UNIVERSITI PUTRA MALAYSIA

A RETROSPECTIVE STUDY (2006-2021) OF FINAL YEAR PROJECT INVOLVING TWO VETERINARY FACULTIES (UPM & UMK) IN MALAYSIA FOCUSING ON SMALL RUMINANTS LIVESTOCK

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CERTIFICATION

It is hereby certified that I have read this project paper entitled "A Retrospective Study (2006-2021) Of Final Year Project Involving Two Veterinary Faculties (UPM & UMK) in Malaysia Focusing On Small Ruminants Livestock", by Noor Alisya Hazleen binti Nor Azazi and in my opinion it is satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the course VPD 4999 – Final Year Project.

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DEDICATION

My humble effort I dedicate to my sweet and loving parents *Mr. Nor Azazi Zakaria & Mrs. Noor Asmah Hashim* and my siblings for their love, motivation and prayers, supporting me endlessly to reach at this level.

To my dearest friends, *Husna, Asrina, Ikha and my FYP partner, Dharshini*, who provide me with unyielding love, advice and encouragement have inspired me to complete this project paper.

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LIST OF ABBREVIATIONS

SBV	Schmallenberg virus
ELISA	Enzyme-linked immunosorbent assay
CAE	Caprine arthritis encephalitis
CE	Contagious ecthyma
^{o}C	Degree Celsius
SGP	Sheep pox and goat pox
CA	Contagious agalactia
NSD	Nairobi sheep disease
PCR	Polymerase chain reaction

ABSTRAK

Abstrak daripada kertas projek yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan kursus VPD 4999 - Projek Ilmiah Tahun Akhir.

KAJIAN RETROSPEKTIF (2006-2021) PROJEK TAHUN AKHIR YANG MELIBATKAN DUA FAKULTI VETERINAR (UPM & UMK) DI MALAYSIA YANG MEMFOKUSKAN TERNAKAN RUMINAN KECIL

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2022

Penyelia: Prof. Dr. Faez Firdaus Jesse Abdullah

Penyakit dikalangan ternakan ruminan kecil (kambing dan biri-biri) terdiri daripada penyakit berjangkit atau tidak berjangkit. Daripada analisis sehingga kini, didapati tiada rekod atau analisis yang diterbitkan yang melibatkan kajian dalam ruminan kecil bagi Projek Tahun Akhir (PTA) oleh graduan Doktor Perubatan Veterinar (DPV) daripada dua buah Fakulti Perubatan Veterinar (UPM & UMK) di Malaysia. Maka, kajian ini

dijalankan untuk mengenal pasti dan menganalisis trend kajian penyakit berjangkit dan tidak berjangkit yang melibatkan ternakan ruminan kecil yang telah dijalankan dalam projek tahun akhir graduan DPV dan menentukan tumpuan topik kajian mengikut ketetapan geografi.Bagi pelaksanaan kajian ini, maklumat yang diperlukan diperolehi daripada sumber tesis projek tahun akhir daripada tahun 2006 sehingga tahun 2021 melalui perpustakaan UPM dan UMK. Data dianalisis dan diringkaskan dalam bentuk graf bar atau carta pai untuk mendapatkan rumusan taburan kajian. Jumlah projek tahun akhir yang melibatkan penyakit ruminan kecil di UPM ialah sebanyak 74 buah kajian manakala di UMK hanya 12 buah kajian. UPM dan UMK telah menunjukkan trend yang sama di mana majoriti kajian tertumpu kepada punca penyakit berjangkit mana sebanyak 96% (71/74 kajian) dan 75% (9/12 kajian) telah direkodkan masing-masing. Bagi tumpuan geografi, 72/74 (97.3%) buah kajian di UPM dan 6/12 (50%) buah kajian di UMK telah dilaksanakan di kawasan bandar manakala 2/74 (0.03%) buah kajian di UPM dan 6/12 (50%) buah kajian di UMK dilaksanakan di kawasan luar bandar. Hasil dapatan daripada kajian ini dapat membantu penyelidik menyusun strategi dalam mengenalpasti topik penyelidikan bagi projek tahun akhir pada masa hadapan dalam kebitaraanpenyakit ruminan.

Kata Kunci: Ruminan kecil; Penyakit; Projek Tahun Akhir; Fakulti Perubatan Veterinar; UPM; UMK& Trend.

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine in partial fulfillment of the course VPD 4999 - Final Year Project.

A RETROSPECTIVE STUDY (2006-2021) OF FINAL YEAR PROJECT INVOLVING TWO VETERINARY FACULTIES (UPM & UMK) IN MALAYSIA FOCUSING ON SMALL RUMINANTS LIVESTOCK

By

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2022

Supervisor: Prof. Dr. Faez Firdaus Jesse Abdullah

Diseases involving small ruminants which are populated by domesticated goats and sheep can be due to infectious or non-infectious causes. Till date, there is lack of analyses on the small ruminant studies that were embarked for the past 15 years involving Final Year Projects (FYP) by Doctor of Veterinary Medicine (DVM) graduates from 2 Veterinary Faculties (UPM & UMK) in Malaysia. Therefore, this study aims to identify and analyse

the trends of infectious and non-infectious caused disease studies involving small ruminant livestock that was carried out in DVM FYP projects, and to determine the focal studies at different geographical settings (UPM and UMK). Information was obtained from the FYP thesis where infectious and non-infectious diseases in small ruminants were selected from the year 2006 till 2021 and the source of these thesis are from the library of UPM and UMK. The data were analysed and summarised in the form of bar graphs or pie charts to obtain the distribution. Total number of FYP involving small ruminant diseases in UPM was 74 studies while in UMK only 12 studies. UPM and UMK showed the same trend where the majority of their studies focused on the infectious causes where it was recorded as 96% (71/74 studies) and 75% (9/12 studies), respectively. For geographical settings, 72/74 (97.3%) studies in UPM and 6/12 (50%) studies in UMK were done in urban areas while 2/74 (0.03%) studies in UPM and 6/12 (50%) studies in UMK were done in rural areas. The outcome result from this study will aid the researcher to strategize the upcoming FYP research in ruminant disease subject matter in future.

Keywords: Small ruminant; Diseases; FYP; Veterinary Faculties; UPM; UMK& Trends.

CHAPTER 1

INTRODUCTION

1.1 Infectious diseases in small ruminants

Livestock industries play a vital role in economic development in developing countries where small ruminant production is a crucial and viable sub part of animal industries in Asia. Small ruminant production systems are complex and play a major role in the life of farmers in developing countries. Major zoonotic animal disease outbreaks, including Brucella, Caseous Lymphadenitis (CLA), Contagious ecthyma (orf), Caprine Arthritis Encephalitis (CAE), *Coxiella burnetii* infection (Q fever), *Schmallenberg virus* infection (SBV), and Bluetongue disease, have been affecting the small ruminant industry which leads to economic losses. Due to the potential risks in every region of the world, particularly tropical regions, these diseases have become a global concern. It is important to give attention to upgrading the herd health programme and enhancing the disease surveillance programme to improve biosecurity in ruminant livestock industry particularly in small ruminants as the occurrences of these diseases will create obstacles for the farm's and livestock's major production. The current goal of Malaysian Agriculture is to increase and improve ruminant production for the country 's food security and safety.

1.2 Non-infectious diseases in small ruminants

Numerous non-infectious diseases that affect sheep and goats can cause animal's death and result in significant financial losses, but they have not gained enough attention. The majority of these diseases are associated with fractures, wounds, poisoning, and dystocia. Infertility in flocks is greatly influenced by reproductive problems such abortion, dystocia, retained placenta, and stillbirth (Mboera and Kitalyi, 1994). Pregnancy toxaemia (ketosis), hypocalcemia (kidding sickness), grass tetany, goitre (iodine deficiency syndrome), white muscle disease (vitamin E/Selenium deficiency), urolithiasis (mineral imbalance), and enterotoxaemia are the main nutritional deficiency illnesses in small ruminants (Sahoo, 2008).

1.3 Department of Veterinary Services (DVS) reported diseases

Baron *et al*. (2016) stated that Peste des petits ruminants (PPR) is a major infectious viral disease of sheep and goats widespread in Africa, the Middle East, and Asia. A global PPR control and eradication strategy has been developed by the Food and Agriculture Organisation of the United Nations (FAO) and the World Organisation for Animal Health (OIE) (OIE and FAO, 2015; Raj *et al*., 2015).

According to Rowe and East (1997), the Caprine Arthritis Encephalitis (CAE) infection is extremely common in countries that practise intensive dairy goat production, including Australia (Cutlip *et al*. 1992), the United States (Greenwood 1995), Alexandria (Baraka *et al*. 2018), Canada, Switzerland, Norway, France (Lofstedt *et al*. 1988), Jordan, and Jordan (Al-Qudah *et al*. 2006). However, in countries that rely on the importation of

livestock, such as Saudi Arabia (Alluwaimi *et al*. 1990), India (Waseem *et al*. 2015), Thailand (Lin *et al*. 2011), Brazil (Bandeira *et al*. 2009), and Malaysia (Jesse *et al*., 2018), the prevalence of CAE is typically lower. In Malaysia, the disease was first reported in 2010 by Noordin *et al*., where 20 goats from a herd of 2000 in a farm manifested nervous signs characteristic of CAE.

Prevalance of Schmallenberg virus (SBV) infection among small ruminants was recorded in one study to be 21.5% overall and 22.1% as true prevalence, indicating possible economic impacts in Peninsular Malaysia. The overall seroprevalence is lower than earlier reports in Europe, where Meroc *et al*. (2014) reported a 98.03% rate in Belgium at the end of the 2012 epidemic, despite the fact that this is the first study (Jesse *et al*., 2022) on SBV infection in Peninsular Malaysia. Similarly, Helmer *et al*. (2016) found that small ruminant flocks in Germany had a 53.3% seroprevalence of SBV. In Turkey, sheep and goats, respectively, have prevalence rates of 39.8% and 1.6%, according to Azkur *et al*. (2013).

Melioidosis cases in humans and livestock are reportedly rising in Malaysia recently (Raja, 2008). The country's animal population is afflicted with an illness, but little information is currently accessible on it. During the flood tragedy in Johor from the year of 2006 till 2007, melioidosis disease was added to Malaysia's list of notifiable communicable diseases in humans as part of the Flood Action Plan, with several cases being documented in flood victims (Hisham *et al*., 2009). Similar to this, more cases of melioidosis have been noted in Asia's tsunami survivors from 2004. (Athan *et al*. 2005; Chierakul *et al*. 2005; Wuthiekanun *et al*. 2006). These cases of *Burkholderia*

pseudomallei exposure in human victims imply that prolonged contact between animals and floodwater containing the agent, which is washed out of soil or surface water, may also increase the risk of exposure for the animals.

In one study by Paul *et al.*, (2020), selected smallholder goat farms on the southwest coast of Peninsular Malaysia were investigated for the prevalence, risk factors, and levels of infection with gastrointestinal coccidia and strongyle parasites. The findings indicated that various kinds of coccidia, cestodes, and strongyles were present in 78.6% of the sampled goats across all farms. The environment and management techniques can be used to explain the high incidence of parasites found in this study. The epidemiology of parasites is known to be favoured by high tropical temperatures, humidity, and rainfall because they promote the best pre-parasitic phases of helminths and coccidia growth (Soulsby., 1982).

1.4 OIE reported diseases

To prevent the transmission of disease and promote safe trade, one of the OIE's primary goals is to assure the transparency of the global animal health situation. The OIE has a list of diseases that must be reported to accomplish this. The notifiable diseases affecting small ruminants include Caprine arthritis/encephalitis, contagious agalactia, contagious caprine pleuropneumonia, enzootic abortion of ewes (Ovine chlamydiosis), Maedi-visna, Nairobi sheep disease, ovine epididymitis (*Brucella ovis*), Peste des petits ruminants, Salmonellosis (*S. abortus ovis*), Scrapie, Sheep pox and goat pox (World Organisation for Animal Health, 2010).

