CLINICOPATHOLOGIC SURVEY AND PREDISPOSING FACTORS OF DISEASES OF DOMESTIC RABBITS IN SELECTED AREAS IN KENYA

A thesis submitted in partial fulfillment of requirements for Masters of Science degree of the University of Nairobi (Clinical Pathology and Laboratory Diagnosis)

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DECLARATION

This thesis is my original work and it has not been presented for award of a degree in any other university.

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DEDICATION

This thesis work is dedicated to my family and friends. Special gratitude to my loving parents, sisters and brothers for the encouraging words during the study. Special thanks go to Velma and Tamara for being there for me throughout this period.

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LIST OF ABBREVIATIONS

APD - Animal production division

ARRP - Animal research review panel

BA- Blood agar

E.P.G. - Eggs per gram of faeces

EDTA - Ethylene diamine tetra acetic acid

EFSA - European Food Safety Authority

FAO – Food and Agriculture Organization of the united nation

GOK- Government of Kenya

H & E- Hematoxylin and eosin stain

IMVIC - Indole, methyl red, voges proskeur and citrate test

KOH - Potassium hydroxide

KES – Kenya shillings

MAC- MacConkey agar media

MOLD - Ministry of livestock development

MPRA - Munich Personal RePEc Archive

MSA - Mannitol salt agar

O-F - Oxidative-fermentative tests

OPG - Oocysts count per gram of feaces

SAS - Statistical Analytical System

SDA - Sabouraud dextrose agar

SIM - Sulphur indole motility test

TSI - Triple sugar iron agar slants

Baso – Basophils

Eosin –Eosinophils

Hb -Hemoglobin

Lymph- Lymphocytes

Mono - Monocytes

MCH- Mean corpuscler hemoglobin

MCHC- Mean corpuscler hemoglobin concentration

MCV- Mean corpuscler volume

Neut.- Neutrophils

PCV – Packed cell volume

RBC – Red blood cells

THROM.- Thrombocytes

WBC- White blood cells

ABSTRACT

A cross sectional study was used to obtain data from sixty one (61) randomly selected rabbit farms in Nairobi, Central, Eastern and Rift valley regions of Kenya in order to characterize production systems and determine the etiology and predisposing factors of diseases that affect rabbit production. Observational assessments and questionnaire interviews were used to determine factors of diseases in the study areas. A total of 2,680 live rabbits, 320 swabs, 363 fecal samples, 120 blood smears and 21skin scrapings were collected from randomly selected rabbits and examined for etiological agents of disease. In addition, 61 live rabbits were transported to the laboratory for further investigations such as blood smear examination, necropsy, Bacteriology, Mycology and Parasitology.

Results showed that rabbit production system in the study areas is small scale commercial. Cross breeds (83.61%) were the frequently kept rabbit breeds, while grass, kale and cabbage were the common forages used to feed these rabbits in 85.25% farms. Housing systems comprising of indoor and outdoor systems were significantly different within and between the counties ($P<0.01$). The majority (42.62%) of the rabbit farms had good sanitation, while 8/61 (13.11%) and 6/61 (9.825%) farms had poor and very poor sanitation scores respectively.

The profile of diseases of rabbits recorded were mainly those of digestive system 40/61 (65.57%). Diseases affecting the cutaneous system were as frequent as those affecting the eyes and ears with a prevalence of 27.87% each.

Enteritis (29.51%) and hepatic coccidiosis (11.48%) were the frequently encountered digestive conditions during post mortem examination, while the prevalence of mange and ear canker were 27.87% and 16.39% respectively. The etiological agents identified as the causes of digestive

conditions were; intestinal coccidia (90.16%), hepatic coccidia (11.48%) and *Passalurus ambiguus* (3.28%). *Sarcoptes scabie* and *Psoroptes cuniculi* were identified from rabbits with mange and Ear canker respectively. Mixed infection of *Staphylococcus aureus, Pseudomonas aerogenosa, Proteus mirabilis and Streptococcus* species were identified from abscess swabs, while *Pasteurella multocida, Pseudomonas aeroginosa* and *S. aureus* were identified as the major etiological agents of pneumonia (14.75%). The frequently identified bacteria from conjuctival (95.83%) and nasopharyngeal (91.67%) swabs were non-pathogenic *Staphylococcus, Escherichia coli* and *S. aureus. Microsporum canis* was identified as the cause of dermatophytosis (3.28%). Isolation of zoonotic etiological agents (*S. aureus, P. aerogenosa*, and *Streptococcus* species) of rabbit diseases confirms the zoonotic health significance of some of the rabbit diseases identified in this study. This study could not reveal specific causes of conditions such as emaciation (14.75%), Sore hock (3.28%), splay leg (1.64%) and cannibalism (1.64%).

From the study it was concluded that diseases of domestic rabbits in Kenya are similer for all the regions except for pneumonia which were frequently encountered in Kiambu and Meru counties ($P = 0.0183$). High numbers of coccidia oocysts were frequently recovered from weaners ($P < 0.001$) and rabbits kept in crowded housing ($P = 0.0293$) while, poorly maintained old hutches was a risk factor to ear canker ($P = 0.0046$). Cold climate also predispose rabbits to pneumonia ($P = 0.0183$). Presence of potential pathogens including coccidia and bacteria are also risk factors to diseases. The researcher recommends dissemination of the findings of this study to both animal health service providers and rabbit keepers and further studies on the epidemiology and suitable practices for the management and control of major diseases of domestic rabbits identified in this study

CHAPTER ONE: INTRODUCTION AND OBJECTIVES

1.1. INTRODUCTION

Rabbits are quick growing and prolific breeders and their meat is not only highly nutritious but also very easily digested (Hernandez and Gondret, 2006). The potential for rabbit production in Kenya is high considering that other sources of meat are often scarce and costly to most families. Rabbit production is one of the fastest growing livestock enterprises globally. This is largely due to the high prolificacy, early maturity, fast growth rate, high genetic selection potential, efficiency in feed conversion and economic utilization of space by rabbits (Lukefahr & Cheeke, 1990).

This study was designed to improve the capacity for production and health of domestic rabbits by determining the diseases affecting domestic rabbits in Kenya, the etiological agents causing these diseases and risk factors involved. The aim of the study is to enhance the capacity for diagnosis of rabbit diseases in Kenya and facilitate quick feed back of the research findings by working closely with the rabbit keepers from representative study sites. These areas were purposively sampled to represent the main rabbit producing regions in the country.

It is estimated that there are 600,000 rabbits in Kenya, most of which are in Central and Rift Valley regions (APD, 2010). However, this data may have changed with time and a comprehensive study is required to establish the current population of rabbits in the country.

Diseases are a major constraint to the welfare and productivity of the rabbits and they negatively affect the financial status of farmers, the environment, food supply and human health (zoonoses) (Rosell and De la Fuente, 2004). Studies on the diseases of domestic rabbits in Kenya have been

rare, scanty and they are based on retrospective evaluation of either cases recorded at the Small Animal Clinic (Aleri *et al.* 2012) or at post mortem examination (Ngatia *et al.*1988) in the University of Nairobi.

Mortality caused by some diseases of rabbits can decimate whole stock and discourage farmers from the rabbit enterprise. One reported mass death (from Mukuruweni, Nyeri) was found to be as a result of aflatoxin poisoning (P.K. Gathumbi, personal communication, December 12, 2012). Many other disease outbreaks have informally been reported by farmers who have suffered heavy losses from unconfirmed mass deaths of rabbits (Borter and Mwanza, 2011).

In addition to inappropriate feeding and feed quality, inadequate breeding stock, improper housing, lack of sanitation program, inadequate prevention and control of diseases are the risk factors that have been known to predispose domestic rabbits to diseases (Patton *et al.* 2008).

A survey of the common diseases that affect laboratory rabbits in Kenya classified these diseases as; gastrointestinal, respiratory, reproductive diseases, nutritional deficiencies and miscellaneous conditions such as fractures and trauma to the back (Cooper, 1976). Although most diseases of rabbits recognized globally may exist in Kenya, the prevalence and etiology of morbidity and mortality of the common diseases in domestic rabbits have been rarely reported (Wesonga and Munda, 1992; Cooper, 1976).

Ngatia *et al.* (1988) reported post mortem findings of the rabbits around Kabete area and indicated that respiratory and gastrointestinal conditions are the most common. A retrospective study by Aleri *et al.* (2012) reported a tremendous increase in clinical cases of rabbit diseases in Nairobi. Some diseases of rabbits are zoonotic and are of public health concern. A tragic report in a daily newspaper described a family in Naivasha which lost four of its members allegedly

after consuming rabbit meat from sick rabbits (Gitonga, 2012). The findings of the investigations were not reported.

Systematic research in rabbit production and health is scant in Kenya and emphasis is laid on other food animals (Borter and Mwanza, 2011). The inadequate laboratory facilities further poses a challenge in confirmation of diseases encountered in the field outbreaks. In this regard, reported diseases may not be adequately confirmed due to disconnect between the laboratory and the field.

1.2. OBJECTIVES

1.2.1. Overall objective

The overall objective of the study was to determine the characteristics of diseases that constrain rabbit production in Kenya and their predisposing factors.

1.2.2. Specific objectives

The specific objectives of the study were;

1. To characterize the rabbit production systems in relation to disease burden in Nairobi, Central, Eastern and Rift valley regions of Kenya.
2. To determine the diseases in domestic rabbits in the selected areas and their etiology
3. To determine the predisposing factors associated with rabbit diseases in the selected areas of Kenya

1.3. JUSTIFICATION

The key objective of the National Livestock Policy in Kenya (MOLD Session paper No.2 of 2008) is to address the challenges in the livestock subsector in the context of livestock breeding, nutrition and feeding, disease control, value addition and marketing, and research and extension (MOLD sessional paper No. 2 of 2008). The policy is consistent with Kenya's development blue print, Vision 2030 and the Millennium Development Goal number 1(One), which aims at eradicating extreme poverty and hunger.

The rabbit has emerged as a key livestock that is increasingly being adopted and raised mainly by small scale farmers in many parts of the country. However diseases are major limiting factors to efficient rabbit production in Kenya and by extension create a challenge to food security in the country.

According to Mailu and others (2012), basic information, on the rabbit industry is currently lacking in Kenya. To promote the development of the rabbit supply chain in Kenya, information on some important aspects including general production details such as rabbit numbers and breed types, housing structures and equipments, feeds and feeding practices, diseases, consumption and marketing are some of the most important constraints limiting rabbit production that should be investigated and assessed. This study aims at investigating the etiology of diseases of rabbits and their predisposing factors in selected areas of the country.

1.4. HYPOTHESES

1. Bacteria, fungi and protozoal agents are the main cause of diseases in domestic rabbits

2. Diseases that limit rabbit production in Kenya are similer in all the regions in Kenya and are predisposed by poor hygiene and poor housing.

CHAPTER TWO: LITERATURE REVIEW

2.1. DISEASES OF DOMESTIC RABBITS

Based on the clinical manifestation and the system of the body affected, rabbit diseases can be classified into gastrointestinal, respiratory, cutaneous, reproductive, metabolic and nutritional diseases and disorders and miscellaneous conditions. The etiological agents may include: bacteria, protozoa, fungi, viruses, genetics, nutritional deficiencies or miscellaneous causes comprising of physical and chemicals agents such as trauma, cold, heat and toxins (Martino and Luzi, 2008: Percy and Barthhold, 2008).

2.1.1. Diseases of the digestive system.

Gastrointestinal diseases are costly to rabbit breeders and they are a major obstacle to rabbit production (Lord, 2012; Harrenstien, 1999). General signs of gastrointestinal diseases include anorexia, diarrhea, constipation or production of soft pellets. Dehydration and death may follow.

Gastrointestinal diseases and conditions are caused by bacteria, viruses and protozoa. The common bacterial diseases of the gastrointestinal system include colibacillosis and salmonellosis (Cooper, 1976) caused by *Escherichia coli* and Salmonella species, respectively. The bacteria may occur either as primary or secondary infections of the gastrointestinal system together with viruses such as Adenovirus, Rota virus, Corona viruses and Rabbit calicivirus (Patton *et al*. 2008).

Adenovirus has been reported to cause outbreaks of enteritis characterized by profuse diarrhea in young rabbits in commercial rabbit farms. Adenovirus outbreaks have been reported together with *Escherichia coli* in young rabbits (Wilber and Maj, 1999).

Wilber and Maj (1999) reported that Corona viruses also cause epizootic enteritis in rabbits aged between 3-8 weeks. The rabbits present with diarrhea usually recognized by stained perineum and thin and dehydrated carcasses. Gross lesions encountered include; watery content within the ceacum, white to tan fecal content, cardiomyopathy characterized by right sided heart dilatation, pleural effusion, pulmonary edema and mesenteric lymphadenopathy.

Rabbit calicivirus is reported to cause viral hemorrhagic disease (VHD) also referred to as Rabbit hemorrhagic disease. Rabbit hemorrhagic disease is contagious and fatal and affects only rabbits older than 40 – 50 days. China, Mexico, Europe and United States have reported per acute outbreaks of the disease. The virus is transmitted through direct contact or through contaminated formites and usually has a predilection for the liver hepatocytes where it causes periportal necrosis that can also spread to affect the whole lobule. The affected rabbits may present with incoordination, convulsions, and bloody nasal discharge. Hepatomegally, spelenomegally, serosal ecchymoses, pulmonary edema and hemorrhages are reported at necropsy (Patton *et al*. 2008; Wilber and Maj, 1999).

Rota viruses may cause mild diarrhea usually in weaned or suckling rabbits. The virus is usually present in the intestines of healthy rabbits and may cause disease when there is co-infection with coccidiosis and *E. coli* (Patton *et al*. 2008; Wilber and Maj, 1999).

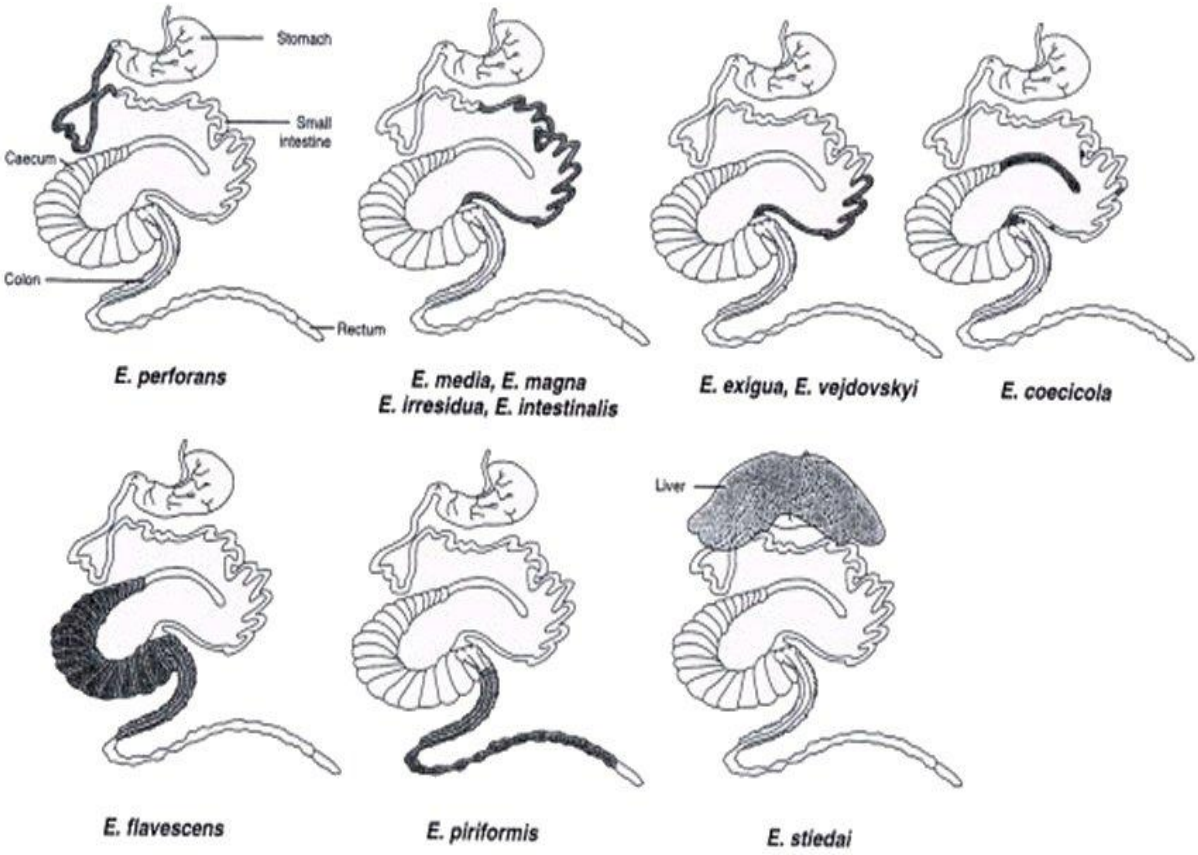
It has been reported that any factor that can lead to increased multiplication of *E. coli* in the ceacum always lead to diarrhea and Typhilitis. The Typhilitis is usually characterized by foul smelling watery, brownish diarrhea, paintbrush hemorrhages on the cecal serosa and death. These factors include intestinal obstruction, ingestion of large numbers of *E. coli* from unhygienic environment and dietary irregularities (Prescot, 1978).

E. coli has also been associated with other conditions including Mucoid enteropathy. Mucoid enteropathy/Mucoid enteritis is believed to be caused by a combination of factors. Amongst these factors include; bacteria (*E. coli),* toxins in feed, dietary irregularities and or obstructions of the gastrointestinal tract, coccidia. Mucoid enteropathy is usually clinically manifested by reduced feed intake, diarrhea, bloat and cecal impaction, presence of mucus in ceacum, colon and intestines and under the rabbit cages. The gross lesions are suggested to occur due to paresis of the whole digestive tract and subsequent multiplication of opportunistic organism like *E. coli* and coccidia (Licois *et al.* 2006). In this regard, the condition is usually confused with coccidiosis (Cooper, 1976). Consequently, most studies recommend prevention through provision of anti - *E. coli* antibiotics such as Colimycin and tetracycline' in pelleted feed (Meshorer, 1976) and provision of crude fibre (hay) in the diet (Harkness and wagner, 1995). However, antibiotics and fluid therapy (in pet rabbits) has been shown to have a poor prognosis (Harkness and Wagner, 1995).

Tyzzer's disease has been reported occasionally in rabbits. Tyzzer's disease is caused by *Clostridium piliformes* and the affected rabbits may show the following clinical signs: sudden onset of watery diarrhea, listlessness, lack of appetite, dehydration and death within 72 hours. At necropsy the rabbits usually present with a classic triad comprising of; stenosis of ileum, intestinal edema, hemorrhage, and necrosis in the wall of the cecum , focal necrosis in the liver and heart (Patton *et al*. 2008; Wilber and Maj, 1999).

Protozoal diseases of the gastrointestinal system include coccidiosis which may be intestinal (Coudert *et al.* 1995) or hepatic coccidiosis caused by *Eimeria* species (Harkness and Wagner, 1995: Patton *et al*, 2008). Parasitological examinations have revealed that *Eimeria* species are

highly tissue specific as shown in Figure 1.0. However, intestinal coccidiosis is more common than hepatic coccidiosis (Coudert *et al.* 2000).



Source: Coudert *et al.* 2000

Figure 1.0: Tissue specificity of intestinal and hepatic *Eimeria* species

Hepatic coccidiosis is caused by *Eimeria stiedae.* The affected rabbits may present with either diarrhea, pendulous abdomen, jaundice or no clinical signs a part from wasting. At necropsy, liver is enlarged and usually has multiple 1 to 3mm diameters slightly raised, discrete to coalescing, yellow-white nodules scattered throughout the parenchyma and dilated bile ducts. Liver histology, impression smears of the nodules and aspiration smears of gall bladder contents have been used to demonstrate the coccidia oocysts (Coudert *et al.* 1995; Darzi *et al.* 2007a).

Depending on the clinical effects such as; weight loss, diarrhea and the resulting mortality, intestinal coccidia species can be classified into three types. These are non - pathogenic to slightly pathogenic coccidia (*Eimeria media, Eimeria exigua, Eimeria perforans, Eimeria coecicola),* moderately pathogenic *(Eimeria irresidua, Eimeria magna, Eimeria piriformis)* and very pathogenic coccidia *(Eimeria intestinalis, Eimeria flavescens)* (Coudert *et al.* 1995). During necropsy, inflammation and oedema can be seen in the ileum and jejunum of infected rabbits. Bleeding and mucosal ulcerations sometimes occur in the intestines (Coudert *et al.* 1995).

Coccidiosis is a major cause of economic losses in rabbits. These losses may occur due to death of rabbits, decreased weight gain, surviving rabbits are predisposed to other diseases and condemnation of affected livers in cases of hepatic coccidiosis. The main recommended control methods for coccidiosis are improved housing system and hygiene. Use of anti-coccidia in feed or water for both prophylaxis and treatment is also effective (Patton *et al*, 2008)

Other protozoal diseases of the rabbits include toxoplasmosis and cryptosporidiosis caused by *Toxoplasma gondii* and *Cryptosporidium parvum* respectively. However reports on their presence in Kenya have not been reported. Cryptosporidiosis has been reported to cause small intestinal enteritis only occasionally (Wilber and Maj, 1999).

Toxoplasmosis has been reported occasionally. The affected rabbits may manifest signs associated with acute or chronic form of the disease. In the acute form, the rabbits manifest with anorexia, fever, lethargy and central nervous signs such as ataxia, posterior paralysis and convulsions. In the chronic forms the rabbits may show progressive emaciation, posterior paralysis and even death. However, sometimes the rabbits may not show any clinical sign. The

gross lesion encountered include; extensive necrosis of the lymph nodes, liver, spleen, and lungs. Microscopy usually reveals extensive necrosis, granulomatous inflammation, tachyzoites and tissue cysts in the lymph nodes, liver, spleen, lungs and central nervous system (Patton *et al*. 2008; Wilber and Maj, 1999).

Helminths of the rabbits are less pathogenic and only cause clinical lesion when there has been massive infestation. The clinical signs include; abdominal distension, lethargy and weight loss. Helminthes are common in wild rabbits and the domestic rabbits are usually affected by the nematodes and cestodes of the rabbits when they feed on forages collected from infected pastures (Lords, 2012). Several cases of gastrointestinal helminthosis in rabbits were reported by other studies outside the country and these include pin worms *(Trichuris* and *Passalurus* spp.), *Trichostrongylus* spp., flukes and tapeworms (Foronda *et al.* 2003).

Other nematodes of rabbits include *Obeliscoides cuniculi* and *Bayliascaris procyonis*. *Bayliascaris procyonis* mainly cause signs of the central nervous system but migratory tract can be seen in the liver, heart and kidneys during necropsy. However, *Obeliscoides cuniculi* is usually found in the stomachs of rabbits (Wilber and Maj, 1999). Rabbits have also been reported to act as intermediate host for cestodes. The cestodes include; the larval stage of *Taenia pisiformis* (*Cysticercus pisiformis*) in the liver and mesentery, the larval stage of *Taenia serialis* (*Coenurus serialis*) in the skeletal muscles and subcutis, and *Echinococcus granulosus* (Lords, 2012).

Lords (2012) reported that primary tumors including adenocarcinoma, lymphoma and leiyomyosarcomas of the stomach are occasionally encountered in rabbits. Lymphomas are more

common in males than female rabbits. Metastatic hemangiosarcomas to the stomach have also been reported (Lords, 2012).

The non-infectious conditions of the digestive system in rabbits include; malocclusion and tooth over – growth/wolf teeth, bloat, intestinal obstructions, and stressors to rabbit (Mondal *et al.* 2006).

Malocclusion may either be acquired or congenital. The condition usually manifests with the lower incisor teeth growing straight out, these may tip and produce sharp spurs which may impinge on soft tissue, causing pain and secondary infections. Congenital type malocclusion has been reported to occur mainly in dwarf breeds of rabbits with mandibular prognathism, while acquired incisor malocclusion usually occur secondary to premolar and molar malocclusion or due to nutritional osteodystrophy, tooth root or gum infections, trauma or other conditions that can distort the alignment of the teeth (Brown, 2001). Nutritional osteodystrophy, may arise in case of inadequate calcium or low fiber diet (Thomas *et al.* 2009).

Obstruction of the small and the large intestine has been reported in rabbits, with the small intestine being more commonly affected (Harcourt-Brown 2002). The main causes of the obstruction include foreign bodies such trichobenzoars (hair balls, wool block), intestinal displacement such as torsion, vovulus, intussusception and paralytic ileus (Lords, 2012; Mondal *et al.* 2006).

Various stressors may lower their immunity to diseases or favor the multiplication of normal flora hence they act as predisposing factors to other disease agents (McWilliams and Deborah, 2001). The common stressors include transportation, especially during the post weaning period; housing in a new hutch or cage; the presence of unusual visitors (people or animals), inadequate

crude fiber or excess energy in the feed and sudden feed changes, chemical agents for example antibiotics and mycotoxins (Moberg, 2000**;** Patton *et al.* 2008; Percy and Barthhold, 2008).

2.1.2. Respiratory diseases

The clinical manifestation of respiratory diseases of rabbits are varied and may include the presence of clear to purulent nasal discharge (the rabbit rubs the nose with its forepaws and the mucus may be present on the paws) and frequent sneezing. Stunted growth is common in affected young rabbits. Complications of respiratory diseases of rabbit may lead to manifestations of varied signs that are not related to the respiratory system. These signs may include: diarrhea, ophthalmitis, sinusitis, torticollis (wryneck) and abscesses, these signs occur due to the multi-systemic nature of some of the diseases (Patton *et al.* 2008).

The causes of respiratory diseases in rabbits include a combination of non-specific causes and infectious agents. The specific infectious agents that cause respiratory diseases of rabbits include bacterial agents such as *Pasteurella* spp., *Bordetella* spp., *Klebsiella* spp., *Staphylococci* spp., *Streptococci* spp. and rarely *Escherichia coli*, S*almonella* and *Listeria* spp. These bacterial infections may manifest as upper respiratory disease ("snuffles") (Cooper, 1976), pneumonia, otitis media, pyometra, orchitis, subcutaneous abscesses, conjunctivitis and septicemia.

Pasteurellosis is one of the major diseases of respiratory system that cause losses in rabbits. Pasteurellosis in rabbits is caused by *Pasteurella multocida* and co-infection with *Bordetella bronchoseptica* is also common. *Pasteurella multocida* is a normal in the upper respiratory tract and may cause respiratory infection when predisposed by other factors including; poor hutch ventilation, pregnancy, underlying infections and environmental disturbances. The disease can

also be transmitted to uninfected rabbits through contact with infected secretion and suckling (Patton *et al*. 2008; Wilber and Maj, 1999).

Staphylococosis is also a common respiratory condition in rabbits that is caused by *Staphylococcus aureus*, this organism is usually present in the upper respiratory tract and it can be transmitted to uninfected rabbits by aerosols, direct contact with carrier rabbits. Apart from respiratory infections, *Staphylococcus aureus* can cause other pathological conditions including multisystemic abscessation, mastitis, pododermatitis and fatal septicaemia (Corpa *et al.* 2010; Patton *et al*. 2008).

Other rare causes of respiratory diseases include: Viral diseases such as myxomatosis, herpes virus and paramyxoviruses, helminthes and mycotic infections such as those caused by *Aspergillus* spp. and tumors such as; thymoma (Percy and Barthhold, 2008)

2.1. 3. Skin diseases

Skin conditions in rabbits are widespread in intensive rabbit production. The common skin conditions of rabbits in Kenya are Ear canker (Aleri *et al.* 2012), ringworm (Dermatomycosis/ trichophytosis) caused by microscopic fungi of different genera (Trichophyton, Microsporum, Achorion) have also been reported globally (White *et al.* 2002).

Ecto-parasites also affect rabbits and they include lice, fleas and ticks that are specific to rabbits. Skin mange mites like *Sarcoptes* spp. and *Notoedres cati*, *Cheyletiella parasitovorax, Psoroptes cuniculi* (Ear mites) or *Chorioptes* (fur mites) are the cause of mange in domestic rabbits (Patton *et al.* 2008; Cutler, 1998).

Ear canker (Acariotic mange) is caused by burrowing mites namely; *Psoroptes cuniculi* and *Notoedres cati*, the mites live in the auricular meatus, where they feeds mainly on serous exudate, skin secretions, and blood (Perrucci *et al.,* 2005). Ear crust, scabs and discharges and head tilting are clinical manifestations that have been associated with mite infection and secondary bacterial infection to the ear (Acar *et al.,* 2007; KyungYeon, 2010; Patton *et al*., 2008; Perrucci *et al.,* 2005; Ulutas *et al.,* 2005). Fur mites include *Cheyletiella parasitovorax* and *Listrophus gibbus* and both are non- burrowing mites. The rabbits affected by fur mites usually present with alopecia, scaliness and crust over the dorsal trunk and scapular area (Wilber and Maj, 1999). *Sarcoptes scabiei* causes *Sarcoptic* mange characterized by alopecia around the nose, ears, feet and around the genitalia (Kaya *et al.* 2010).

Fleas of rabbits include *Ctenocephalides felis* (cat flea), *Ctenocephalides canis* (Dog flea) and *Spilopsyllus cuniculi* (Rabbit flea). Flea infestation in rabbits is rare. However the tick, *Haemaphysalis leporispalustris* has been commonly reported in rabbits (Patton *et al*. 2008).

Secondary bacterial dermatitis and abscesses can occur in *Pasteurella*, S*taphylococcus*, and *Streptococcus* skin infections. The bacterial skin conditions of rabbits include; Foot pad abscesses and sore hocks (Corpa *et al.* 2010; Blair, 2013).

Some viruses such as *Papilloma virus*, *Myxoma virus*, *rabbit pox virus* and *Leporipoxviru*s usually manifest as pedunculated subcutaneous masses on the rabbit (Harkness *et al.* 2010). Skin tumors such as squamous cell carcinoma, malignant melanoma and fibroma have also been encountered in rabbits occasionally (Patton *et al*. 2008).

Myxoma virus causes Myxomatosis in rabbits, a condition transmitted by either direct contact or mosquitoes hence also referred to as "mosquito disease". The disease present varied clinical signs such edema around the nose, ears and lips and a condition referred to as "bighead disease". The rabbits show purulent ocular discharges, and sometimes subcutaneous gelatinous tumors may develop all over the body and eyelids. However, acute outbreaks results in death and occasionally reddening of conjunctiva may be seen (Patton *et al*. 2008; Wilber and Maj, 1999).

2.1. 4. Urogenital diseases and disorders

The common reproductive disorders of rabbits include metritis and mastitis caused by *Staphylococcus aureus, Streptococus* spp. and *Pasteurella* spp. However, *Listeria, Chlamydia* and *Salmonella* species have occasionally been reported to cause metritis and mastitis. Rabbit with mastitis have been reported to have dark to red discoloration of the skin overlying the mammary glands (blue breast). Rabbits with metritis frequently manifest with abortion (Cooper, 1976; Patton *et al*. 2008; Wilber and Maj, 1999).

Cooper (1976) reported cases of vulvovaginitis in rabbits that were caused by Proteus species. Rabbit syphilis or vent disease is another common reproductive disease in rabbits. Rabbit syphilis is caused by a spirochete *(Treponema cuniculi)* and can also present with *orchitis* and *balanitis* (Patton *et al.* 2008). Vent disease is transmitted either venereal or extragenital contact. The affected rabbits usually manifest with crusty lesion on the area around the vulva, muzzle, prepuce, anal and peri-orbital regions; these areas may also show erythema and edema (Wilber and Maj, 1999).

Nutritional deficiencies can also result in reproductive challenges in rabbits. The common nutritional diseases affecting rabbits include; Vitamin A deficiency, Vitamin E deficiency and

hypervitaminosis A, hypervitaminosis D and Pregnancy toxemia "ketosis". These conditions usually show non-specific signs such as low fertility, abortions, fetal resorption, and hydrocephalus, nervous signs such as Wryneck, loss of equilibrium, and in coordination (Wilber and Maj, 1999).

Pregnancy toxemia "ketosis" occurs commonly in rabbits that become anorexic during the last gestation. Obese animals are reported to be more prone to ketosis, and the affected rabbits may manifest with dullness, respiratory distress, prostration and death. A comprehensive review of nutritional conditions of rabbits has been reported in a number of articles (Patton *et al*. 2008; Percy and Barthhold, 2006; Wilber and Maj, 1999; Zimmermann *et al.* 1990).

In rare occasions tumors have also been reported to affect the reproductive systems of rabbits. The tumors include; lymphosarcoma, uterine adenocarcinoma, mammary gland adenoma and adenocarcinoma, pituitary adenoma and interstitial (Leydig cell) tumors. Primary tumors of the kidneys such as; renal carcinoma and nephroblastoma have also been reported in rabbits (Wilber and Maj, 1999). Some reproduction conditions are non-infectious and these may be intrinsic to the rabbit, environmental in origin or due to housing factors. These include: sterility, twisted uterus, delayed birth, parturition outside the nest box, prolapses of the vagina and even abandonment of the litter (Harkness *et al.* 2010; Wilber and Maj, 1999).

2.1.5. Neurological and Musculoskeletal diseases

Diseases of the nervous and musculoskeletal system are common in rabbits and usually present with head tilting and hind limb paralysis or paresis. However, a majority of these disease conditions also affect other body systems (Keeble, 2006). Diseases of the nervous and

musculoskeletal systems are mainly caused by bacterial infection and toxaemia, Encephalitozoonosis, Toxoplasmosis, trauma, metabolic disorders and toxins (Patton *et al*. 2008).

Bacterial infections in rabbits include; Otitis media/interna which is caused by *Pasteurella multocida, Bordetella bronchiseptica, Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Listeria monocytogenes* and *Proteus mirabilis* (Keeble, 2006).

Encephalitozoonosis is a common disease in rabbits caused by *Encephalitozoon Cuniculi* (Wesonga and Munda, 1992). Infection by *Encephalitozoon cuniculi* is usually through ingestion of feed or water contaminated with infected urine and it has been reported to be mainly subclinical. In the subclinical form, the rabbits show kidney lesions including scars on the cortex characterized by multiple small indented gray areas about 2 - 4 mm on the surface. The scars may extend to the medulla. Spontaneous head tilt may be observed when the organism localizes in brain and results in meningoencephalitis. Prevention of encephalitozoonosis is difficult due to the widespread nature of the organism. In this regard, strict hygiene and selection of breeding stock from a clean herd is recommended. The diagnosis is usually made at necropsy and histopathology (Keeble, 2006; Patton *et al*. 2008; Wilber and Maj, 1999).

Toxoplasmosis is a rare disease of rabbits caused by *Toxoplasma gondii*. The acute form of the disease is usually characterized by nervous signs such as ataxia or posterior paralysis and convulsions. However, the chronic form of the disease is usually asymptomatic and the rabbit may show only progressive emaciation (Manning *et al.* 1994; Patton *et al*. 2008).

Posterior paresis or paralysis in rabbits is usually accompanied by other clinical signs such as loss of associated skin sensation, urinary and fecal incontinence. Other than toxoplasmosis and

encephalitozoonosis, posterior paresis or paralysis is also caused by lumbar vertebral fracture/luxation, spondylosis, osteoarthritis, splay leg, ulcerative pododermatitis , intervertebral disc disease, hypovitaminosis A and neoplasia (Keeble, 2006; Patton *et al*. 2008).

Lumbar vertebral fracture/luxations have been reported to be caused by trauma due to struggling when rabbits are not properly restrained during handling (Patton *et al.* 2008). Ulcerative pododermatitis (sore hock) are frequently observed in large breeds. Sore hocks are predisposed by wet, dirty hutch floors, wire mesh floors and the irritating action of urine salts that accumulate in unhygienic housing conditions (Blair, 2013; Cutler, 1998; Keeble, 2006).

