentation of patient signalment, clinical history, diagnostic results, and post-mortem findings for more robust analyses in future work. Additionally, tissue blocks and histopathology slides must be clearly labelled using solvent-resistant permanent markers, including essential information such as case number, case ID, organ, and laboratory reference number. These materials should be stored in designated cabinets under cool, dry, low-humidity, and pest-resistant conditions, arranged in chronological order for efficient retrieval. Immersion oil on slides should be thoroughly cleaned prior to storage to prevent stain deterioration and dust accumulation over time.

APPENDIX

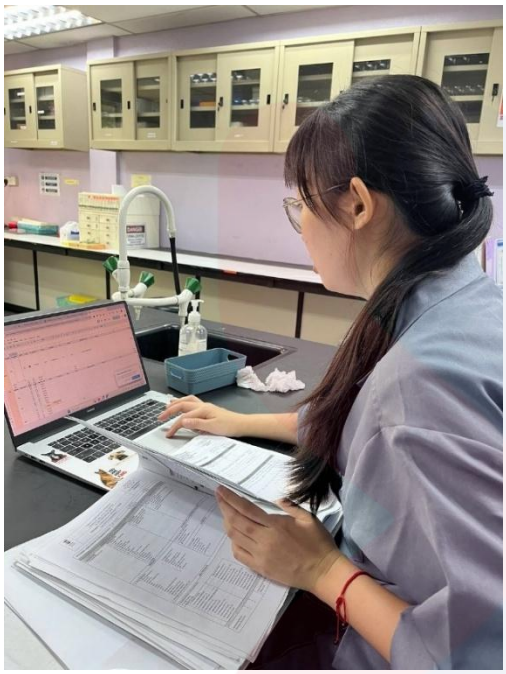

Figure A: Retrieving data from the sample submission form

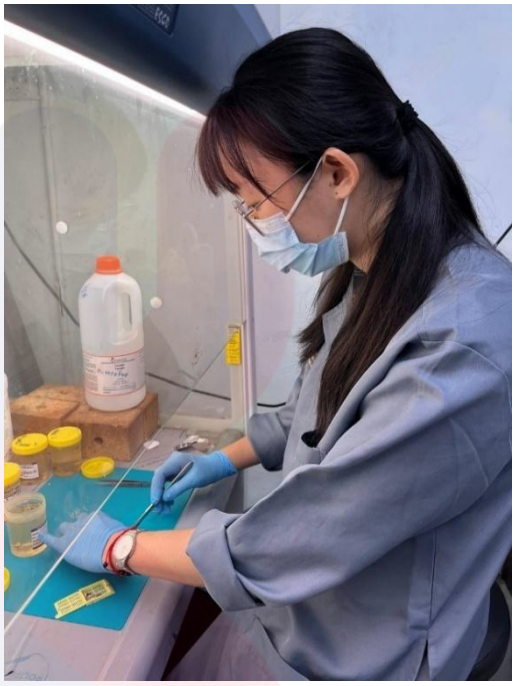

Figure B: Trimming the tissues for cases in 2025

Figure C: Retrieving the archived tissue block

Figure D: Fixing the tissues from cases 2025 with paraffin wax

Figure E: Re-sectioning the archived tissue blocks

Figure F: Transferring tissue ‘ribbon’ from the water bath onto glass slide

Figure G: Staining the slides with Hematoxylin and Eosin stain

Figure H: Mounting a cover slip onto the glass slide

Figure I: Sorting out the histopathological slides

Figure J: Reviewing the histopathological slides

Year	2020		2021		2022		2023		2024		2025	
Category	Frequency	Prevalence	Frequency	Prevalence	Frequency	Prevalence	Frequency	Prevalence	Frequency	Prevalence	Frequency	Prevalence
Infectious	2	100	4	100	8	72.73	6	50.00	5	35.71	2	22.22
Non-infectious	0	0	0	0	2	18.18	1	8.33	3	21.43	1	11.11
Trauma (wound)	0	0	0	0	0	0.00	1	8.33	1	7.14	0	0.00
Trauma (MV/HR)	0	0	0	0	0	0.00		0.00	3	21.43	5	55.56
Others	0	0	0	0	1	9.09	4	33.33	2	14.29	1	11.11
Total	2		4		11		12		14		9	

Table A: Yearly frequency and prevalence of each category.

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