1.5 Justification

Till date, there is lack of analyses on the small ruminant studies that were embarked for the past 15 years involving Final Year Projects (FYP) by Doctor of Veterinary Medicine (DVM) graduates from 2 Veterinary Faculties (UPM & UMK) in Malaysia. Therefore, this study aims to identify and analyse the trends of infectious and non-infectious caused disease studies involving small ruminant livestock that was carried out in DVM FYP projects, and to determine the focal studies at different geographical settings (UPM and UMK).

1.6 Research objectives

The objectives of this study are:

1. To identify and analyse the trends of infectious and non-infectious caused disease studies involving small ruminant livestock that was carried out in DVM FYP projects.
2. To determine the focal studies at different geographical settings (UPM and UMK).

CHAPTER 2

LITERATURE REVIEW

2.1 OIE and DVS reported diseases

2.1.1 Caprine arthritis-encephalitis

Caprine arthritis encephalitis virus (CAEV) is a lentivirus in the family Retroviridae that infects goats and is closely related to maedi-visna virus (MVV) of sheep (Fields *et al*. 2001, Benavides *et al*., 2009). According to Adams *et al*. (1984) and Peterhans *et al*. (2004), CAEV infection occurs worldwide and, like other lentiviruses, it has the potential to induce persistent, lifelong infection, leading to subclinical inflammation in one or more organs, including the brain, lungs, mammary gland, and articular joints (Nord and Ådnøy, 1997, Blacklaws *et al*., 2004). The progressive inflammatory syndromes caused by CAEV have been observed in a variety of tissues, including the joint synovium in animals older than 12 months (caprine arthritis) or, less often, encephalomyelitis in 2-4-month-old goat kids.

CAEV is a single-stranded, icosahedral RNA virus and belongs to subgroup B of small ruminant lentiviruses (SRLVs). CAEV is a monocyte/macrophage-tropic virus that is not associated with immunodeficiency, generally infects dairy goats and was first reported as a retrovirus in 1980 (Crawford *et al*., 1980, Narayan *et al*., 1980). Since then, numerous research have concentrated on characterising the macroscopic and gross lesions

of naturally occurring and experimental SRLV infections in small ruminants (Benavides *et al*., 2013). Interstitial pneumonia or indurative mastitis (commonly known as "hard udder"), lesions similar to those seen in sheep infected with MVV, can also arise from CAEV infection (Maclachlan *et al*., 2011). These lesions are distinguished histologically by interstitial mononuclear infiltration, which frequently includes lympho-follicular hyperplasia and fibrosis (Milhau *et al*., 2005).

In the majority of industrialised countries, including Canada, Norway, Switzerland, France, and the United States, CAEV is widespread among dairy goats. CAEV seroprevalence is greater than 65%. (Kahn and Line., 2003). The first confirmed case of the CAE outbreak in Malaysia was reported in 2010, but no data have been gathered since then (Noordin., *et al*., 2010).

2.1.1.1 Transmission of CAEV

The virus is transmitted to kids mainly via colostrum, even though transmission via aerosol, animal-to-animal contact, and sexual activity can also occur (Phelps and Smith, 1993, Rowe and East, 1997, Peterhans *et al*., 2004, Le Jan *et al*., 2005). According to Lofstedt. and John (2021), the feeding of pooled colostrum or milk to kids is a particularly risky practice, because a few infected does will spread the virus to a large number of kids. Unlikely methods of transmission, as indicated by results of experimental studies (East *et al*., 1993), include in utero transmission to the foetus, infection of the kid during parturition, and infection via natural breeding or embryo transfer. CAE virus has been isolated from peripheral blood of goats infected experimentally (Cork and Narayan,

1980, Adams *et al*, 1980a, Knight and Jokinen, 1982). This would suggest that hypodermic needles or surgical instruments could play a role in transmission.

2.1.1.2 Clinical signs of CAEV

The central nervous system and arthritic forms have often been recognised as the two main clinical presentations of CAE. Weight loss, depression, and demeanour are a few examples of general clinical signs. The course typically appears highly variable (Adams, 1979, Adams and Crawford, 1980). Advanced cases frequently exhibit rough, abnormally long hair coats, and exfoliation of the skin (Crawford and Adams, 1981).

The central nervous system form is typically observed in young goats; ie, 2- to 4-month-old kids. Lameness, ataxia, and an inability to adduct the hind limbs are among the early typical clinical symptoms (Cork *et al*, 1973). Paralysis sets in when the hind legs deteriorate. During this stage, the animal may not be able to stand up and shows opisthotonos. Neck twisting and foot paddling are examples of more severe symptoms. When symptoms are severe, the sickness is usually short and fatal, but in exceptional cases, a goat with the condition may live for a month. Goats that survive the initial phase of the disease will have neurologic deficits similar to Visna of sheep (Cork, 1976). Pneumonia can occur simultaneously in kids with the nervous form of CAE (Baxendel, 1980, Clements *et al*, 1980). The symptoms include rapid shallow respirations, dullness on percussion of the thoracic cavity, and harsh moist lung sounds (Knight and Jokinen, 1982).

Goats with the arthritic form typically age over a year and exhibit a variety of clinical symptoms (Chung and O'Sullivan, 1982; Dawson *et al*., 1983; Ellis and DeMartini, 1983). Animals with the condition eventually lose weight and have a poor hair coat. Mobility decreases and ambulation is difficult due to inflammatory changes within the joint. Goats with severe conditions may be seen walking on their carpi (Ellis and DeMartini, 1983). The carpal joints are the most frequently involved, followed by the hock and stifle joints (Pointon *et al*, 1982). The colour of the synovial fluid changes from brown to reddish-tinged, and its volume occasionally rises (Crawford and Adams, 1981). Some does have also developed a hard udder at parturition, which is suspected to be caused by the CAE virus (Woodard *et al*, 1982). There is evidence that the CAE virus can result in mastitis and a higher somatic cell count in milk (Pointon *et al*, 1982, Hinckley, 1983, Zwahlen *et al*, 1983). A slight degree of udder oedema has also been observed (Sherman, 1983).

2.1.1.3 Diagnosis of CAEV

There are various diagnostic techniques that can be used to confirm this condition, however the clinical signs, history, post-mortem, and histological examination of the tissue were enough to make a presumptive diagnosis. In a case study, a presumptive diagnosis of CAE was made based on the histology results, the history, and the fact that the dam had an episode of indurative mastitis. The kid later had progressive neurological signs and swollen joints after consuming the dam's colostrum and milk (Ellis *et al*., 1983).

Testing including agent identification, nucleic acid recognition techniques, and serological tests can be carried out to achieve confirmatory diagnosis. Leukocytes from milk or peripheral blood can be cultured with suitable caprine cells, such as synovial membrane cells, to isolate viruses. Characteristics of the cytopathic effects include the appearance of syncytia and refractile stellate cells. Electron microscopy and immunolabeling methods can both confirm the presence of CAEV. For rapid detection, quantification, and identification of the small ruminant lentivirus strains, many standard and a few quantitative polymerase chain reaction (PCR) assays have been described and are now routinely used in many laboratories. The most direct procedure is cloning and/or sequencing PCR products. Additionally, a serological test that can identify particular antibodies against the virus can be used to diagnose this disease. The most common serological tests are agar gel immunodiffusion (AGID) and enzyme-linked immunosorbent assay (ELISA), while western blot analysis and radio-immunoprecipitation are only carried out in specialised laboratories. Rather than being measured in weeks or days, the period of time needed for seroconversion after infection might be relatively protracted and unpredictably timed. However, the antibody response usually persists after seroconversion (OIE, 2008).

2.1.2 Contagious agalactia

Contagious agalactia is one of the most serious diseases of small ruminants induced by mycoplasmas after contagious caprine pleuropneumonia (CCPP), affecting many organs and causing systemic infections (Miguel., *et al*., 2012). In many places of

the world, outbreaks have a significant economic impact on countries, particularly those in the Mediterranean basin. The World Organisation for Animal Health (OIE) has identified it as a disease that causes significant losses to the dairy industry (Tardy., *et al*., 2012). The classical etiological agent of this illness, which mostly affects goats and sheep as well as many wild species, is *Mycoplasma agalactiae*.

Mycoplasma agalactiae is a polymorphic bacterium with a genome that is only 1 x 10^9 Da in size with a size range of 124–250 nm. *M. agalactiae* produces colonies with dark centres that have the classic appearance of fried eggs; this occurrence is known as "film and spot." *M. agalactiae*'s biochemical characterisation reveals that it does not ferment glucose or hydrolyze urea or arginine (Khan *et al*., 2001, Khan *et al*., 2004). Giemsa stains from solid agar medium are used to stain the mycoplasma colonies in order to examine the colony characteristics (Kumar., 2000). When Gram stains a mycoplasma, the lack of a cell wall causes the stain to be pink (Rosales *et al*., 2005).

2.1.2.1 Transmission of CA

Auricular, ocular, and nasal secretions, faeces, milk, urine, and excretions from joint lesions are the main sources of infection (Martin *et al*., 2012). There have been reports of sexual transmission through infected males. A significant source of infection is milkers' hands and contaminated equipment. Contaminated milk or colostrum are observed to be the source of vertical transmission (Kinde *et al*., 1994). Animals that are young, malnourished, pregnant, or immunocompromised are comparatively more susceptible to the virus (Levisohn *et al*., 1991). A major concern is the existence of

asymptomatic carriers of the infectious pathogen in a herd. In sheep and goats, respectively, antibodies were still detectable after 3 and 8 years of clinical disease (Nicholas, 1998). Cattle, camels, and numerous other wild small ruminants can serve as reservoirs for the virus in addition to homologous hosts. The genital tracts of females are where these carrier states are more frequently seen (Verbisck, 2010).

2.1.2.2 Clinical signs of CA

Young animals that lack maternal antibodies, weak, debilitated, malnourished, and immunocompromised, as well as animals that are stressed during and after transportation, that are under physiological stress, such as pregnancy, and that are exposed to extreme weather conditions, are frequently affected. *M. agalactiae* can cause acute, subacute, or chronic disease depending on these circumstances. Atypical or asymptomatic forms have also been found in several animals (Zendulkova, 2007). Fever, anorexia, lethargy, and an unwillingness to follow the herd are common clinical signs. These are followed by clinical signs based on the involvement of various organs such the mammary glands, lungs, genitalia, joints, and conjunctiva. Importantly, fever is typical in acute cases and may be accompanied by nervous symptoms, but both symptoms are uncommon in subacute and chronic infections, which are more frequently seen. Lung lesions can occasionally contain *M. agalactiae* (Loria *et al*., 1999). Pneumonia is a common occurrence, although it's not always the case. Common observations include a loss of milk production, milk discolouration, saltiness, and consistency changes, and ultimately agalactia. Kids that consume infectious colostrum and milk may develop septicaemia, arthritis, or pneumonia

which have significant fatality rates (Razin*et al.*, 1998). Lameness, which includes the inability to walk or stand and blindness, is caused by chronic joint involvement and significant corneal losses, respectively (Kwantes and Harby., 1995).