Lead toxicity is common in indoor rabbits housed in old painted buildings where ingestion of lead-based paint can occur. Rabbit may show intestinal ileus, anaemia, mild tremors, hind limb ataxia and seizures. Tumours of the central nervous system are rare and include pituitary adenoma and teratoma (Keeble, 2006).

Muscle weakness is a common condition encountered in rabbits. Muscle weakness is caused by hypovitaminosis E/selenium, cerebrovascular accident, spinal lesions, bacterial infection, toxoplasmosis, sarcocystis, coccidiosis and metabolic diseases including hypocalcaemia, hypokalaemia and hepatic lipidosis (Keeble, 2006).

2.1. 6. Miscellaneous conditions

Miscellaneous conditions in rabbits include behavioral conditions (vices) and other disease conditions caused by nonspecific agents.

A common behavioral condition in rabbits is trichophagy (fur-eating/barbering). Rabbits normally pluck their hair to build nest, usually in their last trimester of pregnancy. The hair may

be accidentally swallowed. It is a habitual behavior for rabbits to eat their hair when growing. The progressive ingestion of small amount of hair may lead to accumulation of hair in the stomach that may fail to pass through the pylorus or block the gastrointestinal tract. Feeding of unbalanced diets that lack essential amino acids or fibers to rabbits and heat stress have been associated with the condition (Mondal *et al.* 2006).

Cannibalism is another abnormal behavior in rabbits. Cannibalism has been associated with diet that is inadequate in quality or quantity, injury or abnormality in kits, or disturbance of the doe following kindling (Patton *et al.* 2008).

Elevated temperatures either due to improper ventilation or high environmental temperatures are the causes of heat prostration (Patton *et al.* 2008)

Tumors in rabbits are rarely reported because the animals are slaughtered before they reach the old age at which most tumors occur (Cooper, 1976). Tumors in rabbits have been observed in the uterus, kidneys, blood, lymph nodes, bones, testicles, skin, and other organs (Patton *et al*. 2008; Wilber and Maj, 1999).

2.2. Factors predisposing to diseases of domestic rabbits.

Factors that contribute to good rabbit health include body soundness and liveability; adequate nutrition; suitable environment; and prevention of transmissible diseases, eradication and control of diseases (Patton *et al.* 2008). The above factors are generally considered as the main risk factors to disease outbreak in most parts of the world.

2.2.1. Body soundness and liveability

Body soundness and liveability is considered to be the ability of the rabbit to survive in the environment. The factors that determine body soundness and liveability include; body morphology, tolerance to temperature, adverse climate and disease, high feed intake even of suboptimal diets and litter size (Lukefahr, 1998).

During selection of rabbits for breeding one should pay attention to qualities such as; alertness, clean smooth skin, clean eyes, ears and perineum, quiet breathing, presence of both testicles and absence of any physical defects that may have a bearing to body soundness and liveability (Schiere, 2004).

Lack of body soundness in rabbits usually indicates an underlying disease or an abnormal condition. Some of the body soundness indicators of diseases in rabbits include (Patton *et al.* 2008);

i. Abnormal posture: this may be manifested in rabbits as sitting still with a hunched up posture, flinching/ recoiling or with sign of pain especially when touched, head tilting and presence of swollen body part.

ii. Change in behaviour: lack of appetite or excessive drinking, teeth grinding, limping, difficulty in breathing

iii. Discharges from eye, ear or nose, diarrhoea or constipation

A recent study by Hungu *et al.* (2013) reported that 71% (51/72) of rabbit farmers in Kenya are able to identify rabbit disease signs. The report further indicates that 69% of these farmers administer treatment on their own depending on the signs observed.

2.2.2. Nutrition of rabbits

Adequate nutrition of rabbits is the most important husbandry practice in the industry (Patton *et al.* 2008). To explain this, several studies have reported interaction and synergism between nutritional factors and rabbit' physiology, behaviour and environment (McWilliams and Deborah, 2001).

Nutrition for example influences the function of Gut associated lymphoid tissue (GALT) in rabbits. GALT function is to recognize foreign antigens that may be present in the ingested food. In rabbits, these tissues are usually located in the digestive tract predominantly at the Peyers patches, appendix and sacculus rotundus (Carabano and Piquer, 1998). Their function in body immunity is usually dependent on adequate nutrition and nutrient absorption so as to replace the gut cell lost during their function (McWilliams and Deborah, 2001).

Additionally, nutrition is also an important factor for the rabbit's ability to cope with environmental stressors such as heat, cold and inappropriate husbandry practices (Amici *et al.* 2010). This is because stress results in increased adrenal gland activity which in turn causes decreased digestive process including cecotrophy. Cecotrophy is the ingestion of specially

produced soft faecal pellets, which are usually produced at night in the domestic rabbit. Cecotrophy allows the rabbit to consume poor quality, high fibre diets and obtain necessary nutrients, such as essential amino acids and vitamins (de Blas and Wiseman, 2003).

Rabbit like all other animals require a balanced diet consisting of protein, energy (carbohydrates and fat), crude fibre, minerals and vitamins (de Blas and Wiseman, 2003). The amount of these feed components recommended for the rabbits depend on the age of rabbits and physiological status such as pregnancy and lactation.

Inadequate or improper nutrition have been primarily associated with diseases such as cecal impaction (and associated enterotoxemia), Colibacillosis, and Mucoid enteropathies (McWilliams and Deborah, 2001).

It has been stated that the major reason behind the low production of rabbits in the tropics (present at 50%) is mainly due to inadequate nutrition and partly due to the heat stress (Cheeke, 1986). Unavailability of rabbit feed was reported as one of the constraints to rabbit keeping in Kenya (Mailu *et al.* 2012; Hungu *et al.* 2013; Serem *et al.* 2013). These authors recommend the importance of collecting and assessing the basic information on rabbit feeds and feeding practices in Kenya.

Commercial rabbit feeds are either too expensive or unavailable to farmers in the rural areas. This has led to farmers using commercial rabbit pellets and locally available plant forages in equal frequency (Hungu *et al.* 2013). These plants include vegetables grown in the farmer's gardens and other freely growing weeds (Table 2.1) Fresh green forages are considered to be rich in proteins. Grains, brans and tubers are considered as rich in energy. All these are important parts of animal nutrition and they should be provided in appropriate amounts (Schiere, 2004.)

Table 2.1: Some common forages used as safe rabbit feed (Lukefahr, 2010; Price and Regier, 1982).

Scientific name of forage	**Common name**	**Nutrient content as % dry matter**
Avena spp.	Oats	Protein 12-13%, high energy
Helianthus annuus	Sunflower	High protein 16-18%, high energy
Ipomoea batatas	Sweet potato	protein 16 -20% ,70% starch
Musa paradisiacal	Banana leaves and peels	High energy
Daucus carota	Carrot	High protein content 12-13%, rich in minerals
Tridax procumbens	Coat button	High Protein 12-13%
Bidens pilosa	Black jack	High Protein 20%

Despite being available and cheap, many types of forage may have some natural undesirable attributes which may make them unsafe as animal feeds. These forages should therefore be feed to these animals in controlled amount (Table 2.2) (Cheeke, 1998; Lebas *et al.*, 1986).

Table 2.2: Common forages with toxic factors that should be fed to rabbits in controlled amount (Lebas *et al.,* 1986; Lukefahr, 2010; Price and Regier, 1982)

Forage name	**Risk factors**	**Nutrient content as a % dry matter**
*Solanum tuberosum (*Irish potatoes)	peelings served cooked and avoid green parts	Suspected to be high in energy
*Oryza sativa (*Rice straws)	Uncontrolled fermentation produces mycotoxins	High energy
Eichhornia crassipes (Water hyacinth, water lily)	risk of poisoning if sourced from polluted water	25% digestible energy,
*Arachis hypogaea (*Groundnut seeds, tops)	lack the essential sulphur amino acids, seeds can be affected by aflatoxins	Protein 50%
*Zea mays (*maize corn*)*	Must be supplemented with Nitrogen	Low protein
Beta vulgaris (Sugar beets)	Very rich in potassium, hence may cause digestive disorders	80% digestible energy, protein 17-18%, very rich in minerals
Pennisetum purpureum	Poor growth if not supplemented	Low protein 6-8%
Calliandra calothyrsus	Low digestibility	High condensed Tannin 11%
Leucaena leucocephala (Leucina)	High non protein amino acid Mimosine. Diet should have less than 10% Leucina.	Protein 28%

Table 2.2: Common forages with toxic factors that should be fed to rabbits in controlled amount (continued)

Forage name	**Risk factors**	**Nutrient content as a % dry matter**
Medicago sativa (Alfalfa)	High saponin and unpalatable	High protein and energy
*Brassica spp(*Turnip, cabbage, cauliflower, kale)	High Goitrogens, may cause goiter if feed in excess	Protein 15-25%, high energy
Amaranthus (Pigweed)	High oxalates, limit diet to moderate	Protein 20%
Phaseolus vulgaris (beans)	High lectins, cook all beans	High protein
Gossypium spp.(Cotton)	High gossypol, may cause digestive problems, limit content in diet	Protein 13
Vigna unguiculata (Cowpea)	High saponin, may be un palatable	High protein 17-23%

Some plants have been considered poisonous (Table 2.3), hence should not be fed to the rabbits (Cheeke, 1998; Price and Regier, 1982).

Table 2.3: Common plants considered as poisonous to rabbits

Scientific name	**Common names**
Colocasia esculenta	Arrow root
Crotalaria spp.	rattlebox
Ipomoea violacea	morning glory
Lycopersicon esculentum	tomato
Solanaceae (nightshade family)	Tomato, pepper, eggplant, angel trumpet, nightshade, tobacco, night-blooming jasmine, four o'clock, Jerusalem cherry
Opuntia ficus	Cactus
Calendula officinalis	Calendula, pot marigold
Lantana camara	Lantana
Aloe vera	Aloe, true aloe
Sesbania punicea	Red sesbania
Cannabis sativa	Hemp, marijuana
Tanacetum vulgare	Tansy
Brunfelsia spp.	Yesterday, today and tomorrow
Astragalus spp.	Milk vetch
Areca catechu	Areca palm, Betel nut palm
Acacia berlandieri	Guajillo

Some plants may have undesirable artificial attributes which may arise depending on handling and storage conditions of both pellets and forages. These undesirable attributes include; mycotoxins, fats and fatty acids, amino acids, coccidiostats, heavy metals (arsenic, aluminium, cadmium, lead, mercury, molybdenum), and chlorinated dioxins and dibenzofurans (Mézes, 2008).

Common mycotoxins include deoxynivalenol, zearalenone, fumonisins and aflatoxins. All these mycotoxins have been associated with growth of moulds on the forages (Skladanka *et al.* 2010). Aflatoxins are highly toxic, mutagenic, teratogenic and carcinogenic compounds produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxins have not only been implicated as causative agents in human hepatic and extra-hepatic carcinogenesis but also in morbidities and mortalities in domestic animals (Lakkawar *et al*., 2004; Makkar and Singh, 1991) and rabbits (Borter and Mwanza, 2011). However, the progression of signs is diverse depending on the age, sex, diet and animal species and this often make clinical diagnosis difficult. Improper or prolonged packaging and storage, manufacturing/pelleting equipment and storage bins has been suggested to contribute to mycotoxin contamination of feed (Houssein and Brasel, 2001).

Contamination of forages and commercial feed with pesticides, antibiotics and herbicide residues can also be a major source of poisoning for rabbits (Schiere, 2004). Most rabbit keepers are aware of the poisonous plants (Schiere, 2004). The challenge is that not all parts of these plants are poisonous. These plants can also be poisonous to one species of animal but not the other (Lebas *et al.*, 1986)

Forages, especially when wet have been associated with some negative effects in rabbits. Bloat, nitrate poisoning, prussic acid toxicosis (Collins and Hannaway, 2003) and enteritis complex

(Schiere, 2004) are some of the problems associated with succulently fed forages. Bloat mainly manifests as abdominal distention followed by death.

Nitrate toxicity is caused by Nitrate accumulation mainly in annual forages, grasses, weeds and small grains. Nitrate accumulation is common in forages exposed to stressful environments such as, drought, heavy rain, plant diseases, frost, hail, soil nutrient deficiencies, chemical injury (herbicide) and heavy fertilization forages. Nitrate toxicity manifest as cyanosis of mucous membranes, dyspnea, staggering, incoordination, frothing in the mouth and diarrhea (Collins and Hannaway, 2003).

Prussic acid toxicity is associated with feeding animals in drought or frost damaged forages within 5-7 days after rain. The clinical signs associated with Prussic acid toxicity include increased voiding of urine and feces, convulsions, paralysis, coma, staggering, drooling (salivation), runny eyes (lacrimation), and dyspnea (Collins and Hannaway, 2003).

2.2.3. Rabbit housing

A suitable environment for the rabbit should only expose the animal to minimal stress or stressors (McWilliams and Deborah, 2001). Stressors in rabbits include heat, cold, handling, nutrition, light and dark cycles and interaction or lack of interaction.

Even though proper housing protects rabbits from these stressors, several studies have concluded that a strong interaction exists between housing and nutrition, hence a balance should be provided between these two factors (EFSA, 2005; McWilliams and Deborah, 2001). Stress weakens the acquired immunity of rabbits resulting in immune suppression of the affected animals and makes them more susceptible to diseases like Pneumonia, Coccidiosis and Mucoid

enteritis (Patton *et al.* 2008). Stressed rabbits may also decrease, or stop feeding and this may result in weight loss, slowed digestive process and/or diarrhea.

Stress-associated hormonal secretions slow digestive processes and also result in formation of Stress trichobezoars. Stressed rabbits are prone to over-grooming or barbering". Additionally low fibre diets or diets deficient in copper, protein or magnesium have also provoked barbering in mature rabbits and these results in formation of Stress trichobezoars (Mondal *et al.* 2006).

Housing cages should have hiding and resting places such as raised platforms, enrichment objects such as wood stick and mirrors, roughage feed such as hay and grass cubes or gnawing sticks. These items assist to minimize stress (Dalle Zotte *et al.* 2009). Rabbits kept in cages without enrichment object are reported to be aggressive, and manifest behaviour associated with stress (Zs *et al.* 2010). Cages should be spacious, have good floor with proper drainage, adequate feeding and water equipment. Some reports recommend minimum rabbit house dimensions for bucks and does as shown in the table 2.4 (EFSA, 2005).

To ensure proper drainage of urine and faecal material, wooden floors should have the slates spaced 1-1.5cm a part (Patton *et al.* 2008). Wire mesh floors have been reported to predispose to Sore hock. To prevent this condition, wire mesh floors should have footrests made of either wood, metal or plastic (Rosell and De la Fuente 2008). High cage humidity and temperatures have also been reported to increase the growth and survival rates of various species of fleas (Cooke, 1990).

Table 2.4: The recommended cage sizes for various ages of rabbits

Age/status of rabbits	Length(cm)	width(cm)	Height(cm)	Floor area/animal (cm^2)
Female,without a nest box	60-65	40-48	30-35	2400-3120
Growers (4-10 weeks)in Pairs	40-42	25-28	28-30	500-585
Growers (4-10 weeks) in Dual purpose cage# + nest place	85-90	40-48	30-35	485-540
In Grower cage ∋	80-100	50-60	30-35	450-600

Where; # 7-8 rabbits in a cage; ∋ 9-10 in a cage. *Source*: (EFSA, 2005):

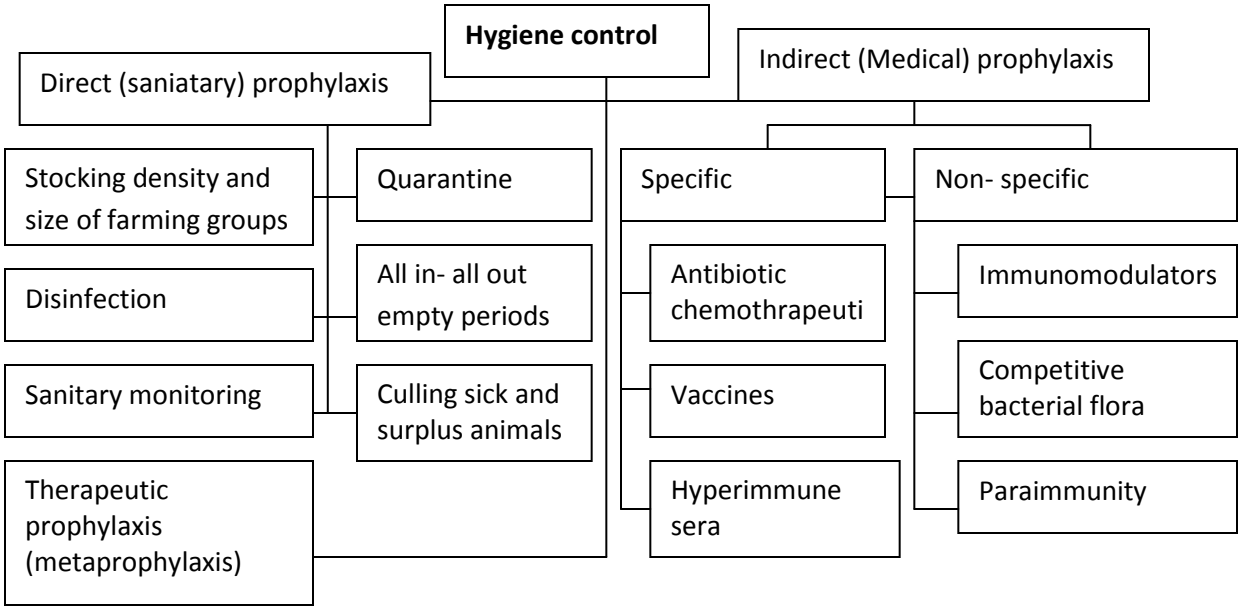
Normally, rabbits show linear dominance hierarchy for each sex. They also naturally establish social ranks within groups by physical fights and confrontation (Verga *et al.* 2007). In this regard old and dilapidated cages should be replaced since they may not only allow accidental mixing of rabbits but also cause direct wounds and injury. This may predispose the rabbits to fight wounds and skin abscesses.

2.2.4. Prevention, eradication and control of rabbit diseases

McWilliams and Deborah (2001) said that "Since the beginning of modern commercial rabbit production, the average morbidity and mortality rate has not dropped because, as health problems have been solved, health problems have developed." In this regard, health monitoring should be done for efficient disease control. Health and disease monitoring programme should include; disease prevention, treatment and hygiene control standards (Grilli *et al.* 2002).

Hygienic control include among others; practises enhancing sanitation in the farm, administration of drugs and vaccines to prevent diseases, early treatment of any disease encountered and bio-security (Figure 2.0).

Vaccines have been developed for various diseases including; Rabbit Haemorrhagic Disease, Myxomatosis, Pasteurellosis, Colibacillosis and Staphylococcosis (Lavazza *et al*., 2004). Effective vaccines against various coccidian species have also been successful during field trials in Benin (Akpo *et al.* 2012). However, these vaccines are not available yet to rabbit farmers in Kenya at present and more research is necessary in this area.



(Source: Grilli *et al*.. 2002).

Figure 2.0: Schematic presentation of disease control strategies in a rabbit farm

Good husbandry should engender bio-security practises. Bio-security includes all the facilities and operational practises meant to prevent introduction of disease causing organisms (EFSA, 2005). Disease causing organism can be introduced in the farm in three main ways; physical

transfer of organisms by visitors to the farm, biological transfer from new, sick, or contaminated rabbits being brought onto the farm and mechanical transfer resulting from equipment, supplies, or machinery being brought to the farm from another farm or location. Bio-security measures used to control diseases in rabbit farms are stated below (EFSA, 2005; Patton *et al.* 2008);

Controlled movement of visitors to the rabbit houses and design of buildings and materials for construction and caging such that they allow ease of cleaning and disinfection and also exclude wild mammals and birds from the rabbit house.

A rabbit farm should be secured by fences and the rabbit house should be located some distance from other rabbits. Facilities to isolate sick rabbits from the healthy ones should be provided.

Routine disinfection of rabbit cages should be done using both physical and chemical disinfectants such as solution of sodium hypochlorite (bleach) and lye water (sodium hydroxide, PH 9).

Newly introduced rabbits should be quarantined in separate hutches for at least one month before mixing them with other rabbits in the farm. Practices that include "all in, all-out" approach should be implemented; allocating 2 to 3 weeks period in which hutches are left free of any rabbits. During the period of rest the building should be thoroughly cleaned and disinfected. In this regard, a combination of bio-security, nutrition, housing, feeding, breeding, management and disease control amongst other factors determine the success of a rabbit productions system.

CHAPTER THREE: MATERIALS AND METHODS

3.1. Study Area

The study was carried out between the periods January 2012 and May 2013 in selected areas of Kenya where domestic rabbit keeping is established (Hungu *et al.* 2013; MOLD 2010; Serem *et al.* 2013).The areas were purposively selected with assistance of the Department of Livestock production, Ministry of Livestock Developement, which already had data on areas where rabbit production in Kenya has been established.

These areas included: (1) Nairobi county and its surrounding areas of Karen, Ngong', Dagoretti, Ongata Rongai and Kiambu County (Thika town, Kabete and Kikuyu). (2) Central Kenya region of Nyeri County (Nyeri town, Othaya, Mukurweini and Karatina). (3) Eastern region of Meru County (Cenral Imenti, South Imenti), (4) Rift Valley region of Nakuru County (Nakuru town and Gilgil) and (5) Coastal region of Taita Taveta County (Wundanyi and Taita) respectively. The actual sampling sites are illustrated in Figure. 3.0, while the coordinates of the study sites are as shown in Appendix 3.

3. 1.1. Climatic conditions of the areas under study

Nairobi, Nyeri, Meru and Nakuru are classified as the highlands of Kenya. Nyeri, Meru and Nakuru are areas with an altitude of over 1500 m which receive an annual rainfall of over 1000 mm. The temperature ranges from a minimum of 10°C to a maximum 24.6°C with an average of 18.7°C. Taita Taveta and Wundanyi have an altitude of less than 1500 m (humid lowlands) and the average temperature is 23°C (FAO, 2006).

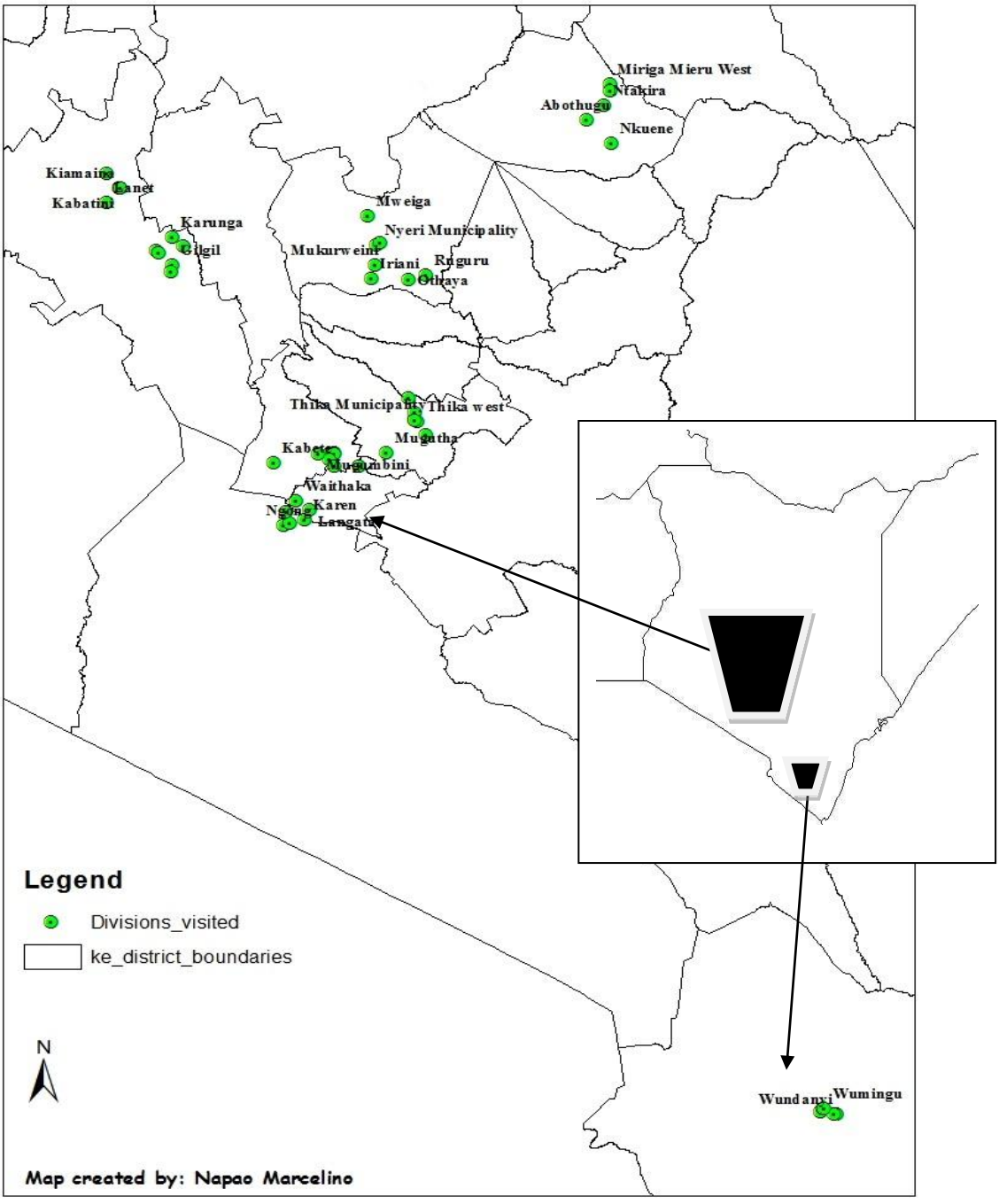


Figure 3.0: Map of Kenya showing the administrative divisions where samples on rabbit diseases were collected between January 2012 and May, 2013.

3.2. Study methods

3.2.1. Selection of study rabbits and farms

A cross-sectional survey was done in the selected regions and districts visited were purposively selected to include; the locations and villages where domestic rabbit farming was commonly practiced. The minimum numbers of rabbits to be examined were three hundred and eighty four (384). This was calculated using the method described by Martin *et al.* (1987)**: $N = Z^2 \times PQ/L^2$**

Where N = Number of rabbits to be examined, P = Prevalence of diseases estimated at 50%,

Z = Z statistic at confidence interval of 95% (1.96)

Q = 1- P, L = desired Precision at 5% at confidence interval of 95%.

Using simple a random sampling method, 80% of all the registered rabbit farms from each location were randomly selected from the list of rabbit keepers as provided by the livestock production offices in each area (Appendix 3). However, due to the variation in number of registered rabbit keepers in each county, the number of rabbits kept per farm and husbandry practices, larger numbers of rabbits (2680) were examined. This is due to the fact that larger samples more accurately represent the characteristics of the populations from which they are derived (Marcoulides, 1993).

3.2.2. Farm questionnaire survey

In each farm visited, a questionnaire on rabbit husbandry practices (Appendix 1) was filled with either the rabbit attendant or owner, depending on the person who was closely attending to the rabbits between the two. This was used to characterize the farm husbandry practices such as

feeding, breeds kept and routine management procedures including the disease signs previously encountered in each farm.

3.2.3. Examination and isolation of rabbits for sample collection

Clinical examinations of the rabbits were done in randomly selected rabbits (bucks, does and weaned kits) in each farm visited. The clinical examination at each farm covered 80% of the rabbits in the farm. The parameters that were obtained included body condition scores (section 3.2.8), skin and hair quality, sanitary conditions (section 3.2.7.), and health status of the rabbits. The observations were recorded in a clinical score card and observation sheet (Appendix 2).

3.2.4. Handling and restraint of rabbits during examination and sample collection

The live rabbits were physically restrained during the clinical examination and samples collected as described by Malley (2007). The handler grasped the rabbit's scruff over the thoracic spine, controlling the lumbar spine with the other hand. The rabbits were then restrained on a non-slip table surface by applying mild, downward pressure on the back.

Personal protective clothing such as gloves, laboratory coats and gumboots were used and subsequently cleaned and disinfected using Virkon® (Antec International Limited, Chilton Industrial Estate Sudbury, United Kingdom) (oxone, sodium dodecylbenzenesulfonate, sulphamic acid and a buffer) after visiting each farm.

3.2.5. Clinical sample collection, handling and transportation

The samples that were collected at the farm level were swabs (nasopharyngeal, conjuctival, discharge), skin scrapings, fecal samples, blood smears and live rabbits for euthanasia and

necropsy. Each of these were identified and labeled with the background information in the farm, the rabbit age, sex, breed and farm of origin (Appendix 1). Appendix 4 illustrates the specific samples collected from the different study sites visited.

3.2.5.1. Microbiological swabs

Conjuctival and nasopharyngeal swabs were collected from randomly selected apparently healthy live rabbits. Other swabs were also collected from rabbits showing various clinical signs such as abscesses, ocular discharges and infected wounds (Appendix 1).

Swabs were placed separately in sterilized airtight corked Bijou bottles with transport media as the primary receptacle. The Bijou bottles were arranged in bottle holders with a lid as secondary receptacle. Cotton wool was placed around each Bijou bottle to reduce chances of the bottles braising during transportation. Additional tissues for bacteriology were collected during necropsy of dead or euthanized rabbits (Section 3.2.9.5.).

3.2.5.2. Ear and skin scrapings

Superficial and deep skin scrapping samples were collected from rabbits that clinically showed skin lesions such as alopecia, localized erythema, ear scabs, crusts or scratching. The scrapping were collected using sharp surgical blades after which the wounds were disinfected using cotton swabs soaked in 70% ethanol. The scrapings were submitted for fungal (Section 3.2.9.2.) and/or parasitic isolation (Section 3.2.9.3.).

3.2.5.3. Blood smears

Blood smears were prepared from one randomly selected rabbit in each farm. Before blood collection, the pinna was disinfected using cotton swabs soaked in 70% ethanol until the veins

dilated. Using a 21 gauge, 3.8 cm disposable needle, approximately 2 drops of blood were collected to make a thin smear. Pressure was applied on the punctured vein using disinfected cotton wool to control bleeding. The prepared smears were air dried, fixed in methanol and arranged in slide holders with tight lids for transportation to the laboratory to be examined for hemoparasites as described by Burnett *et al.,* (2006).

3.2.5.4. Fecal samples

From each farm, 5 samples comprising 25 g of fresh feces each were obtained from the litter and under the cages. Where rabbits were housed in groups, samples were collected from different areas of the cage(s) (Cerioli *et al*, 2008). The samples were stored in plastic fecal pots and refrigerated at 4ºC until examined by flotation technique to determine number of coccidia oocysts and nematode eggs (Section 3.2.9.3.1).

Skin scrapings and fecal samples were collected in plastic pots with lids as the primary receptacle. The pots were arranged in their holders, with cotton wool around each pot and the lid tightly closed. All samples were transported in a cool box at 4ºC, delivered and processed in the laboratory within 48 hours after collection.

3.2.5.5. Rabbits for necropsy.

From each farm visited, at least one live rabbit showing clinical signs of disease or reported to have a recent disease history was collected. The rabbits were identified with each farm using colored markers on the pinna and transported in individual secure and well ventilated carrier cages to the Department of Veterinary Pathology, Microbiology and Parasitology (University of

Nairobi) for close observation, hematology and necropsy. Water was also provided at regular interval during transportation.

In the laboratory, live rabbits were housed in individual cages and provided with the commercials rabbit feeds and clean water *ad libitum* for seven days to acclimatize before sample collection. However, weak and severely sick rabbits were sacrificed humanely using Sodium Pentobarbitone (Section 3.2.9.5.) for necropsy and further sample collection (ARRP, 2003). The carcasses were disposed of in a secured departmental disposal pit.

3.2.6. Assessment of housing density

The length and width of each cage was measured and the floor area of the cages calculated. The area was divided by the number of rabbits (weaned, bucks and does) per cage to determine the housing density which was classified as;

Too crowded - less than 0.03 m^2 / rabbit

Crowded - 0.03-0.04 m^2 / rabbit

Adequately spaced - 0.042-0.06 m^2/ rabbit

Too much spaced - more than 0.07 $m^{2/}$/ rabbit).

The classification for housing density was Modified from (EFSA, 2005; Postollic *et al.*, 2006). Who reported that floor area for conventional cages for rabbits range between 0.045 – 0.06 m^2 / rabbit or 15 rabbits/m^2

3.2.7. Assessment of housing sanitation

The general sanitation in the rabbit cages were assessed and scored on the basis of cleanliness of the cage floors, feeding equipment and ventilation (González *et al.* 2008) as follows:

Very poor sanitation - Dirty floors, soiled water and feed/feeding equipment, poor urine drainage, poor ventilation of hutch (cage odour), hutch poorly maintained presence of pungent ammonia smell in the rabbit houses.

Poor - dirty floor, soiled water and feed/feeding equipment, adequate ventilation, hutch poorly maintained)

Fair - Dirty cage floor, feed/feeding equipment on the floor, proper ventilation, and hutch properly maintained)

Good - Clean floor, feed and water/feeding equipment raised above the floor, ventilation proper, hutch well maintained)

Very good - Clean floor, feeding and water /equipment raised above floor, ventilation adequate, hutches neat, and animals individually housed)

3.2.8. Assessment of body condition

Body condition refers to the amount of muscle and fat surrounding the body. To evaluate this, rabbits were examined by palpating rump and the loin for vertical protrusion of the bone (Spinous process) and fullness of muscle over and around the vertebrae. Body condition of each rabbit was scored in a 3 point scale as; Poor, Fair or good according to Bonanno *et al.*, (2008).

Where: Poor = Loin and rump are poor (prominently palpable bones and less muscle cover)

Fair = Loin intermediate and rump poor

Good = Loin and rump are intermediate.

3.2.9. Isolation and characterization of etiological agents

3.2.9.1. Bacteriology

The bacteriological examinations were based on standard protocols for bacteriology (Carter, 1979). The bacteriological samples were streaked on 5% sheep blood agar (BA) medium, MacConkey agar media (MAC) and incubated at 37°C for 18-24 hours under aerobic atmosphere or in candle jar according to the kind of bacteria suspected to be present in the sample. Gram stains of the colonies were performed to identify the bacterial morphology and microscopic characteristics of the isolates.

Other tests that were also performed include: Evaluation of the macroscopic characteristics of colonies on blood agar plate and MacConkey agar media, catalase activity, oxidase tests and coagulase test with rabbit plasma. Staphylococcus species isolates were transferred to Mannitol Salt Agar (MSA) for evaluation of their capability to ferment mannitol.

MacConkey Agar was used to identify the Gram-negative bacteria that ferment lactose. Detection of *Enterobacteriaceae* family was confirmed using their reaction in Triple Sugar Iron Agar slants (TSI), IMVIC (Indole, Methyl red, Voges Proskeur and Citrate) tests and Sulphur Indole motility tests (SIM). Further biochemical tests comprising of urease tests, nitrate reduction tests and O-F (Oxidative-Fermentative) tests were carried out as described by Carter, (1979).

3.2.9.2. Mycology.

Skin scrapings were examined for fungal elements by direct microscopy in 10% Potassium hydroxide and Lactophenol (cotton blue) mounting fluid. Isolation of fungi was done by using the selective media, *Sabouraud Dextrose Agar* (SDA) incubated for 5 days at room temperature. Additionally slide cultures were prepared from samples which were positive for fungal growth. These were used for morphological identification of the fungus based on thorough macroscopic and microscopic features as per the key described by Carter (1979).