2.1.2.3 Diagnosis of CA

Clinical signs such as decreased milk production, mastitis, keratoconjunctivitis, and articular lesions, are used to make a primary or tentative diagnosis of the organism. Lameness, ocular discharges, articular swellings, and milk that has a yellowish-green colour are indications of *M. agalactiae* infection. The laboratory isolation and identification of the pathogen confirms the clinical diagnosis (Nicholas., 2002). The diagnosis is made using samples of milk, blood, urine, articular exudates, auricular, ocular, vaginal, or nasal discharges (Martin *et al.*, 2012). During the post-mortem examination, samples are taken aseptically from the mammary glands, regional lymph nodes, pulmonary lesions, and articular exudates for the isolation of infected tissues (Kizil and Ozdemir., 2006). *M. agalactiae* produces fried-egg colonies. Characterization of isolates based on biochemical tests is not usually recommended (Kumar., 2000) due to morphology, growth, and metabolic similarity to some other mycoplasmas (Poveda., 1998).

Growth precipitation (GP), immunofluorescence (IF), complement fixation test (CFT), indirect haemagglutination (IHA), haemagglutination inhibition (HI), agglutination, latex agglutination test (LAT), double immunodiffusion (DID), single radial immunodiffusion (SRID), enzyme linked immunosorbent assay (ELISA), radio

immunoassay (RIA), and immunoperoxidase (IP) are some of the important serological tests for detecting *M. agalactiae* (Poumarat *et al*., 2012, Kumar., 2000& Giangaspero *et al*., 2012).

2.1.3 Contagious caprine pleuropneumonia

In parts of Africa, Asia, and the Middle East, a bacterium known as *Mycoplasma capricolum capripneumoniae*, or Mccp, causes the serious and often fatal disease called contagious caprine pleuropneumonia (MacKay ., 2022). The disease, one of the mycoplasmal infections, causes significant losses in almost 40 countries, and morbidity and mortality rates, particularly in exotic breeds, can reach 100% (DaMassa *et al*. 1992; OIE 2014). The class Mollicutes, which lack cell walls yet have galactan and small genomes, includes these pathogenic bacteria. They have a limited capability for biosynthesis and cause a number of infections in animals (Nicholas and Baker 1998; Razin *et al*. 1998). According to Cottew *et al*. (1987) and Manso-Silván *et al*. (2009), Mccp is classified in the *Mycoplasma mycoides* cluster and has several species and subspecies.

2.1.3.1 Transmission of CCPP

The main transmission route is through inhalation of infected aerosols. Direct contact with affected animals is the main source of contamination (Thiaucourt *et al*. 1996; OIE 2017). According to Lignereux *et al*. (2018), airborne transmission can cause distant spread, with a reported 50 m distant transmission. The transmission role of infected objects, vectors, fomites, and animal products is still unknown (EFSA AHAW Panel *et*

al. 2017). Pathogens can survive longer in conditions that are moist, cold, and overcrowded environments and may cause severe outbreaks. Mccp transmission is impeded by a shorter survival period (3–14 days) in an external environment (OIE 2009). Low temperature extends survival while high temperature quickly inactivates Mccp (within 60 min at 56°C and within 2 min at 60°C).

2.1.3.2 Clinical signs of CCPP

Clinical signs of the respiratory system being involved, exacerbated by mycoplasma-induced systemic serofibrinous and inflammatory cascade, that affect the lower respiratory tract (including the lungs), pleura and pleural cavity, and associated organs (heart), occasionally the upper respiratory tract, and rarely the eyes, joints, udder, liver, and kidneys, are characteristics of CCPP. The disease may present in peracute, acute, or chronic forms. When fully susceptible herds are exposed to the virus, severe disease forms like acute and peracute usually result, but chronic disease forms only appear in endemically affected areas. In peracute form, sudden death can happen within 24 to 72 hours and is always absent of respiratory signs (MacOwan 1976; MacOwan and Minette 1976; Samiullah 2013). The symptoms of severe fibrinous pleuropneumonia, which include anorexia, depression, dyspnea, high fever (41–44°C), coughing, nasal discharge, lagging, lying down, thorax pain, loss of body condition, and heavy morbidity (up to 100%) and mortality (80–100%), are common in less acute or chronic forms and mildly affected or relatively resistant animals (MacOwan and Minette 1976; Rurangirwa and McGuire 1996; Radostitis *et al*. 2009; OIE 2014). Snoring or wheezing respiratory

sounds, frequent and productive coughing, abdominal respiration with rapid and painful (pleurodynia) respiratory movements, are seen in clinical cases. In the terminal stages, immobility, usually recumbency and if standing, then with base wide and stretched neck (OIE 2009; Hussain *et al*. 2012; Wang *et al*. 2014; Shah *et al*. 2017; Tharwat and Al-Sobayil 2017).

2.1.3.3 Diagnosis of CCPP

Following a clinical tentative diagnosis, the diagnosis may require microbiological, biochemical, serological, and gene-based identification. Culture, isolation, and identification are three examples of microbiological techniques that, despite being very conventional, are still regarded as the standard for detecting Mccp. However, there are two main factors that make the microbiological diagnosis of CCPP difficult: first, the very poor in vitro growth of Mccp, and second, the common contamination of samples by other mycoplasmas that grow quickly (Thiaucourt *et al*. 1996). Additionally, Mccp's fastidiousness and special requirements exacerbate the diagnostics issue. Thus, other diagnostic techniques should be used (Thiaucourt *et al*. 1996).

The development of PCR has greatly improved the diagnosis of CCPP since it makes it possible to easily identify the mycoplasma even in mixed cultures, from clinical samples such pleural fluid and lung, and from this material dried on filter paper (Lorenzon *et al*., 2002). According to PCRs based on the 16S RNA genes, all *M. mycoides* cluster members can be detected, and then *M. c. capripneumoniae* can be specifically identified by restriction enzyme digestion (Bölske *et al*., 1996). Woubit *et al*. (2004) described a

specific PCR that skips the restriction enzyme step. Due to its sensitivity, rapidity, and specificity, PCR/denaturing gradient gel electrophoresis (DGGE) offers significant advantages in detection.

2.1.4 Ovine chlamydiosis

The Gram-negative bacterium *Chlamydia abortus* is the cause of ovine chlamydiosis, also known as enzootic abortion of ewes (EAE) or ovine enzootic abortion (OEA). In many sheep-rearing regions of the world, particularly where flocks are closely gathered during the parturient period, chlamydial abortion in late pregnancy causes significant economic loss (Longbottom & Coulter, 2003; Aitken & Longbottom, 2007). Usually, abortion takes place in the final two to three weeks of pregnancy, with the appearance of stillborn lambs and grossly inflamed placentas. Additionally, full-term stillbirths and weak lambs that typically do not survive past 48 hours might occur from infection. Moreover, it is not unusual for an infected ewe to give birth to one dead lamb and one or more weak or healthy lambs.

Pathogens belonging to the Chlamydiaceae family of obligate intracellular Gram-negative bacteria infect a variety of mammalian and avian species. Among all bacterial species, members of the Chlamydiaceae share a biphasic developmental cycle. *Chlamydia psittaci*, *Chlamydia felis*, and *Chlamydia abortus* are chlamydial species that have zoonotic potential. Due to its potential to induce severe systemic infection in both animals and humans, *C. abortus*, the agent that causes EAE, is one of these that has attracted increasing scientific attention (Essig and Longbottom., 2015).

2.1.4.1 Transmission of OEA

The products of abortion are the main sources of environmental contamination and transmission to susceptible humans and naive ewes where extremely large numbers of organisms have been found in the placentas and vaginal discharges of aborted ewes and coats of the dead lambs. An ewe frequently gives birth to living and dead lambs as well as live healthy lambs when placental infection is lower. It may also give birth to weak lambs that do not survive for more than 24 hours (Longbottom, 2003; Aitken and Longbottom, 2007). Such live lambs are a substantial zoonotic concern and crucial sources of infection for naive animals. After a few days, once the vaginal secretions have fully dried up, the risk of infection transmission is considerably decreased or almost eliminated, however caution should still be taken.

2.1.4.2 Clinical signs of OEA

Prior to abortion, infected animals do not exhibit any clinical illness, however ewes may exhibit behavioural changes and vulval discharge in the last 48 hours of pregnancy. Around day 90 of pregnancy, chlamydial invasion of placentomes causes a progressively diffuse inflammatory response, thrombotic vasculitis, and tissue necrosis, which coincides with a period of rapid foetal growth. The foetal liver and lung show milder abnormalities, and in cases of severe placental damage, there may be signs of hypoxic brain damage (Buxton *et al*., 2002; Longbottom *et al*., 2013). The impairment of maternal-fetal gaseous and nutritional exchange, disruption of pregnancy hormonal

regulation, and induced cytokine aggression are likely to contribute to abortion (Entrican, 2002).

2.1.4.3 Diagnosis of OEA

On the basis of flock history and, if recovered, an investigation of the placental membranes, an initial presumptive diagnosis of EAE can be made. EAE commonly presents as thickening and reddening of the intercotyledonary membranes due to oedema, with inflamed cotyledons, and frequently a creamy exudate on the membrane surface. The placental membranes are usually unaffected in toxoplasmosis, a common cause of abortion, but the cotyledons exhibit white foci of necrosis (Aitken and Longbottom, 2007).

There are numerous serological, antigen, and molecular based tests that can be used to confirm a diagnosis of abortion due to *C. abortus* infection. Blood, placental cotyledons and membranes, a foetus, foetal tissues, and vaginal swabs are typical samples submitted. Even though it is obviously inappropriate for a quick diagnosis and depends on the availability of specialised facilities and technical expertise, isolation and culture are nevertheless regarded as the gold standard. Microscopic analysis of placental smears stained with Giemsa, modified Macchiavello, Brucella differential, or modified Ziehl-Neelsen stains might lead to an initial rapid provisional diagnosis for the detection of chlamydial organisms/antigens (Sachse and Longbottom., 2012). Then, using monoclonal antibodies and antiserum that are specific for the antigen, this can be confirmed using ELISA or fluorescent antibody tests. Due to its rapidity, high throughput, and ease of

standardisation of the assay, real-time PCR has recently been the preferred technique for many diagnostic laboratories, while DNA microarrays using the ArrayTube platform show great promise (Sachse *et al*., 2005; Ehricht *et al*., 2006; Borel *et al*., 2008).

2.1.5 Nairobi sheep disease

The main member of the family *Nairoviridae* under the order *Bunyavirales* is Nairobi sheep disease orthonairovirus (NSDV) (Abudurexiti *et al*., 2019). NSDV is on the OIE list of notifiable animal diseases and causes acute gastroenteritis in small ruminants with a case mortality of 30–70% in susceptible populations (OIE, 2021). NSDV is a biosafety level (BSL) 3 agent because of its zoonotic potential. The NSD virus is the NSD serogroup's prototype virus. In susceptible populations, fatality rates can reach 90% in sheep and goats suffering from severe hemorrhagic gastroenteritis. The only known vertebrate reservoirs and amplifying hosts of NSD are sheep and goats. The disease was initially discovered near Nairobi, Kenya, in 1910, and the NSD virus was shown to be the causative agent in 1917 (Montgomery, 1917).

Three segments make up the NSDV single-stranded RNA genome. The small (S) segment, the medium (M) segment, and the large (L) segment, respectively, encode the nucleocapsid protein (N), the glycoprotein precursor (GPC), and the RNA-dependent RNA polymerase (Frias-Staheli *et al*., 2011).

2.1.5.1 Transmission of NSD

Ticks are among the most significant vectors affecting livestock and humans because they are known to transmit a greater variety of pathogenic microorganisms than any other arthropod vectors (Keesing *et al*., 2010). Since NSDv spreads through the feeding of competent infected ticks, its geographic distribution is constrained to regions with favourable environmental conditions for them (Baron and Holzer, 2015). The two primary tick species associated with the transmission of NSDv are *Haemaphysalis intermedia* in Asia and *Rhipicephalus appendiculatus* in East Africa (Baron and Holzer, 2015). Adult ticks that haven't been fed can transmit the virus for more than two years after being infected. *R. pulchellus, R. simus* and *Amblyomma variegatum* are some of the vectors in Africa. Transovarial transmission has been proven in *R. appendiculatus,* as well as in *R. pulchellus* in Somalia. All previously identified host ticks are capable of transstadial transmission (OIE, 2016).

2.1.5.2 Clinical signs of NSD

According to Yadav *et al*. (2011), NSDv causes febrile illness, nausea, vomiting, and headaches in humans as well as hemorrhagic gastroenteritis, fever, abortion, and high mortality in small ruminants (Terpstra, 1969). Typically, diarrhoea starts one to three days after the onset of fever and gets worse as the illness progresses. Animals that are pregnant frequently have abortions. However, some sick animals survive for up to 11 days. Death usually occurs 2–7 days after the initial clinical signs, with some animals dying before the typical clinical signs develop. In the later stages of the illness, dehydration and debilitation from diarrhoea are typically associated with death. In animals with severe clinical

symptoms, the prognosis is poor (Spickler, 2022). Additionally, some animals have a blood-stained mucopurulent or serosanguineous nasal discharge, and the superficial prescapular and precrural lymph nodes are frequently palpable. There may also be conjunctivitis (OIE, 2016).

2.1.5.3 Diagnosis of NSD

During the initial febrile stage, NSDV virus can be isolated from live animal plasma (uncoagulated blood), but once the body temperature drops, little to no virus can be detected in the blood (Sally, 2019). Virus can be found in the spleen and mesenteric lymph nodes at necropsy. For virus isolation, a variety of cell lines, in particular BHK-21-C13 or BSR cells, can be used. The virus can then be identified using RT-PCR, immunofluorescence to check for viral antigens, or other methods. Some laboratories use RT-PCR for diagnosis, and it has been claimed that this technique can find viruses in blood even after the animal's temperature has returned to normal. Antigens can be found in clinical samples (such as spleen and mesenteric lymph nodes) by agar gel immunodiffusion, and an ELISA has been published in the literature. Currently, no commercial tests are available to identify viral antigens. Antibodies to the NSDV virus have been found using a variety of serological techniques. A rising titer should be detected using paired serum samples (Iowa State University, 2016). The OIE states that ELISAs can also be used, however indirect immunofluorescence is the most suitable assay. Complement fixation and indirect hemagglutination have also been used, even though

seldom, virus neutralisation antibodies are usually difficult to demonstrate (Iowa State University, 2016).

2.1.6 Brucellosis

In the Mediterranean region, brucellosis is a common disease and a significant zoonotic risk. Particularly in the Middle East, Arabian Gulf, and Mediterranean, *Brucella melitensis* is a reemerging pathogen. The infection severely infects livestock and has a detrimental effect on developing countries' economies (Radostits *et al*., 2007). Brucellosis control has made significant progress, but it still poses a serious risk to the public's health and is very costly (Rossetti *et al*., 2017).

A Gram-negative bacteria belonging to the genus Brucella is responsible for brucellosis. These microorganisms are intracellular, non-motile, facultatively anaerobic coccobacilli. Numerous mammals, including humans, sheep, camels, cattle, goats, swine, and wildlife, are susceptible to brucellosis (Godfroid, 2017; Kandeel *et al*., 2014). Three Biovars are visible in the pathogen and they are pathogenic to small ruminants, however they are distributed differently geographically. While Biovar 2 predominates in Turkey and Saudi Arabia, Biovar 1 is more prevalent in Libya and Oman. The three countries that Biovar 3 occurs most frequently are Egypt, Jordan, and Tunisia.

2.1.6.1 Transmission of Brucellosis

Brucella typically spreads among animals through contact with birthing tissues and fluids that are infected (e.g., placenta, aborted foetuses, foetal fluids, vaginal

discharges). The bacterium can also be detected in affected animals' milk, blood, urine, and semen. Animals can contract the bacterium through oral consumption, direct contact with mucous membranes (eyes, nose, and mouth), or skin breaches. Infected items (fomites) including equipment, clothing, shoes, hay, feed, or water can also spread Brucella. Some animals carry the germs but don't exhibit any signs of illness. For extended periods of time, these animals can shed the bacterium into the environment, infecting other animals in the herd (Iowa State University, 2008).

The most typical way for humans to become infected is via ingesting unpasteurized/raw dairy products, according to the CDC (2019). Infection will spread to individuals who consume milk and/or cheese products produced from infected animals if the milk is not pasteurised (CDC, 2019). Infection may also result through breathing in the bacteria. People who work with the bacteria in laboratories are typically at higher risk. Employees who work in slaughterhouse and meat packing factories have also been reported to come into contact with the bacteria and get infections. By coming into contact with animals that are infected, bacteria can potentially enter wounds in the skin or mucous membranes. This presents a challenge to those who work closely with animals or animal waste (newborn animals, foetuses, and excretions that may result from birth) (CDC, 2019).

2.1.6.2 Clinical signs of Brucellosis

Abortions, stillbirths, and the birth of underdeveloped offspring are the main signs in sheep and goats that are naturally infected. Aborted animals might retain the placenta.

Sheep and goats typically only have one abortion, but subsequent pregnancies may result in uterine reinvasion and organism shedding (Ashraf *et al*., 2015). Despite shedding the organism, some affected animals carry their pregnancies to term. Animals who have an abortion as well as those whose udders get infected after a normal birth have significantly lower milk yields. However, clinical signs of mastitis are uncommon. Males can develop acute orchitis and epididymitis, which result in infertility. Both sexes can occasionally develop arthritis (Nicoletti, 2013). Many sheep and goats that are not pregnant are still asymptomatic. From the perspective of public health, brucellosis is crucial. Undulant fever, an acute febrile illness that can progress to a more chronic state and cause serious complications affecting the musculoskeletal, cardiovascular, and central nervous systems, is frequently contracted by humans through direct animal contact or consumption of contaminated dairy products (Mantur *et al*., 2007). It is a well-known occupational disease that affects shepherds, people who work in abattoirs, veterinarians, dairy sector professionals, and those who work in labs (Agasthya *et al*., 2007).

2.1.6.3 Diagnosis of Brucellosis

In most cases, Rose Bengal Plate Test (RBPT) is used in conjunction with indirect enzyme-linked immunosorbent assay (i-ELISA) for brucellosis field screening (Shuaib *et al*., 2018). For the best diagnosis and control, better methods combined multiple serological tests with molecular detection and culture (El-Sharkawy *et al*., 2019). The limits of conventional detection techniques can be overcome by rapid, sensitive, and highly specific nucleic acid amplification techniques like the polymerase chain reaction

(PCR) (Elfaki *et al*., 2005). Additionally, some bacterial infections, such *Chlamydia abortus*, interfere with brucellosis in small ruminants (Bhandi *et al*., 2019). A new PCR technique for diagnosing brucellosis has high specificity and sensitivity (Kaden *et al*., 2017). The method can also be used to detect brucellosis in milk and milk products (Shakerian *et al*., 2016).

2.1.7 Peste des petits ruminants

Peste des petits ruminants (PPR) is a fatal viral disease that affects wild small ruminants as well as sheep and goats (Furley *et al*., 1987). The causal agent is *Peste des petits ruminants virus,* which belongs to the genus Morbillivirus of the family Paramyxoviridae. It is believed to also happen in camels (Roger *et al*., 2001). PPR is most often a "stomatitis-pneumoenteritis complex" syndrome, contradicting Gargadennec and Lalanne (1942) description of the condition as having rinderpest-like symptoms. It is a significant infectious viral disease of domestic and wild small ruminants that threatens food security and farmers' ability to maintain a sustainable way of life throughout Asia, Africa, and the Middle East (Banyard *et al*., 2010).

The genome of the *peste des petits ruminants virus* has six transcriptional units in the sequences 3′ N, P, M, F, H, and L5′ that encode for the six proteins N, P, M, F, H, and L. (Bailey *et al*., 2007). Using different start codons and RNA editing, respectively, the P open reading frame is used to produce two additional non-structural proteins, C and V (Mahapatra *et al*., 2003). Peste des petits ruminants virus primarily affects sheep and

goats, with few cases of disease outbreaks in camels (Roger *et al*., 2001, Saeed *et al*., 2004, Khalafalla *et al*., 2010, Kwiatek *et al*., 2011b).

2.1.7.1 Transmission of PPR

Virus can be transmitted to close-in-contact susceptible animals via exhaled aerosol or clinical excretions (lacrimal, nasal, saliva, faeces) from infected animals. The virus is sensitive to temperature and easily becomes inactive in a dry environment (Rossiter and Taylor, 1994). There is no known carrier state since infected animals that recover from the disease develop a lifelong protective immunity (Hamdy *et al*., 1976). However, viruses can spread in animals suffering from a mild disease, causing outbreaks of disease when populations with weak immune systems interact with those who are infected and suffering from a mild form of disease (Couacy-Hymann *et al*., 2007b, Banyard *et al*., 2014). The development of a disease may also be influenced by additional host characteristics, such as age, sex, breed, or season.

2.1.7.2 Clinical signs of PPR

Although goats and sheep are the virus's main hosts, goats appear to be more prone to disease than sheep (Nanda *et al*., 1996), with some goat breeds being thought to be more susceptible than others (Couacy-Hymann *et al*., 2007a). The disease usually takes 4-6 days to incubate, although it can take anything from 3 to 14 days. Animals exhibit pyrexia (up to 41°C) during the acute stage of the disease, which can last for three to five days and be accompanied by depression, anorexia, and dryness of the muzzle. Watery

nasal and lachrymal discharges gradually become mucopurulent with excessive salivation. Oral lesions that have developed over time may become necrotic. When the disease is severe, a deposit of fibrin (caseous deposit) appears on the tongue as these necrotic lesions progress. In later stages of the disease, animals develop diarrhoea and coughing with laboured, abdominal breathing. The animal might then develop dyspnea, lose weight over time, become emaciated, and eventually die. Within 10 to 15 days of infection, animals may convalesce and regain their pre-infection health in some circumstances, especially in mild infections. With a high case fatality rate in the acute stage of the disease, the morbidity rate can exceed 100%. (Pope *et al.*, 2013). The virulence of the virus strain and the condition of the infected animal's immune system can have a significant impact on the clinical signs and mortality described above (OIE, 2012).

2.1.7.3 Diagnosis of PPR

Antibody to PPRV detection is often done using ELISA methods. Currently, the OIE advises using virus neutralisation assays (FAO, 1996) and competitive PPRV-specific anti-H monoclonal based ELISA (cH-ELISA) (Anderson & McKay, 1994). The indirect ELISA (Ismail *et al.*, 1995), immunofiltration (Dhinakar Raj *et al.*, 2008), a novel sandwich ELISA (Saravanan *et al.*, 2008), haemagglutination tests (Dhinakar Raj *et al.*, 2000; Ezeibe *et al.*, 2008), and latex agglutination tests (Keerti *et al.*, 2009) are a few alternatives that are available (Libeau *et al.*, 1995; Choi *et al.*, 2005).

The "gold standard" test for disease diagnosis is virus neutralisation, albeit it is a time-consuming procedure that needs tissue culture facilities. For the detection of

antibodies, a commercially available competitive ELISA based on either the H or N protein is used, and RT-PCR, particularly real-time RT-PCR, is frequently used to detect nucleic acid. Last but not least, a pen-side test using an immunochromatographic lateral flow device has been created using a monoclonal antibody that is specific to the virus H protein (Bruning-Richardson *et al*., 2011). Recent field testing has validated this test for detection up to 4 days after infection, prior to the onset of severe clinical symptoms (Baron *et al*., 2014b).