3.2.9.3. Parasitology

3.2.9.3.1. Fecal and gastrointestinal parasites.

To assess the intensity of infestation, coccidia oocysts and nematode eggs per gram of feces were counted using the modified McMaster Technique as described by MAFF (1986). The numbers of eggs and coccidia oocysts within each grid of chamber were counted under a compound microscope at x 10 magnifications. The total number of nematode eggs or coccidia oocysts were multiplied by 50 to give either the eggs per gram of faeces (e.p.g.) or oocysts per gram of feaces (o.p.g.) Morphological and colour differences were used to distinguish various eggs (Soulsby, 2005). The average e.p.g. and o.p.g were calculated for each farm.

Fecal samples that were positive for nematode eggs were cultured for worm identification using the Baermann techniques as described by Soulsby (2005). Helminths from the fecal cultures and gastrointestinal tract were recovered and preserved in 70% ethanol and identified using morphological characteristics according to Soulsby, (2005).

3.2.9.3.2. Ecto-parasites

Each skin scraping was divided into two portions. One portion was used to examine for ectoprasites (Soulsby, 2005) while the other portion was cultured for fungal isolation (section 3.2.9.2). The scrapings were digested in 10% potassium hydroxide (10 volumes 10% KOH to 1 volume of scrapings) in a test tube and centrifuged for 5 minutes at 2000 rotations per minute. The sediments were placed on a microscope slide and examined for the presence of mites. These were identified using the key published by Soulsby, (2005).

Visible ectoparasites were picked and preserved in 70% ethanol and identified under microscope as described by Soulsby, (2005).

3.2.9.4. Hematology

In the laboratory, the dorsal surfaces of the pinna of the live rabbits sampled from the farms were first cleaned using cotton swabs soaked in 70% ethanol until the veins dilated. Using a 21 gauge 3.8 cm needle and syringe, approximately 2 ml of blood was collected and placed in 2% Ethylene Diamine Tetra Acetic acid (EDTA) for complete hematology. Hematological analysis was done using an automated cellcounter (Melet Schloesing *MS4 Vet hematology analyzer*.) and manual differential count was done as described by Zinkl and Jain (1986).

3.2.9.5. Necropsy

After the blood samples were analyzed, the clinical signs in each live rabbit were recorded and the animals were humanely sacrifised for post mortem examination by intraperitonial injection of Sodium Pentobarbitone (Euthasol®, Virbac AH, Inc. Texas) at 100mg/kg body weight.

Death was confirmed by both auscultation of the heart using a stethoscope for any mechanical heart activity and also by cardiac puncture. A 21 gauge needle was inserted into the heart and absence of blood on aspiration confirmed that the rabbit was dead. Necropsies were performed using a comprehensive protocol developed by the Department of Veterinary Pathology, Microbiology and Parasitology, University of Nairobi.

Tissue samples were collected from all organs showing lesions for histopathology, bacteriology and parasitology. These included the liver, lungs, kidney, spleen, heart and any other organ with lesion. The samples for histopathology were preserved in 10% buffered formalin. The samples were routinely processed for histopathology examination as described by Kiernan (1981). Affected tissues and skin scrapings were obtained aseptically and processed for bacteriology as described in Section 3.2.9.1. Skin scrapings and fecal samples were also collected and processed for parasitological examination as described in section 3.2.9.3.

3.2.10. Data Management and analysis

The disease condition diagnosed during necropsy and etiological agents recovered during laboratory analysis for each animal was tallied to the rabbit characteristics (i.e age) and with the husbandry practices such housing type, feeding, sanitation and the history as recorded from the farm of origin. The data was entered into Ms Excel, processed and exported to SAS V9 (SAS Institute Inc, 2002) statistical package for descriptive statistics. Means and frequencies were used to show the production systems and disease characteristics in different study sites, breeds and age of the rabbits affected. The associations between the parameters were tested statistically using Chi square (χ^2) statistics and t-tests for any significance.

CHAPTER FOUR: RESULTS

A total of sixty one (61) farms were visited, sixty one (61) questionnaires filled and two thousand six hundred and eighty (2680) live rabbits examined. In addition, sixty one (61) rabbits, three hundred and twenty (320) bacteriological samples, three hundred and sixty three (363) fecal samples, one hundred and twenty (120) blood smears, sixty one (61) whole blood, twenty one (21) skin scrapings and ten (10) ear crust scrapings were collected for further studies (Appendix 4).

4.1. Husbandry practices in rabbit production in Kenya

4.1.1. Average number of rabbits kept per farm

The distribution of farms and live rabbits examined in the study is shown in table 4.0.

Table 4.0: The number of farms visited per county and the average number of rabbits kept per farm in the study sites within the period January 2012 – May 2013.

County	Number of farms visited	Average number of rabbits/ farm ± SD
Nyeri	7	61.86 ± 49.83
Kiambu	17	59.24 ± 50.43
Nairobi	13	59.92 ± 43.79
Meru	6	48.00 ± 41.55
Nakuru	12	34.78 ± 26.36
Taita- Taveta	6	24.17 ± 13.50
Total	61	2680

Amongst the interviewed rabbit keepers, 38/61 (62.30%) were males and 23/61 (37.70%) were females. Majority 32/61 (52.46 %) of the interviewed persons were full time farmers, while 29/61 (47.54 %) were in different careers (part time farmers).

Thirty one (50.82%) interviewees were aged between 30-60 years, 16/61 (26.23%) were above 60 years while 14/61 (22.95%) were aged between 17-30 years. The age distribution of the rabbit farmers was consistent (P = 0.2907) across all the counties despite Nyeri and Taita- taveta counties having no rabbit keepers below thirty years old as shown in Figure 4.0 below

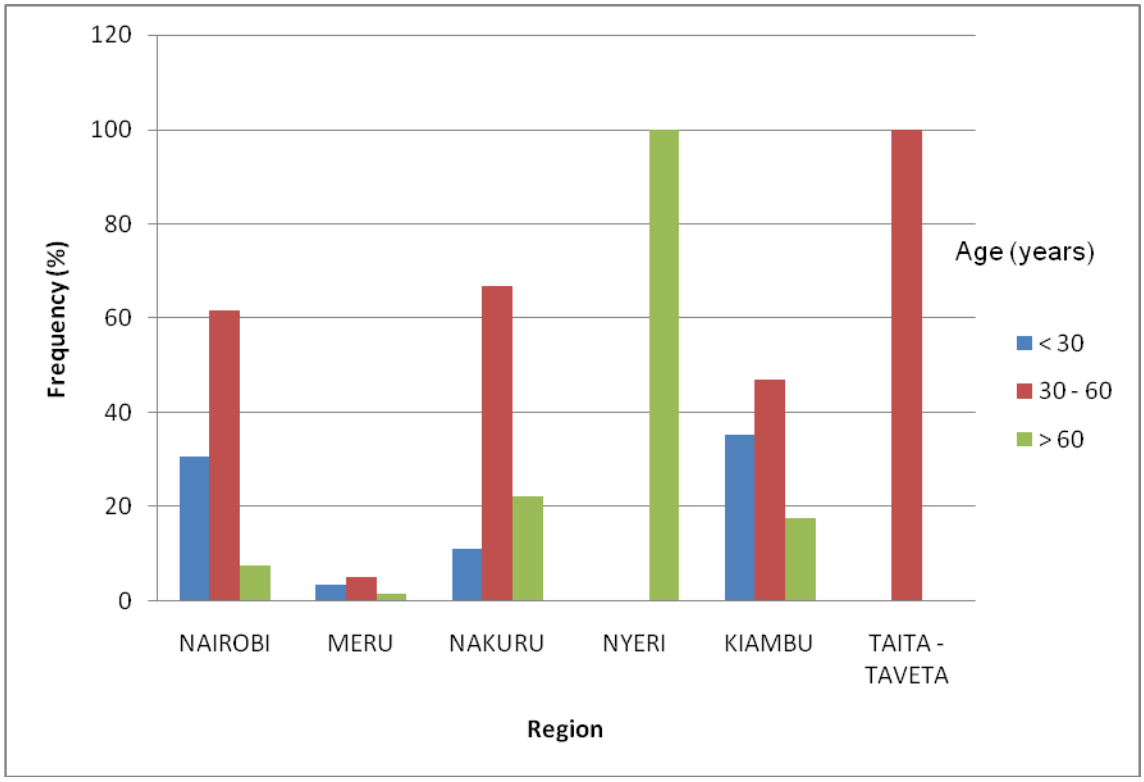


Figure 4.0: The age distribution of rabbit keepers interviewed in the six counties studied in Kenya within the period January 2012 – May 2013.

4.1.2. Breeds of rabbits kept

It was observed that all the farms kept more than one rabbit breed. Cross breeds were the most frequent, being observed in 83.61 % (51/61) of the farms. Forty eight farms (78.69%) kept New Zealand white, while 44/61(72.13%) kept Californian white. Other local breeds occasionally observed included; Checkered white in 3.28% (2/61) of the farms, Kenya white and ILRI grey each in 3.28% (2/61) of the farms while Akouti was observed in 1.64% (1/61) of the farms (Figure 4.1.) . These breeds of rabbits were evenly distributed in the different study sites visited (Figure 4.2.)

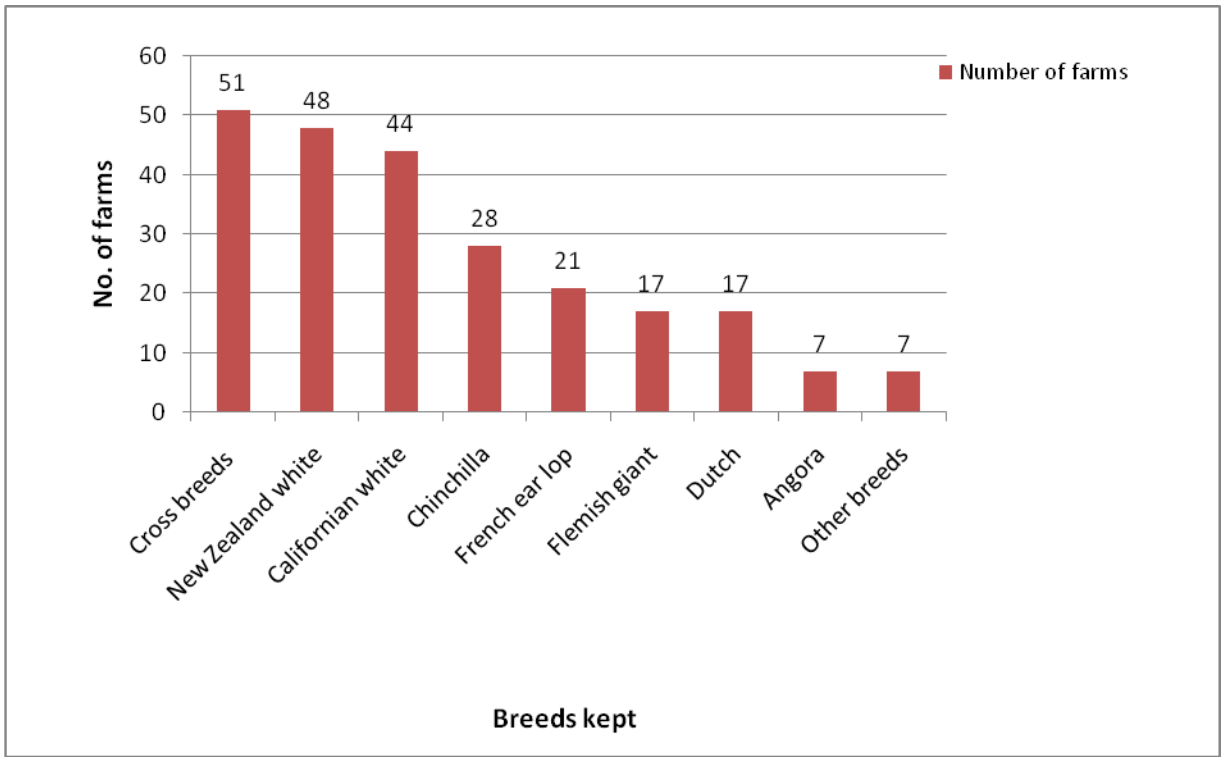


Figure 4.1: The Rabbit breeds encountered in the 61 farms visited within the period January 2012 – May 2013.

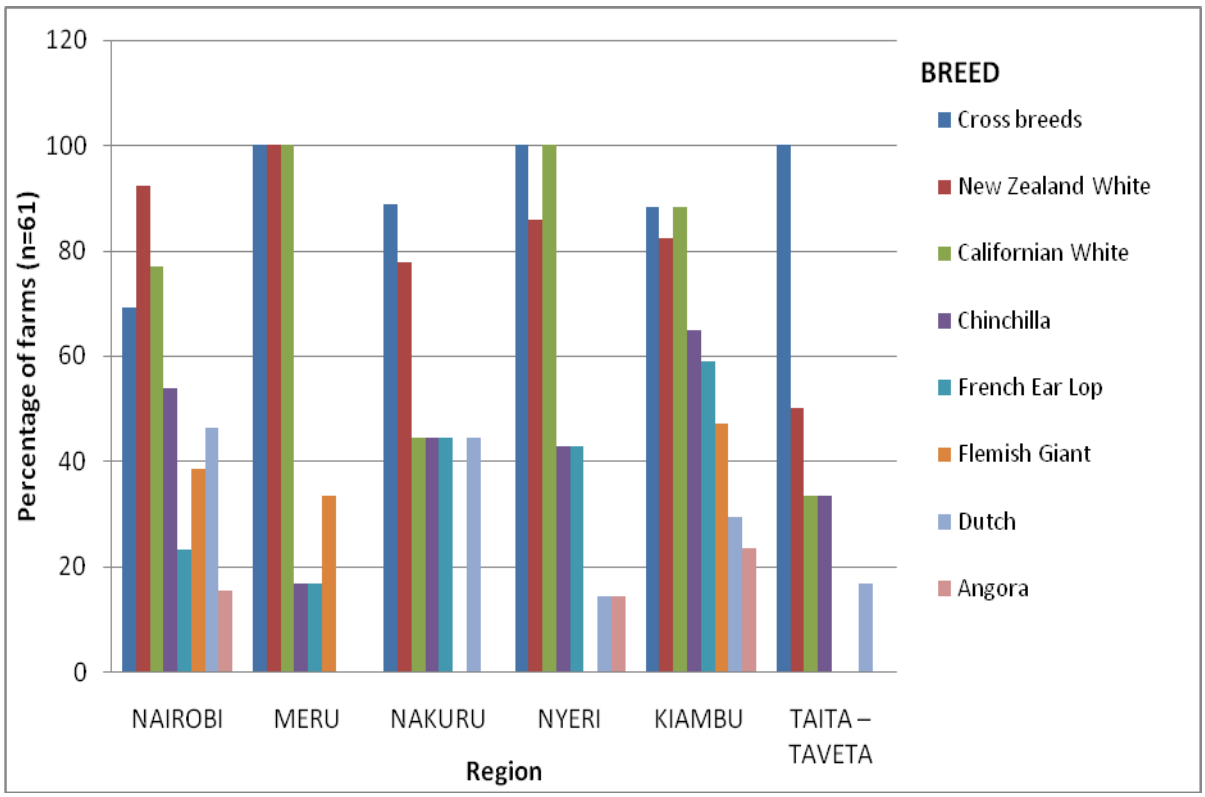


Figure 4.2: The distribution of various breeds of rabbits in the regions visited within the period January 2012 – May 2013.

4.1.3. Feeds and feeding practices

Out of the 61 farms, 51 (83.61%) of the farms used both commercial rabbit pellets and forages, 7 (11.48%) used forages only, while 3 (4.92%) farms used commercial pellets as the only source of feed for their rabbits. In addition, 52 (85.25%) of these farms used different types of grass, Kales and cabbages. Besides the forages mentioned above, 47 (77.05%) farms also used gallant soldier (*Galinsoga parviflora*), 45 (73.77%) used sweet potato vines (*Ipomoea batatas),* 44 (72.13 %) used black jack (*Bidens pilosa),* 24 (39%) wandering jew (*Commelina benghalensis),* 55.74% (34) Muthunga (*Launaea cornuta*), while 6.56% (4) of the farms occasionally reported other forages such as: Spinach (*Spinacia oleracea),* Lucerne (*Medicago sativa),* sugarcane (*Saccharum* spp), sweet potato peels, Barley (*Hordeum vulgare*), Muguka (*Catha Edulis),* carrots (*Daucus carota),* Desmodium(*Desmodium trifolium*), and bean husks (*Phaseolus vulgaris*) (Appendix 5).

4.1.4. Feeding and watering equipment

Assessment of farms revealed that, 12/61(19.67%) farms had no feeding equipments within the cages. Fired clay feeders were used in 28/61(45.90%) of farms, plastic and wooden feeders were each used in 8/61 (13.11%) of the farms, while 5/61 (8.20%) of the farms used alluminium feeders. Dirty equipment were found in 8 (13.11%),) of the farms. These feeders had either rabbit fecal pellets in them, urine soaked feed or mould growing in them.

Water containers used on these farms were made of fired clay 25 (40.98%), plastic 24 (39.34%), aluminium and wood 4(6.56%). Piped water and hanging bottles with nipples were also used in 2/61 (3.3%) farms in addition to fired clay. However, six (9.84%) farms had no watering equipments within the cages.

4.1.5. Housing

4.1.5.1. Types of housing units.

Indoor cages were commonly found in Nairobi county 9/13(69.23%) and Nakuru 4/12 (33.33%) and to a limited extent in Meru, Nyeri and Kiambu counties as illustrated in Figure 4.3. The difference in the indoor (Figure 4.4) and outdoor housing types (Figure 4.4 B) was significant between farms and also counties ($P < 0.01$).

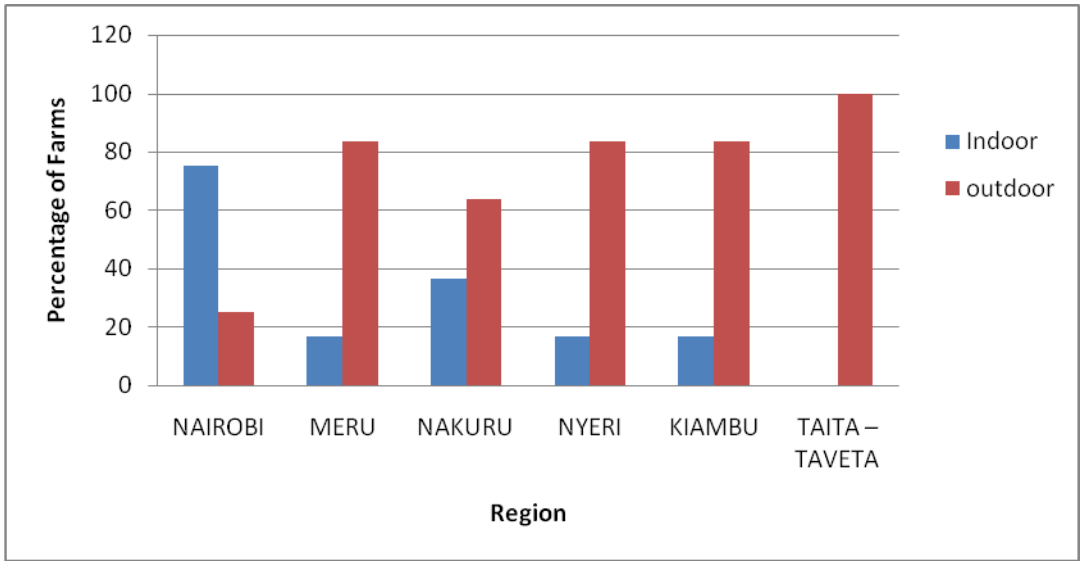


Figure 4.3: The housing types used by rabbit keepers in different study sites in Kenya within the period January 2012 – May 2013.

All the farms had rabbit houses raised above the ground; some units being one level and others tiered (Figure 4.4). Among the reasons given for using houses above the ground included; protection of the rabbits from predators 27/61 (44.26%), protection from dump grounds 20/61(32.79%) and to increase the number of rabbits kept per unit area 14/61(22.95%). Tiered

cages (Figure 4.4) were significantly higher in Nairobi 9/13 (69.23%), Meru 4/6 (66.67%) and Nakuru 6/12 (50%), but lower in Taita- taveta (0%) and Nyeri 1/7 (1.43%) ($P < 0.01$).

A total of 41/61 farms (67.72%) had neat and well maintained cages (Figure 4.4 A), 12/61 (19.67%) farms housed their rabbits in old cages, while 7/61 (11.48%) used poorly maintained and dilapidated cages (Figure 4.4 B).

The majority 31/61 (50.82 %) farms separately housed the rabbits in groups according to their age and sex (Figure 4.4 C). However, individual cages (Figure 4.4 A) where one rabbit is kept per cage were as common as grouped cages where all the rabbits are grouped together in one hutch. Each of these were observed in 15/61(24.59%) of the farms (Figure 4.5)

Figure 4.4: Indoor housing with tiered hutches and raised hutch floor (Arrows) in Farm Kf3 in Kiambu County.

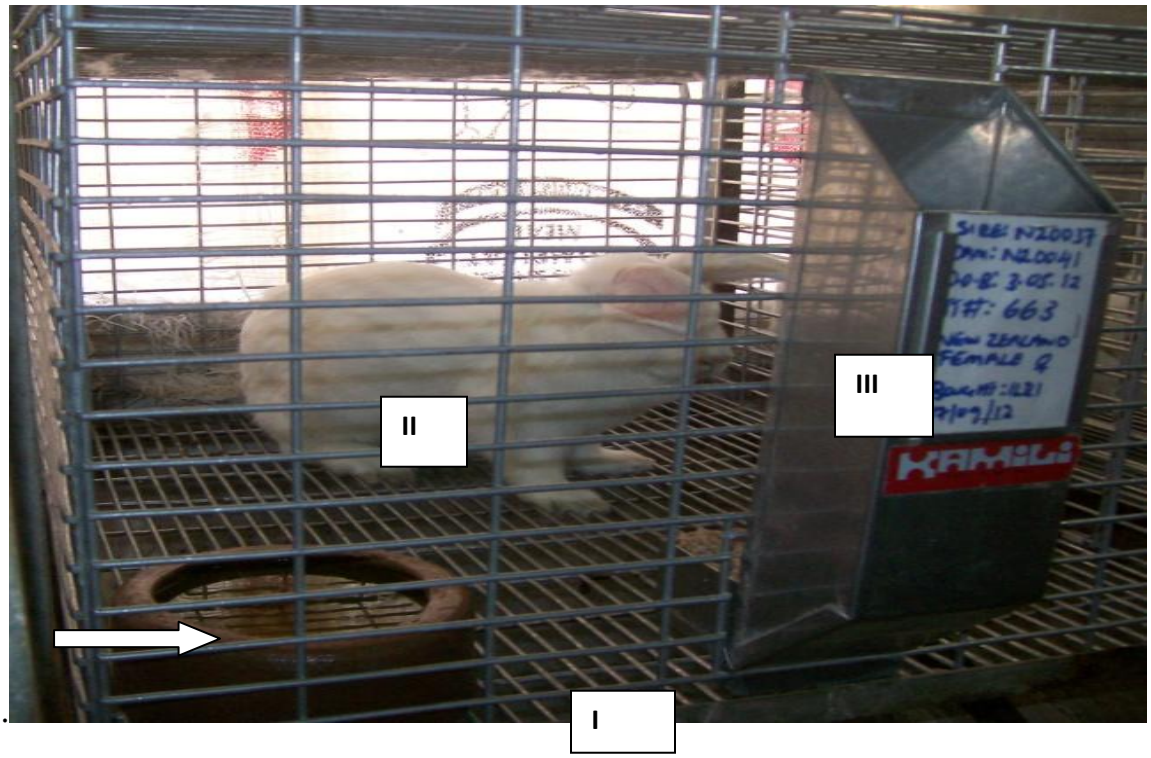
. 

Figure 4.4 A: Neat indoor cages with wire floor (I), rabbits individually housed (II), very good sanitation score, fired clay water container (Arrow) and Aluminium feed trough (III) in farm APD 001 in Nairobi County.

Figure 4.4 B: Poorly maintained raised outdoor rabbit hutches with dusty ventilation (I), accumulated fecal material blocking the wire mesh floor (arrow), mixing of rabbits of different ages and sex due to poor building structures (II) in farm TFI in Taita- Taveta County.

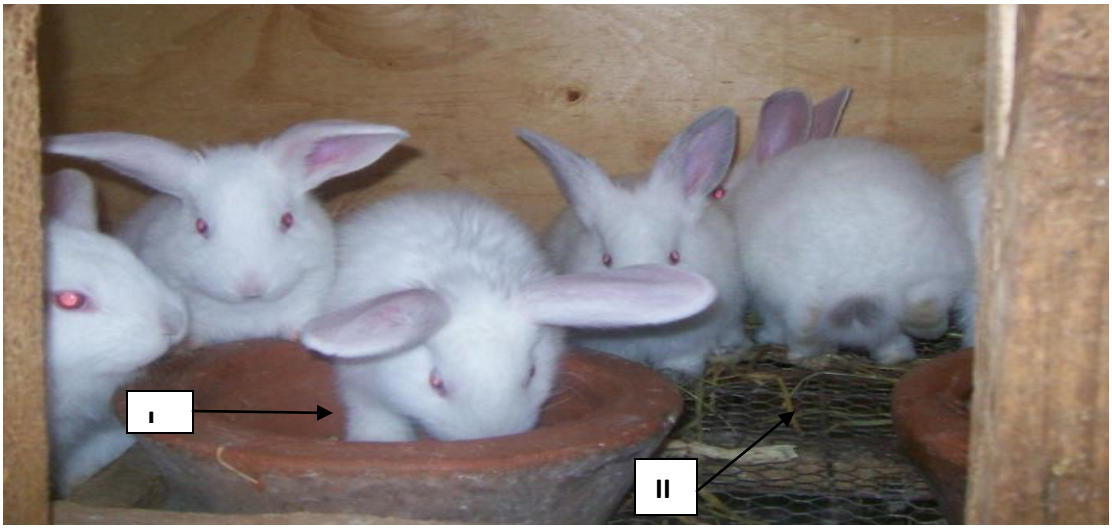


Figure 4.4 C: Grower rabbits housed in groups in a hutch with (I) rabbit stepping in the feed container and (II) wilted hay on the floor in farm LFI in Kiambu County.

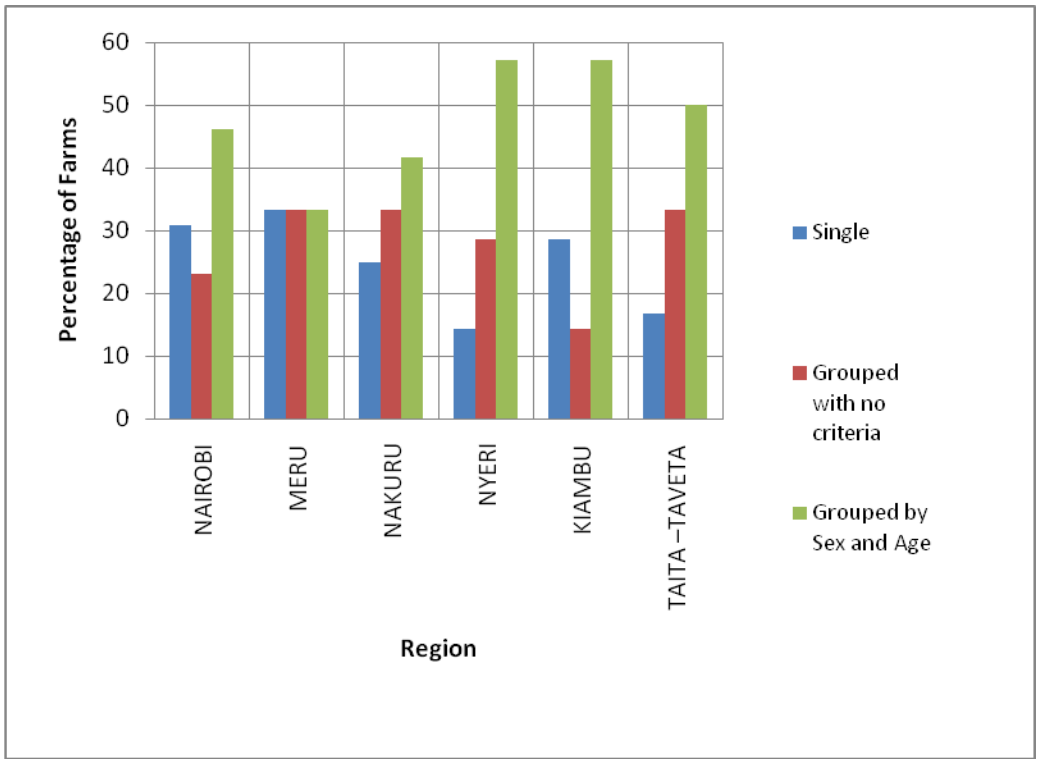


Figure 4.5: The percentage of farms where rabbits were housed singly or in groups in the study sites in Kenya within the period January 2012 – May 2013.

4.1.5.2. Housing density and cage sanitation

A majority 49/61(80.32%) of farmers housed their rabbits on adequate space. In contrast, crowding was observed on 4/61(6.56%) farms, while on one farm the rabbits were too crowded (Figure 4.6)

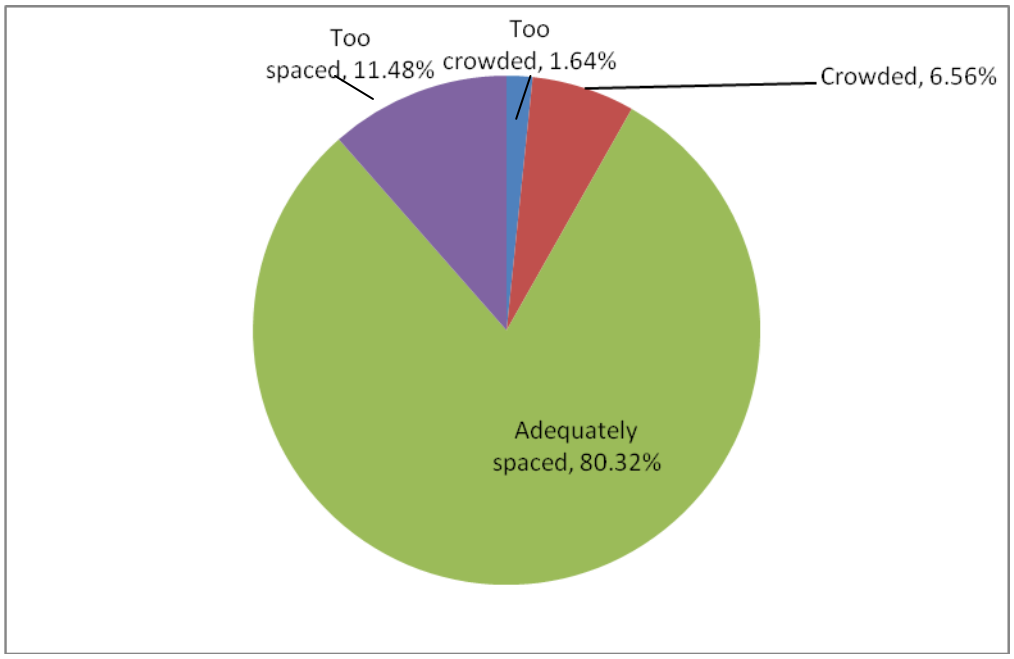


Figure 4.6: Housing density scores of the rabbit farms in the study sites in Kenya within the period January 2012 – May 2013.

With regard to sanitation, the majority of the rabbit farms 26/61 (42.62%) had good housing sanitation, 17/61 (27.87%) farms had fair sanitation, while 8/61 (13.11%), 6/61 (9.825%) and 4/61 (6.56%) farms had poor, very poor and very good housing sanitation respectively.

Poor and very poor housing sanitation were recorded in Nairobi (27.27%), Nakuru (25%) and to a lesser extent in Kiambu (5.88%) counties (Figure 4.7). Despite this, there were no significant differences in farm sanitation scores between the counties (P = 0.6074)

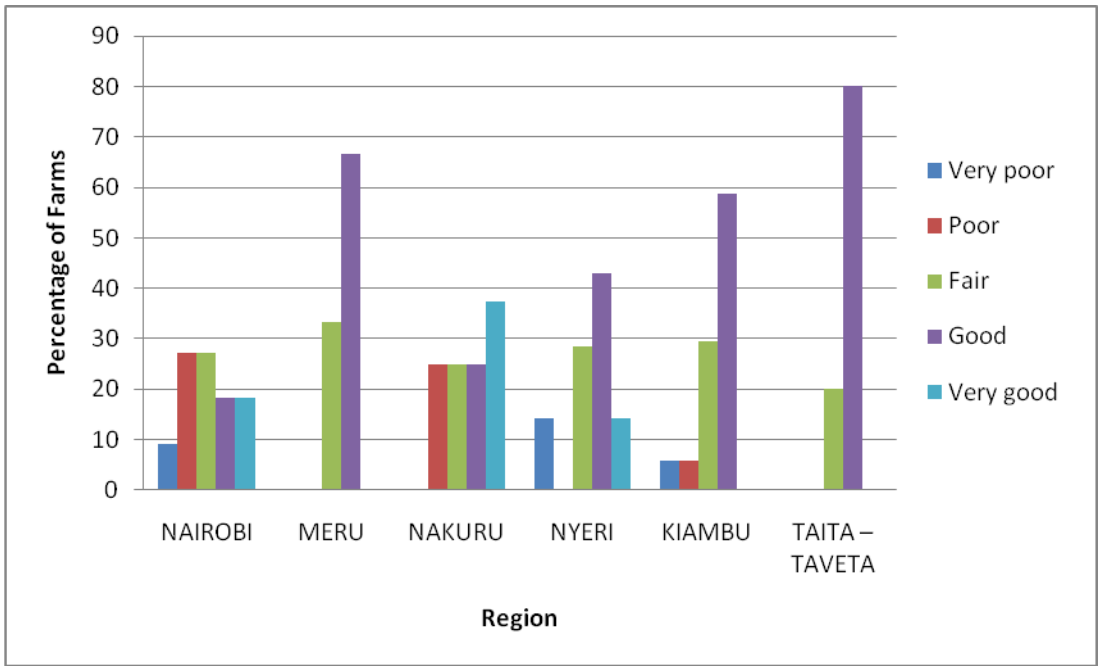


Figure 4.7: Percentage distribution of housing sanitation scores for the rabbit farms in the study sites in Kenya within the period January 2012 – May 2013.

4.1.6. Clinical signs reported by farmers

Fifty (81.97%) respondents reported that even though they did not know the diseases affecting rabbits by name, they could easily identify a sick rabbit. The commonly reported clinical signs were diarrhea in 50/61 (81.97%) farms, sudden death in 45/61 (73.78%) and abdominal distension in 42 (68.85%) amongst other clinical signs. The clinical signs were also reported by the farmers with different frequencies in the different breeds of rabbits as shown in Appendix 6.0, Figure 4.7 A and Table 4.1.

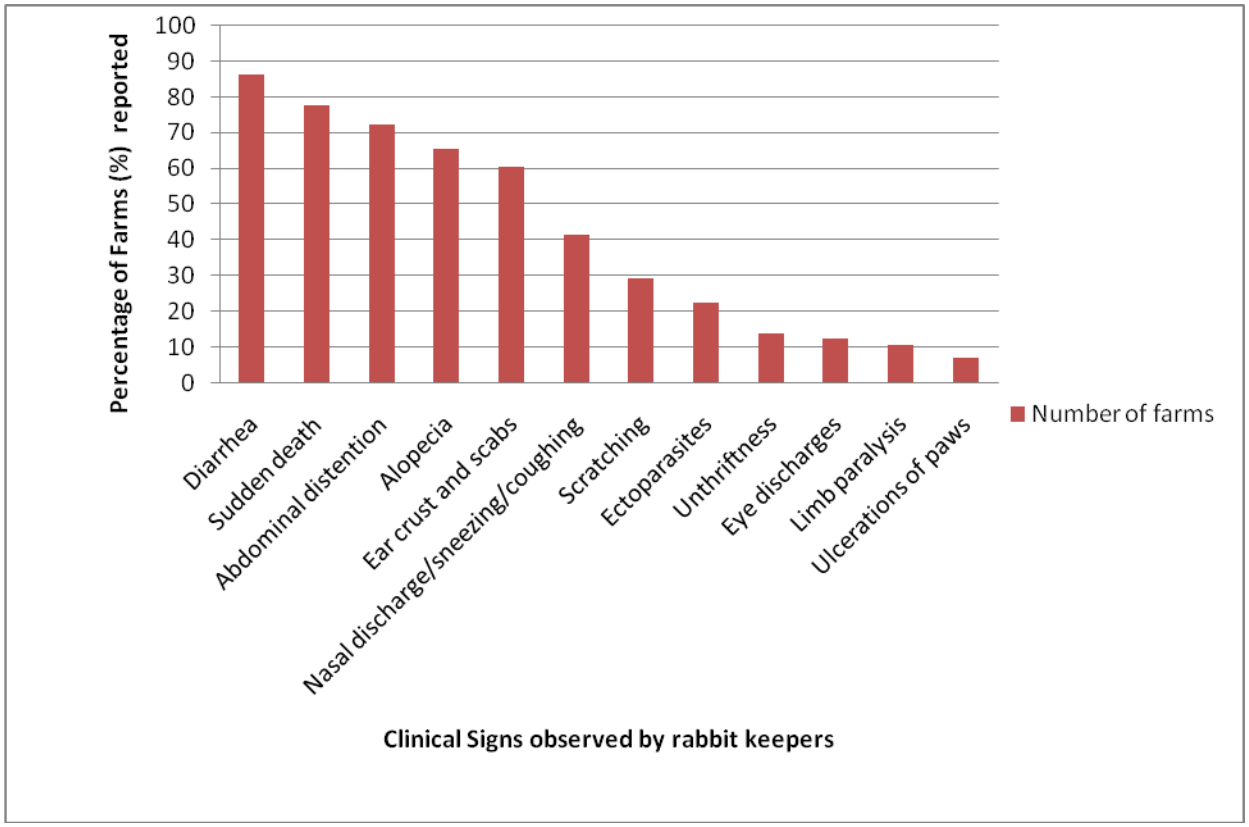


Figure 4.7 A: The clinical signs observed in rabbits as reported by keepers in different study sites within the period January 2012 – May 2013.

Table 4.1: Clinical signs reported by the rabbit farmers in different rabbit breeds in the study sites for the period January 2012 - May2013

Clinical signs observed	Frequency of farms (n= 61 in all study sites) (%) in which the clinical signs were reported								
	NZW	CW	FG	CH	FEL	DU	ANG	CROS	OTHERS
Nasal discharge/sneezing/coughing	18 (29.51)	17 (27.87)	3 (4.92)	10 (16.93)	3 (4.92)	1(1.64)	1(1.64)	7(11.48)	-
Sudden death	27(46.55)	24 (41.38)	1(1.64)	7 (12.07)	5 (8.62)	4 (6.56)	3 (5.17)	12 (20.69)	-
Abdominal distention	35 (57.38)	33 (54.1)	7(11.48)	11 (18.03)	7(11.48)	4 (6.56)	4 (6.56)	13 (21.31)	1(1.64))
Diarrhea	31 (50.82)	32(52.46)	6 (9.84)	10 (16.93)	9 (14.75)	4 (6.56)	4 (6.56)	13 (21.31)	1(1.64)
Scratching	12 (19.67)	10 (16.93)	3 (4.92)	7(11.48)	2 (3.28))	3 (4.92)	1(1.64)	10 (16.93)	1(1.64)
Paw ulceration	3 (4.92)	2 (3.28)	-	-	-	-	-	2 (3.28)	-
Ear crust/scabs	33 (54.1)	30 (49.18)	7(11.48)	13 (21.31)	4 (6.56)	6 (9.84)	3 (4.92)	11 (18.03)	2(3.45)
Alopecia	19(31.15)	18 (29.51)	5 (8.20)	7(11.48)	4 (6.56)	3 (4.92)	3 (4.92)	8 (13.11)	1(1.64)
unthrift	7(11.48)	6 (9.84)	1(1.64)	3 (4.92)	1(1.64)	-	2 (3.28)	3 (4.92)	-
Limb Paralysis	5 (8.20)	4 (6.56)	-	-	-	-	-	1(1.64)	-
Ectoparasites	12 (19.67)	11 (18.03)	1(1.64))	4 (6.56)	1(1.64))	2 (3.28)	1(1.64)	6 (9.84)	1(1.64)
Eye discharges	7(11.48)	4 (6.56)	-	1(1.64)	1(1.64))	-	1(1.64)	4 (6.56)	-

KEY: NZW- New Zealand white

FEL- French ear lope

FG- Flemish giant

DU- Dutch

CW- Carlifornian white

CH- ` Chinchilla

ANG- Angora

CROS- crossbreeds

OTHERS: Checkered white, Ilri grey Akouti

* Items in bracket represent percentage (%) number of farms that reported the clinical sign in a particular breed of rabbit.

4.1.7. Clinical findings during examination.

Examination of rabbits revealed varied clinical presentations indicative of diseases. The major clinical findings in the rabbits are described below, while a summary of these findings is given in Appendix 8.

4.1.7.1. Ear canker and infections

The study revealed Ear Canker as the most frequently observed condition affecting the ear. Physical examination revealed waxy scabs and firm dry crust within the external ears of the rabbits. The condition was observed to affect either both (bilateral) or one (unilateral) of the ear as seen in Ten (10) and four (4) rabbits respectively from a total of 10/61(16.39%) farms. Ear Canker was mainly characterized by presence of crusts and scabs 5/10 (50%) (Figure 4. 8), crusts, bleeding wounds and foul smelling discharges within the ear pinna 1/10 (10%), emaciation, crusts, abscesses in the ear and head tilting in 4/10 (40%) cases (Figure 4. 8A). The blood picture of one of the rabbits which presented with head tilting and ear abscesses showed leucocytosis (white blood cell count $14.38 \times 10^3/\mu L$), the differential count revealed lymphocytes (32%), neutrophils (65%) and eosinophils (3%) (Appendix 16).

Rabbit keepers from 7/10 farms reported to have "treated '' the animals for Ear Canker by administering mineral oil and glycerol in the ear lesions. However 6/10 (60%) of the farmers reported recurrences of Ear Canker after the treatments and culled the affected rabbits. However, during examination, clinical cases of Ear Canker were observed in three farms in which the owners of these farms reported to have never observed any ear condition in their farms.

The ear mites, (*Psorotes cuniculi)* (Figure 4.8 B) was isolated from all the ten (10) ear crust scrapings collected from the clinical cases of ear canker. *Staphylococcus aureus, Escherichia coli, Proteus mirabilis* and *Klebsiella pneumoniae* were consistently isolated from swabs taken from ears of 4 rabbits that were diagnosed with complicated ear canker characterized by head tilting, otitis externa and foul smelling ear discharge.

4.1.7.2. Conjunctivitis

Conjunctivitis was observed in five rabbits from 5/61(8.20%) farms. The affected conjunctivas were generally congested and covered with whitish, mucopurulent discharges (Figure 4.9). Three cases were seen in kits which were four (4) weeks old while two cases were in adults three (3) and ten (10) months respectively. *Staphylococus aureus* was isolated from all the swabs taken from these rabbits. In one farm Gentamycin eye ointment was applied and reportedly recovery occurred in three (3) days.

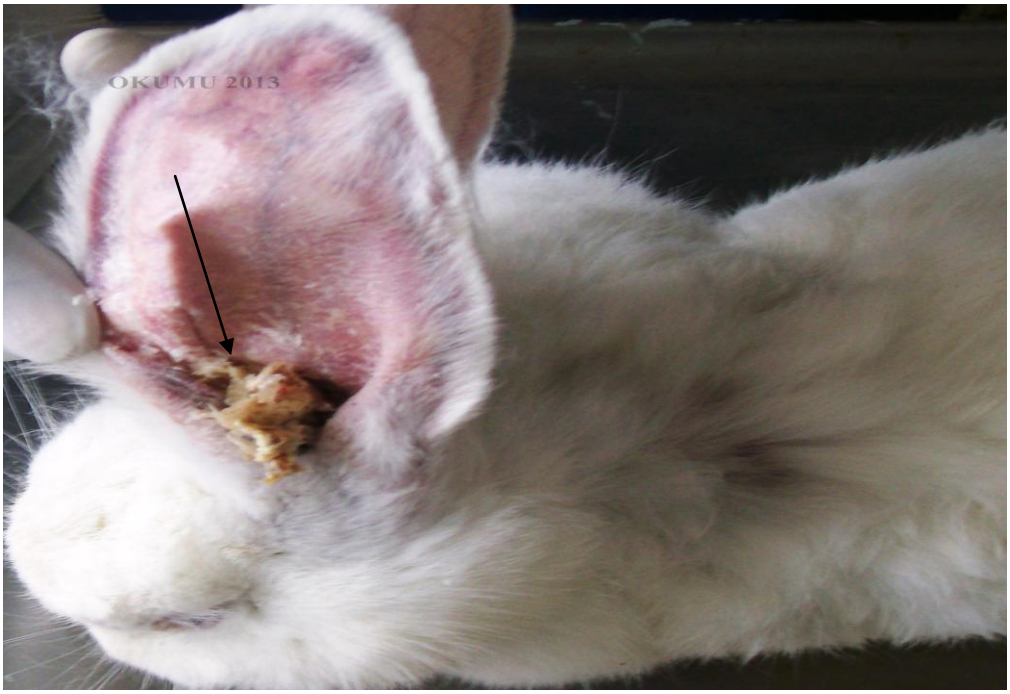


Figure 4.8: Crusts in the left ear (Arrow) in a rabbit with ear canker due to *Psoroptes cuniculi* mites (Case number NKF2).

Figure 4.8 A: Head tiltingtowards the right ear (Bold arrow) in a rabbit diagnosed with Ear canker (Case number NF2).

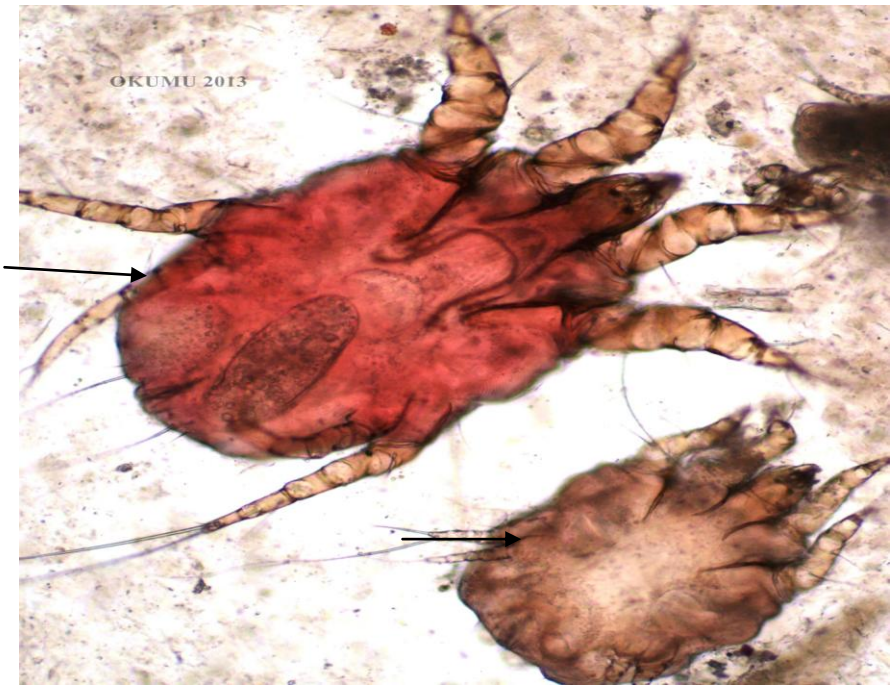


Figure 4.8 B: *Psoroptes cuniculi* mites isolated from ear scrapings from the rabbit in Figure 7.23A. (X 10).

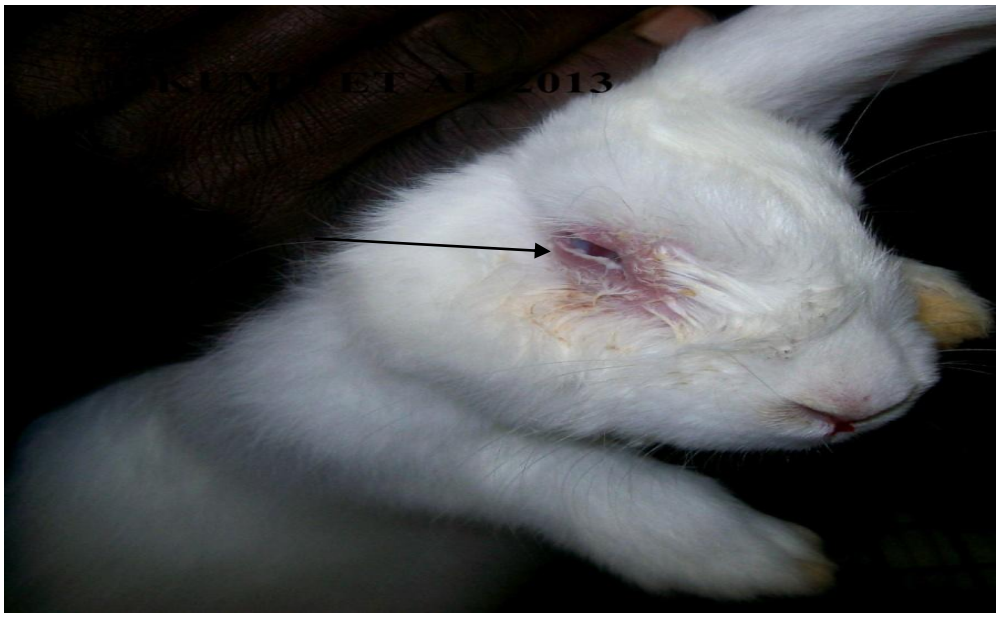


Figure 4.9: Mucopurulent dicharges (Arrow) in a 4 weeks old Newzealand white rabbits diagnosed with *conjuctivitis. Staphylococus aureus* was isolated from the conjuctival swab (Case number APD 001).

4.1.7.3. Rough fur coat and depression

In 8/61 (13.11%) farms, the clinical signs observed in twenty four (24) rabbits were rough hair coat. Further in 6/61 (9.84%) of these farms, 8 rabbits were depressed and appeared dull in addition to the rough hair coat observed.

4.1.7.4. Diarrhea

Clinical signs associated with diarrhea were characterized by soiling of the perineum observed in Sixteen (16) rabbits from a total 7/61 (11.48%) farms. Additionally a total of six (6) rabbits with diarrhea were found lying dead in the cages in 5/61 (8.20%) of these farms. Further, presence of diarrhea in rabbits was supported by the presence of watery, mucoid and abnormally soft feces observed in 1/61 (1.64%), 2/61(3.3%) and 5/61(8.2%) farms respectively during assessment of the cages.

4.1.7.5. Coughing and nasal discharges.

Clinical signs associated with pneumonia (sneezing accompanied by coughing and purulent nasal discharge and licking the upper lips after each bout of sneeze) were observed in 10 rabbits in 7/61 (11.48%) farms.

Pasteurella multocida was also isolated from three nasopharyngeal and one conjuctival swab collected from 2 farms where sneezing in rabbits were observed. *Klebsiella pneumoniae* were isolated from nasopharyngeal and two conjunctival swabs collected from three apparently healthy rabbits in three farms where clinical signs of pneumonia were observed. *Pseudomonas aeroginosa* was also isolated from nasopharyngeal swabs in two rabbits that presented with sneezing and nasal discharges

4.1.7.6. Sore hock and paw ulcerations

Sore hock was diagnosed in two rabbits from 2/61(3.28%) farms, while paw ulceration was observed in five (5) rabbits from 5/61(8.20%) farms. All these farms had cage floors made of wire mesh.

The paw ulcerations were characterized by presence of bleeding wounds on the rabbit paws. Paw ulcerations were all unilateral and affected either the front legs (2/5), hind legs (2/5) or both (1/5). In one case the paw ulcers occurred together with abscesses (Figure 4.10). The two cases of sore hocks observed affected the hind limbs of rabbits. In one rabbit sore hock was bilateral and presented with gangrenous dermatitis and arthritis. The severely affected limb was swollen, reddened and had foul smelling purulent discharge. The perineum of this rabbit was also wet due to urinary incontinence (Figure 4.11). The blood picture for this particular rabbit showed leucocytosis (white blood cell count $22.58 \times 10^3/\mu L$) ((Appendix 15).

Five (5) swabs taken from three (3) rabbits showing paw ulcerations and two (2) rabbits having sore hock with Joint abscess / arthritis revealed mixed bacterial infection. The bacteria isolated included *Staphylococcus aureus, Streptococcus species, Citrobacter species* and *Corynebacterium* species. Three rabbit keepers 3/61 (4.92%) treated the paw ulcers by spraying the affected feet with aerosol spray® (oxytetracycline).

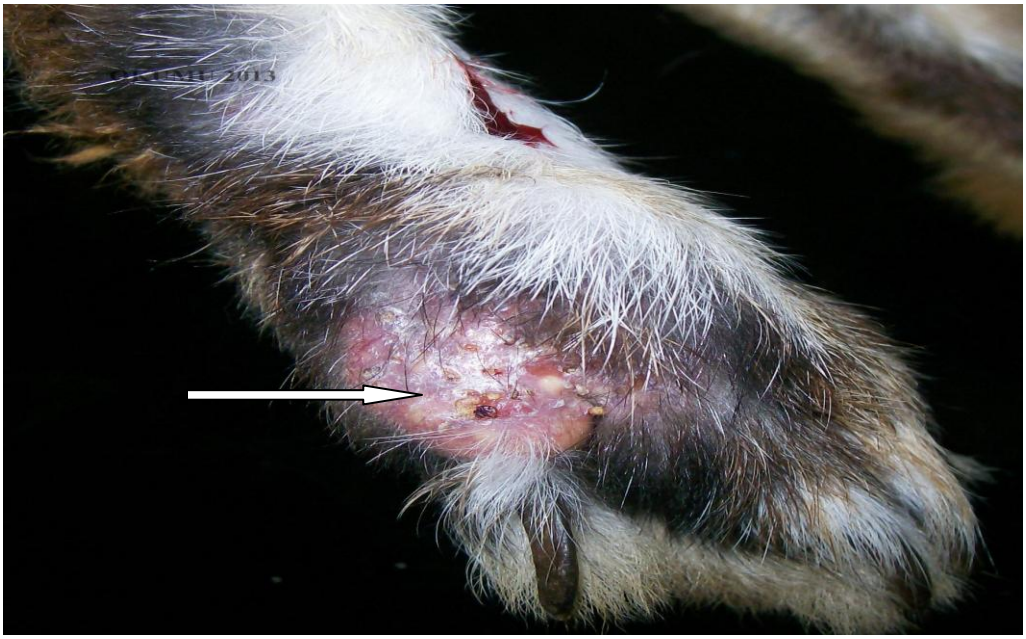


Figure 4.10: Paw ulcers with abscesses (arrow) in a cross breed rabbit from Nakuru County (Case number NKF2).

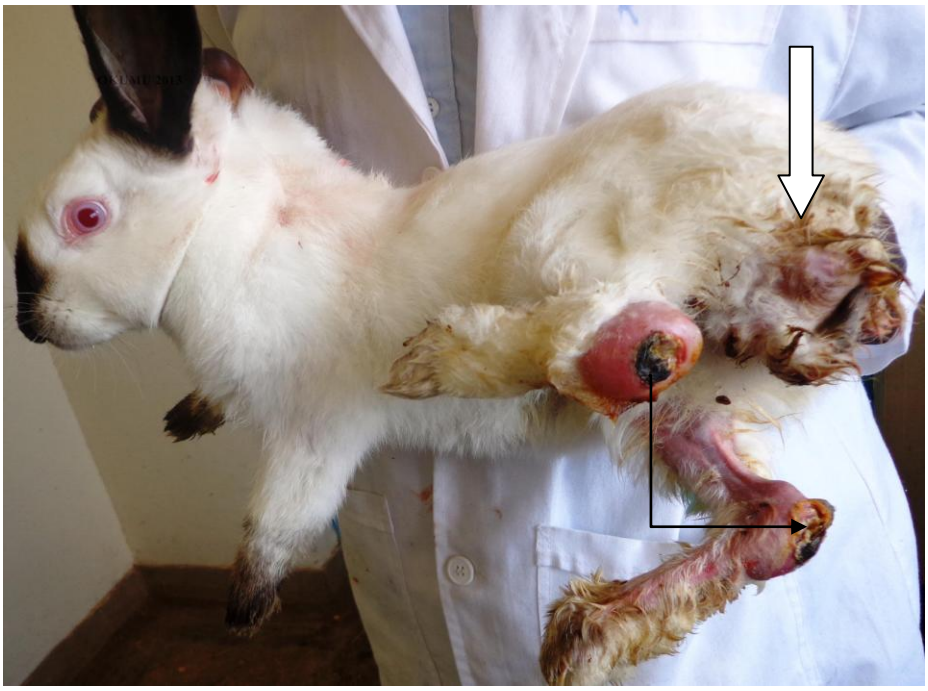


Figure 4.11: Severe sore hock in a rabbit with wet perineum due to urinary incontinence (bold arrow) and gangrenous dermatitis and arthritis (Double arrow) in a rabbit from Nairobi County (Case number 395/2012).

4.1.7.7. Skin infections

Skin conditions that were observed in the study included; mange, abscesses, fungal infections, flea infestation and wounds. These conditions were reported in 17 (27.87%), 4 (6.56%), 2 (3.28%), 2 (3.28%) and 3 (4.92%) farms respectively.

4.1.7.7. 1. Mange

Generalized alopecia was observed in 5 rabbits sampled from 5/61(8.20%) farms. The condition was characterized by loss of hair on the neck region, dorsum and the ventrum just under the hind limbs. The rabbits showed either emaciation 2/5(40%), bald patches on the skin surrounded by rough hair coat and skin dandruff 2/5(40%), and reduced feed consumption was reported by the owner of 1/5(20%) rabbit. This condition affected a whole flock in 1/5 (20%) farm, rabbits housed in groups and those in adjacent cages in 1/5 (20%) farm, while in 3/5 (60%) farms, one rabbit was infected in each case. The scrapping did not reveal any parasite. In three (3/5) cases the farmers reported to have given ecto-parasite treatment either by dusting with insecticide (2) bought from agro veterinary shops or injection by a veterinarian (2). The specific compounds could not however be identified due to lack of records.

Localized mange was observed in 12 rabbits in 5/61(8.20%) farms. Localized mange was characterized by alopecia around the nostril in 5/12(41.67%), upper and lower mandibles 4/12 (33.33%) and the skin around the fore and hind paws in 3/12 (25%) rabbits. The affected areas had whitish pimples or crusts that were surrounded by zones of alopecia and erythema (Figure 4.12). The organism isolated from the 12 skin scrapings sampled from these rabbits was predominantly *Sarcoptes scabiei* mites (Figure 4.13).

Rabbit farmers in three farms reported that they treat localized mange by spraying the affected skin area with paraffin oil, while some farmers in two farms isolated these animals and left them to heal with time. All these farms reported reoccurrence of the condition after a short duration of one week to 4 weeks.

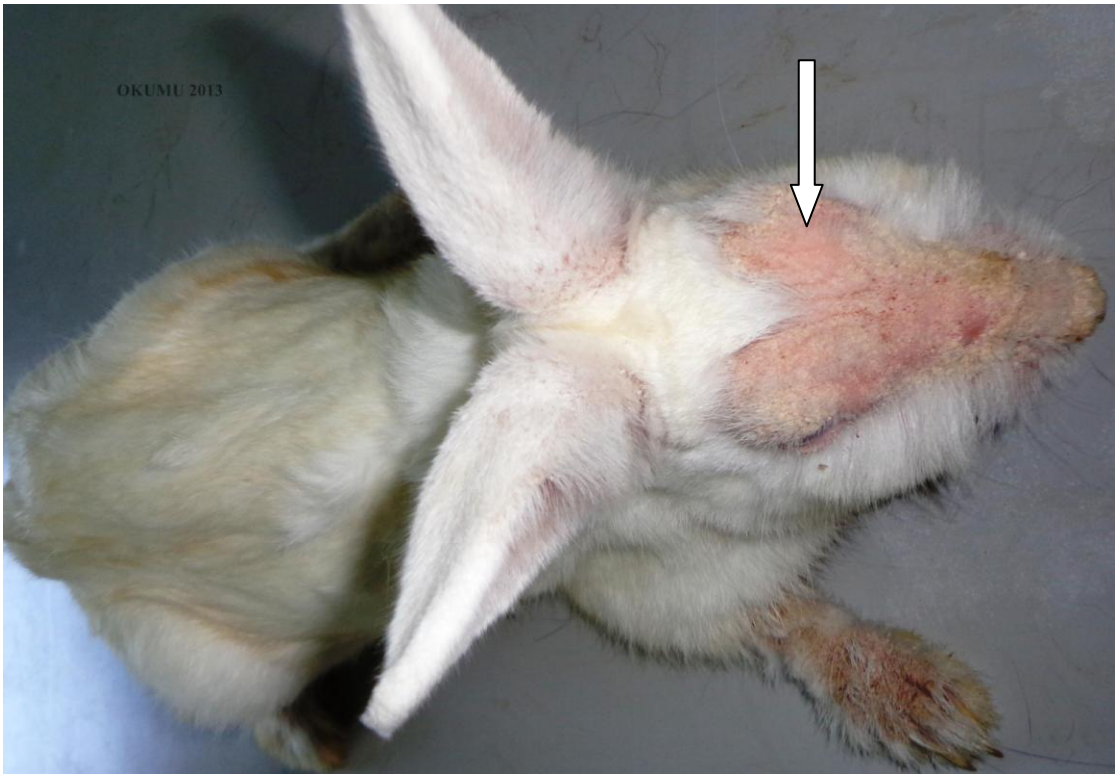


Figure 4.12: Alopecia, and erythema around nostrils, upper and lower lips, eye and fore paws in case of multifocal mange caused by *Sarcoptes scabiei* mites in a Newzealand rabbit sampled from Kiambu County (case number KF1).

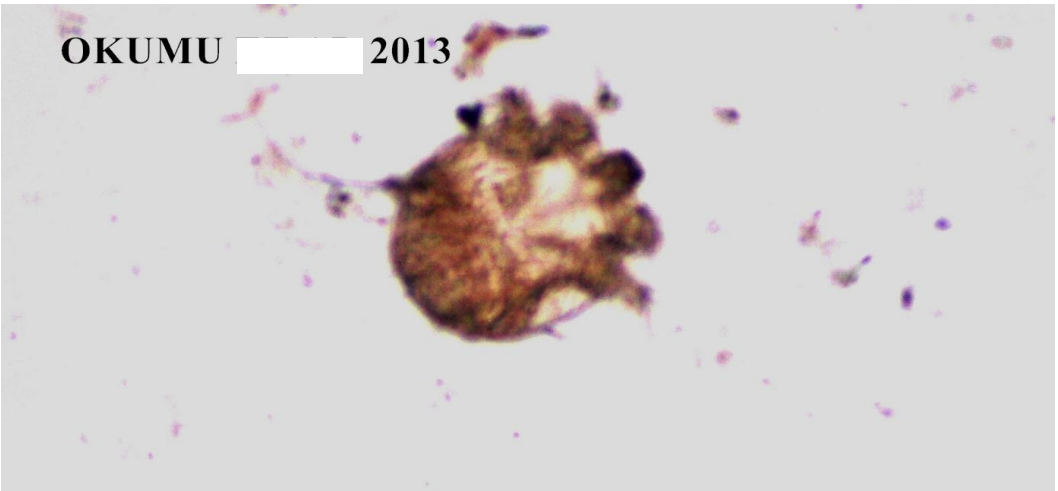


Figure 4.13: *Sarcoptes scabiei* mites isolated from a rabbit with localized mange (X 10)

4.1.7.7. 2. Flea infestation

Fleas were observed in 2/61 (3.28%) cases from 2/61 farms. In both cases the rabbits were housed closely (overcrowded). In one farm, poultry were housed just under the hutch. The fleas were mainly distributed below the abdomen, ears and neck. The rabbits in both cases were observed to be consistently scratching the fur with the fore paws. The isolated flea was the dog flea *Ctenocephalides canis* (Figure 4.14).

4.1.7.7. 3. Skin abscesses and wounds

Soft swellings on the skin were encountered on six (6) rabbits from 4/61 (6.56%) farms. These swelling were located mainly around the mandible in (2/6), dorsal thoracic vertebrae, scruff and rump (2/6) and on the upper eyelid (1/6). Two rabbits that had subcutaneous abscesses showed multi focal areas of open wound, where the abscesses had opened up and were drying. These abscesses ranged between 2 cm to 4.5 cm in diameter and had soft consistency (Figure 4.15). Swabs taken from the subcutaneous abscesses from the two rabbits revealed mixed infection with *Staphylococcus aureus* and *Streptococcus* species.

Other conditions encountered included traumatic wounds which were observed in four (4) rabbits from 3/61 (4.92%) farms. These occurred where the rabbits were housed in groups, and they involved the male rabbits. The wound included fight wound on the ears, and around the nose in 2/61 (3.28%) farms in one farm, traumatic wounds on the abdomen characterized by skin lacerations and bleeding was observed in a rabbit which was housed in a dilapidated hutch

Decubital wounds were seen mainly on the hock joint in four Chinchilla kits from the same farm. The kits had been born with bilateral splay hind legs.

Figure 4.14: Dog flea *Ctenocephalides canis* isolated from a rabbit housed together with poultry in Taita- Taveta County (Case number TF3) (X 10).

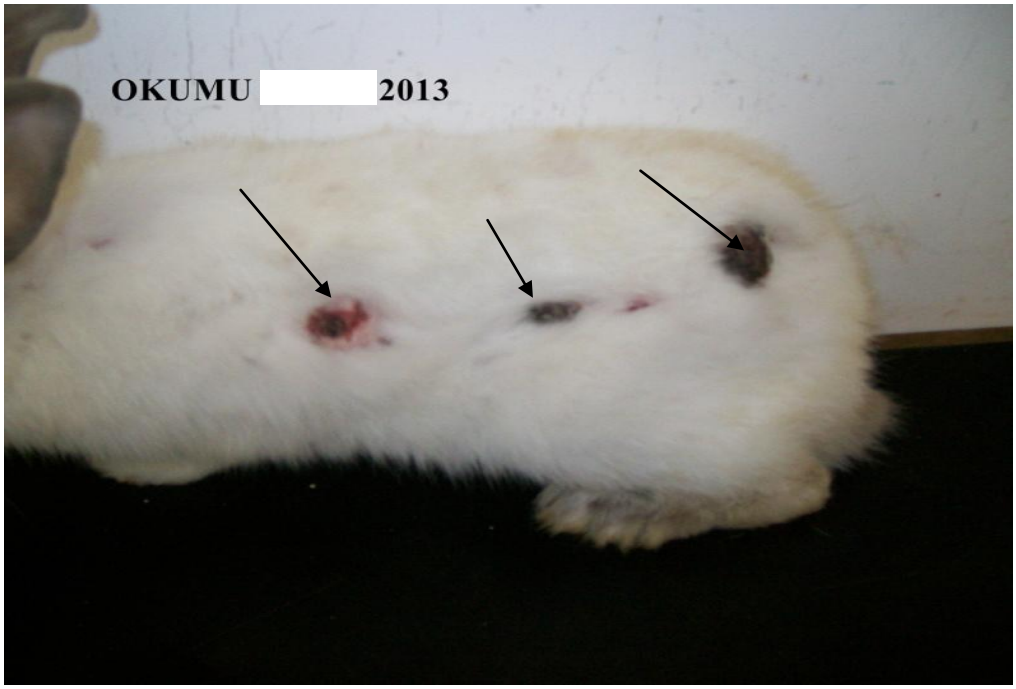


Figure 4.15: Multifocal open wounds (arrows) on a rabbit diagnosed with subcutaneous abscesses (Case number MF2).

4.1.7.7. 4. Dermatophytosis

Dermatophytosis was diagnosed in two (2) rabbits that were observed with circumscribed areas of alopecia of 3cm and 4.2 cm diameter on lower mandible and on the scruff respectively. The skin scrapping revealed *Microsporum canis* after fungal culture. The fungus was characterised by spindle shaped macroconodia (Figure 4.16).

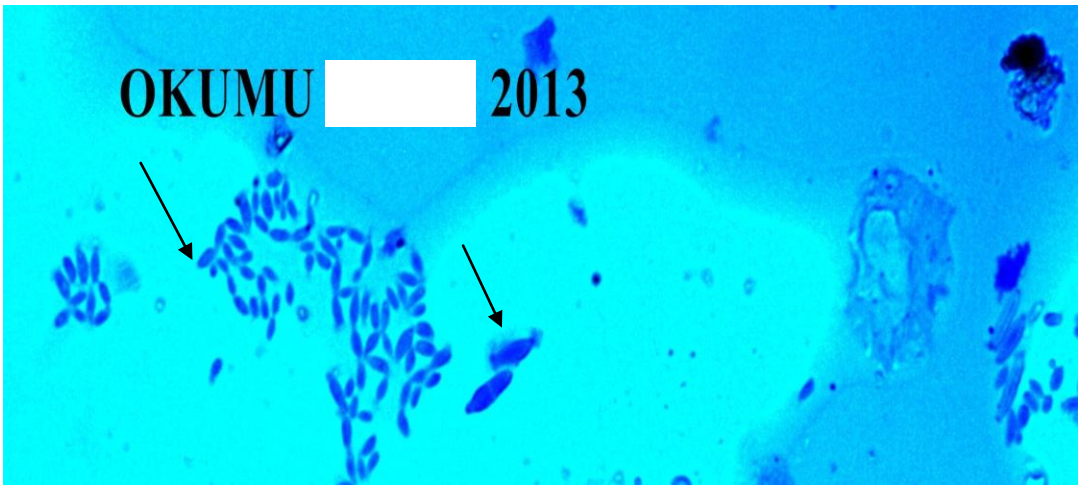


Figure 4.16: Macroconidia of *Microsporum canis* (arrows) from a slide culture of skin scrapings collected from a rabbit diagnosed with dermatophytosis in Nairobi County (LCPB X 100) (Case number APD 009).

4.1.7.8. Cage barbering and cannibalism

Other miscellaneous conditions such as cage barbering where rabbits were seen frequently chewing the wooden structures used to construct the cages was observed in one farm. Similarly in another farm one rabbit was observed to eat the kits after kindling (cannibalism). In another farm, a rabbit was observed with long incisors (overgrown teeth) on the maxilla.

4.1.7.9. Splay legs

Splay leg was observed in one farm in three Chinchilla rabbits aged eight (8) weeks. Splay leg was characterized by bilateral hind leg abduction and leg in-coordination during locomotion (Figure 4.17). The rabbits were born in that condition. The owners reported that the buck which had been used to serve the does had previously been reported to sire kits with similar problem in a nearby rabbit farm.