2.1.8 Sheep pox/Goat pox

According to Buller *et al*. (2005), sheep pox and goat pox (SGP) viruses belong to the Poxviridae family, Chordopaxvirinae sub-family, and Capripox virus genus. These are large, enveloped, and double-stranded DNA viruses (Tulman *et al*., 2002). The nucleotide identities of the SGP and lumpy skin disease (LSD) viruses are 97% similar (Bhanuprakash *et al*., 2006). The genomes of SGP viruses, on the other hand, have certain nucleotide variations that show they are phylogenetically different and that both of them likely derived from an LSDV-like virus. Aspartic acid at position 55 of P32 in the SP virus is one of the most significant differences amongst SGP viruses since it is absent from that position in the other members of the genus. Because they include lipids, capripox viruses (CaPVs) are vulnerable to a variety of disinfectants, lipid solvents, and acids (Tulman *et al*., 2002; Hosamani *et al*., 2004; AHA, 2011). Orthopoxviruses and CaPVs cannot be easily distinguished morphologically. These viruses are susceptible to

highly acidic or alkaline pH; for instance, 2% HCl or H_2SO_4 can destroy these viruses entirely within 15 minutes (OIE, 2014).

2.1.8.1 Transmission of SGP

The virus enters through the respiratory system, and the most common method of transmission is an aerosol infection brought on by close contact with infected animals. Additionally, contamination can spread through contact with contaminated objects, and through skin abrasions by insect bites or iatrogenically. However, there is no proof that this method of transmission is significant in the field. Because it is challenging to recover live virus on tissue culture from scabs materials, it is thought that although viruses are shed in the secretions and excretions of infected animals, they are not significant sources of transmission during outbreaks. SGP viruses spread mostly through the movement of infected animals (Kitching, 2004; Radostits *et al*., 2006; AHA, 2011). Infected animals shed infectious virus and viral DNA at their highest levels between 1-2 weeks after inoculation, and this secretion persisted for an additional 3-6 weeks (Kitching *et al*., 1989; Bowden *et al*., 2008). One of the crucial vectors for SGP viruses is thought to be the species *Stomoxys calcitrans*. Goats that are susceptible could contract the pox virus from previously infected flies (Bhanuprakash *et al*., 2006).

2.1.8.2 Clinical signs of SGP

The swelling of the nostrils is typically the first sign of the disease, which is then accompanied by thick nasal discharges and watery ocular discharges. Infected animals

have high body temperatures (41 and 42°C), and keratitis might result (Daoud, 1997). The malignant form of SP has been identified as the most common type in lambs. High temperature, severe depression, prostration, and nasal and ocular secretions are all observed. Un-wooled skin, as well as the mucosa of the digestive, respiratory, and urogenital tracts, develop lesions. They start off as papules, progress to nodules, occasionally to vesicles, pustules, and lastly to scabs. Rarely, but occasionally, this type of disease has been associated with pox lesions in the heart muscles. In the benign type, which affects adults more frequently, just skin lesions develop, especially under the tail, and there is no systemic reaction, and animals recover in 3 to 4 weeks. Complications include abortion and secondary pneumonia (Radostits *et al*., 2006; Iran Veterinary Organisation, 2014).

2.1.8.3 Diagnosis of SGP

Clinical signs and laboratory confirmation are required for the diagnosis of SGP. Initially, the main test for identifying these viruses was the agar gel precipitation test. As time has gone on, the usage of soluble virus antigen fractions has been incorporated, and many tests and modifications of them have been created (Rao *et al*., 2000). The important laboratory diagnostic procedures for these diseases include histopathology, electron microscopy, and virus detection. In skin biopsies, significant numbers of distinctive "SP cells" with inclusion bodies and typical capripox virions can be observed using electron microscopy. Before neutralising antibodies develop, virus detection can be done. The virus can be cultured in tissue culture, but the time it takes for virus cytopathic effects to

develop and the requirement, with some strains, for several blind passages before this develops, limit virus isolation as a technique of rapid diagnosis. The presence of the pox virus in the oedema fluid is determined via a direct fluorescent antibody test, and the antigen can be found in lymph gland biopsies by ACID employing specific immune sera. There is additionally an ELISA for antigen detection (Radostits*et al*., 2006; AHA, 2011). Due to its high contagiousness, SGP necessitates immediate and precise laboratory confirmation. Zheng *et al*. (2007) described duplex PCR assay which can be finished in less than 5 hours and offers significant cost, material, and time savings.

2.1.9 Schmallenberg virus

German and Dutch dairy cattle were reported to have nonspecific clinical signs for a few days in the late summer and autumn in 2011 such as fever, decreased milk output, and diarrhoea. While several viruses that cause well-known endemic and emerging diseases were ruled out as the cause, metagenomic analysis discovered a hitherto unknown orthobunyavirus. Following its isolation from the blood of an acutely diseased cow kept in the German town of Schmallenberg, the virus was given the name Schmallenberg virus (SBV) (Hoffmann *et al*., 2012). SBV is a member of the Simbu serogroup within the genus Orthobunyavirus (family Bunyaviridae) (Hoffmann *et al*., 2012). *Orthobunyaviruses* are divided into 18 serogroups, and SBV belongs together with Akabane virus (AKAV), Aino virus (AINOV), Simbu virus, Douglas virus, and Sathuperi virus to the Simbu serogroup (Goller *et al*., 2012, Yanase *et al*., 2012).

SB virions are spheric enveloped particles with short surface projections and thin filamentous nucleocapsid strands, just like common species of the Bunyaviridae. Orthobunyaviruses have three segments in their negative-stranded, tripartite RNA genomes: a small (S), a medium (M), and a large (L). The nucleocapsid (N) protein and a small non-structural protein (NSs) are encoded by the S-segment, the glycoproteins Gn and Gc as well as non-structural protein (NSm) are encoded by the M-segment, and the RNA-dependent RNA polymerase is encoded by the L-segment (Walter and Barr, 2011, Chowdhary *et al*., 2012).

2.1.9.1 Transmission of SBV

Bunyaviruses linked to human and animal diseases are frequently spread in Asia and Africa by insect vectors such as mosquitoes and biting flies (*Culicoides spp.*). It was immediately apparent that *Culicoides spp.* play a role in SBV transmission after it was discovered (Rasmussen *et al*., 2012). SBV genomic sequences were found in biting flies, specifically the Ceratopogonidae family's *Culicoides obsoletus* species group. It was also demonstrated that several Culicoides species, including *Culicoides dewulfi*, *Culicoides chiopterus*, *Culicoides punctatus*, and others, were positive for SBV genomic markers. During the first and early second trimesters of gestation, vertical transmission of SBV from an infected dam to foetus causes abortion, stillbirth, and the birth of newborns with malformations (Bilk *et al*., 2012; Wernike *et al*., 2014). Direct transmission of SBV from infected ruminants to naive animals by contact or oro-nasal/feco-oral routes has not been documented (Wernike *et al*., 2013), despite the fact that experimentally infected animals

shed SBV RNA in faeces, oral, and nasal fluids (Wernike *et al*., 2013). Both nasal and oral inoculations of sheep and cattle, respectively failed to result in viremia in the animals (Wernike *et al*., 2013). Surprisingly, SBV was found in the semen of infected bulls (Schulz *et al*., 2014), but transmission of SBV from infected bulls to dams by natural mating or artificial insemination has not yet been thoroughly studied (Schulz *et al*., 2014).

2.1.9.2 Clinical signs of SBV

The majority of SBV infections in adult sheep and goats are subclinical. There have been a few reports of clinical disease in adult animals (6% cattle, 3% sheep, and 1% goats), yet acute clinical cases of SBV are uncommon (Afonso *et al*., 2014). Reduced milk production and diarrhoea in goats have at least once been documented (Helmer *et al*., 2014). There have been reports of fever, diarrhoea, and decreased milk production in sheep despite the fact that the causal relationship has not yet been conclusively proved (Afonso *et al*., 2014). When SBV infects cattle and sheep, the clinical results of abortion, stillbirth, and deformed newborns are similar to those seen with other Simbu serogroup viruses including Akabane and Aino (Luttikholt *et al*., 2014; Lievaart-Peterson *et al*., 2015). The musculoskeletal deformities arthrogryposis, lordosis, scoliosis, torticollis, and brachygnathia inferior are frequently seen in foetuses during transplacental infection (Tsuda *et al*., 2004; De Regge., 2017).

2.1.9.3 Diagnosis of SBV

Real-time reverse transcription polymerase chain reaction (RT-qPCR) assays based on the L- or S-segment are the most common methods for viral detection (Bilk *et al*., 2012, Hoffmann *et al*., 2012). Additionally, SBV can be isolated on insect, hamster or African green monkey cell lines (Hoffmann *et al*., 2012; Wernike *et al*., 2013b). Micro-neutralization, indirect immunofluorescence tests, and commercially available ELISAs are test techniques used to detect antibodies. These procedures can be used to test large populations and to perform seroepidemiological studies (Humphries and Burr, 2012; Loeffen *et al*., 2012; Breard *et al*., 2013). The results of neutralisation tests, however conducted with slight changes in procedure, were fully agreed among the participants of a limited ring trial among European laboratories. In comparison to numerous used ELISAs, the neutralisation test was slightly more sensitive (van der Poel *et al*., 2014).

2.1.10 Contagious ecthyma

Contagious ecthyma in ruminant animals is a zoonotic disease caused by the orf virus, a member of the genus *Parapoxvirus* and subfamily *Chordopoxvirinae* of the *Poxviridae* family (De la Concha-Bermejillo *et al*., 2003; Li *et al*., 2012). *Bovine papular stomatitis virus* (BPSV), pseudocowpox virus (PCPV), red deer Parapoxvirus of New Zealand (PVNZ), seal poxvirus, Auzdyk disease, and Chamois CE virus are other members of the genus Para poxvirus (Mercer *et al*., 1997; Moss, 2001; Delhon *et al*., 2004). According to numerous reports, CE is affecting new species of animals, indicating the variety of hosts caused by pathogen interactions (Fairley *et al*., 2008).

The DNA molecule of the contagious ecthyma virus is linear and double stranded. The ovoid, criss-cross-patterned DNA molecule of the Orf virus has a high G+C content of roughly 64% and a low A+T content (Delhon *et al*., 2004; Maor *et al*., 2017). The genome contains 132 putative genes, 89 of which are highly conserved and some of which are varied. While the conserved genes were located in the genomic centre region, the variable genes were primarily seen in the terminal end (Friederichs *et al*., 2014; Yogisharadhya *et al*., 2017). Some of these genes are typically linked to pathogenesis, immune response modulation, and virulence (Fleming *et al*., 2017; Peralta *et al*., 2018).

2.1.10.1 Transmission of CE

Epitheliotropic infection by contagious ecthyma proliferates and causes localised sores in skin cells (Nandi *et al*., 2011). Abrasion and cuts to the animal's skin often cause the lesions, providing a pathway for the viral infection (Moss, 2001). Contagious ecthyma can be transmitted through contaminated fomites, ear tagging equipment, dipping, or direct or indirect contact with infected animals (Allworth *et al*., 1987; Nettleton *et al*., 1996; Nandi *et al*., 2011). Contagious ecthyma can spread due to additional reasons like drenching, major and/or minor surgery, pregnancy, protracted chemotherapy, immunosuppression, and autoimmune disease (Hosamani *et al*., 2009). However, CE lesions have also been observed in humans who have been infected, typically as a single skin sore or a few noticeable lesions on the fingers or hand (Maor *et al*., 2017). There were additional reports of painful lesions with redness, inflammation, lymphadenopathy, and sores that looked like erysipelas (Georgiades *et al*., 2005). Once more, human cases

of immunosuppressed conditions that were also associated with fungus-like Orf lesions have been documented (Hsu CH *et al*., 2016). Despite being extremely rare, human to human CE transmission has still been documented (Khan *et al*., 2012).