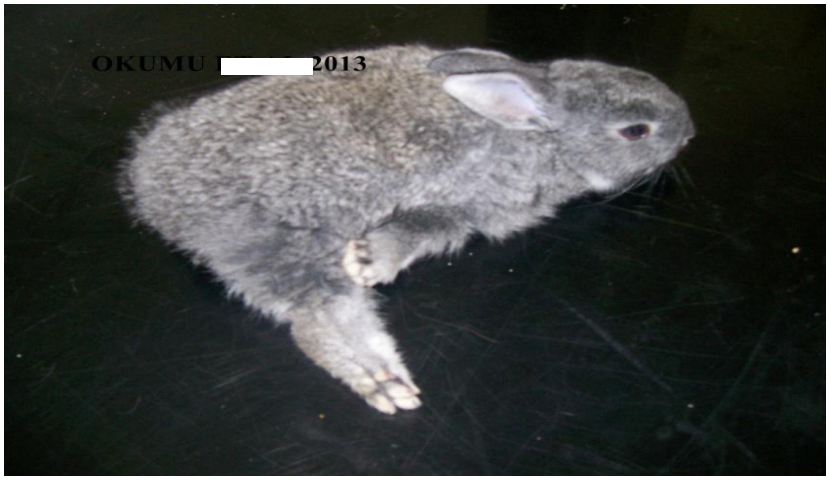


Figure 4.17: Bilateral fore and hind splay leg in an eight week old rabbit from Nakuru County (Case number NKF7).

4.1.7.10. Single ear

Adult female Newzealand and California cross breed rabbit in one farm was observed with a single ear. The offspring of this rabbit were however normal

4.1.7.11. Gastrointestinal parasites

4.1.7.11. 1. Coccidiosis

A total of 302 faecal samples were collected from various farms in the different study sites. A total of 257/302 (85.10%) fecal samples tested positive for coccidia oocysts counts using the McMaster technique. The various ranges of coccidia oocysts (opg) that were recovered in feaces collected from the 61 farms are as shown in (Figure 4.18) and Appendix 7.

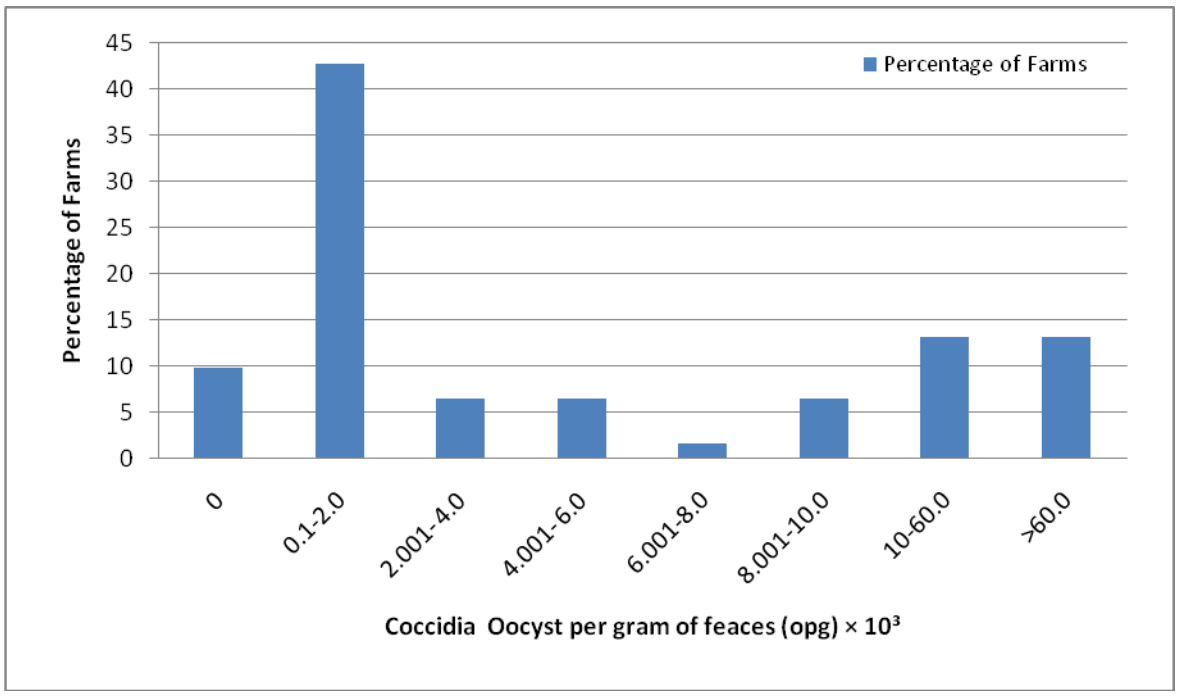


Figure 4.18: The percentage of farms where various ranges of coccidia oocysts (opg) were recovered in feaces collected between the periods January 2012 – May 2013.

The average coccidia oocysts count (opg) in 55/61 farms (90.16%) ranged between 100 to more than 60000 opg. In 6/61 (9.84%) farms, all the 30 fecal samples tested negative for coccidian Oocysts (Figure 4.18) and 3/61 (3.28%) of the farms that tested negative reported to have treated their rabbits against coccidiosis using sulphur antiobiotics in water. In three (3) other farms, sanitation scores were very good. Furthermore, Coccidia oocysts were recovered from fecal samples collected from either the tiered or one level rabbit houses in all the counties. Fecal samples from tiered rabbit houses in Kiambu, Meru, Nairobi and Nakuru had higher coccidia opg as compared to those collected from one level rabbit houses/cages. Despite this, there was no significant association between the coccida opg counts and the number of cage tiers ($P = 0.0572$), type of cage floors ($P = 0.1723$) or house sanitations ($P = 0.6312$).

Fecal samples from houses where rabbits were kept in crowded groups had relatively higher coccidia opg compared to those from singly housed rabbits. There was a significant association between the coccidia opg counts and the housing density (P = 0.0293).

Relatively high Coccidia opg were recovered in fecal samples collected from farms in Nyeri 4/6 (57.14%) and Nairobi 6/13 (46.15%) counties and to a limited extent in Meru 2/6 (33.33%) County, while low counts were recovered from Kiambu 13 (76.47%) and Taita – Taveta (66.57%) counties, (Figure 4.19 and appendix 14). There was no significant variation in Coccidia opg from the different regions (P= 0.4163).

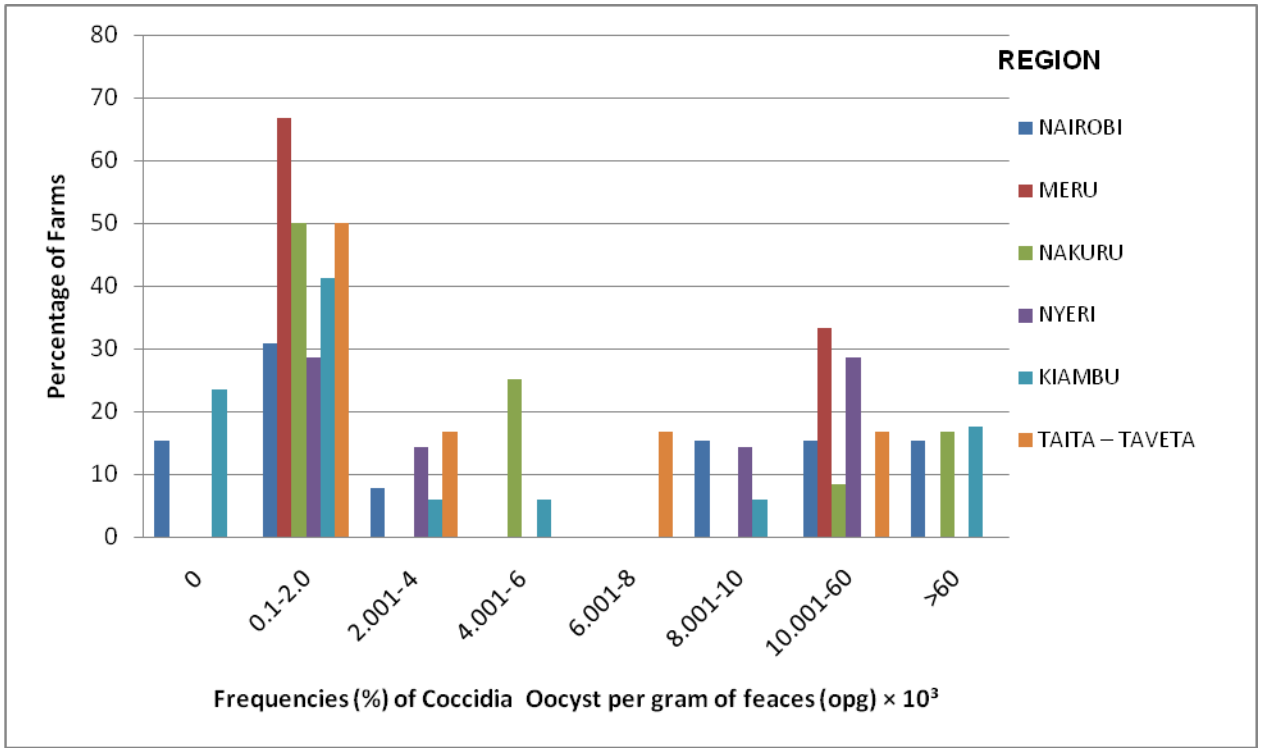


Figure 4.19: Percentage of study farms where various levels of coccidia oocysts (opg) were recovered in rabbit feaces collected from various counties in Kenya during the periodsJanuary 2012 – May 2013.

4.1.7.11. 2. Helminthosis

Typical strongyle nematode eggs were recovered from 6/302 (1.99%) fecal samples collected from the rabbit houses/cages in the 61 farms. The nematode egg counts from the 6 samples were as follows: 100, 200, 400, 600, 5000, and 6000 EPG respectively. The study however did not recover the larvae from the samples after fecal cultures.

4.1.8. Diseases diagnosed during post mortem examination.

4.1.8.1. Body systems affected

The post mortem examination done on the sixty one (61) rabbits sampled from the study sites revealed that diseases of domestic rabbits usually affect multiple body systems and may be manifested clinically or sub clinically. The study encountered multiple infections of rabbits with different diseases as illustrated in Table 4.2.

The digestive sytem was the most frequently affected 40/61 (65.57%). This was followed by conditions affecting cutaneous system 17/61(27.87%) and those affecting the eyes, ears and oral cavity which were encountered in a total of 17/61(27.87%) rabbits. Diseases of the digestive system mainly affected the small intestinal tract and the liver. For the cutaneous system, diseases were mainly encountered on the epidermis, while a few extended to the dermis. The prevalence of developmental, behavioral and other conditions that did not affect one specific body part or system (miscellaneous conditions) was 14/61 (22.95%), while the prevalence of disease affecting respiratory system and musculoskeletal system (limbs and muscles) was 7/61(11.48%) and 5/61 (8.20%) respectively

Table 4.2: Frequencies of rabbit diseases affecting different body systems diagnosed in the 61 rabbits during post mortem examination between the periods January 2012 – May 2013.

Body system affected	Diseases diagnosed	Number of affected rabbits
	Enteritis	18
Digestive System	Hepatic coccidiosis	7
	Mucoid enteritis	5
	Bloat	3
	Helminthiasis	2
	Constipation	1
	Intusussception	1
	Gastritis	1
	Peritonitis	1
	Volvulus	1
Total		**40**
Eyes, ears and oral	Ear canker	6
	Conjuctivitis	5
	Otitis externa	4
	Retrobulbar abscess	1
	Over grown teeth	1
Total		**17**

Body system affected	Diseases diagnosed	Number of affected rabbits
Cutaneous system	Generalised alopecia	5
	Sub-mandible abscess	3
	Localized mange around eyes	2
	Flea infestation	2
	Dermatophytosis	2
	Localised mange around nostril	1
	Traumatic wound	1
	Subcutaneous abscess	1
Total		**17**
Miscellaneous conditions	Emaciation	9
	Nephritis	2
	Trichophagy	1
	Cannibalism	1
	Septicemia	1
Total		14
Respiratory system	Pneumonia	9
Total		**9**

Rabbits sampled from Nairobi, Nyeri, Kiambu and Nakuru County had higher frequencies of diseases affecting the gastrointestinal tract as compared to those sampled from Taita-Taveta and Meru (Figure 4.20). Despite this, there was no significant difference in the body system affected by these diseases across all the counties (P = 0.2142) (Appendix 9).

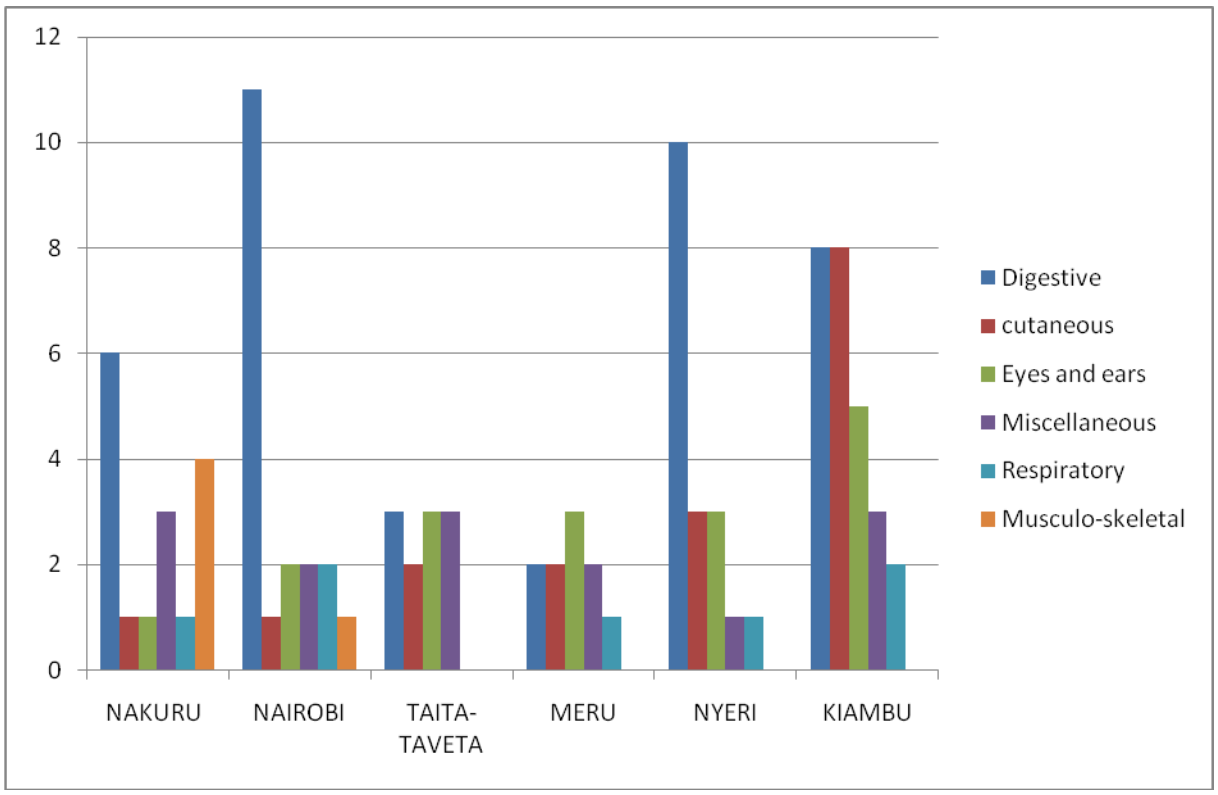


Figure 4.20: Frequencies of diseases affecting various body systems in rabbits sampled from the six counties within the period January 2012 – May 2013.

Diseases affecting the gastrointestinal system were more prevalent in adult rabbits (aged above twenty four (24) weeks) 19/61 (31.15%) and in growers (aged between 6 and 24 weeks) 14/61 (22.95%). Gastrointestinal diseases were the most frequently diagnosed condition in weaners aged between 1 to 5 weeks 7/14 (50%) while there was no respiratory condition diagnosed in these weaners (Appendix 10). The frequencies of diseases affecting the various body systems that were diagnosed at post mortem varied significantly according to the age groups of the rabbits (P= 0.0087) as shown in figure 4.21 below.

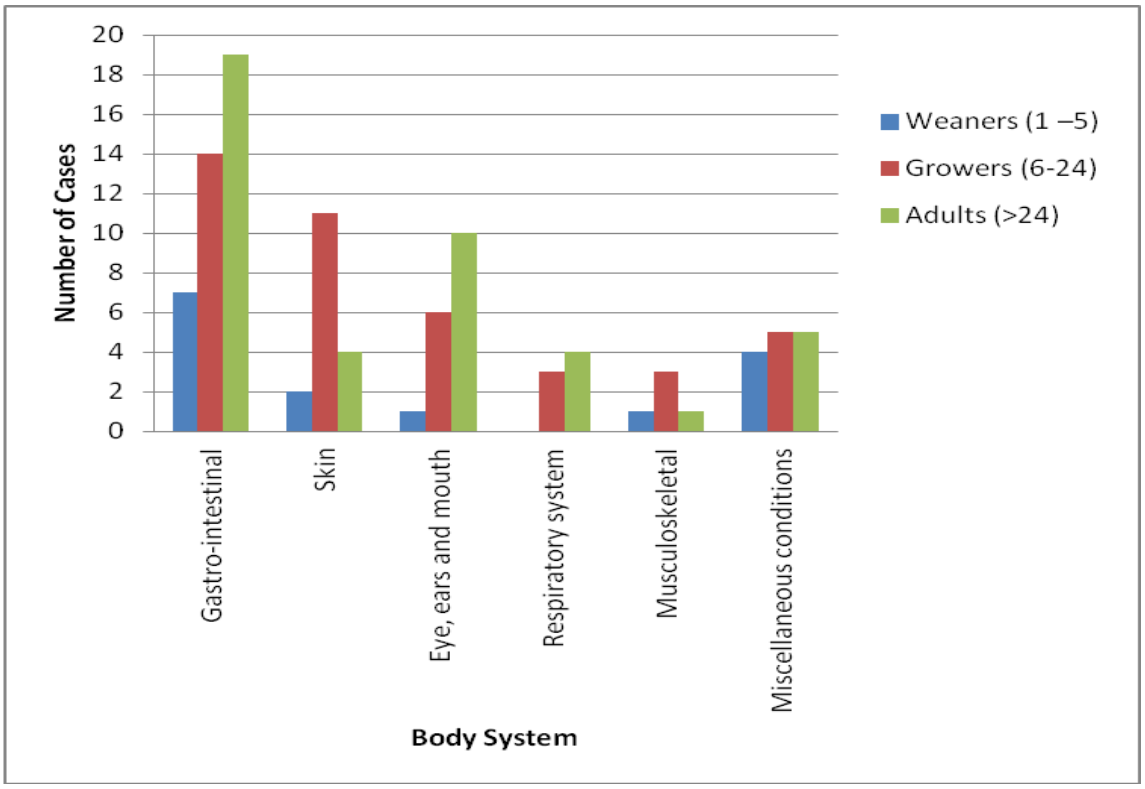


Figure 4.21: Frequencies of diseases at post mortem affecting various body systems in different age groups of rabbits sampled from the six counties within the period January 2012 – May 2013.

4.1.8.2. Digestive conditions affecting domestic rabbits in Kenya

Enteritis, hepatic coccidiosis, Mucoid enteropathy and bloat were the commonly diagnosed digestive diseases of rabbits during post mortem examination (Figure 4.22).

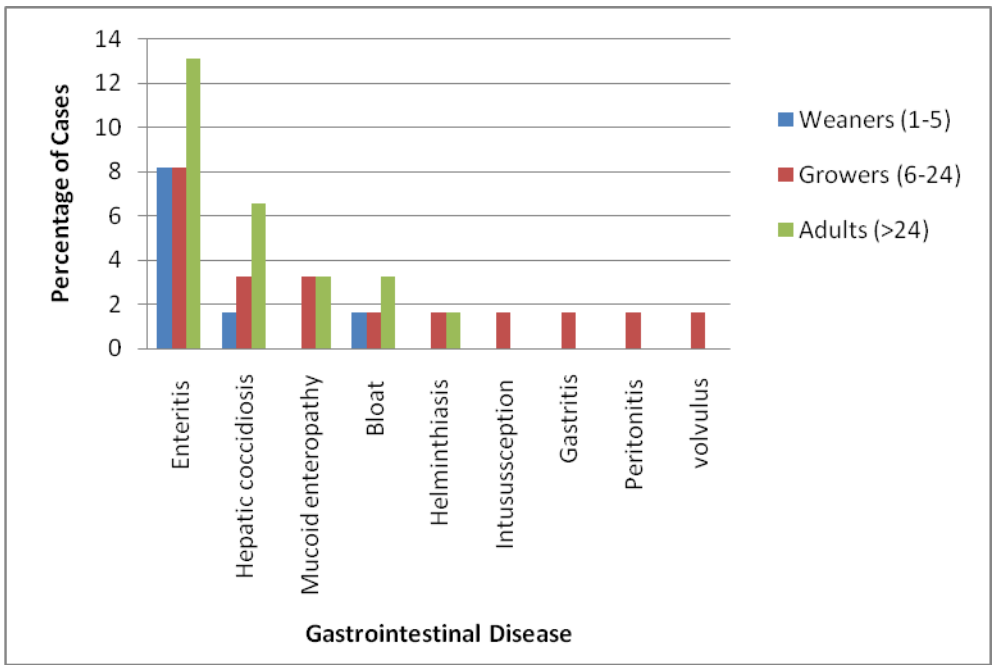


Figure 4.22: Prevalence of various digestive diseases at post mortem in different age groups of rabbits sampled from the 6 counties within the period January 2012 – May 2013.

4.1.8.2.1. Enteritis and intestinal coccidiosis

Prevalence of enteritis was 18/61 (29.51%). This condition was diagnosed in rabbits which clinically had either, rough hair coat 8/61 (13.11%), soiled perineum 7/61 (11.48%), or those that produced watery 1/61 (1.64%) or abnormally soft feces 2/61 (3.28 %) (Figure 4.23). In two rabbits aged 8 and 10 weeks respectively, the owners reported clinical signs of uncoordinated movement, ataxia and recumbency. The rabbits were eating normally even in their recumbent position. The fecal samples revealed heavy infection with intestinal coccidia (opg were too many

to count in this case). Another rabbit (NGF4) was diagnosed with hemorrhagic enteritis, emaciation and nephritis. The fecal sample from this rabbit had relatively high coccidia oocysts count of 58,800 opg. Blood picture in this case (Appendix 16) presented with leucocytosis (white blood cell count 15.38 × 10^3/μL), dehydration (red blood cell count of 8.89 × 10^6/μL, packed cell volume of 59.9 %, and hemoglobin value of 23.3 g/dL). The three farms from which these three rabbits were collected had reported mortality rates of 27.5%, 40% and 88% respectively within one week. They reported that the commonly affected rabbits were aged between 4 weeks and 15 weeks.

At necropsy the rabbits diagnosed with enteritis showed the following gross lesions: the intestinal mucosa was generally congested in 17/61 (27.86%) rabbits, and 5/61 (8.2%) rabbits had petechial hemorrhages in the intestinal mucosa, while 8/61 (13.1%) rabbits had bloody intestinal content (hemorrhagic enteritis) (Figure 4.24). Additionally, yellowish slightly mucoid intestinal content were observed in 8/61 (13.1%) rabbits, while watery intestinal content were encountered in 3/61 (4.92%) rabbits. Histology revealed the following in the intestinal epithelium: lymphocytic infiltration of the lamina and presence of coccidia oocysts and coccidia schizonts (Figure 4.25).

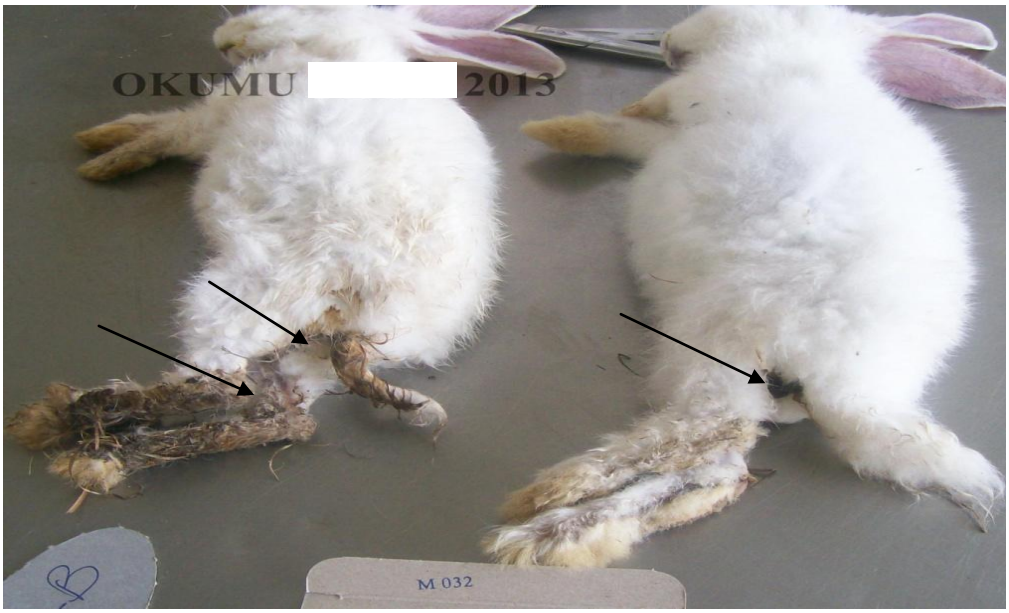


Figure 4.23: Newzealand white rabbit carcasses showing matted perineum (arrows) and rough hair coat due to diarrhea in cases of enteritis caused by *intestinal coccidiosis* in two rabbits (case number 423/012).

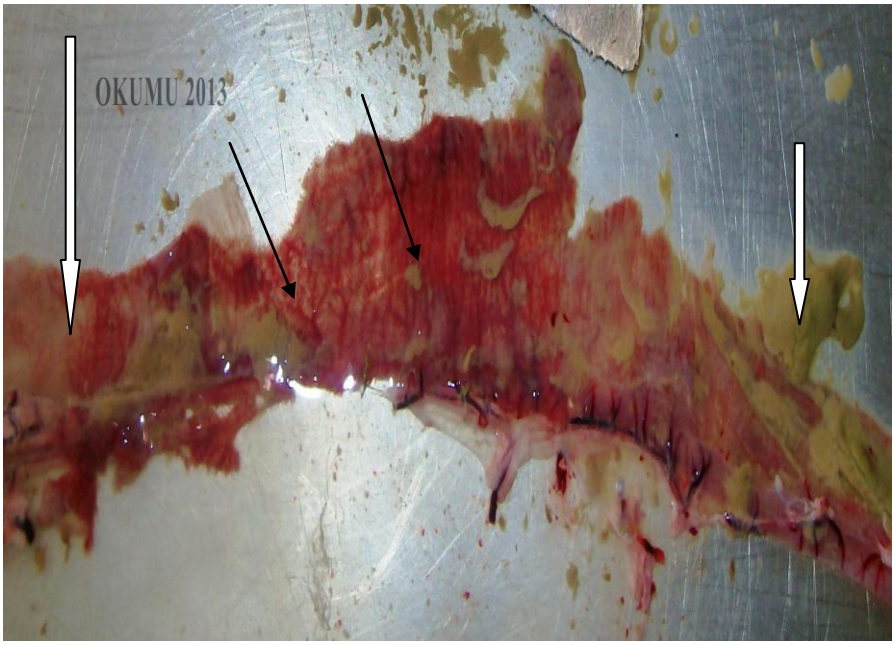


Figure 4.24: An opened segment of the intestines from a rabbit showing hemorrhages and congestion on the intestinal mucosa (arrow) and yellowish mucoid intestinal content (bold arrow) in a case of hemorrhagic enteritis due to *intestinal coccidiosis* (case number 423/012).

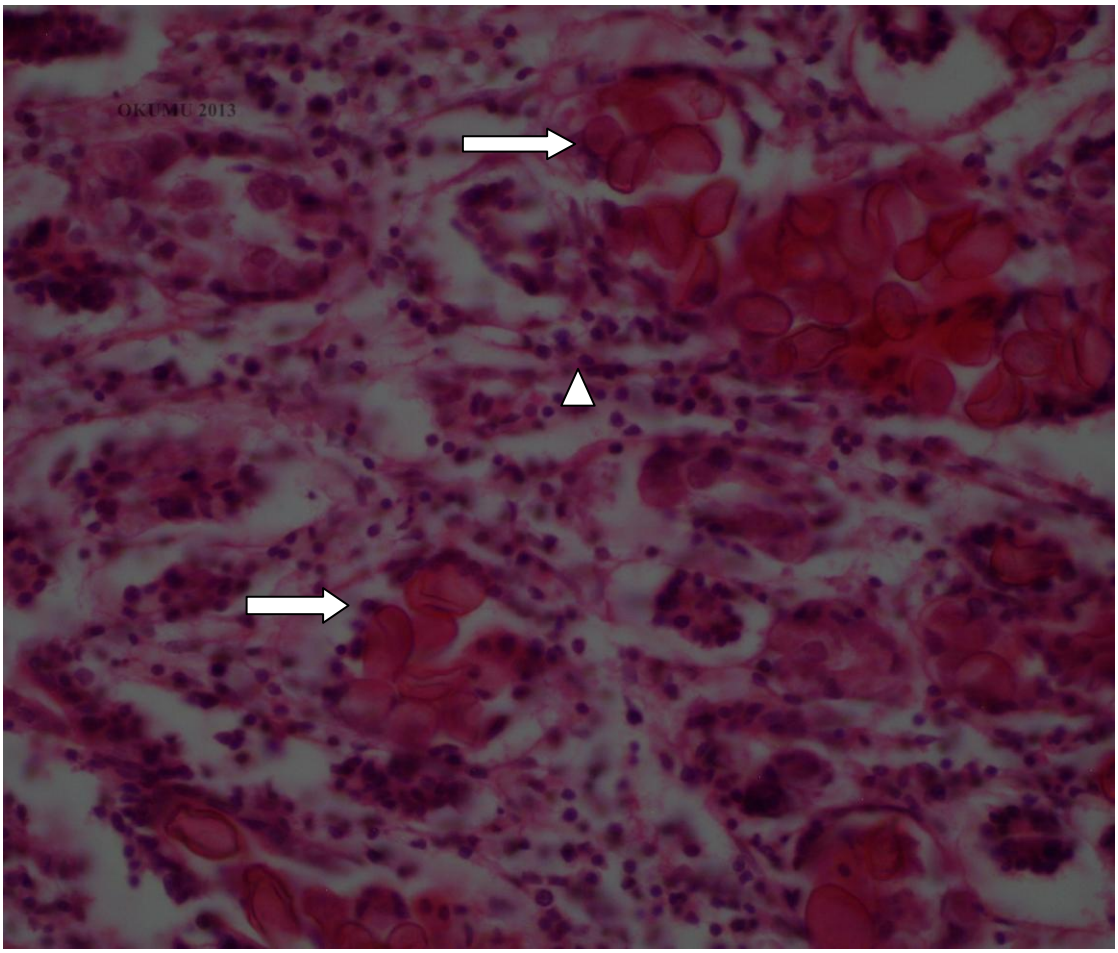


Figure 4.25: Histological section of a rabbit intestine showing coccidia oocysts in the intestinal epithelium (arrow) and lymphocytic infiltration in the lamina of the villi (Arrow head) X 400 H/E in a case of *intestinal coccidiosis*.

A total of 61 fecal samples were collected from intestines and ceaca of rabbits of different age groups during post mortem examination. 55/61 (90.16%) fecal samples were positive for coccidian oocysts ranging between 100 to over 60,000 opg. Relatively, high numbers of coccidia Oocysts (opg) were recovered in weaners aged 4 weeks and 5 weeks more frequently than in growers and adults rabbits ($P < 0.001$) as illustrated in Table 4.3below.

Table 4.3: Distribution of coccidian oocysts count per gram of feaces collected at post mortem from intestines and ceaca in different age groups of the 61 rabbits sampled from the 6 counties within the periods January 2012 – May 2013.

Age group (Weeks)	Frequencies of Coccidia Oocyst per gram of feaces (opg) × 10^3								
	0	0.1 – 2.0	2.001-4	4.001-6	6.001-8	8.001-10	10.001-60	>60.0	Total
Weaners (1 –5)	0	1	1	2	0	2	5	3	14
Growers (6-24)	3	11	2	1	1	0	1	3	23
Adults (>24)	3	14	1	1	0	2	2	2	24
Total	6	26	4	4	1	4	8	8	61

4.1.8.2.2. *Passalurus ambiguus*

During necropsy two rabbits aged 26 (TF3) and 32 (NkF7) weeks were diagnosed with helminthiasis. These rabbits presented with emaciation, enteritis and also firm and dry fecal material within the ceaca. Numerous whitish coloured worms identified as rabbit pin worms (*Passalurus ambiguus*) were observed in the ceaca of both rabbits (Figure 4.26 Figure 4.26A, and 4.26B). The fecal samples revealed 6000 and 4000 pin worm e.p.g. and 8000 and 1000 opg respectively.

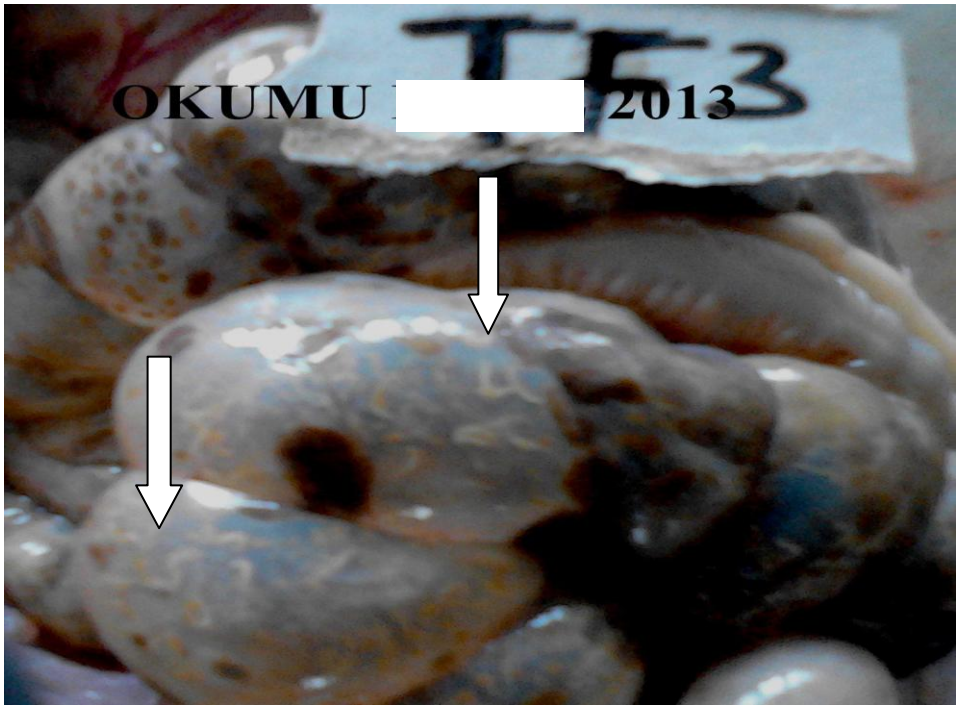


Figure 4.26: Unopened ceacum of a rabbit from Taita- Taveta county showing whitish *Passalurus ambiguus* (Rabbit pin worms) visible through the ceacal wall (arrow) in a rabbit diagnosed with helminthiasis (Case number TF3).