2.1.10.2 Clinical signs of CE

Animals can contract CE, which is contagious worldwide. Even though it was clearly detected in other wild ruminant species, this disease primarily affects domesticated sheep and goats (Peralta *et al*., 2018; Tedla *et al*., 2018). It is zoonosis, according to many case reports from farmers, butchers, and other people who work in the livestock industry. The characteristic of CE is the presence of acute cutaneous pustular lesions that often progress through several stages, from macule to papule to vesicle to pustule to scab development (Fleming *et al*., 2015; Peter *et al*., 2017). The skin, muzzle, tongue, ears, nose, and occasionally the eyelids may all experience the lesions, which can also be multifocal and extensive (Jesse *et al*., 2018). In some severe cases, the udders and genitalia were also affected (Maganga *et al*., 2016). Blisters frequently form during disease manifestation, break, and then develop into wet and dry scabs. Younger animals often die from starvation as a result of the affected animal's painful scabs on its mouth, lips, and tongue, which typically prevent it from eating (Nfi, 1991; Zamri-Saad *et al*., 1992; Bala *et al*., 2018a). Additionally, the mortality rate can increase to 90% in cases of secondary bacterial or fungal infections, especially in lambs and kids (Maganga *et al*., 2016; Gelaye *et al*., 2016; Fleming *et al*., 2017).

2.1.10.3 Diagnosis of CE

Agar gel immunodiffusion (AGID), agar gel precipitation test (AGPT), indirect immunofluorescence, ELISAs, complement fixation test (CFT), and serum neutralisation tests are serological testing that were found to be beneficial for CE diagnosis by detection of CE antibodies (Said *et al*., 2013, Bora *et al*., 2016). The animal is typically infected by the virus through wounds, abrasions, and scars that can be detected in the epidermal tissue (Mola, 2019). The following laboratory examinations, such as transmission electron microscopy (TEM) and histopathology, can also be used to identify clinical symptoms of CE (Nandi *et al*., 2011; Said *et al*., 2013; Bala *et al*., 2019a). Squamous epithelial cells show vacuolization of the keratinocytes, swelling and eosinophilic cytoplasm when observed under the microscope for histopathology and screening (Gumbrell and McGregor 1997).

Additionally, other PCR assays are currently used to detect CE viruses (Abdullah *et al*., 2015). PCR is a global molecular assay with a high acceptance level. Numerous researchers have used extensive PCR to characterise the partial nucleotides of the major envelope (B2L) gene (Guo *et al*., 2003; Zhang *et al*., 2010; Bora *et al*., 2012), F1L gene (Abdullah *et al*., 2015), and VIR gene (Kottaridi *et al*., 2006; Oem *et al*., 2009). B2L, F1L, and VIR are prominently considered as CE virus genes proving (Friederichs *et al*., 2014; Yogisharadhya *et al*., 2017).

2.2 Veterinary Research Institute (VRI) data

The Department of Veterinary Services, Perak collaborated with the Veterinary Research Institute (VRI), Ipoh, Perak on a high impact project (Small Ruminant Program) where the study's goal was to evaluate helminthiasis and blood protozoan infections in local smallholder farms in Perak between 2012 and 2013. The results of the studyshowed that of 218 faecal samples for parasites it was observed that coccidiosis infection (64.7%) and helminthiasis infection (37.9%), followed by *Moniezia sp.* (5.3%) infection, were the most commonly identified infections. According to a recent study by Chandrawathani *et al*. (2014), over an 80-year period the VRI diagnosed theileriosis infection among small ruminants is around 4%. *Haemonchus contortus, Trichostrongylus spp*., *Oesophagostomum spp*., *Cooperia curticei, Strongyloides papillosus, Paramphistomum spp*., and *Eurytrema pancreaticum* are the most prevalent gastrointestinal (GI) parasites reported in goats and sheep in Malaysia (Shanta, 1982; Sani *et al*., 1985; Sani *et al*., 1986; Amin-Babjee *et al*., 1990; Wahab and Adanan, 1993; Premaalatha *et al*., 2014). Recently, Tan *et al*. (2017) discovered GI parasites in which more than half of the collected samples were infected with strongyle with the prevalence of 57.7%. In Malaysia, one of the main causes of mortality and morbidity in small ruminants was gastrointestinal nematodiasis, which primarily refers to haemonchosis (Nor Azlina *et al*., 2011).

The Department of Veterinary Services Malaysia (DVS) has implemented preventative measures in accordance with the OIE's guidelines for managing Bluetongue outbreaks (BT). As BT must be reported to the OIE, it is included in the National Animal Disease Surveillance Program (DVS, 2011; DVS, 2014). The programme is one of the crucial elements in Malaysia's animal health activities and aids in identifying the control

and eradication of significant and reportable animal diseases to safeguard the nation's livestock industry and animal welfare (DVS, 2011). Samples for testing BTV antibodies in livestock animals in Peninsular Malaysia have been sent to VRI and this study has concluded that BTV still exists and is circulating among ruminant livestock.

Early in 2012, the Parasitology Section of the Veterinary Research Institute (VRI) discovered a trypanosomiasis outbreak. Trypanosomiasis, which is caused by *Trypanosoma evansi*, is endemic in Malaysia (Cheah, 1999). In early 2012, several livestock were found to have Surra. Trypanosomiasis in deer has been documented by Nurulaini *et al*. (2007).

2.3 Urban vs non-urban ruminant diseases reported

Ectoparasitism was more prevalent in the inland region of Kelantan (73.71%) than it was in the coastal region (50.71%) (Vivi *et al*., 2020). This research showed a statistically significant relationship in prevalence between different state regions. The presence of conserved forested areas, which offer favourable climatic and environmental conditions for ectoparasites to thrive, is linked to the high prevalence of ectoparasitism in the inland regions of Kelantan (Watanabe *et al*. 2016).

There is one study that investigated the prevalence, risk factors, and levels of infection with gastrointestinal coccidia and strongyle parasites in selected smallholder goat farms in the southwest coast of Peninsular Malaysia. The results revealed that various species of coccidia, cestodes, and strongyles were present in 78.6% of the sampled goats across all farms (Paul *et al*., 2020). The environment and management practices can be

used to explain the high incidence of parasites found in this study where high tropical temperatures, humidity, and rainfall are known to favour the epidemiology of parasites by ensuring optimal development of pre-parasitic stages of helminths and coccidia.

According to one study on *Rickettsia asembonensis* in small ruminants that was first reported in Malaysia, domestic animals (sheep and goats) may be a source of rickettsial diseases in Malaysia. The tropical climate of Malaysia promotes a favourable environment for the growth of ticks and fleas carrying the Rickettsia bacterium (Van *et al*., 2022). The local community, particularly agricultural workers and others who work with animals, are at risk from zoonotic diseases as a result of increased exposure to these vectors and their reservoirs. The competency of the goat and sheep as reservoirs of this new pathogen has not yet been determined by this preliminary study, but the molecular evidence of rickettsioses in these samples raises concerns about the complexity of the host-reservoir system of this bacterium (Van *et al*., 2022).

2.4 Reported studies by veterinary students

A retrospective study was conducted to determine the distribution of diseases of sheep and goats encountered at the State Veterinary Hospital, Maiduguri, between the years 2009 to 2013. A total of 1298 cases were documented during the time period. Disease occurrence was found to be higher in sheep than in goats. The most frequent diseases of sheep were parasitic, digestive and surgical conditions. Similarly, infectious

diseases, parasitic diseases and surgical conditions were encountered in goats (Innocent *et al*., 2015).

2.5 Malaysia study by veterinary students

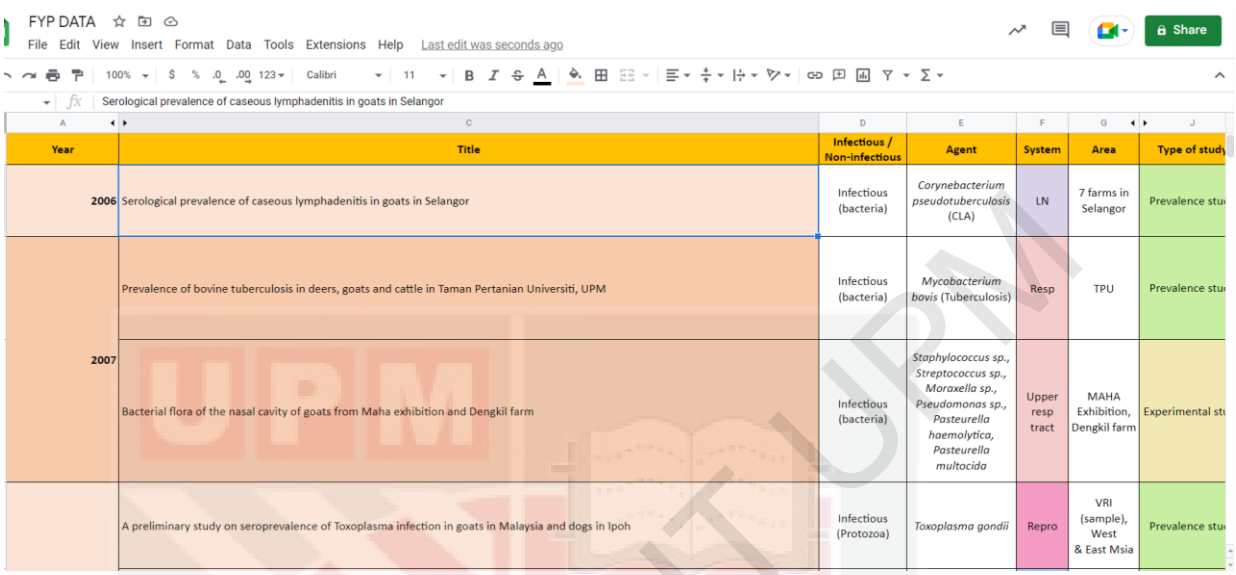
Currently, there is no study on trends of overall infectious and non-infectious diseases that was done by veterinary students in Malaysia. There is only one study reported on specific disease which is bovine brucellosis where the trends of this disease in Malaysia between 2000 and 2008 was reported by Mukhtar *et al*. (2013) where it showed that bovine brucellosis is widespread among herds in Peninsular Malaysia at a low within-herd seroprevalence rate. Another retrospective study on common health problems from twelve-year post-mortem records of ruminant cases was reported by Maisarah *et al*. (2019) where this study observed that circulatory system was the most common system affected, followed by respiratory and alimentary systems.

CHAPTER 3

MATERIALS AND METHODS

3.1 Case selection

Information was obtained from the Final Year Project (FYP) paper of Doctor of Veterinary Medicine (DVM) students from 2006 until 2021 (15 years) involving two veterinary faculties in Malaysia which are UPM and UMK, where infectious and non-infectious diseases of small ruminants were selected. The data was taken from theses stored at the Library of UPM and UMK. A table was created using Microsoft Excel Worksheet for data collection. Relevant available data were tabulated into the table. The data that were taken were based on two groups which are infectious and non-infectious diseases. Each group consists of several systems including respiratory, ocular, GIT, reproductive, integument, limb/hoof, blood, and lymph nodes. The agent, area of study, and type of study were also tabulated.



FYP DATA

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Serological prevalence of caseous lymphadenitis in goats in Selangor

Year	Title	Infectious / Non-infectious	Agent	System	Area	Type of study
2006	Serological prevalence of caseous lymphadenitis in goats in Selangor	Infectious (bacteria)	*Corynebacterium pseudotuberculosis* (CLA)	LN	7 farms in Selangor	Prevalence stu
2007	Prevalence of bovine tuberculosis in deers, goats and cattle in Taman Pertanian Universiti, UPM	Infectious (bacteria)	*Mycobacterium bovis* (Tuberculosis)	Resp	TPU	Prevalence stu
	Bacterial flora of the nasal cavity of goats from Maha exhibition and Dengkil farm	Infectious (bacteria)	*Staphylococcus sp., Streptococcus sp., Moraxella sp., Pseudomonas sp., Pasteurella haemolytica, Pasteurella multocida*	Upper resp tract	MAHA Exhibition, Dengkil farm	Experimental st
	A preliminary study on seroprevalence of Toxoplasma infection in goats in Malaysia and dogs in Ipoh	Infectious (Protozoa)	*Toxoplasma gondii*	Repro	VRI (sample), West & East Msia	Prevalence stu

Figure 1: Microsoft Excel Worksheet data tabulation

3.2 Statistical methods

Data of diseases in small ruminants, agents, system affected, area of study, and type of study will be analysed and summarised to obtain the distribution using bar graphs or pie charts. The data will also be analysed to answer the objectives and hypotheses of this study. In this study no comparison is made for the data studied in this study for the two veterinary faculties and this study was designed to obtain data studies that have been conducted previously according to the content of table stated above. The data will be presented as percentage (descriptive data).

CHAPTER 4

RESULT

4.1 Number of thesis studied in UPM and UMK from 2006 till 2021

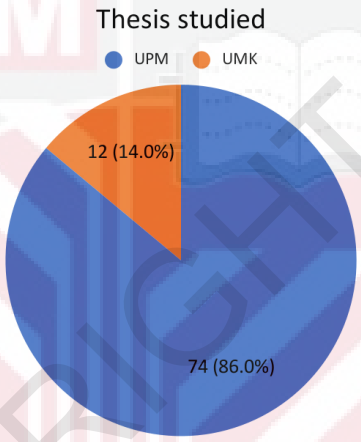

Figure 2: Number of thesis studied in UPM and UMK from 2006 till 2021

Overall, there are a total of 74 theses (86%) studied in UPM and 12 theses (14%) studied in UMK.

4.2 Systems affected by infectious agents in small ruminants in UPM and UMK

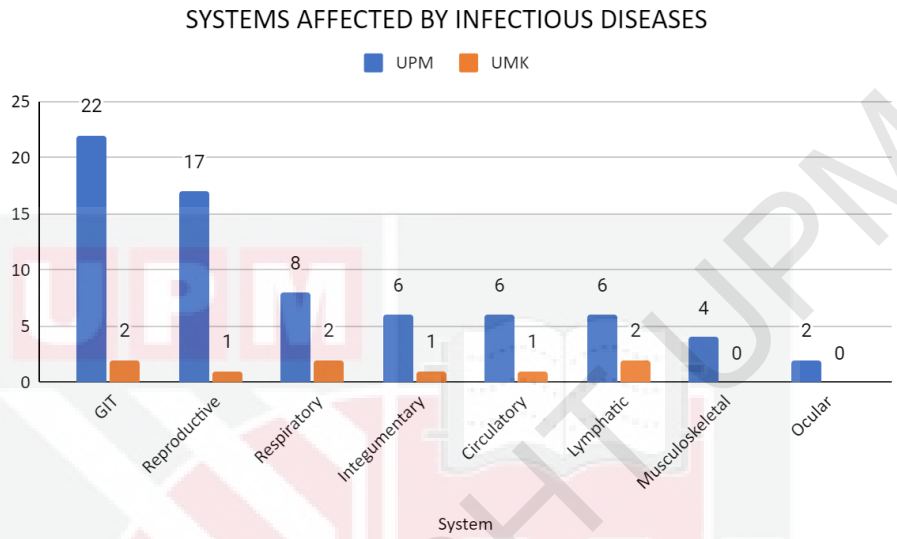

Figure 3: Number of systems affected by infectious agents in small ruminants in UPM and UMK

Based on Figure 3, according to theses studied in UPM, gastrointestinal tract has the highest number of studies [22 out of 71 studies (31%)], reproductive system recorded 17 out of 71 studies (23.9%), respiratory system has 8 out of 71 studies (11.3%), integumentary system has 6 out of 71 studies (8.5%), circulatory system also has 6 out of 71 studies (8.5%), lymphatic system has 6 out of 71 studies (8.5%) as well, musculoskeletal system has 4 out of 71 studies (5.6%), and ocular has 2 out of 71 studies (2.8%). In UMK, gastrointestinal tract recorded 2 out of 9 studies (22.2%), reproductive system recorded 1 out of 9 studies (11.1%), respiratory system recorded 2 out of 9 studies (22.2%), integumentary system recorded 1 out of 9 studies (11.1%), circulatory system recorded 1 out of 9 studies (11.1%), and lymphatic system recorded 2 out of 9 studies

(22.2%). There is no study done on musculoskeletal and ocular systems in UMK for the past 15 years.

4.3 Number of infectious agents in small ruminants in UPM and UMK

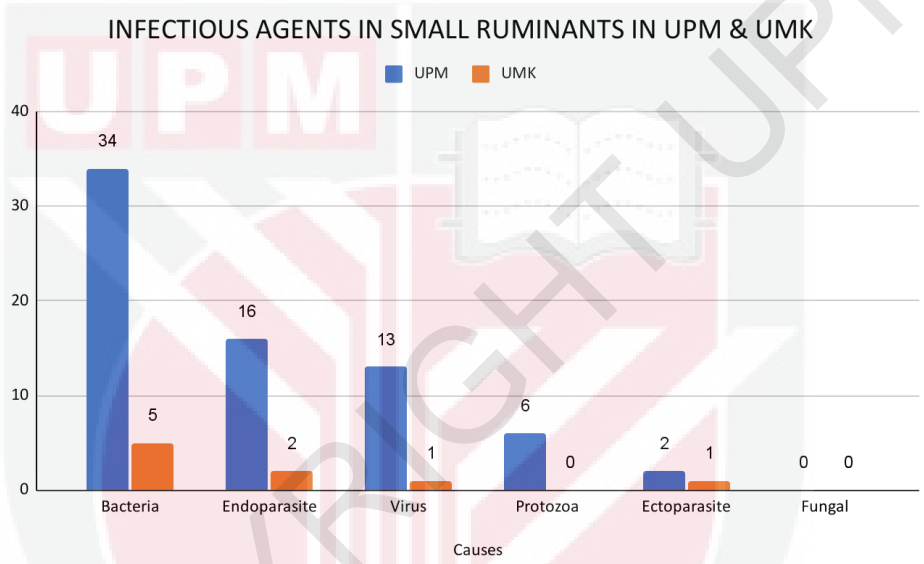

Figure 4: Number of infectious agents in small ruminants in UPM and UMK

71 infectious agents of small ruminant diseases were reported in UPM and 9 infectious agents in UMK from the year 2006 till 2021. As shown in the distribution graph above, data revealed that 34 out of 71 (47.9%) infectious agents studied in UPM were bacteria which indicates the highest number throughout 15 years, followed by endoparasite [16 out of 71 agents (22.5%)], virus [13 out of 71 agents (18.3%)], protozoa [6 out of 71 agents (8.5%)], and ectoparasite [2 out of 71 agents (2.8%)]. On the other hand, UMK recorded 5 out of 9 (55.6%) infectious agents were bacteria indicating the highest number

of agents that has been studied there, followed by endoparasite [2 out of 9 agents (22.2%)], virus [1 out of 9 agents (11.1%)], and ectoparasite which have the same number of studies [1 out of 9 agents (11.1%)]. There is no disease that was caused by protozoa studied in UMK. Both UPM and UMK had never studied on fungal diseases for the past 15 years.

4.4 Number of infectious agents (species) in small ruminants in UPM

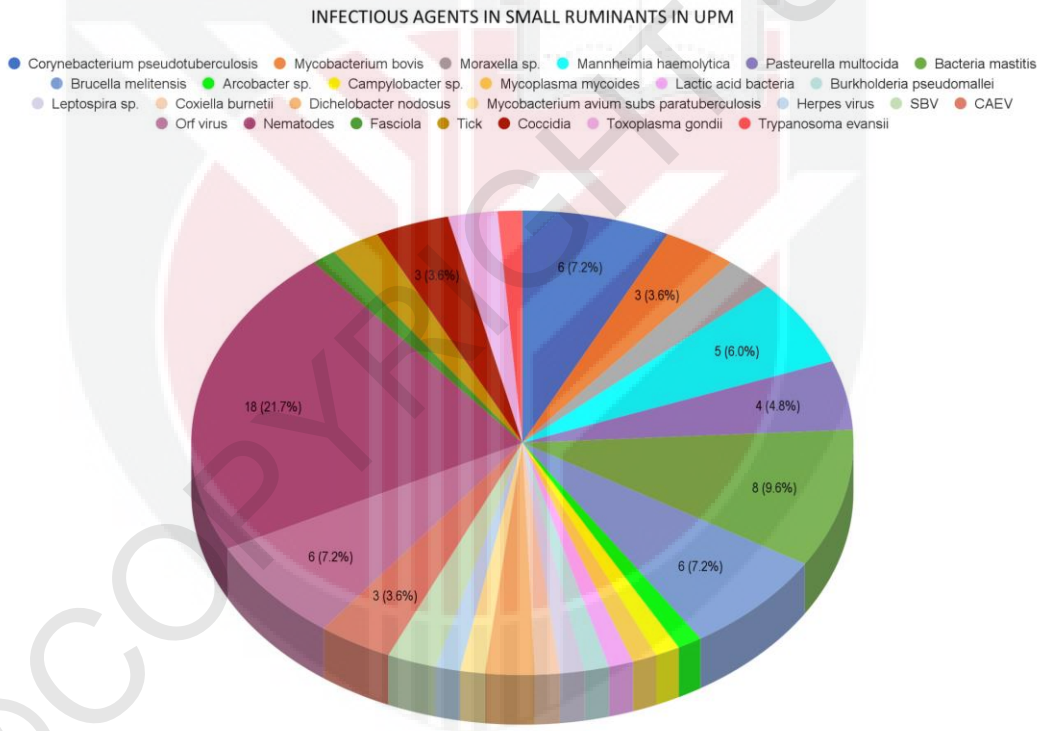

Figure 5: Number of infectious agents (species) in small ruminants in UPM

Total theses studied are 74 but the number of infectious agents covered in the studies are 83. Based on the pie chart above, 21.7% of 83 infectious agents affecting small ruminants

are *nematodes*, followed by bacteria mastitis (9.6% of 83 agents), *Orf virus* (7.2% of 83 agents), *Corynebacterium pseudotuberculosis* (7.2% of 83 agents), *Brucella melitensis* (7.2% of 83 agents), *Mannheimia haemolytica* (6.0% of 83 agents), *Pasteurella multocida* (4.8% of 83 agents), *Coccidia* (3.6% of 83 agents), *Mycobacterium bovis* (3.6% of 83 agents), *Caprine Arthritis-Encephalitis Virus* (CAEV) (3.6% of 83 agents), tick (2.4% of 83 agents), *Toxoplasma gondii* (2.4% of 83 agents), *Moraxella* sp. (2.4% of 83 agents), *Dichelobacter nodosus* (2.4% of 83 agents), *Schmallenberg virus* (SBV) (2.4% of 83 agents), *Fasciola* (1.2% of 83 agents), *Trypanosoma evansii* (1.2% of 83 agents), *Arcobacter* sp. (1.2% of 83 agents), *Campylobacter* sp. (1.2% of 83 agents), *Mycoplasma mycoides* (1.2% of 83 agents), lactic acid bacteria (1.2% of 83 agents), *Burkholderia pseudomallei* (1.2% of 83 agents), *E. coli* (1.2% of 83 agents), *Leptospira* sp. (1.2% of 83 agents), *Coxiella burnetii* (1.2% of 83 agents), *Mycobacterium avium subs paratuberculosis* (1.2% of 83 agents), and *Herpes virus* (1.2% of 83 agents).