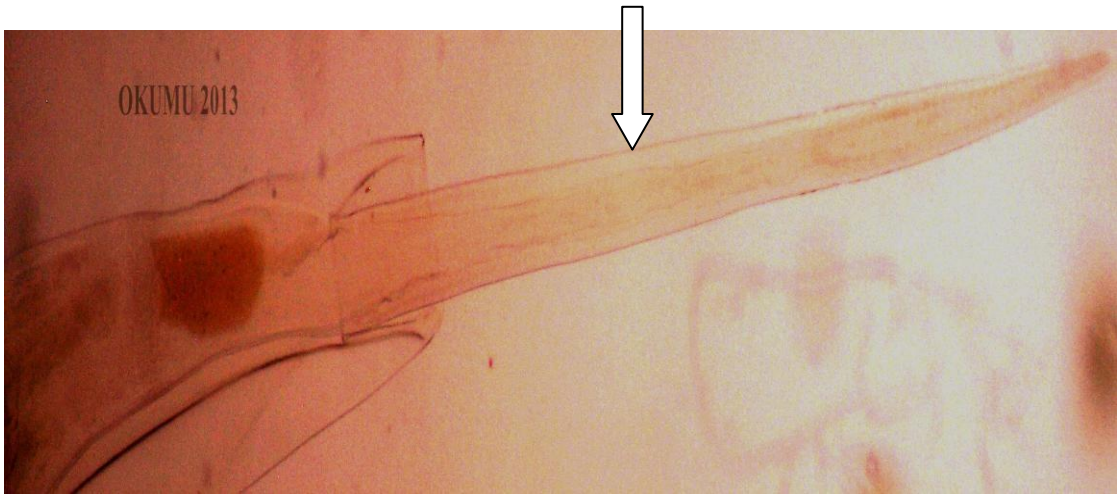


Figure 4.26A: Female *Passalurus ambiguus* recovered from the ceacum of a rabbit sampled from Taita- Taveta county (TF3) showing a long tail posterior (arrow) to the anus

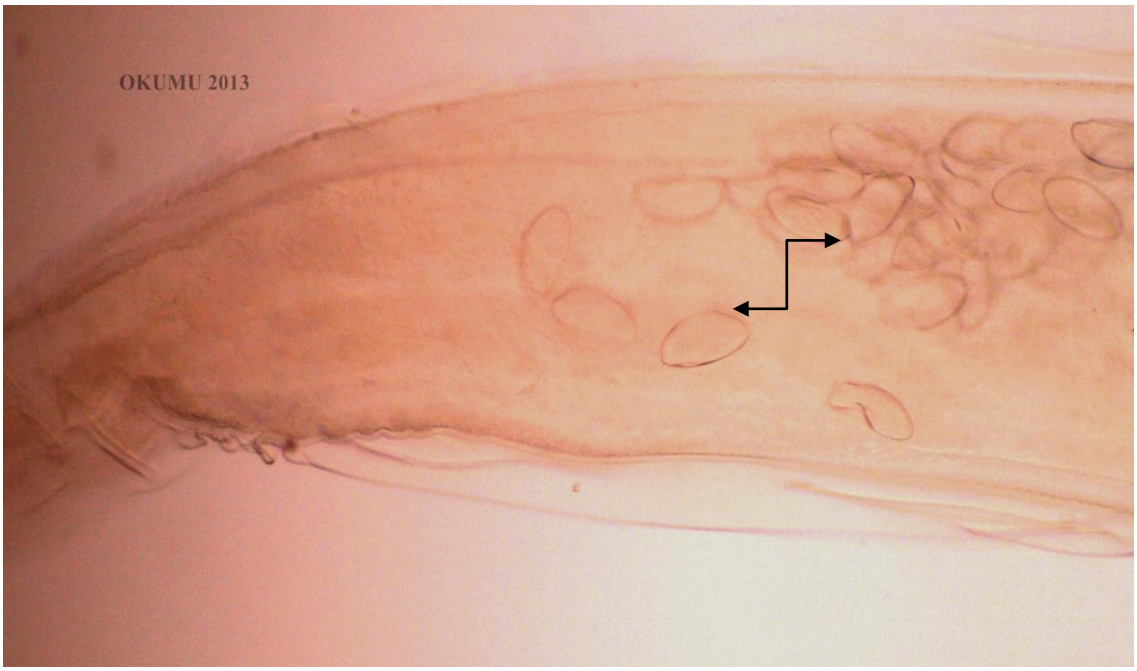


Figure 4.26 B: Oval eggs flattened on one side in the uterus of a female pinworm (Double arrow) RIGHT (X 10)

4.1.8.2.3. Intestinal obstructions

Two rabbit carcasses 2/61 (3.28%) which had been reported with diarrhea were diagnosed with intussusceptions and volvulus respectively at post mortem. Intussusception was grossly characterized by invagination of the middle portion of the ileum into the distal portion, while volvulus was characterised by complete twisting of a loop of ileal portion of the intestines around its mesenteric attachment, causing severe congestion, intestinal hemorrhages and strangulation of mesenteric blood vessels. The fecal samples revealed 2000 and greater than 60000 coccidia OPGs.

4.1.8.2.4. Hepatic coccidiosis

Hepatic coccidiosis was diagnosed in 7/61(11.48%) rabbits, the rabbits clinically presented with poor body condition. The gross findings at necropsy were emaciation 4/61 (6.56%), enteritis 2/61(3.28%) and Ear canker 1/61(1.64%). The main gross lesions observed in the liver were the presence of raised, multi-focal whitish to yellowish nodules of about 0.5 – 1 millimeter in diameter (Figure 4.27). Histological picture revealed multifocal areas of coagulative liver necrosis, bile duct proliferation, hyperplasia of the epithelial cells of the billary duct, *Eimeria stiedae* oocysts, and gametocytes within the bile ducts of all the seven rabbits (Figure 4.27A)

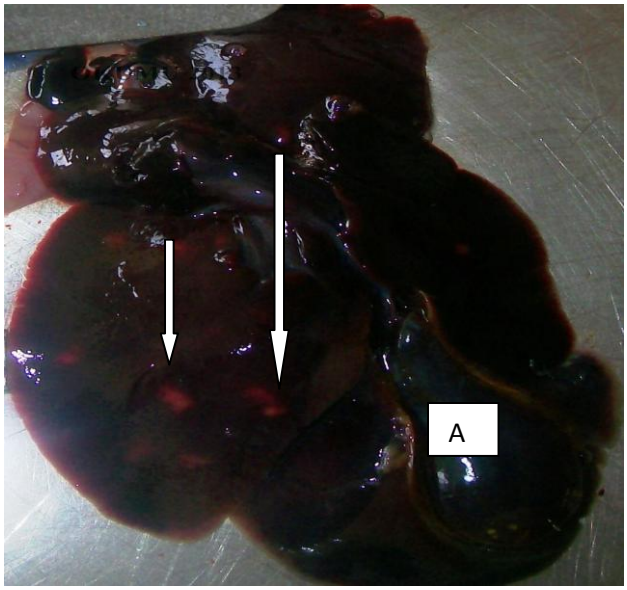


Figure 4.27: Multi-focal whitish to yellowish nodules (arrow) on the liver surface and distended gall bladder (A) in a case Hepatic coccidiosis in a rabbit sampled from Meru County (case number Mf5B)

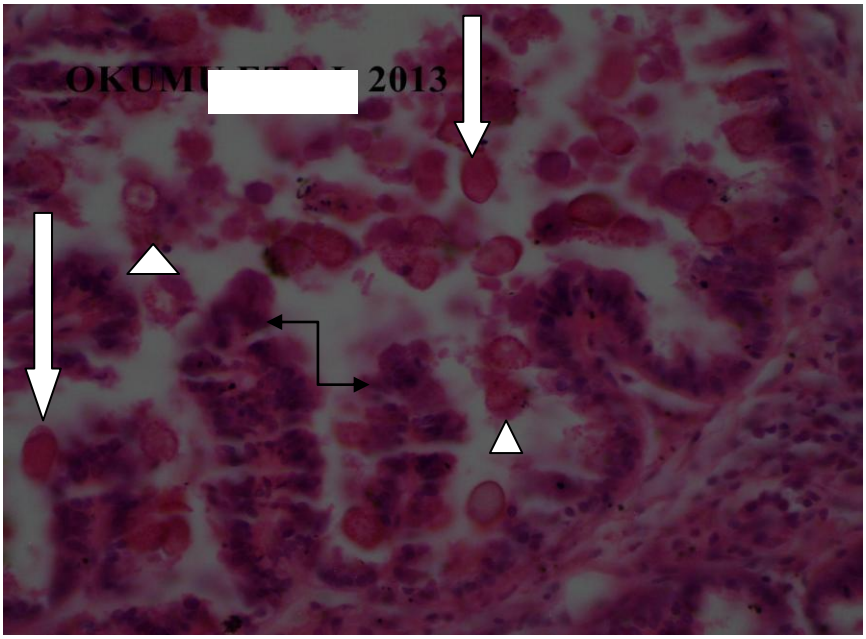


Figure 4.27 A: Liver section of a rabbit showing *Eimeria stiedae* oocysts (arrow), gametocytes (arrow head) and proliferation of bile duct epithelium (double arrow) in a case of hepatic coccidiosis in a rabbit sampled from Meru County (case number Mf5B) (X 400 H/E).

4.1.8.2.5. Mucoid enteropathy

Mucoid enteropathy was diagnosed in 5/61 (8.20%) rabbits from the 5 farms. Clinical assessment revealed mucoid feces in 2 (3.27%) farms. In the five (5) farms the owners reported mortality rates of 33.33% and 75% in four and one farm respectively within a period of 1 week. The main clinical sign observed was abdominal distension (bloat) and gross changes included the presence of copious gelatinous mucoid content that caused obstruction of the ceacum in all the five rabbits (Figure 4.28). The histology of the intestines was characterised by goblet cell proliferation within the lamina propria of intestinal mucosa of the rabbits (Figure 4.28A). One rabbit with mucoid enteropathy also had multiple ulcers on the gastric mucosa (Figure 4.29). In three rabbits with mucoid enteropathy from amongst the 5 farms coccidia oocyst counts were found to be relatively high (between 10,000 to over 60,000 OPG). On the contrary, one rabbit had no coccidia Oocyst. The farm reported that the bloat occurred when the rabbits were subjected to new commercial pellets (change of feed). However, they reported that complete withdrawal of the feed reduced the mortalities to zero. Histology of mucoid enteropathy was characterised by goblet cell proliferation within the lamina propria of intestinal mucosa of the rabbits.

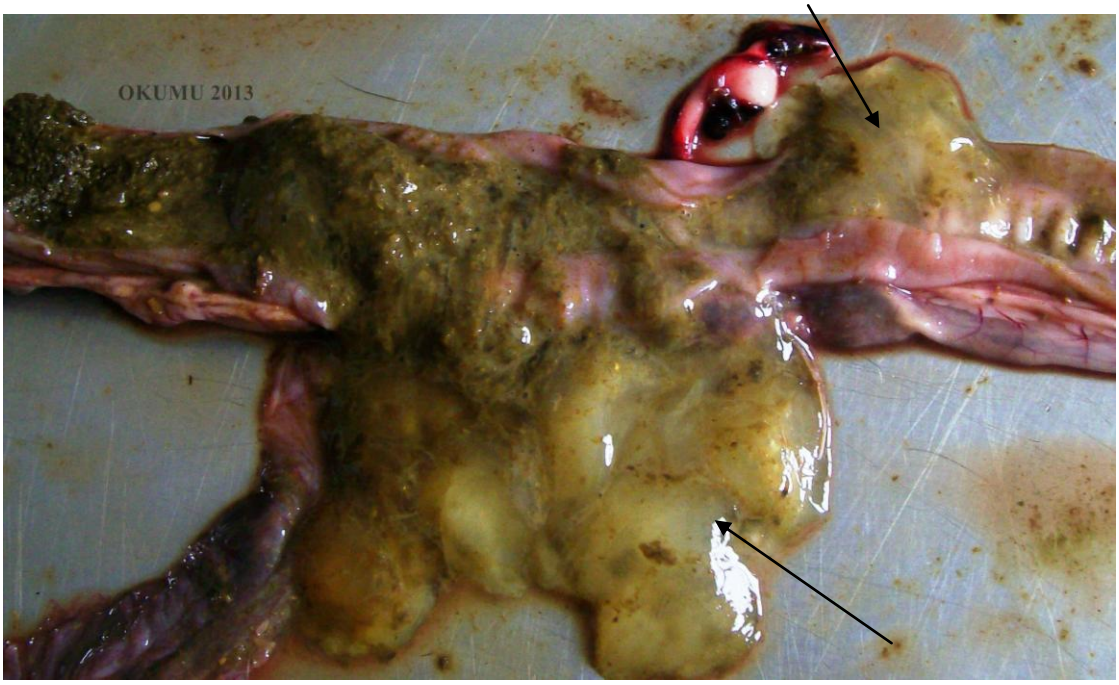


Figure 4.28: Copious gelatinous mucoid content (arrows) in the cecum of a rabbit from Nairobi County diagnosed with *mucoid enteropathy* (Case number 353/2012).

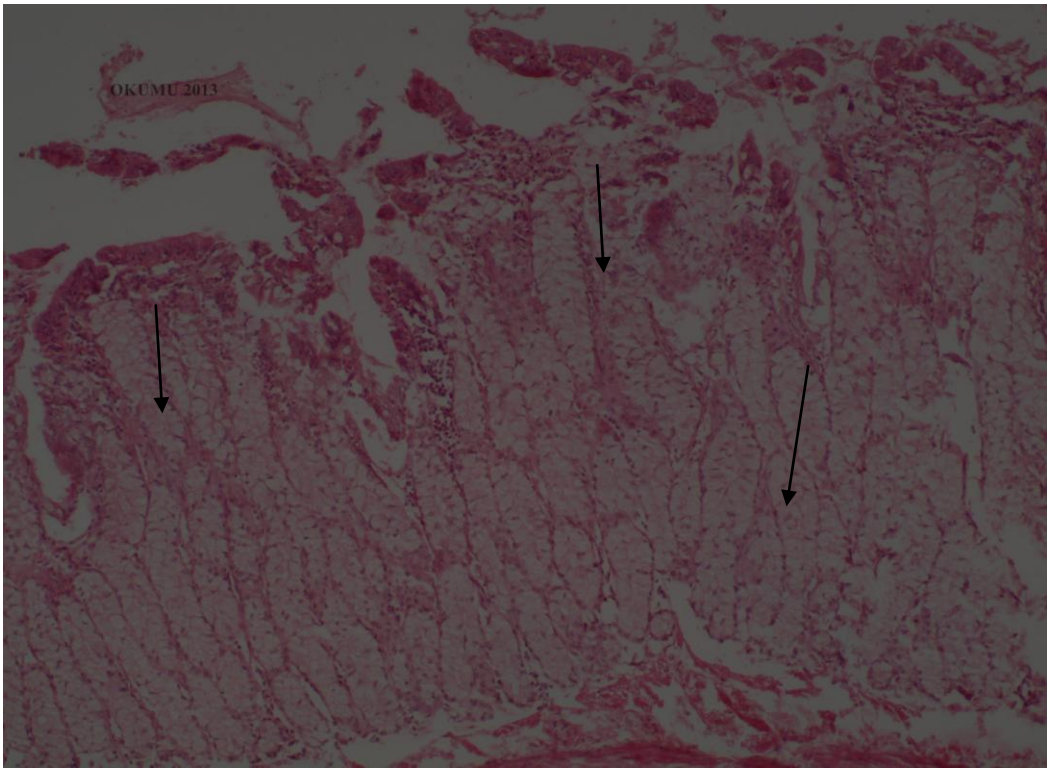


Figure 4.28A: Histological section of the intestine of a rabbit diagnosed with *mucoid enteropathy* showing goblet cell proliferation (arrows) in the lamina propria of the villi (X 40 H/E) (Case number 353/2012).

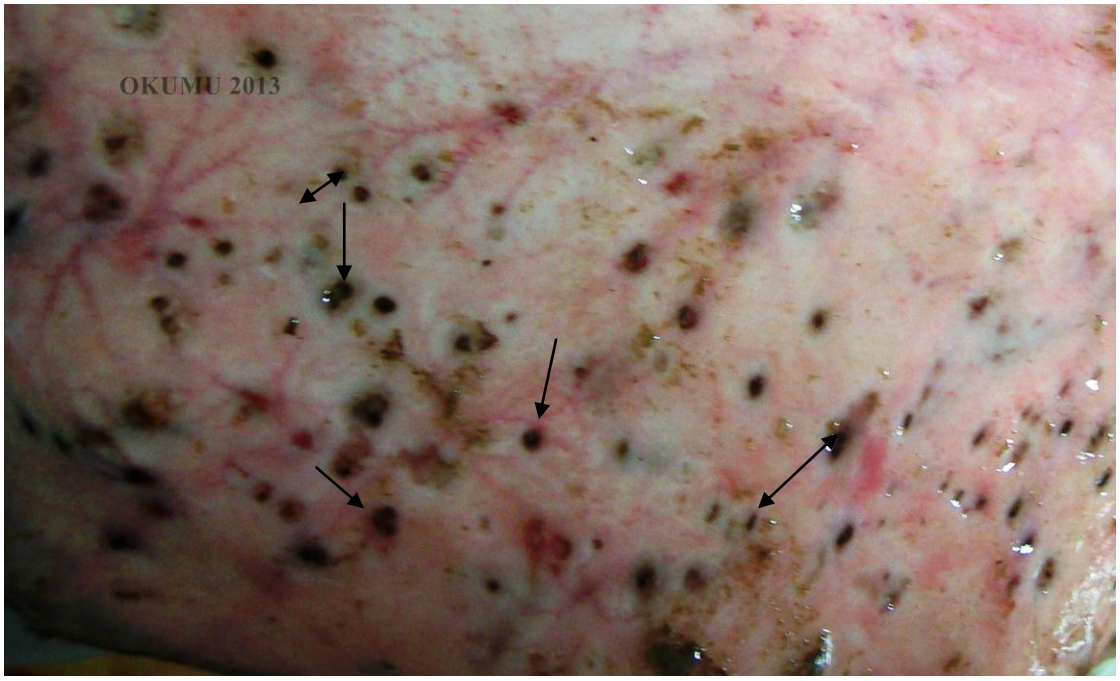


Figure 4.29: Opened stomach of a rabbit showing multifocal gastric ulcers (arrows) in a rabbit diagnosed with *mucoid enteropathy* suspected to have occured after a change of feed.

4.1.8.2.6. Hemorrhagic typhilitis and pregnancy toxaemia

Two adult rabbit carcasses were found dead on two farms, one in Kiambu county and another in Nairobi county. The owners reported a history of watery diarrhea and recent kindling respectively. At necropsy the rabbit with watery diarrhea was diagnosed with Hemorrhagic typhilitis and presented the following gross lesions; ecchymotic serosal hemorrhages on the cecum, enlarged spleen and copious gelatinous mucoid content within the ceacum. *Escherichia coli* were isolated from the liver, spleen and lung cultures. Histology revealed congestion of the intestinal blood vessels, infiltration of intestinal epithelium with neutrophils and multifocal areas of hemorrhages within the ceacal mucosa. The rabbit that was reported to have kindled did not show any gross lesions and was suspected to have died from pregnancy toxemia.

4.1.8.3. Skin conditions affecting domestic rabbits in Kenya

In this study, skin conditions were frequently encountered during clinical examinations in the farms and at post mortem examination. Of the 61 rabbits sampled from the farms, skin conditions were encountered in 17/61 (27.87%) rabbits. These skin conditions were diagnosed more frequently in growers 11/17 (64.70%) and less frequently in adults 4/17 (23.53%) and weaners 2/17 (11.76%) as illustrated in Figure 4.30 and Appendix 11

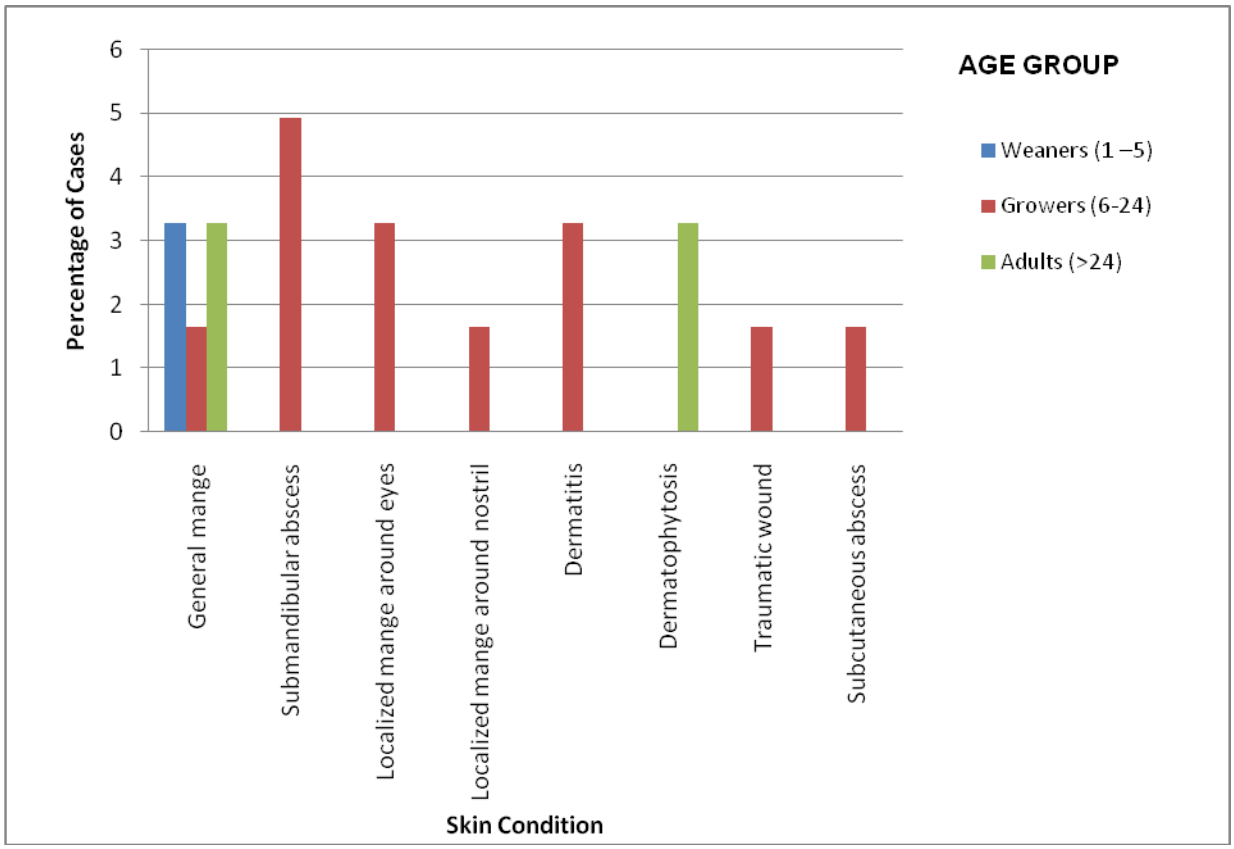


Figure 4.30: Prevalence of skin conditions/diseases in different age groups of rabbits during post mortem examination of the rabbits sampled from the six counties within the period January 2012 – May 2013.

During post mortem examination, 5/61(8.20%) rabbits had skin lesions that were consistent with localised mange. All the affected rabbits were in fair to poor body condition, three (3) rabbits had concurrent Ear canker, and two (2) others had helminthosis.

During post mortem examination, four rabbits from 4/61(6.56%) farms were diagnosed with subcutaneous abscesses 1/61 (1.64%) and sub mandibular abscesses 3/61 (4.92%). Swabs from the submandibular abscesses revealed mixed bacterial infection with *Pseudomonas aerogenosa* (*1/*3), *Staphylococcus aureus* (3/3), *Proteus mirabilis* (1/3), *Streptococcus* spp. *(*3/3) and *Escherichia coli* (3/3). The subcutaneous abscesses revealed *Staphylococcus aureus* and *Streptococcus* species.

4.1.8.4. Conditions affecting the eye, ears and oral cavity

The various conditions of the eye, ear and oral cavity in different age groups of rabbits are illustrated in figure 4.31 and appendix 11.

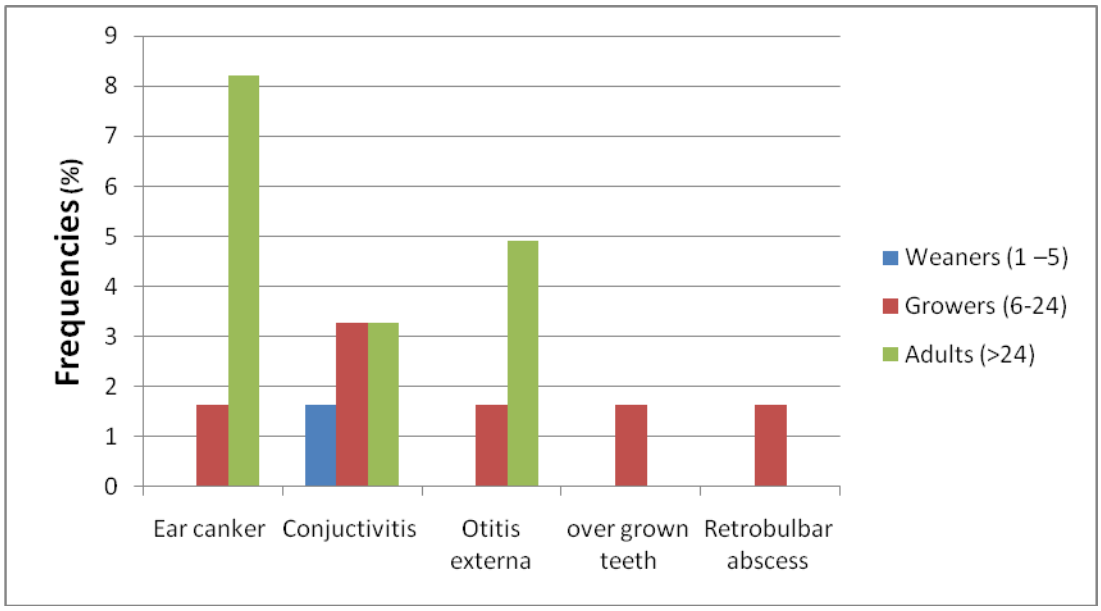


Figure 4.31: The frequencies of diseases affecting the eye, ears and oral cavity in different age groups of rabbits sampled from the six counties for post mortem examination.

4.1.8.4.1. Ear canker and otitis externa

During post mortem examination Ear canker was encountered in 6/61 (9.84%) rabbits. Four out of the sixty one (6.56%) rabbits were observed with hyperemia and exudate within the pinna (Otitis externa). Ear canker was the the most frequently diagnosed condition of the ear.

4.1.8.4.2. Conjunctivitis, wolf teeth and abscesses

Five rabbits were diagnosed with conjunctivitis; these rabbits included one weaner, two growers and two adults. Two adult rabbits also showed submandibular and retrobulbar abscesses

respectively during post mortem examination. The rabbit diagnosed with retrobulbar abscesses also presented with protruding left eye balls (Exophalmus) and overgrown incisor teeth. Histology of these cases revealed osteomyelitis and cellulitis characterized lymphocytes infiltration of the lower and upper mandible, and neutrophilic infiltration of the connective tissue of the conjunctiva. Conjuctival swabs from the five rabbits revealed *Staphylococcus aureus* (5/5) and *Pasteurella multocida* (1/5) while, both swabs from the submandibular abscesses and retrobulbar abscess revealed mixed bacterial infection with *Pseudomonas aerogenosa* (1/2), *Staphylococcus aureus* (2/2*), proteus Mirabilis* (1/2), *Streptococcus* spp. (2/2) and *Escherichia coli* (2/2).

4.1.8.5. Respiratory conditions

The common respiratory tract lesions encountered in different age groups of rabbits diagnosed with pneumonia at necropsy are illustrated in Table 4.4 below. Pneumonia was the frequently encountered respiratory condition in rabbits during post mortem examination. Pneumonia presented with varied clinical signs including purulent nasal discharges, coughing and sneezing and sudden death.

Table 4.4: Gross lesions observed in the respiratory system of different age groups of rabbits during post mortem examination

Age group (weeks)	Lobar pneumonia	Fibrinous pneumonia	Hemorrhagic tracheitis
Weaners (1 –5)	-	-	-
Growers (6-24)	5	1	1
Adults (>24)	2	1	1
Total	7	2	2

Post mortem examination revealed pneumonia in 9/61(14.75%) rabbits. Seven (7) rabbits diagnosed with pneumonia also showed frothy exudate within the trachea and lungs, congestion and hemorrhages within either the cranial or caudal lung lobes (Lobar pneumonia) and trachea (Figure 4.32). Lung tissues sampled from five animals diagnosed with pneumonia revealed mixed infection with *Pasteurella multocida, Pseudomonas aeroginosa* and *Staphylococcus aureus* in 3/5(60%), *Klebsiella pneumonia* and *Staphylococcus aureus* 2/5(40%) while, lung tissue samples from two rabbits did not reveal any agent.

The gross lesions observed during post mortem examination from two (2) rabbits from two different farms in Meru (MF5B) and Kiambu (KFI) included the following: purulent nasal discharges (Figure 4.33), consolidation of the apical lobe of the right lung and pleural adhesions. The lungs were also covered with thick fibrinous material (Figure 4.33A). The rabbits were diagnosed with fibrinous pneumonia. Histopathology revealed interstitial pneumonia characterized by multifocal and peri-vascular and peri-bronchiler infiltration with Neutrophils and macrophages. The alveolar septae were thickened and also infiltrated with neutrophils and fibrinous inflammatory exudates while the alveolar airways were free of exudate (Figure 4.33 B). *Pasteurella multocida* was isolated from lungs tissue samples from the two (2) rabbits diagnosed with interstitial and Fibrinous pneumonia respectively.

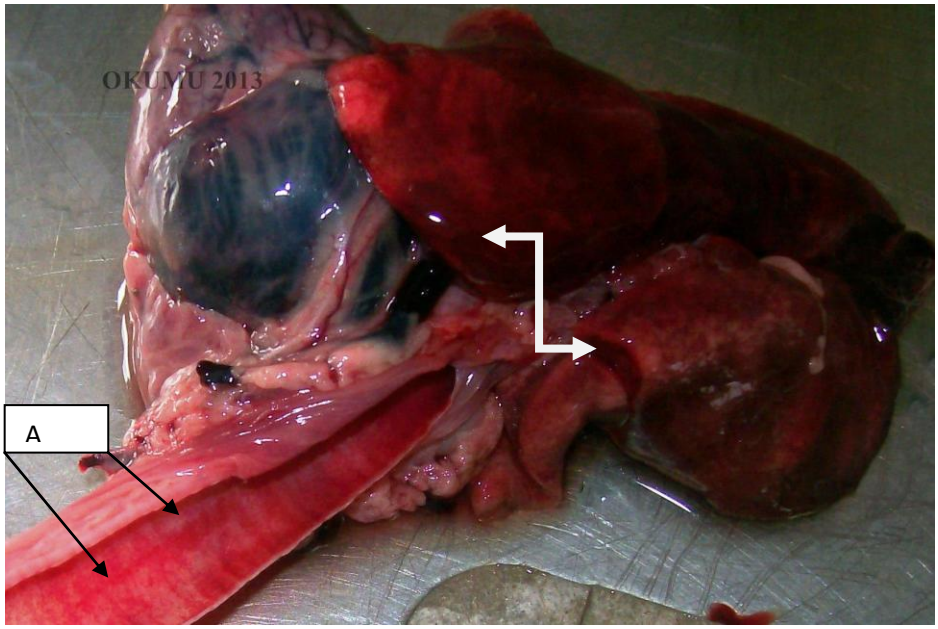


Figure 4.32: Opened trachea of a rabbit showing hemorrhages in the tracheal mucosa (Hemorrhagic tracheitis) (arrow A) and apical lung lobes (Double arrow) in a rabbit diagnosed with pneumonia from a farm in Nairobi county (Case number 158/2012).

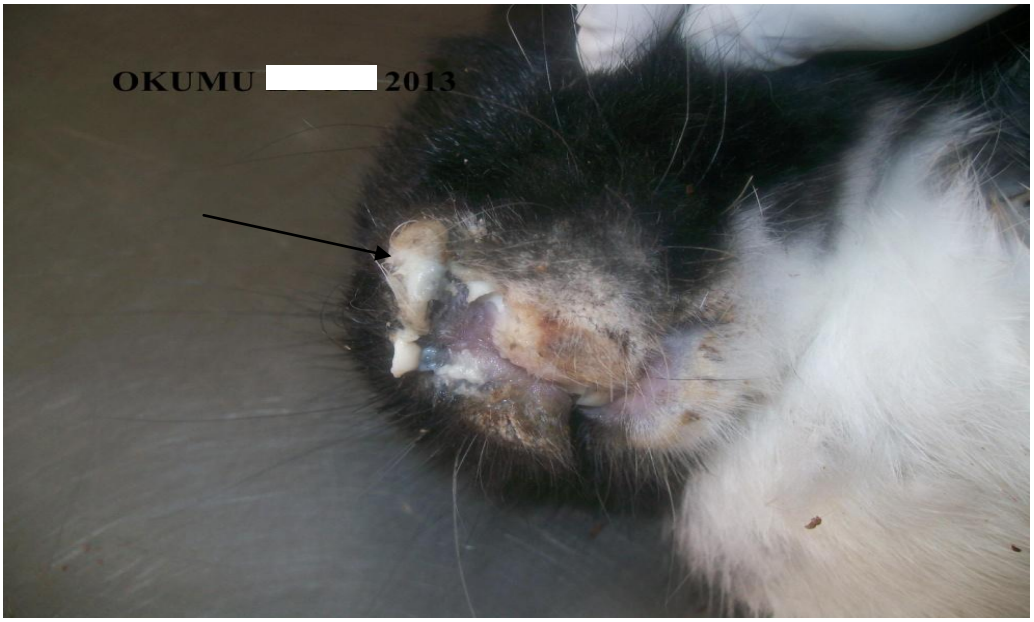


Figure 4.33: Purulent nasal discharges (arrow) from a Dutch breed rabbit carcass diagnosed with pneumonia from a farm in Kiambu County (Case number KF8).

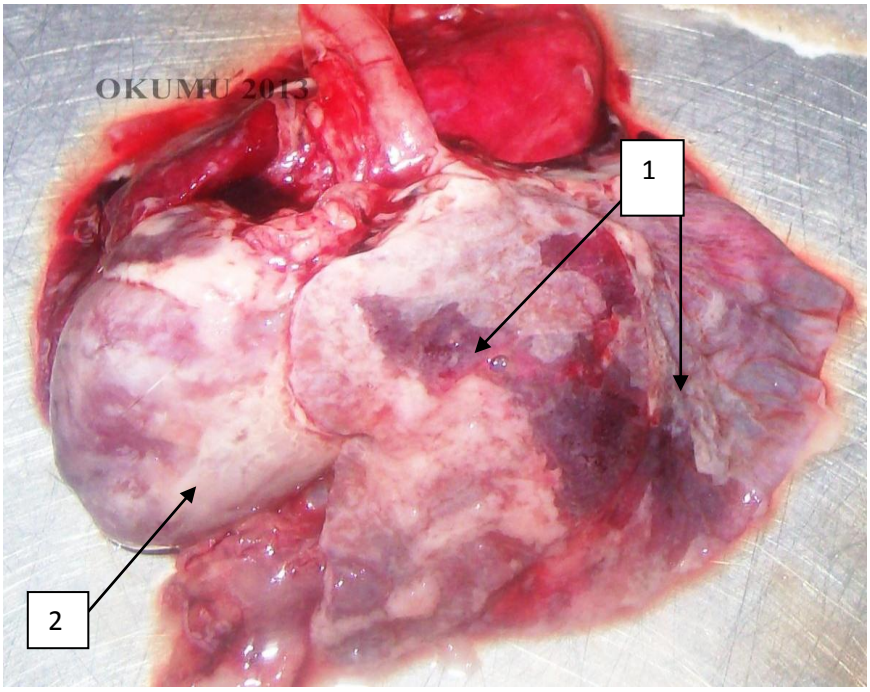


Figure 4.33 A: Fibrin cover on the lung surface (arrow 1) and heart pericardium (arrow 2) of a rabbit diagnosed with fibrinous pneumonia from a farm in Meru County (Case number MF5B).

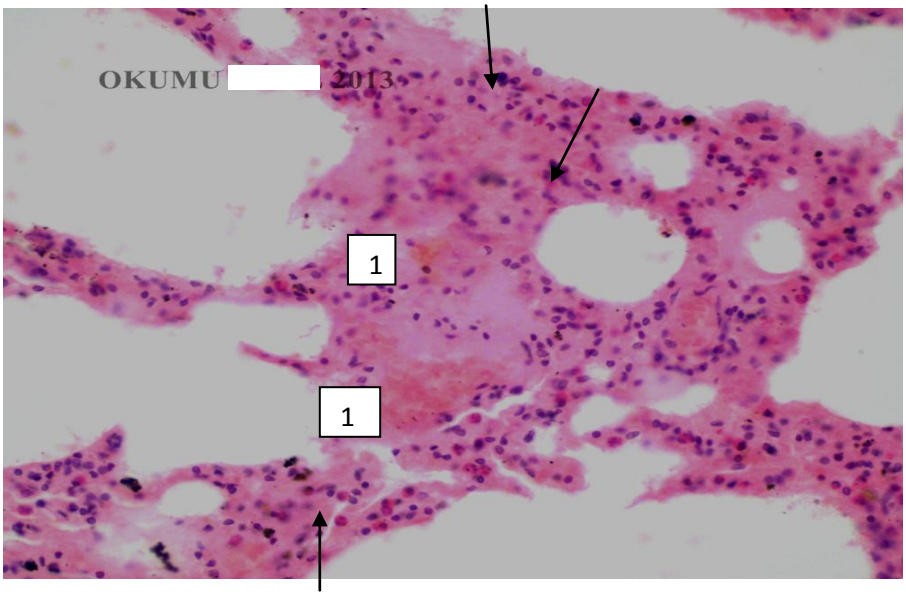


Figure 4.33 B: Lung section showing thickened inter-alveolar septae (1) infiltrated with neutrophils (arrows) and fibrinous inflammatory exudates in a rabbit diagnosed with pneumonia from a farm in Kiambu County (Case number KF8) (H&E X 400).

4.1.8.6. Musculoskeletal conditions

The main conditions affecting the musculoskeletal system of rabbits in this study were sore hock and splay leg. During the post mortem examination, one adult female rabbit with sore hock also had urinary incontinence and retrograde flow of urine into the uterine body. The uterine body and horns were filled with urine (Figure 4.34). Histopathology revealed arthritis of the hock joint and osteomyelitis of the tibia characterized by infiltration of the bone marrow matrix and the connective tissue surrounding the affected hock joints with lymphocytes and neutrophils.

Post mortem examination of the rabbit with splay leg revealed decubital wounds on the medial parts of the both the fore and hind limbs which the rabbit dragged on the ground during locomotion. This case also showed malformed hock and carpal joints with multifocal abscesses in the joints (arthritis). Histology of these joints confirmed mixed infiltration with lymphocytes and neutrophils.

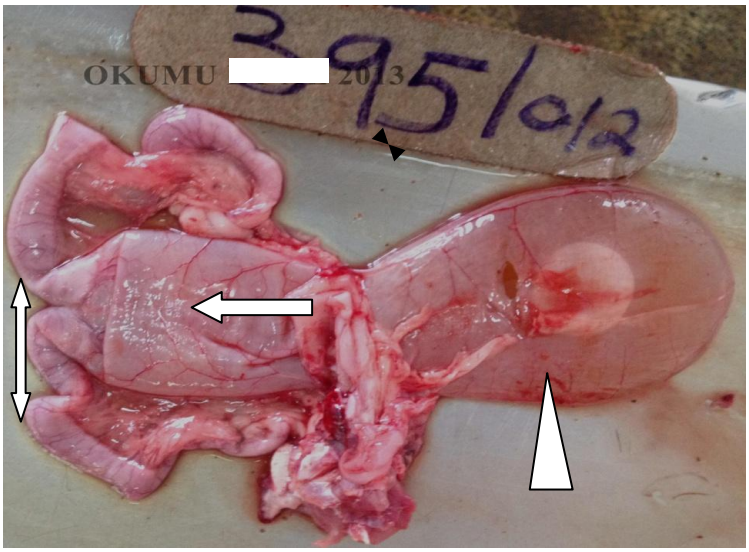


Figure 4.34: Uterine body (arrow), uterine horns (double arrows) and urinary bladder (arrow head) distended with urine from a rabbit diagnosed with sore hock and urinary incontinence (Case number 395/2012).

4.1.9. Bacteria isolated

A total 320 bacteriological samples were collected from 61 randomly selected apparently healthy live rabbits and 54 rabbits showing various clinical signs. These were sampled as follows; 120 conjuctival swabs, 120 nasopharyngeal swabs, 20 tissues from dead rabbits, 50 tissues from euthanized rabbits, 10 swabs from abscesses and infected wounds. The types of bacteria isolated from respective samples are as shown in Table 4.5.

Non-pathogenic *Staphylococcus, Escherichia coli* and *Staphylococcus aureus* were frequently isolated from conjuctival and nasopharyngeal swabs. The frequencies of isolation of these three bacteria isolates were: 59/120(49.17%) and 65/120 (54.12%), 42/120(35%) and 58/120 (48.33%), 28/120 (23.33%) and 32/120 (26.67%) in conjuctival and nasopharyngeal swabs respectively. There were no bacteria isolated in 5/120 (4.17%) and 10/120(8.33%) of the conjuctival and nasopharyngeal swabs respectively as illustrated in Table 4.5.

Ten (10) swabs were collected from abscesses. The frequently isolated bacteria from the abscesses were *Beta hemolytic Streptococcus* spp. in 8/10 samples (80%), *Staphylococcus aureus* in 6/10(60%), *Proteus mirabilis* in 3/10 (30%), *Pseudomonas aeroginosa* and *Corynaebacterium renale* in 3/10 (30%) samples.

Table 4.5: Bacteria isolated from the various bacteriological samples collected from different rabbits in the various study sites in Kenya within the period January 2012 – May 2013.

Bacteria isolated	Frequencies of bacteria in samples collected				
	Conjuctival swabs	nasopharyngeal swabs	Tissues(lung, liver, spleen)	abscesses	Infected wound swabs
E.coli	42	58	15	7	1
Non-Pathogenic *Staphylococcus*	59	65	21	-	-
Streptococcus spp.	32	36	13	8	2
Micrococcus spp.	13	26	14	-	-
Staphylococcus aureus	28	36	15	6	2
Enterobacter spp.	2	2	6	-	-
Bacillus spp.	1	2	6	--	-
Proteus mirabilis	1	-	-	3	-
Pasteurella multocida	1	3	3	-	-
Bordetella bronchiseptica	1	5	1	-	-
Klebsiella pneumoniae	2	1	3		1
Pseudomonas aeroginosa	1	-	3	3	1
Corynaebacterium renale	-	2	-	1	-
Citrobacter spp.	-	1	3	-	-
No growth	5	10	1	-	-

4.1.10. Predisposing factors to diseases of domestic rabbits

The study revealed that environmental factors, animal factors and presence of pathogens are some of the risk factors that predispose domestic rabbits to diseases. The environmental factors included the location of farm, type and maintenance status of housing structures and housing density. Animal factors included age and genetic factors of rabbits, while presence of potential pathogens including coccidia and bacteria in both sick and healthy rabbits is also a risk factor to diseases.

4.1.10.1. Age and housing density

Relatively high numbers of coccidia opg (greater than 10, 000 opg) were identified from weaners (50%) than growers (25%) and adults (25%) ($P < 0.001$) and in rabbits housed in crowded housing ($P = 0.0293$). Despite this, there was no association between the coccidia opg counts and the number of cage tiers ($P = 0.0572$), type of cage floors ($P = 0.1723$) or house sanitations ($P = 0.6312$).

4.1.10.2. Status of housing structures

Ear infections were mainly associated with housing poorly maintained and old housing ($P = 0.0046$), but not with age of rabbits ($P = 0.7475$) or region of the farms ($P = 0.8767$). However, the skin conditions did not reveal any significant association with the husbandry practices including type of housing ($P = 0.1509$).

4.1.10.3. Location of farm

Respiratory conditions associated with pneumonia were commonly encountered in Kiambu (4/10, 40%) and Meru (3/10, 30%) county than in the other counties (3/10, 30%) (P = 0.0183).

4.1.10.4. Underlying diseases

Enteritis affected rabbits of all ages despite the level of farm sanitation (P = 0.2488). Intestinal and hepatic coccidiosis were the main condition associated with enteritis (P = 0.0425).

Rabbits in good body condition scores were observed in 41/61 (67.21%) farms, 14/61 (22.95%) and 5/61 (8.20%) farms had rabbits in fair and poor body condition scores respectively. However emaciation was encountered in 9/61 (14.75%) rabbits during post mortem examination. The diseases diagnosed in these rabbits included intestinal coccidiosis 3/9 (33.33%), hepatic coccidiosis 2/9 (22.22%), retrobulbar abscesses 1/9 (11.11%) and helminthiasis 1/9 (11.11%). However, 2/9 (22.22%) rabbits did not show any other lesion apart from emaciation

4.1.10.5. Hereditary genetics and poor management

Cannibalism, trichophagy and splay legs were each encountered once and these cases were reported with history of inadequate nest preparation prior to kindling, lack of enrichments in the cages e.g. hay and suspected hereditary developmental disorders from the sire respectively.

4.1.10.6. Forage type

The respondents reported that they were in several instances able to associate certain clinical signs of diseases to particular forages when fed freshly to their rabbits.

Wandering jew (*Commelina benghalensis*) was reported to be commonly associated with abdominal distension (bloat) 26/61(42.62%) and diarrhea 25/61 (40.98 %). In 3/61 (4.92%) farms, the owners reported that they found the rabbits dead after feeding on Wandering jew (sudden death), while 2/61(3.28%) farms reported that they occasionally observed their rabbits coughing after giving this feed.

Fresh Kale, different types of grasses, cabbage, sweet potato vines and peels were occasionally reported to cause diarrhoea, bloat and sometimes the rabbit were found dead (Sudden death) sometime after feeding the above material with no clinical signs observed. In 2/61 (3.28 %) and 1/61 (1.64 %) farms, fresh Kales and Barley were reportedly associated with slow growth or weight gain (Appendix 12).

All 61 rabbit keepers reported to wilt their forages even though only 45/61(73.37%) did it routinely. Few farms reported clinical signs when wilted forages were fed to the rabbits except for Wandering jew which most farmers reported that they did not see any difference in the clinical signs in rabbits even after wilting. Despite these, there was no statistically significant difference in the clinical signs reported by farmers when the forages were fed fresh or after wilting ($P = 0.0596$) (Appendix 13).

CHAPTER FIVE: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1. Characteristics of rabbit production in Kenya

Rabbit keeping in Kenya is practiced by farmers across all ages groups (P = 0.7626) and gender, with the majority being those over 30 years. This is consistent with the findings of Hungu *et al.* (2013) and Serem *et al*. (2013). This observation depicts a change from the past scenario in which rabbit keeping was mainly practiced by young boys and women (Borter and Mwanza, 2011). The present study also shows that rabbit keeping is practiced by different strata of society including farmers and other careers, implying that it is now a widely accepted economic enterprise in Kenya.

The diverse age and career profiles of rabbit keepers may be attributed to multi factorial reasons. The active promotion of rabbit production and opportunities for value addition by the government and non-governmental and private institutions in Kenya has motivated more farmers to keep rabbits (Hungu *et al.* 2013; Mailu *et al.* 2012).

Land size and availability is another factor. Rabbit keepers around Nairobi county and central Kenya regions (Nyeri, Kiambu and Meru) have relatively high numbers of rabbits per farm. These are high potential areas characterized by small land sizes and high population densities (Mutugi, 2004). Rabbit production requires less space and is therefore more sustainable in these areas with smaller land sizes compared to other agricultural activities. However, the study revealed that some of the high potential areas (Kiambu and Meru counties) recorded the highest numbers of pneumonia cases (P = 0.0183). This can be attributed to exposure of the domestic rabbits to cold temperatures which are common in these areas. Rabbit keepers in these areas also

tend to house their rabbits in groups and in tiered housing, so as to minimize the space utilized. This may explain the reason why relatively high coccidia OPG were identified from farms where grouped housing was practiced (P = 0.0293) and to less extent in farms with tiered cages (P = 0.0572).

Rabbit production is still a small scale industry (Hungu *et al.* 2013) in Kenya. Yet the husbandry practices are similar to those of large scale commercial rabbit production systems described by Finzi (2000). Increased operation and investments cost amongst these farmers may make the industry unsustainable due to market uncertainties. The high cost of investments, breeding stock and production cost may justify the low numbers of rabbit keepers aged below thirty (30) years and above sixty (60) years due to the relatively lower acess to regular income of these age groups.

Cross breeds and other locally bred rabbits are becoming common among Kenyan farmers. This may be due to the fact that these breeds have been shown to perform well in terms of fertility, mothering ability and longevity (Lukefahr, 2010). Local rabbits have been reported to possess unique characteristics such as small body size, low feed requirements, tolerance to local pathogens and sub-optimal housing and management conditions (Lukefahr, 1998; Oseni *et al.* 1997).

French ear lop and Angora breeds were relatively less common in Kenya probably because Angora breed have been reported to have low conception rate, growth rate and litter size and high mortality rate (Eiben *et al.* 2010; Ozimba and Lukefahr, 1991) and may have been considered by farmers as less suited for domestic rabbit production. However, the findings of this study did not reveal any association between the rabbit breeds and disease preferences. It is

important that further investigation should be done to find out the disease resistance levels in the various domestic rabbit breeds.

The other reason for high frequencies of cross breeds and local breeds may be the relatively high prices of exotic breeding stock. Mailu *et al.* (2012) reported that the average price of an exotic adult rabbit in Kenya is 1115 KES/rabbit (US $12.9). In this regard, cross breeds and local breeds are viable options that farmers can afford. However, proper selection of breeding stock should be done to eliminate spread of hereditary conditions such as splay leg and cannibalism (Patton *et al.* 2008) reported in this study. Furthermore the importance of keeping different species of pedigree breeding stock in the rabbit breeding centers should be emphasized as a key option in the industry even as promotion of local breeds is encouraged for other reasons. This may help in genetic conservation of rabbit breeds in the country and would also be of strategic importance to a sustainable rabbit value chain in Kenya.

The use of both forages and pellets as the main source of feed was consistent with findings of Hungu *et al.* (2013). The use of forages was relatively less common in the metropolitan areas of Kiambu and Nairobi counties compared to agricultural areas of Nakuru, Nyeri, Meru and Taita-Taveta. These two metropolitan counties generally used more commercial pellets and provided forages mainly vegetable wastes as supplement and enrichment when available. The reason for the similarities between the two counties can be speculated to be due to very small land sizes. Farming practices in these two areas are carried out mainly on plots as backyard farming (Foeken and Mwangi, 2000). In this regard, availability of freely growing forage weeds is almost impossible and farmers compensate these by using vegetable wastes collected from the markets and kitchen refuse.

Rabbit feeding is mainly done on locally available forage plants and weeds, which is similar to recommendations made by Leng (2006), Finzi (2000) and Lukefahr (1998). This type of practice not only lowers production costs but also eliminates the possibility of resource depletion through competition for human food (Leng, 2006). However, microclimatic conditions in these counties also vary and these may be a contributing factor to the forage type and availability. This may explain the reason for the significant differences (P = 0.0135) on types of forage used in various counties.

Most farmers reported that they observed clinical signs less frequently when they used wilted forages than un-wilted forages except for wandering jew which the farmers did not report any difference even after wilting. Despite this fact, there was no significant difference in the frequency of clinical signs observed by the farmers when either the wilted or un-wilted forages were used (P = 0.0596). This finding further suggests that diseases of domestic rabbits are not only predisposed by type of feed but also a combination of factors including housing, age of rabbits, farm location and presence of underlying diseases or pathogens.

5.2. Etiology of diseases of domestic rabbits and their predisposing factors

The study findings revealed that the clinical signs that were commonly observed by rabbit farmers were those associated with diseases affecting the digestive and cutaneous systems respectively. The observation that the frequently observed diseases include gastrointestinal conditions (65.57%), skin conditions (27.87%) and conditions affecting the eyes, ears and mouth (27.87%) supports the findings reported by Aleri *et al.* (2012), who reported that ear canker and gastrointestinal diseases were the most prevalent clinical conditions in Kenya. The difference in the prevalence of these diseases between the present study and the study by Aleri *et al.* (2012)

may be explained by the difference in methodology approach. Aleri *et al.* (2012) reported only the clinical cases around Nairobi County from cases that were received at the Small Animal Clinic of University of Nairobi. The current study on the other hand covered many areas representing different regions of Kenya and an objective assay of parameters was incorporated.

5.2.1. Diseases of digestive system

An important finding in this study was that enteritis was the most commonly diagnosed condition (29.51%) and was clinically manifested as diarrhea. Previous studies have also reported diarrheal diseases to be the most common causes of mortalities in rabbits (Patton *et al.* 2008; Rosell *et al.* 2010) and that diarrhea is generally assumed to be caused by either lack of dietary fibre, coccidia or bacterial proliferation (Rashwan and Marai, 2000). However, the current study revealed causes of diarrhea as either bacterial or parasitic in nature. Intestinal and hepatic coccidiosis were the main conditions associated with enteritis ($P = 0.0425$). This study isolated relatively high numbers of coccidia oocysts from feces with 25/61 (40.98%) farms recording an average of 4000 and more of cocidia OPG. This study postulates that the high frequency of cases of diarrhea and enteritis reported by the farmers and diagnosed during post mortem examination, respectively are due to coccidiosis. Other studies reported that suckling rabbits cannot be infected with coccidia before they are nineteen (19) days old due to innate immunity (Pakandl *et al.* 2008). This finding is consistent with our findings since coccidia oocyst positive fecal samples were obtained from rabbits aged four weeks and above.

The present study found that only 12/61 (19.67%) farms in Kenya had coccidia oocysts count of less 1000 opg (acceptable coccidia level) while the other farms had high coccidia oocyst opg. However, González *et al.* (2008) concluded that coccidia count of 1000 opg or less is considered

satisfactory in domestic rabbits and does not need any medical intervention. The high level of coccidia oocysts load on most farms can be associated with the high frequency of diarrhea reported by rabbit keepers. Furthermore, our study revealed good and fair sanitation levels in a significant 26/61 (42.62%) and 17/61 (27.87%) farms respectively despite the relatively high coccidia burden within these farms ($P = 0.6312$). This finding was in contrast to other studies by González-Rodendo *et al.* (2008) and Pakandl *et al.* (2008) who concluded that good hygienic practices are usually sufficient to maintain low coccidia levels in a farm. This finding however, supports the conclusion by Pakandl (2009) that rabbit producers cannot rely on hygiene alone for prevention of coccidiosis in their farms.

Use of sulphonamides for treatment and control of coccidiosis was reported by a few farmers (9.84%) and was seemingly effective since all the six farms that used it for treatment tested negative for coccidia oocysts. However, prolonged use of sulphonamides for prophylaxis against coccidiosis has been associated with several challenges globally. These challenges include; drug resistance (Pakandl, 2009), drug toxicity to rabbits (Tyrrell *et al.* 2002; Pakandl, 2009) and reduced acceptability of rabbit meat by the public (Pakandl, 2009). The effects of sulphonamides and other anticoccidia on treatment and prophylaxis of coccidiosis on domestic rabbit farms in Kenya should be investigated.

Fecal samples collected during post mortem examination revealed higher coccidia burdens (Greater than 10, 000 OPG) in weaners aged between four (4) and five (5) weeks than in growers and adult rabbits ($P < 0.001$) and in rabbits housed in crowded groups ($P = 0.0293$) . These can be attributed to several factors. First, naïve rabbits are more susceptible to infection from adult carriers especially after weaning (Pakandl *et al.* 2008; Papeschi *et al.* 2013) and since most rabbit

keepers in Kenya (31/61 (50.82 %) mainly housed their rabbits in groups, housing and husbandry practices are likely risk factors. Secondly, weaning stress has been reported to lower immunity of rabbits to infection (Papeschi *et al.* 2013) and possibility of ingesting coccidia contaminated solid feed during weaning period may raise the intensity of infection for the weaners. Our study also showed high coccidia levels from a few adult rabbits aged more than 24 weeks 7/61 (11.48%) which had been diagnosed with enteritis. This was in contrary to findings by Papeschi *et al.* (2013) that rabbits develop immunity to *Eimeria* species by 3 months of age.

Studies by Coudert *et al.* (2000) and González *et al.*(2008) recommended the use pharmacological prophylactic coccidiostats if the oocysts count reaches between 4000-5000 OPG. Furthermore Pakandl, (2009) reported successful use of vaccination for control of experimentally induced coccidiosis. In this regard investigation on effective control methods of coccidosis including vaccination in domestic rabbits in Kenya should be done.

Post mortem findings revealed Intestinal obstructions (3.28%), mainly volvulus and intussusceptions in two rabbits. These obstructions are usually associated with hyperperistalsis induced by the coccidial infection of the intestines as was found in the two rabbits (Weisbroth and Scher, 1975).

The study recovered nematode eggs from (6/302, 1.99%) fecal samples and Pinworms (*Passalurus ambiguus*) from 3.28% rabbits. Other studies have reported these worms to be less pathogenic even though diarrhea and death has been reported in cases of heavy infection (Rinaldi *et al*., 2010; Lords, 2012). Our study however, revealed relatively high numbers of coccidia opg from all the fecal samples and rabbits from which nematode eggs and Pinworms were recovered. In this regard, the study could not ascertain whether the enteritis was due to the coccidia oocysts

or the helminths. It is therefore important that further investigation be done to establish if any pathogenic synergism exists between the two pathogens (coccidia and pinworms).

This study identified the possible causes of Mucoid enteropathy to be due to high coccidia infection (3/61, 4.92%) change of feed (1/61, 1.64%) and suspected consumption of toxins in feed (1/61, 1.64%). However, other studies have reported that *Mucoid enteropathy* is caused by several factors such as bacteria, clostridia, toxins, dietary irregularities and or obstructions of the gastrointestinal tract (Hotchkiss and Merritt, 1996; Licois *et al.* 2006; (Meshorer, 1976). *Typhilitis* caused by *E. coli* was reported in one rabbit. Studies by D'Incau, *et al.* (2004) and (Prescot, 1978) reported that production of pathogenic/virulence factors of *E. coli* are usually associated with predisposing factors such as gastric obstruction and ingestion of excess organisms from heavily contaminated feed. However, the study did not find a significant association between the occurrence of either *Typhilitis* or Mucoid enteropathy and the farm (P = 0.0812) Due to the limited resources, the study did not characterize the toxins and genetic profiles of *E. coli* strains isolated from the rabbits showing diarrhea. However, microbial isolation and histopathological evaluation were used to identify the etiology.

This study further revealed that bloat frequently occurred concurrently with either *Mucoid enteropathy* 5/61 (8.20%) or heavy intestinal coccidiosis in weaned rabbits 3/61 (4.92%). However, the role of heavy intestinal coccidiosis leading to bloating in the weaned rabbits could not be determined in this study.

5.2.2. Diseases of respiratory system

Pneumonia in rabbits was diagnosed in 9/61(14.75%) rabbits in this study. This was consistent with the finding by Aleri *et al.* (2012) and Ngatia *et al.* (1988). From the retrospective study by Aleri *et al.* (2012), it was reported that pneumonia was the third most commonly reported condition (12%) after Ear canker and gastrointestinal conditions. The same study further reported that pneumonia had the highest case fatality of 85%. The present study revealed that pneumonia caused death in two out of the five rabbits that were found dead on five (5) farms. The other three (3) rabbits were diagnosed with enteritis.

The present study revealed that pneumonia is caused by mixed bacterial infections. The bacteria isolated were *Pasteurella multocida*, *Pseudomonas aeroginosa* mixed with *Staphylococcus aureus* and *Klebsiella pneumonia* mixed with *Staphylococcus aureus* from the lung tissue samples. The findings were similar to those of other researchers that *Pasteurella multocida* and *Pseudomonas aeroginosa* are the common bacterial causes of upper respiratory tract infections (Mohamed and Abdelsalam, 2008; Martino and Luzi, 2008; Rougier *et al.* 2006).

This study also revealed that pneumonia occurred commonly in Kiambu and Meru counties ($P = 0.0183$). These two counties also had significant numbers of farms with outdoor rabbit housing ($P < 0.01$). Kiambu (altitude 1500- 1800 meters above sea level) and Meru (altitude 1200- 5000 meters above sea level) are known for cold weather with temperatures daily average temperetures of 18.7°C. In this regard, the outdoor housing in the cold weather was considered as a possible predisposing factor to pneumonia in these regions. A study by Kline and Winternitz, (1915) reported that apart from bacterial infections, external factors such as cold and irritating gases can also predispose animals to pneumonia. It further reported that the pneumonia

predisposed by cold is usually characterized by tracheitis, laryngitis and bronchitis, a feature that was observed in our study in 2/61 (3.28%) rabbits diagnosed with pneumonia. However, Mohamed and Abdesalom, (2008) also reported depressed immunity related to stress such as transportation as predisposing to pneumonia. Our study however diagnosed pneumonia in seven rabbits that clinically manifested pneumonic signs (coughing, sneezing and/or nasal discharges) and two rabbits that were found dead in the farms. In this regard, the rabbits were infected at the farm level hence transportation could not have predisposed the rabbits to pneumonia in this study.

5.2. 3. Infections of the eye, ears and oral cavity

Non-pathogenic *Staphylococcus, Escherichia coli* and *Staphylococcus aureus* were the bacteria that were frequently isolated from conjuctival and nasopharyngeal swabs in our study. In the present study bacteria were isolated from 115/120 (95.83%) conjunctiva samples and 105/120 (87.50 %) nasopharyngeal swabs. These findings are consistent with previous studies by Okuda and Campbell (1974), Cooper *et al.* (2001) who isolated bacteria from 99% and 83% of the samples respectively. In this study *Staphylococcus aureus* were isolated from 23.33% of the conjuctival samples almost similar to the findings by Okuda and Campbell (1974) in which *Staphylococcus aureus* were isolated from 26% of the conjuctival samples. However, the two findings are in contrast to the study by Cooper *et al.* (2001) in which no pathogenic staphylococcus were isolated from conjuctival swabs.

This difference can be explained by the methodology and management of rabbits during the studies. The samples for the present study were collected from randomly selected rabbits from the farms and included both the healthy rabbits and those that were clinically sick. Hence aerosol

spread of microorganism from the sick to the healthy rabbits could not be ruled out in the present study, since this was afield sampling study. The housing and feeding practices, exposure to antibiotics in feed or water were different for most of the rabbits. The study by Cooper *et al.* (2001) reportedly was done on clinically healthy rabbits kept under controlled laboratory environment. This is contrasted with the current study conducted on farms and under different management and hygienic conditions. Another observation is that the swabs used in the present study were soaked in nutrient agar compared to previous studies by Cooper *et al.* (2001) where dry swabs soaked in saline were used.

The relatively high prevalence of *Staphylococcus aureus* isolated from the conjunctiva and nasopharyngeal samples may have been due to the fact that this organism is a versatile opportunistic microorganism which is capable of persisting and multiplying in different environmental conditions (Cucarella *et al.* 2004; Okerman *et al.* 1984) and in this regard it is an important risk factor to respiratory and eye diseases of domestic rabbits.

Our study isolated mixed bacterial infection from all the five cases of conjunctivitis with *Staphylococcus aureus, Streptococcus* species and *Pseudomonas aeroginosa* being the predominant bacteria in all the cases. This finding was consistent with that of Hinton, (1977) who reported that purulent conjunctivitis in rabbits is mainly caused by *Staphylococcus aureus* and sometimes *Pasteurella multocida*. Furthermore, Corpa *et al.* (2010) reported that *Staphylococcus aureus* also causes several pathological manifestations including multisystem abscessation, pododermatitis and fatal septicaemia in rabbits (Corpa *et al.* 2010). This was manifested in rabbits diagnosed with submandibular abscess 3/61(4.92%), subcutaneous abscesses 1/61(1.64%) and retrobulbar abscesses 1/61(1.64%) in our study. While, isolation of

streptococcus species was consistent with findings of Tyrrell *et al.* (2002) *Streptococcus* species is commonly isolated from mandibular and maxillary abscesses.

One rabbit diagnosed with overgrown teeth also had concurrent retrobulbar abscesses, conjunctivitis and osteomyelitis due to infection of the mandibles. In this connection, the infection of the mandible was suspected to have caused the overgrown teeth. Brown (2001), reported infections of gum and tooth root as one of the causes of overgrown teeth and malocclusions.

In this study, Ear canker caused by the mite *Psoroptes cuniculi* was the most common disease condition of the ear 10/61 (16.39%) reported. This was similar to the findings of Aleri *et al.* (2012). Previous reports found that the predisposing factors to Ear canker include among others high temperatures and humidity as well as poor hygiene and microclimate (EFSA, 2005). Kenya being a tropical country, climatic conditions alone are conducive for the occurrence Ear canker. As observed in the four rabbits in present study, complication by secondary bacterial infection is also common (Aiello *et al.* 1998; Ulutas *et al.* 2005). Our study revealed that Ear canker occurred frequently in farms with old poorly maintained housing (P= 0.0046) irrespective of the breed affected (P= 0.0146). This could be attributed to fact that these old rabbit housing structures are owned by farmers who have kept rabbits for more years. These houses also had no history of mite control and ear mite infection may occur frequently due to continued cycle from enzootically infected housing when new animals are introduced (Chitwood and Lichtenfels, 2013).

The study also revealed that most rabbit keepers 7/10(70%) undertake self medication for Ear infections. A similar finding was reported by Hungu, (2011). However, a few farmers 3/10 (30)

could not identify rabbits with Ear canker. It is possible that the reoccurrence of Ear canker on the farms may be attributed to both inadequate treatment and control methods done by the rabbit farmers. Past studies have concluded that apart from cleaning the ears by removing the debris with oil or iodine, subcutaneous injection with 2 doses of 1% ivermectin solution at 300-400 µg/kg body weight is both curative and prophylactic when done 14 days apart. In addition to Ivermectin, injection with streptomycin-penicillin combination and antibiotic ear drops may lead to complete recovery from Ear canker (Acar *et al.* 2007; Aleri *et al.* 2012; KyungYeon and OhDeog, 2010).

5.2.4. Skin infections

The present study encountered mange caused by *Sarcoptes scabiei* in 12 rabbits from 5/61 (8.20%) farms. The high prevalence of *sarcoptic* mange reported by farmers in Newzealand White (56.90%) and Califonia White breeds (51.7%) could be attributed to the fact that these two breeds are the ones commonly kept by farmers in Kenya (Hungu *et al.* 2013). Previous studies by Scott *et al.* (2001) indicate that *sarcoptic* mange is a rare condition globally except in Africa where it is slightly more common. In our study the five rabbits diagnosed with *sarcoptic* mange at post mortem examination were in poor body condition and also had concurrent infections with Ear canker and helminths. This finding probably occurred due the chronic nature of the disease which has been reported to cause deterioration in the physical condition of the animal including; weight loss and suppressed immunity (Arlian, 1989; Eshar, 2010).

The reoccurrence of sarcoptic mange after the attempted treatment by the farmers is also attributed to inadequate treatment and control methods. Studies have shown that treatment of *sarcoptes* mange is similar to that of *psoroptes* mange (Acar *et al.* 2007; Aleri *et al.* 2012; Kaya

et al. 2010; Wagner and Wendlberger, 2000). Due to the enzootic nature of mites, environmental disinfection by dusting or spraying the hutches is a recommended control method (Darzi *et al.* 2007b; Wagner and Wendlberger, 2000).

The study encountered generalized alopecia in five rabbits. The inability to isolate any etiological agents from these rabbits was probably due to the prior treatment given to the rabbits. However it is suspected that the causes of the generalized alopecia to be fur mites due to the alopecia and dandruff that was frequently observed on the dorsum and ventrums of the affected rabbits. Fur mites (*Cheyletiella parasitivorax*) are non-burrowing mites, which have been previously associated with alopecia (generalized mange) in rabbits in Kenya (Cooper, 1976). Diagnosis of these mites has been done successfully from microscopic examination of skin surface tape strips and hair coat combings (Kim *et al.* 2008; Paterson, 2006: Flatt and Wiemers, 1976). The present study used only skin scrapings and could therefore have missed these mites inadvertently,

Fight wounds were occasionally observed on rabbits (3.28%) in spite of adequate housing density. The practice of housing rabbits either in groups or in old and dilapidated hutches could easily allow unplanned mixing of the rabbits leading to the fights and aggression (Morton *et al.* 1993). These wounds inflicted during fights or from sharp objects within the housing structures may get infected and manifest as abscesses (Corpa *et al.* 2010). This study recorded subcutaneous abscesses and submandibular abscesses in 4/61(6.56%) rabbits. This observation stresses the importance of use of well maintained housing constructed with appropriate structures and flock size for rabbit keeping.

This study encountered dermatophytosis in two rabbits from 2/61 (3.28%) farms and isolated *Microsporum canis* as the etiological agents involved in both cases. The rabbits did not show other clinical signs apart from submandibular alopecia. Past studies have shown that dermatophytosis in rabbits is majorly caused by either *Microsporum canis* or *Trichophyton mentagrophytes* (Cafarchia *et al.* 2010; Rochette and Van Meirhaeghe, 2010). These organisms are reported to be not only zoonotic but can also be enzootically established in the rabbit houses and may easily spread to other rabbits (Rochette and Van Meirhaeghe, 2010). However in the present study, there was no evidence of flock infection and the disease in the two rabbits were sporadic among many other rabbits housed in groups.

Infestation of rabbits with the dog flea, *Ctenocephalides canis iwas* recorded in 2/61 (3.28%) rabbit farms observed in this study was consistent with a previous study (Hungu, 2011) in which fleas infestation was also reported amongst domestic rabbits housed in the same premises with chicken. Although *Ctenocephalides canis* is less pathogenic and less common in rabbits, the flea is an intermediate host and a biological vector of pathogens including bacteria (*Yersinia pestis*), helminthes, protozoa and *Rickettsia felis*, and it is a potential source of zoonosis to human (Horta *et al.* 2006; Oliveira *et al.* 2002). In this regard, effective flea control practices including housing and dusting of rabbit cages/ hutches with insecticide should be undertaken for further investigation in domestic rabbits in Kenya.