4.5 Number of infectious agents (species) in small ruminants in UMK

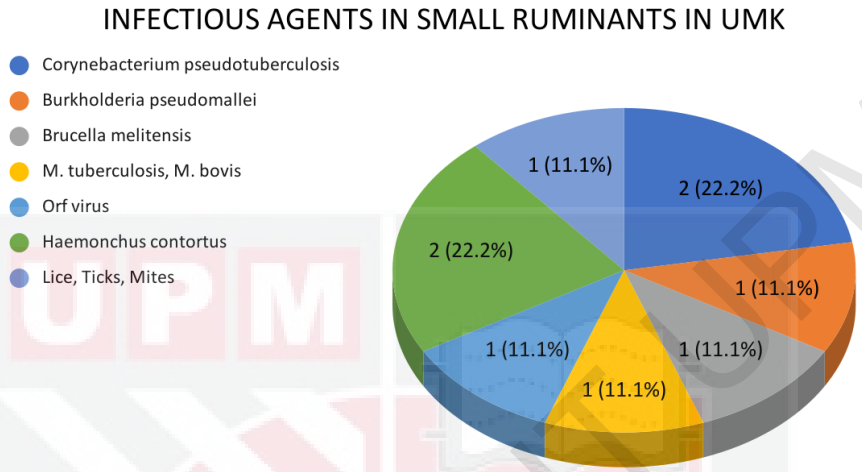

Figure 6: Number of infectious agents (species) in small ruminants in UMK

Figure 6 shows infectious agents in small ruminants according to FYP in UMK with a total of 9 agents. *Haemonchus contortus* and *Corynebacterium pseudotuberculosis* have the same number of cases (22.2% each), followed by lice, ticks, mites, *Orf virus*, *Burkholderia pseudomallei*, *Brucella melitensis*, and *Mycobacterium tuberculosis* and *M. bovis* which every of them recorded 11.1% cases.

4.6 Non-infectious causes in small ruminants in UPM and UMK

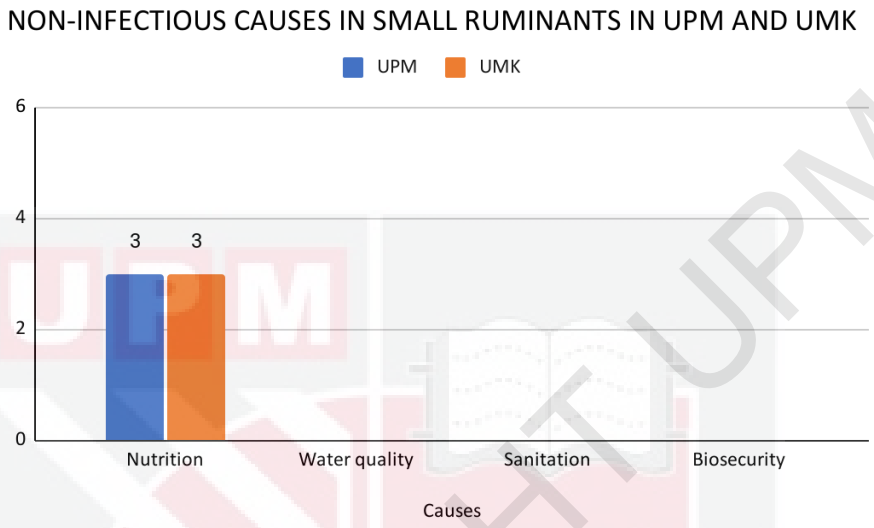

Figure 7: Number of non-infectious causes in small ruminants in UPM and UMK

Based on the graph above, there are 3 studies reported in UPM, and 3 studies reported in UMK. Both UPM and UMK reported studies on nutrition factor.

4.7 Geographical settings

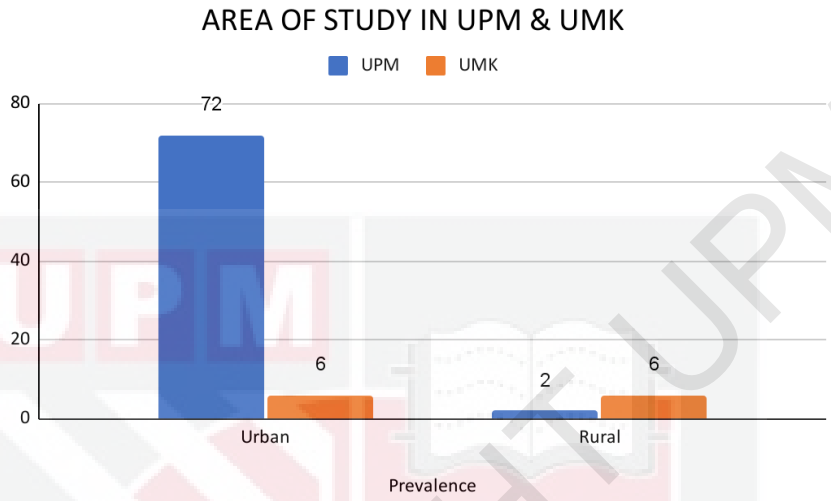

Figure 8: Prevalence of UPM and UMK study

As shown in Figure 8, 72 out of 74 (97.3%) of the reported small ruminant diseases studies in UPM were done in urban areas and only 2 out of 74 (2.7%) studies were done in rural areas. In UMK, urban and rural areas have the same number of studies which are 6 out of 12 (50%).

4.8 Types of study in UPM and UMK

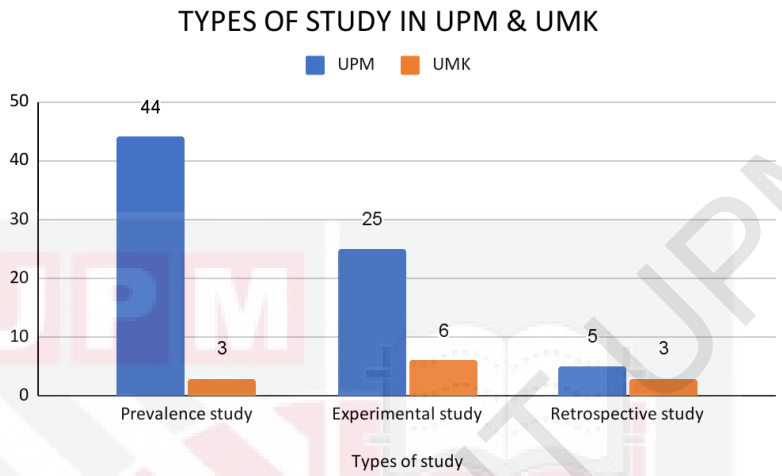

Figure 9: Types of study in UPM and UMK

The graph shows the number of types of study in UPM and UMK from 2006 until 2021. UPM recorded the highest number on prevalence studies [44/74 (59.5%)], followed by experimental studies [25/74 (33.8%)], and retrospective studies [5/74 (6.8%)]. Meanwhile, the highest number of studies in UMK is experimental studies which is 6 out of 12 studies (50%). Retrospective and prevalence studies recorded the same number which are 3 out of 12 (25%).

CHAPTER 5

DISCUSSION

According to Jesse *et al*. (2020), major outbreaks of transboundary animal diseases and zoonotic diseases have caused devastating economic losses for the small ruminant industry. In this study, the majority of diseases studied were infectious diseases which recorded 96% in UPM and 75% in UMK during the past fifteen (15) years of study. For non-infectious diseases, there are only 4% studies in UPM and 25% in UMK. This proves that people studied more on infectious diseases compared to non-infectious diseases in small ruminants. This study is in agreement with Lesley *et al*. (2017) where they stated that humans have been concerned on ways to stop and cure infectious diseases for thousands of years. Most farmers think that infectious diseases are more important compared to non-infectious diseases as they can be transmitted to other animals which leads to production loss especially those diseases that have high mortality rate. Besides, they also can be a zoonotic potential which can harm the farmers and workers.

Findings in this study showed that gastrointestinal tract is the most common system that has been studied in UPM while in UMK, the same trend was shown. This shows that infectious and non-infectious gastrointestinal tract (GIT) illnesses are quite prevalent in small ruminants (Jenna and Misty, 2020). This is the reason why farmers are more concerned about gastrointestinal diseases compared to other systems. Moreover, the diagnostic procedure for GIT disease is simple because the samples taken are only faecal

samples and it is easy to conduct such as faecal egg counting and faecal cultures. Faecal egg counting is the most common ante mortem means of diagnosis of nematodes and it is a cheap and easily performed technique (Lughano and Dominic, 1996).

The highest agents covered in this study are bacteria for both vet schools, UPM and UMK. Findings from this study showed that the most common disease that was caused by bacteria that had been studied is caseous lymphadenitis. According to Lisa (2001), this disease is common in a herd or flock because it is difficult to eradicate by virtue of its poor response to therapeutics, its ability to persist in the environment, and the limitations in detecting subclinically infected animals. Besides, according to Kumaragurubaran and Manimuthu (2021), stated that among the various infectious diseases, diseases caused by bacterial pathogens contribute to severe economic loss to the goat farmers. Various factors such as increased in herd size, reduced ventilation in farms and poor husbandry practices can predispose to bacterial diseases.

The non-infectious diseases that have been studied in both veterinary schools (UPM & UMK) are due to nutrition factors. This study is in agreement with Lughano and Dominic (1996) which stated that the major non-infectious cause of unthriftiness in goats is malnutrition. According to Abecia *et al*. (2006), malnutrition has a prominent impact on reproductive function. Besides, an adequate mineral supplementation is key to prevent the effects of copper, selenium, and other micronutrients deprivation, which may include, among others, loss of condition (Javier *et al*., 2021).

In UPM, the highest number of studies that have been done is prevalence study. Prevalence studies are often used as a baseline measurement for the monitoring of control

programmes. For example, prevalence of bovine tuberculosis in deers, goats and cattle in Taman Pertanian Universiti, UPM was done. This will aid the researcher to plan in controlling the disease outbreak. Besides, prevalence study will help them to identify strategies that could increase the proportion of cases that are diagnosed, allow for earlier diagnosis and higher-quality treatment, and improve the proportion of bovine tuberculosis cases being captured by routine surveillance data. In UMK, the highest number of studies that have been done there is experimental study. This is because UMK veterinary school was just established in 2014 which means they would focus more on experimental studies first rather than prevalence and retrospective studies. Usually, the researchers want to discover the cause and effect among variables and they can further analyse relationships through testing. It helps researchers understand a specific environment fully. Moreover, the studies can be replicated so that the researchers can repeat their experiments to test other variables or confirm the results again.

Most studies in UPM were done in urban areas. This is because most of the FYP students in UPM chose urban areas to do their projects as these areas are much easier to access. It is also easier to find accommodation compared to rural areas. Studies in UMK showed the same trend in which the number of studies in urban and rural areas are the same. However, the number of studies in rural areas are much higher compared to UPM. This is because most of the students there did their projects in that state itself and there are many rural areas in Kelantan such as Pasir Puteh, Tumpat, Machang, Gua Musang, Jeli, and Kuala Krai.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

In conclusion, from this study the data on infectious and non-infectious diseases in small ruminants were tabulated and analysed. Therefore, the objectives of this study were achieved where the trends of infectious and non-infectious caused disease studies were identified and focal studies at different geographical settings were determined. The outcome from this study will aid the researcher to strategize the upcoming research in this field and the data from this research will be used in teaching and learning for ruminant disease subject and clinical ruminant rotation.

In future studies, it is recommended to expand the area for data collection and include more farms from rural areas because disease can happen anywhere regardless of the place. To ease data collection, it is good to advise all researchers to include species of animal in the thesis title.

CHAPTER 7

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