5.2. 5. Musculoskeletal conditions

The present study revealed that sore hock (chronic ulcerative pododermatitis) and associated paw ulceration occurred in 5/61(8.2%) farms, all the farms used rabbit houses that had wire mesh floor with no foot rests. Despite this, this study did not find any association between the floor type and occurrence of sore hock. Past studies have reported Sore hock as a health and welfare problem in rabbits housed in cages with wire mesh floors. These studies also reported sore hock with a variable prevalence rates; 9.1% in females and 7.5 % males (Rosell and De la Fuente, 2013), and overall prevalence of 6.4% (Sánchez *et al.* 2012) and 12% (Mirabito, 2003). Other likely factors that could have predisposed the rabbits to sore hock are prolonged contact with wet and urine soaked poorly drained hutch floor as observed in 1/61(1.64%) farm and urinary incontinence 1/61(1.64%). Rosell and De la Fuente (2009) recommended the use of slated (wood, metal, plastic) footrests in the hutches to the occurrence of sore hock in rabbits. However, use of foot rests in rabbit houses is still an uncommon practice among rabbit keepers in Kenya.

This study revealed that osteomyelitis and arthritis characterized by joint abscesses are caused by secondary bacterial infection of the wounds. The wounds may have resulted from either paw ulceration in case of sore hock or decubital wounds in the case of splay leg. Studies have reported *Staphylococcus aureus* as the main etiological agent involved in Pododermatitis, associated abscesses and osteomyelitis (Blair, 2013; Corpa *et al.* 2010; Selva *et al*. 2008). In the present study we isolated *Staphylococcus aureus* from all the five swabs taken from the joint and paw abscesses.

5.2. 6. Miscellaneous conditions

Cannibalism and trichophagy occurred each in 1/61(1.64%) rabbit farms in the present study. This study could not reveal specific causes of these conditions even though poor kindling nest preparation was considered as the likely cause of cannibalism. Mondal *et al.* (2006), reported that trichophagy is an abnormal behavior in rabbits that is predisposed by unbalanced diet lacking in essential amino acids or fibers and heat stress. However, cannibalism has been reported to be predisposed by injury or malformations in kits or disturbance of the doe following kindling (Patton *et al.* 2008) and abnormal maternal behavior (González and Zamora, 2008). Appropriate selection of breeding stock and proper kindling nest preparation is reccomended to reduce the incidences of such vices and other hereditary traits.

This study encountered emaciated rabbits in 9/61(14.75%) rabbits, seven out of the nine emaciated rabbits presented with concurrent infections with other diseases. This finding supports other past studies that concluded that emaciation and unthriftness in animals is associated with underlying diseases (Rosell and De La Fuente, 2008) and the concurrent anorexia caused by pain during disease (Bareille *et al.* 2003). In this regard, feeding rabbits on balanced diet and continuous disease monitoring and control is important for attaining faster growth and market weight of domestic rabbits.

The findings of this study suggest that rabbit diseases are a major constraint to domestic rabbit production in Kenya. Furthermore, the study revealed that environmental factors including location of the farm and type of housing, age of rabbits and presence of pathogens are some of the risk factors that predispose domestic rabbits to diseases. The study also revealed the insidious nature of some of the diseases of rabbit and how they negatively affect weight gain in

domestic rabbits. It is also evident that there exists knowledge gap on the management and control of diseases of domestic rabbits among the rabbit keepers. The frequent isolation of pathogenic bacteria including; *Staphylococcus aureus, Pseudomonas aeroginosa* and *Pasteurella* species in rabbit samples is of great public health and zoonotic concern. These findings will be disseminated to veterinary professionals and rabbit keepers through continuous professional's development activities and publication with an aim of equipping the stakeholders with knowledge on good rabbit husbandry practices, disease management and control.

5.3. CONCLUSIONS

From the study the conclusions are:

1. Cross breeds, Newzealand white and Californian white are the frequently kept domestic rabbit breeds in Kenya.

2. Sanitation scores of housing units in significant number of rabbit farms in Kenya range from fair to very good

3. Diarrhea, alopecia and ear crust and scabs are the commonest complaints by rabbit keepers in Kenya.

4. Diseases of the digestive system, skin and the ears are the main causes of morbidity and mortalities in domestic rabbit in Kenya

5. The etiological agents involved in causing diseases of domestic rabbits in Kenya are mainly coccidia, bacteria, fungi, fleas, nematodes and mites.

6. Location of farm, type and maintenance status of housing structure, housing density, age and genetics of rabbits and presence of potential pathogens including coccidia and bacteria are the risk factors that predispose domestic rabbits to diseases.

5.4. RECOMMENDATIONS

The study therefore recommends:

1. Dissemination of the findings of this study to both animal health service providers and rabbit keepers through workshops and booklets and inclusion of courses on rabbit diseases in the undergraduate curriculum.

2. Surveillence of rabbit disease outbreaks in the regional Veterinary investigation laboratories (VIL) should inform on the rabbit disease incidences and prevalence in time and space and facilitate informed disease diagnosis, treatment and control.

3. Further research on the use and development of locally and cheaply available forage materials for improved nutrition in domestic rabbits.

4. Investigations on the suitable treatment regimes, hygiene and housing in the control of the major diseases of domestic rabbits in Kenya as identified in this study and other previous studies.

5. Investigations and characterization of potential toxins in rabbit feeds and their effect on rabbit health and production

6. Further studies on the epidemiology and management of the major diseases of domestic rabbits identified in this study.

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APPENDICES

APPENDIX 1: Questionnaire on rabbit husbandry practices and diseases

INVESTIGATION OF ETIOLOGY AND PPREDISPOSING FACTORS TO DOMESTIC RABBIT DISEASES IN SELECTED AREAS IN KENYA

Questionnaire on rabbit husbandry practices and diseases

Date of interview …….

Time begin ……

Interviewer's name: ……

Supervisor' name ……

Name of Household Head……

County ---------- District.....Location ----------

Sub-location.....Village.....

GPS READING (Eastings……) *Northings* (……)

Elevations (----------)

A) Background information.

1. Interviewees Name.....Sex 1=Male 0=Female
2. Age of the interviewee: (1) Up to 30 years (2) >30 – 60 years (3) Over 60 year
3. Occupation: (1) farming (2) trading (3) Employee (4)other

I. Number of rabbits kept ……..

II. BREEDS & DISEASE

Please note the breeds CURRENTLY KEPT by farmer and then ask the following question(s) to fill in the table below as necessary - Is the [BREED] affected by [SYMPTOM/DISEASE]? Yes = 1, No = 0 N/A=-9

Symptom Is breed among farmer's portfolio? *Tick as appropriate*	NZW □	CW □	FG □	CH □	FEL □	DU □	ANG □	Other specify	Cross specify
Sudden death									
Pneumonia (nasal discharges and Coughing)									
Bloat (abdominal distention)									
Diarrhea									
Mange (skin itching & scratching)									
Paw ulcerations									
Alopecia (loss of hair)									
Ear canker									
Unthriftyness (stunted growth)									
Hind limb paralysis									
Ectoparasites (fleas, mites, lice, ticks)									
Eye discharges									

Specify name of breed here……..

Specify cross here [……..] x [……..]

III. FORAGES & DISEASE

Which of the following forages do you use to feed your rabbits? Tick as appropriate against all applicable feed types then ask the question

In your estimation, HAS [UNWILTED FORAGE] caused the [SYMPTOM/DISEASE] in your rabbits? Yes = 1, No = 0 N/A=-9

FORAGE	Kale	Cabbage	Grass	Gallant soldier	Black jack	Wandering jew	Sweet potato vines	Datura	Muthunga	Other
Tick in box if applicable	□	□	□	□	□	□	□	□	□	specify
Sudden death										
vPneumonia (nasal discharges and coughing)										
Bloat										
Diarrhea										
Unthriftyness										
Hind limb paralysis										

In your estimation, has [Wilted FORAGE] caused the [SYMPTOM] in your rabbits? Yes = 1, No = 0 N/A=-9

FORAGE	Kale	Cabbage	Grass	Gallant soldier	Black jack	Wandering jew	Sweet potato vines	Datura	Muthunga	Other
Tick in box if applicable	□	□	□	□	□	□	□	□	□	specify
Sudden death										
Pneumonia (nasal discharges and coughing)										
Bloat										
Diarrhea										
Unthriftyness										
Hind limb paralysis										

IV. HOUSING & DISEASE

Please rate on a scale of 1 – 5 the general impression of the rabbit house sanitation and tick below in the table. *There will be 4 judges within the farm at any particular moment so each would make a point of scaling this item independently.*

1 = very poor, 2=poor, 3=fair, 4=good, 5= very good

Judge	Very poor	Poor	Fair	Good	Very good
1					
2					
3					
4					

V. Housing density (number of rabbits per cage)

Please rate the general impression of the rabbit housing density- (Overcrowding) and tick below in the table. *There will be 4 judges within the farm at any particular moment so each would make a point of scaling this item independently.*

1 =Too Crowded 2 =Crowded 3 =adequately spaced 4 =More than adequately spaced 5 =Too much space

Judge	Too Crowded	Crowded	Adequately spaced	More than adequately spaced	Too much space
1					
2					
3					
4					

APPENDIX 2: CLINICAL SCORE CARD AND OBSERVATION SHEET

Name of Household Head……

Location.....Sub-location.....Village.....
GPS READING (Latitude……) *Longitude* (……)

RABBIT HEALTH
Body condition score Good ☐ Fair ☐ poor ☐
Demeanor Active ☐ Dull ☐
Locomotion ☐ dragging ☐ Paralyzed ☐
Posture Tilting of head ☐
Dental status tartar ☐ broken ☐ tooth missing ☐ abscess foreign material ☐
Coughing/sneezing (YES) ☐
Eye/nasal discharges (YES) ☐
Perineum(clean/soiled) (Yes) ☐
Body surface swelling ☐ nodules ☐ abscess ☐ erosions ☐ local erythema ☐
Fur coat alopecic ☐ Rough ☐ smooth ☐
Parasites ticks ☐ mites ☐ lice ☐ fleas ☐
itching/scratching ☐
Ear scabs ☐ crusts ☐ Discharges ☐
FEEDING
Feeding equipments (yes/No) (dirty/clean)
Type of feeding container Aluminium ☐ wooden ☐ plastic ☐ clay ☐ Any other ☐

watering equipments (yes/No) (dirty/clean)
Type of water container Aluminium ☐ wooden ☐ plastic ☐ clay ☐ Any other ☐
Feed in troughs (yes/No) ☐
Water in troughs (yes/No) ☐
ENVIRONMENT
Fecal characteristics pellets ☐ watery ☐ Mucoid ☐ blood tinged ☐ Soft ☐
Housing type Outdoor cages ☐ Indoor cages ☐
No of tiers 1- 3 ☐ 3-5 ☐ more than 5 ☐
Cage Elevation Tiered ☐ One level ☐
Housing floor wire mesh ☐ wood ☐ ground) ☐
Housing group cages ☐ Individual ☐
Odour bad ☐ normal ☐
Housing density crowded ☐ Not crowded ☐
Housing structure neat ☐ old ☐ poorly maintained ☐
Hygiene clean ☐ dirty ☐

(b). clinical case

4. Total number of rabbits…….. Number sick ……. Number dead……
5. Age…….. Sex …… breed…….
6. Identity……..
7. Farm questionnaire number…….
8. History……
   ……
9. Any treatment given……..……
   ……

10. Clinical signs observed……
……..
11. Clinical diagnosis…….
12. Confirmed diagnoses……
……
13. Post mortem diagnosis……
……
14. Samples collected

Live rabbit for screening ……

☐ wabs (nasal/conjuctival) ……..
Age…….. sex …… breed……..… clinical signs……
History……
Rabbit identity…….

☐ Carcass……
Age…….. sex …… breed……..… clinical signs……
History……
Rabbit identity…….

☐ Fecal samples…….
Age…….. sex …… breed……..… clinical signs……
History……
Rabbit identity…….

☐ Blood smear……
Age…….. sex …… breed……..… clinical signs……
History……
Rabbit identity…….

☐ Skin scrapping……..…
Age…….. sex …… breed……..… clinical signs……
History……
Rabbit identity…….

APPENDIX 3: Geographical coordinates and elevations of the study sites visited during the period January 2012 – May 2013.

District visited	Divisions/ locations	Geographical coordinates			Farm identity
		Longitude (Degree/minute/seconds)	Latitudes (Degree/minute/seconds)	Altitude (Meters)	
Dagoretti	Waithaka	E36^{0}42'04.1″	S01^{0}17'98.6″	1872	NGF7
		E37^{0}43'20.11″	S01^{0}16'87.1″	1838	NGF6
	Dagoretti	*	*	*	158/2012
Gilgil	Gilgil	E36^{0}19'14.2″	S00^{0}29'84.5″	2008	NKF2
		E36^{0}16'04.2″	S00^{0}26'78.5″	1851	NKF5
		E36^{0}21'15.6″	S00^{0}25'79.5″	2228	NKFI
		E36^{0}18'58.8″	S00^{0}31'39.9″	2011	NkF10
	Karunga	E36^{0}18'73.7″	S00^{0}24'33.0″	2315	NKF3
		*	*	*	Nk11
Imenti North	Ntakira	E37^{0}38'66.3″	N00^{0}01'81.5″	1627	MF4
	Miriga Mieru West	E37^{0}39'69.5″	N00^{0}06'52.0″	1625	MF2
		E37^{0}39'69.5″	N00^{0}04'84.1″	1400	MF3
	Miriga Mieru East	E37^{0}39'92.2″	N00^{0}05'71.8″	1497	MF1
Imenti South	Nkuene	E37^{0}39'96.4″	S00^{0}05'24.4″	1473	MF6
Kajiado North	Ngong	E36^{0}39'51.6″	S01^{0}22'98.9″	2051	NGF2
		E36^{0}40'47.8″	S01^{0}22'81.8″	1946	NGF1
		E36^{0}39'74.1″	S01^{0}20'58.1″	1930	VF
	Ongata rongai	*	*	*	358/2012
Kiambu	Municipality	E36^{0}48'72.1″	S01^{0}09'05.4″	1793	KF6
		E36^{0}48'15.9″	S01^{0}09'08.0″	1826	KF5
		E36^{0}48'72.1″	S01^{0}09'07.6″	1829	KF4
		E36^{0}48'14.6″	S01^{0}09'75.5″	1797	KF3
		E36^{0}49'14.6″	S01^{0}09'81.6″	1727	KF2
		E36^{0}52'97.7″	S01^{0}10'95.0″	1589	KF1
Kieni West	Mweiga	E36^{0}55'21.6″	S00^{0}19'78.3″	1932	Nf4
		E36^{0}15'92.2″	S00^{0}27'46.0″	1966	Nf3
Kikuyu	Thogoto	*	*	*	NGF8
	Kabete	E36^{0}37'52.8″	S01^{0}10'57.4″	2087	LF1
		*	*	*	29/2012
Langata	Karen	E36^{0}43'33.6″	S01^{0}21'97.5″	1805	NGF3
		*	*	*	423/2012

	Mugumbini	E36^{0}45’72.5″	S01^{0}20’73.0″	1794	NGF4
	Langata	E36^{0}43’94.1″	S01^{0}20’34.7″	1828	APDOO1
Mathira	Ruguru	E037^{0}05’63.8″	S00^{0}22’51.1″	1945	Nf7
Meru Central	Abothugu	E37^{0}35’61.1″	S00^{0}00’02.8″	1923	MF5
Mukurweini	Mukurweini	E36^{0}56’39.2″	S00^{0}32’27.5″	1876	Nf6
Nakuru North	Kabatini	E36^{0}08’83.3″	S00^{0}14’65.4″	1934	NKF4
	Kiamaina	E36^{0}08’86.8″	S00^{0}13’38.8″	1941	NKF6
		E36^{0}08’93.8″	S00^{0}13’93.1″	1950	NKF9
	Lanet	E36^{0}06’54.8″	S00^{0}16’90.5″	1864M	NKF7
		E36^{0}20’54.8″	S00^{0}10’90.5″	1859	NkF 12
Nyeri Central	Municipality	E36^{0}56’50.3″	S00^{0}25’74.0″	1883	Nf2
		E36^{0}56’99.0″	S00^{0}25’41.5″	1805	Nf6
Nyeri South	Othaya	E37^{0}02’48.3″	S00^{0}33’21.9″	1756	NF1
	Iriani	E36^{0}56’10.1″	S00^{0}32’64.0″	1890	Nf5
Taita	Wundanyi	E38^{0}21’67.0″	S03^{0}23’95.4″	1427	TF4
		E38^{0}21’49.5″	S03^{0}23’95.7″	1494	TF2
		E38^{0}18’75.6″	S03^{0}23’65.2″	1631	TFI
		E38^{0}19’47.8″	S03^{0}22’80.8″	1655	TF5
	Wumingu	E38^{0}19’53.0″	S03^{0}22’78.0″	1680	TF3
Thika	Mugutha	E36^{0}58’44.5″	S01^{0}08’54.0″	1532	F7
	Municipality	E37^{0}03’64.6″	S01^{0}01’52.2″	1523	F4
		E37^{0}05’71.2″	S01^{0}04’63.2″	1544	FI
	Thika west	E37^{0}03’95.1″	S01^{0}01’77.7″	1525	F2
		E37^{0}04’64.8″	S00^{0}59’94.1″	1535	F5
		E37^{0}04’03.2″	S01^{0}01’68.8″	1504	F3
		E37^{0}02’53.6″	S00^{0}56’91.9″	1582	F6
Voi	Voi town	*	*		TF8
westlands	Kangemi	*	*	*	150/2012
	Loresho	*	*	*	353/2012

Appendix 4: Samples collected from the different study sites from January 2012 – May 2013.

Region	Farms visited	Questionnaires	Microbiology swabs			Parasitological samples		Blood smears	Rabbits for necropsy
			Nasopharyngeal	conjuctival	abscesses	fecal	Skin /ear scrapping		
Kiambu	17	17	34	34	3	102	6	34	17
Meru	6	6	10	10	1	36	3	11	6
Nakuru	12	12	24	22	2	72	8	24	12
Nairobi	13	13	26	26	3	78	7	25	13
Nyeri	7	7	14	14	1	42	3	14	7
Taita-Taveta	6	6	12	14	0	33	4	12	6
Total	61	61	120	120	10	363	31	120	61

Appendix 5: Forages used by Rabbit keepers in different study sites visited in Kenya within the period January 2012 – May 2013.

Region	Grass (%)	Cabbage (%)	Kales (%)	Gallant soldier (%)	Black jack (%)	Sweet potato vines (%)	Muthunga (%)	wandering jew (%)	Others (%)
Nairobi	11 (84.62)	12 (92.31)	13 (100)	8 (61.54)	7 (53.85)	9 (69.23)	6 (46.15)	2 (15.38)	1 (7.69)
Meru	6 (100)	5 (83.33)	5 (83.33)	6 (100)	6 (100)	6 (100)	6 (100)	4 (66.67)	2 (33.33)
Nakuru	11 (91.67)	12 (100)	12 (100)	12 (100)	12 (100)	12 (100)	12 (100)	7 (58.33)	0
Nyeri	7 (100)	7 (100)	7 (100)	7 (100)	7 (100)	5 (71.43)	3 (42.86)	3 (42.86)	0
Kiambu	12 (70.59)	12 (70.59)	11 (64.71)	9 (52.94)	7 (41.18)	9 (52.94)	7 (41.18	3 (17.65)	1 8.33)
Taita-Taveta	5 (83.33)	4 (66.77)	4 (66.67)	5 (83.33)	5 (83.33)	4 (66.67)	0	5 (83.33)	0

Appendix 6: The clinical signs in rabbits reported by farmers in different study sites within the period January 2012 – May 2013.

Clinical signs	Number of farms reported (%)
diarrhea	50 (86.21)
ear crust and scabs	35 (60.34)
alopecia	38 (65.52)
Nasal discharge/sneezing/coughing	24 (41.37)
abdominal distention	42 (72.41)
scratching	17 (29.31)
paws ulceration	4 (6.90)
unthriftness	8 (13.79)
Limb paralysis	6 (10.34)
eye discharges	7 (12.07)
ectoparasites	13 (22.41)
Sudden death	45 (77.59)

Where: ( ) indicates the number of farms as a percentage of the total farms visited during the the study.

APPENDIX 7: Frequencies of Coccidia Oocysts count per gram of feces (opg) in fecal samples collected from farms in the different study sites within the period January 2012 – May 2013.

	Frequency of farms (%)							
Region	Coccidia oocyst per gram of feaces (OPG) × 10^3							
	0	o.1 – 2	2.001- 4	4.001- 6	6.001-8	8.001-10	10-60	>60
Nairobi	2 (15.38)	4 (30.77)	1 (7.69)	0 (0.00)	0 (0.00)	2 (15.38)	2 (15.38)	2 (15.3)
Meru	0 (0.00)	4 (66.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (33.33)	0(0.00)
Nakuru	0 (0.00)	6 (50.00)	0 (0.00)	3 (25.00)	0 (0.00)	0 (0.00)	1 (8.33)	2 (16.6)
Nyeri	0 (0.00)	2 (28.57)	1 (14.29)	0 (0.00)	0 (0.00)	1 (14.29)	2 (28.57)	0 (0.00)
Kiambu	4 (23.53)	7 (41.18)	1 (5.88)	1 (5.88)	0 (0.00)	1 (5.88)	0 (0.00)	3 (17.6)
Taita – taveta	0 (0.00)	3 (50.00)	1 (16.67)	0 (0.00)	1 (16.67)	0 (0.00)	1 (16.67)	0 (0.00)

Where: ( ) indicates the number of farms as a percentage of the total farms visited in the county.

Appendix 8: Frequencies of clinical signs observed in farms (%) during clinical examination of rabbits in the different study sites within the period January 2012 – May 2013.

Clinical signs observed	Number of farms (%) observed
Ear scabs and crusts	10 (16.39)
Rough hair coat	8 (13.11)
soiled perineum	7 (11.48)
Sneezing/coughing	7 (11.48)
Eye discharges	6 (9.84)
Depressed	6 (9.84)
Localized erythema	6 (9.84)
Found dead	5 (8.20)
Paw ulceration	5 (8.20)
Scratching	5(8.20)
Others	5 (8.20)
Skin swellings	4 (6.56)
Head tilting	4 (6.56)
Ear discharges	2 (3.28)
Dragging hind limbs	2 (3.28)

Where: ( ) indicates the number of farms as a percentage of the total farms visited during the the study.

Appendix 9: Frequencies of diseases affecting various body systems as diagnosed in 61 rabbits during post mortem examination.

COUNTY	Body system affected					
	Gastro-intestinal	cutaneous	Eyes, ears and mouth	Miscellaneous	Respiratory	Musculo-skeletal
NAKURU	6	1	1	3	1	4
NAIROBI	11	1	2	2	2	1
TAITA- TAVETA	3	2	3	3	0	0
MERU	2	2	3	2	1	0
NYERI	10	3	3	1	1	0
KIAMBU	8	8	5	3	2	0
Totals	**40**	**17**	**17**	**14**	**7**	**5**

Appendix 10: Frequencies of diseases in various body systems as diagnosed during post mortem in different age groups of rabbits within the period January 2012 – May 2013.

Age group(weeks)	Frequency of diseases on various body systems.					
	Gastro-intestinal	Skin	eye, ears and mouth	Respiratory system	Musculoskeletal	Miscellaneous conditions
Weaners (1 –5)	7	2	1(1.64)	0	1	4
Growers (6-24)	14	11	6	3	3	5
Adults (>24)	19	4	10	4	1	5
Total	40	17	17	7	5	14

APPENDIX 11: Frequencies of skin condition/diseases in different age groups of rabbits sampled for post mortem examination from the farms in the different study sites within the period January 2012 – May 2013.

Age group (weeks)	General mange	Sub-mandible abscess	Localized mange around eyes	Localized mange around nostrils	Dermato-phytosis	Traumatic wound	Subcutaneous abscess
Weaners (1 –5)	2	-	-	-	-	-	-
Growers (6-24)	1	3	2	3	-	1	1
Adults (>24)	2	-		-	2	-	-
Total	5	3	2	3	2	1	1

APPENDIX 12: Clinical signs reported by farmers (%) when fresh forages were fed to the rabbits in the different study sites within the period January 2012 – May 2013.

Clinical signs	Kales	cabbages	grass	sweet potato vines	wandering jew	Others (including barley)
Bloat	9(14.75)	5(8.20)	4(6.56)	4(6.56)	26(42.62)	3(4.92)
Diarrhea	9(14.75)	6(9.84)	3(4.92)	3(4.92)	25(40.98)	2(3.28)
Nasal discharge/sneezing/coughing	4(6.56)	-	-	-	2(3.28)	-
Sudden death	4(6.56)	4(6.56)	2(3.28)	-	3(4.92)	1(1.64)
Stunted growth	2(3.28)	-	-	-	-	1(1.64)

Note: Items in bracket represent percentage (%) number of farms that reported the clinical sign when particular fresh feed was fed to rabbits in all the study sites

-: Clinical sign not reported in any farm.

Appendix 13: Clinical signs reported in farms (%) when wilted forages were fed to rabbits in the different study sites within the period January 2012 – May 2013.

Clinical signs	Kales	cabbages	grass	sweet potato vines	wandering jew
Bloat	6(9.84)	2(3.28)	-	2(3.28)	26(42.62)
Diarrhea	6(9.84)	4(6.56)		2(3.28)	25(40.98)
Nasal discharge/sneezing/coughing	-	-	-	-	2(3.28)
Sudden death	2(3.28)	4(6.56)	2(3.28)	-	3(4.92)
Stunted growth	2(3.28)	-	-	-	-

Note: Items in bracket represent percentage (%) number of farms that reported the clinical sign when particular wilted feed was fed to rabbits in all the study sites

-: Clinical sign not reported in any farm.

Appendix 14: Frequencies of fecal coccidia count for the six counties in which the survey was conducted between the periods January 2012 to May, 2013.

County	Coccidia OPG × 10^3								
	0	0.1 – 2.0	2.001-4	4.001-6	6.001-8	8.001-10	10.001-60	>60.0	Total
Kiambu	4	7	1	1	-	1	-	3	17
Meru	-	4	-	-	-	-	2	-	6
Nakuru	-	6	-	3	-	-	1	2	12
Nairobi	2	4	1	-	-	2	2	2	13
Nyeri	-	2	1	-	-	1	2	1	7
Taita- Taveta	-	3	1	-	1	-	1	-	6
Total	6	26	4	4	1	4	8	8	61

Appendix 15: Hematology parameters for sampled rabbits and the reference values

		WBC	PCV	RBC	Hb	MCV	MCH	MCHC	THROM.	Differential leukocyte counts				
		$10^3/\mu L$	%	$10^6/\mu L$	g/dL	f L	pg	%	$10^3/\mu L$	Neut. %	Lymph %	Mono. %	Eosin. %	Baso %
Reference values		**5–12.5**	**33–50**	**5–8**	**10–17**	**58–67**	**17–24**	**29–37**	**250–650**	**20–75**	**30–85**	**1–4**	**1–4**	**1–7**
Rabbit ID	**Age wks**													
150/2012	24	9.57	33.3	4.85	11.8	68.8	24.3	35.4	75	65	35	0	0	0
158/2012	40	7.42	48.3	7.36	14.99	65.7		30.8	144	41	56	0	3	0
29/2012	34	5.5	33.7	5.49	12.3	61.4	22.4	36.4	125	35	64	0	1	0
353/2012	>24	7.23	31.8	5.27	13.1	60.5	24.8	41.1	61	38	62	0`	0	0
358/2012	>24	8.47	35.0	6.51	14.1	53.9	21.6	40.2	106	68	32	0	0	0
395/2012[1]	28	22.58	37.5	7.27	12.89	51.6	17.7	34.1	187	39	52	0	9	0
423/2012	22	5.46	32.5	4.9	11.2	66.4	22.7	34.5	33	40	55	4	0	1
APD 001	21	8.24	48.7	6.96	11.2	70.1	16	22.9	203	37	63	0	0	0
F6	15	7.50	35.4	6.06	12.1	64.3	21.9	34.1	236	35	59	3	2	1
F5	20	6.67	38.8	5.76	13.4	67.4	23.3	34.5	67	40	57	1	1	1
KF1[2]	>24	9.52	31.7	4.90	12.5	64.7	25.5	39.4	59	65	32	0	3	0
KF2	5	10.37	31.4	4.21	11.4	74.6	27.0	36.3	201	34	66	0	0	0
KF3	4.5	4.9	32.7	4.76	9	68.7	18.9	27.5	427	35	65	0	0	0
kF4	>24	8.84	34.3	5.12	12.4	67	27.0	36.1	157	28	72	0	0	0
kF5	>24	9.82	37.5	5.73	14.75	65.6	25.6	39.2	334	63	36	1	0	0
Kf6	12	8.0	36.1	5.25	14.0	68.9	26.6	38.7	118	38	62	0	0	0
KF7[3]	5	2.2	42.7	4.9	10.2	87.0	20.8	23.9	556	low	77	0	0	0
KF8[4]	>24	17.0	33.8	5.37	23.8	63.1	44.3	70.4	744	59	41	0	0	0
LFI	>24	9.52	33.7	5.15	12.7	65.6	24.7	37.6	113	51	49	0	0	0

Age wks: AGE IN WEEKS; >24 weeks (adults with specific age not given).[1] Sore hock and intestinal coccidiosis, [2]Sarcoptic scabiei, [3]Emaciation and intestinal cocidiosis, [4]Pneumonia. References values source (Fraser *et al.,* 1991).

Appendix 16: Hematology parameters for sampled rabbits and the reference values

		WBC	PCV	RBC	Hb	MCV	MCH	MCHC	THROM.	Differential leukocyte counts				
		$10^3/\mu L$	%	$10^6/\mu L$	g/dL	f L	pg	%	$10^3/\mu L$	Neut. %	Lymph %	Mono. %	Eosin. %	Baso %
Reference values		**5–12.5**	**33–50**	**5–8**	**10–17**	**58–67**	**17–24**	**29–37**	**250–650**	**20–75**	**30–85**	**1–4**	**1–4**	**1–7**
Rabbit ID	**Age wks**													
MF1	>24	6.18	28.2	4.65	11.2	60.8	24.0	39.7	514	42	58	0	0	0
MF2[1]	20	3.94	31.1	5.13	11.8	60.8	22.4	36.9	118	Low	70	0	0	0
MF2b	13.5	9.8	31.6	4.75	12.3	66.7	25.8	38.9	199	34	66	0	0	0
MF3	>24	4.33	33.3	5.35	12.3	62.3	22.9	36.9	284	36	63	0	1	0
MF4	16	5.27	31.7	4.95	12.0	64.1	24.2	37.8	154	59	41	0	0	0
MF5	5	11.31	30.4	4.59	12.0	66.3	26.1	39.4	1004	59	47	0	1	0
MF5B[2]	72	14.66	31.9	4.89	12.7	65.3	25.9	39.8	183	61	39	0	0	0
MF6	16	5.88	29.8	4.99	11.4	59.8	22.8	38.2	107	53	47	0	0	0
MFIb	10	5.07	28.5	4.54	11.2	62.8	24.6	39.2	112	24	76	0	0	0
NF1	5	3.74	31.8	4.76	12.5	66.9	26.2	39.3	218	33	65	0	2	0
NF2[4]	8	14.38	28.9	4.53	11.5	63.9	23.3	39.7	201	48	48	0	4	0
NF3	15	4.72	28.4	4.58	13.3	63.9	26.3	41.4	102	60	40	0	0	0
NF4	4	-	-	-	-	-	-	-	-	47	48	0	4	1
NF5	8	8.94	28.9	5.67	14.8	69.1	26.1	37.8	138	19	79	0	4	0
NF6	8	-	-	-	-	-	-	-	-	60	40	0	0	-
NF7	50	10.14	35.5	5.57	14.7	63.9	26.3	41.4	102	22	78	0	0	0
NFIB	10	5.35	32.2	5.55	12.2	58.1	21.9	37.8	114	47	51	0	2	0
NGF2	38	18.53	37.7	6.21	15.8	60.8	25.4	41.9	183	68	32	0	0	0
NGF3	>24	23.92	10.7	7.1	16.4	60.7	24.4	40.8	83	54	44	0	2	0
NGF4[3]	4.5	15.38	59.9	8.89	23.0	67.4	25.8	38.3	418	51	49	0	0	0
NGF7	42	8.5	33.3	5.42	13.1	61.6	24.1	39.3	134	64	34	0	2	0

Age wks: AGE IN WEEKS; >24 weeks (adults with specific age not given). [1]Subcutaneous abscess and emaciation.[2]Hepatic coccidiosis and pneumonia, [3]Intestinal coccidosis, [4]Ear canker with head tilting, **- :** Blood hemolysed. References values source (Fraser *et al.,* 1991)

Appendix 17: Hematology parameters for sampled rabbits and the reference values

		WBC	PCV	RBC	Hb	MCV	MCH pg	MCHC %	THROM. 10^3/µL	Differential leukocyte counts				
Reference values		10^3/µL	%	10^6/µL	g/dL	f L				Neut. %	Lymph %	Mono. %	Eosin. %	Baso%
		5–12.5	**33–50**	**5–8**	**10–17**	**58–67**	**17–24**	**29–37**	**250-650**	**20–75**	**30–85**	**1–4**	**1–4**	**1–7**
Rabbit ID	Age wks													
NGF8	4	7.07	38.9	5.66	14.7	68.8	25.9	37.7	157	29	70	0	1	0
NGFI	17	10.96	35.1	5.84	14.5	60.2	24.8	41.3	142	45	53	0	2	0
NKF10	5	9.34	40.3	6.30	12.8	64.0	20.3	31.7	4392	35	62	0	3	0
NKF11	5	-	-	-	-	-	-	-	-	45	52	0	2	1
NKF2	34	6.79	27.9	4.17	10.7	67.1	25.6	38.3	794	38	61	0	1	0
NKF3	19	7.25	42.2	7.11	12.2	66.5	15.7	23.7	3694	32	68	0	0	0
NKF4	31	13.97	34.4	4.82	10.7	71.1	21.5	30.2	312	33	66	0	1	0
NKF6	4.5	11.31	57.5	8.58	12.4	67.1	14.4	21.5	3684	27	73	0	0	0
NkF7	8	9.34	40.3	6.30	12.8	64.0	20.3	31.7	4392	35	62	0	3	0
NKF8	>24	9.91	38.5	5.11	13.3	75.4	26.0	34.5	538	59	41	0	0	0
NKF9	16	-	-	-	-	-	-	-	-	46	53	1	0	0
TF1	20	11.4	38.6	6.29	15.69	62.0	24.9	40.1	256	65	35	0	0	0
TF2	10	15.64	51.7	8.13	20.3	63.7	25.0	39.2	382	33	63	0	4	0
TF3	26	9.3	35.9	5.34	13.49	67.4	25.3	37.5	652	68	32	0	0	0
TF4	16	10.64	40.4	5.98	14.5	67.6	24.2	38.5	261	38	62	0	0	0
TF5	28	10.41	31.49	4.98	12.69	63.2	25.5	40.1	1907	56	44	0	0	0
TF7	20	8.09	28.8	4.5	12.5	63.3	27.8	43.4	87	36	64	0	0	0
TF7B	97	7.49	29.2	4.3	12.5	66.7	29.1	42.8	290	44	55	1	0	0
TF8	18	6.99	34.2	5.18	14.0	66.2	27.0	40.9	67	57	41	0	2	0
TF8B	18	12.13	36.2	6.10	15.1	59.4	24.7	41.7	496	62	38	0	0	0
VF1	5.5	7.2	33.1	4.89	9.2	67.7	18.8	27.8	525	32	66	0	2	0

Age wks: AGE IN WEEKS; >24 weeks (adults with specific age not given), **- :** Blood hemolysed. References values source (Fraser *et al.,* 1991)