PRODUCTION CHARACTERISTICS AND CONSTRAINTS OF RABBIT FARMING IN CENTRAL, NAIROBI AND RIFT VALLEY PROVINCES, KENYA

A thesis submitted in partial fulfilment of the requirements for Master 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 has not been presented for a degree in any other University.

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This work is dedicated to all who work tirelessly to improve the welfare of animals.

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LIST OF ABBREVIATIONS

MOLD- Ministry of Livestock Development

USDA- United States Department of Agriculture

NALEP- National Agriculture and Livestock Extension Program

4K- Kuungana, Kufanya Kusaidia Kenya

RBC- Red Blood Cells

WBC- White Blood Cells

PCV- Packed Cell Volume

Hb- Haemoglobin

MCV- Mean Corpuscular Volume

MCH- Mean Corpuscular Haemoglobin

MCHC- Mean Corpuscular Haemoglobin Concentration

µm- micrometer

EDTA- Ethylenediaminetetraacetic Acid

CBC- Complete Blood Count

OPG- Oocysts per gram of faeces

EPG- Eggs per gram of faeces

H & E- Haematoxylin and Eosin stain

PAS- Periodic Acid Schiff

ABSTRACT

Rabbit farming is a recognized enterprise in Kenya for livelihood support, hunger and poverty alleviation. This study provides information on Production Characteristics and Constraints of Rabbit Farming in Kenya. The field work was carried out in parts of Central, Nairobi and Rift Valley Provinces, Kenya. The research aimed to specifically i) determine the production characteristics and constraints of rabbit farming in Central, Rift Valley and Nairobi provinces in Kenya ii) To estimate baseline haematology values of rabbits from Central, Nairobi and Rift Valley Provinces in Kenya and to determine the prevalence and pathology of diseases in rabbits from Central, Nairobi and Rift Valley provinces Kenya.

The collection of data was done using questionnaire and observation sheet and secondary data which were collected from the Department of Veterinary Pathology, Microbiology and Parasitology on pathology cases as well as samples collected from live and dead rabbits. The study revealed that rabbit farmers in Central, Nairobi and Rift Valley provinces practice small scale farming largely due to small land space. Forty four percent (44%) of farmers were aged 50 years and above. A large proportion of farmers (51%) had kept rabbits between 1 and 5 years, indicating a sustained interest in rabbit farming. The most common breeds of rabbits kept were New Zealand white (73%), Californian (60%) and their cross breeds (51%) which were all suitable for meat production. This study revealed that farmers have limited access to technical information in rabbit farming and this was seen in the poor design and construction of the rabbit hutches. Majority of farmers (64%) bought their breeding stock from other farmers, with only a

small proportion buying from breeding centres (17%). This practice of buying replacement stock among farmers was likely to lead to inbreeding. The major constraints of rabbit farming are those dealing with production; disease (83%), predators like rats (29%), death of rabbits (69%) and unavailability of rabbit feed (19%). Various intervention measures aimed at supporting rabbit farming are required.

The haematology of the rabbits ranged within the normal values in most parameters. The WBC count in male rabbits however, 17.8 x 10^3 / µl, was significantly higher ($P>0.05$) than in female rabbits in the study (6.67 x 10^3 / µl) and ranged outside the values reported for rabbits. This was indicative of an underlying disease or age factor of the rabbits. The eosinophil counts were exaggerated in both male and female rabbits (0-23 in males and 0-19 in females) and this was suggestive of a chronic parasitism of which coccidia were suspected. Coccidia were the most prevalent parasite infection in this study and were observed in 72% of the farms examined. Low numbers of Strongyle nematode eggs were observed in 2.4% of farms and this was indicative of low prevalence of this infection. *Psoroptes cuniculi* and *Sarcoptes scabiei* were the most common external parasites observed, *Ctenocephalides canis* and *Echidnophaga gallinacea* were only observed in 2 rabbits in the study. Post-mortem and histopatholgy findings showed a high incidence of disease and death caused by gastrointestinal conditions (49%) and respiratory infections (12%). Enteritis was confirmed in 29 cases (31%), intestinal coccidiosis in 10 (11%) and hepatic coccidiosis in 1 case (1%). Aflatoxicosis (3%) and ear canker (2%) were some pathological conditions recorded. Research and training on rabbit diseases, feeds, marketing and rabbit housing is needed to support the growth of this industry in Kenya.

CHAPTER ONE

1.0 INTRODUCTION AND OBJECTIVES

1.1 Introduction

The domestic rabbit is raised mainly for meat (Payne and Wilson, 1999) and provides useful skins, manure and wool from some breeds (Owen et al.,1977). In many developing countries, rabbit production has remained in the hands of children and micro-scale producers, but the rabbit is now recognised potentially as an important industry in the developing world (Karikari and Asare, 2009). Rabbit farming has been practiced for many years, in Europe and the United States of America (USA), (Owen et al.,1977) while in Kenya as in other developing countries, it is steadily growing from a hobby to a commercial enterprise in the rural and urban areas (Ministry of Livestock, Annual Report 2005).

This industry is favoured due to the rabbit's small body size, high rate of reproduction, adaptability to inexpensive housing and useful by-products (Owen et al., 1977). There are successful rabbit farms in the tropics and sub-tropics and the size of these varies from the large commercial rabbitries to small backyard rabbitries (Owen et al.,1977). Farming enterprises are classified as ultra-smallholder (less than two breeding does per unit), smallholder units (more than two does but less than ten does), and medium units (more than 10 but less than 50 does) and large holder rabbit units (more than 50 does) (Oseni et al., 2008).

The past situation in Kenya is that, compared to other livestock sub-sectors, there were fewer adult farmers interested in rabbit production and consumption, but the situation is changing. The dominant players being the youth, self help groups and farmers near tourist hotels in towns such as Mombasa and Nairobi where there is ready market (Ministry of Livestock, Annual Report 2003). As in all facets of agriculture, the profits from rabbit farming depend a great deal on management and market opportunities. If an area has a steady demand for rabbit meat and a stable processor, the rabbit farmer can net a reasonable profit and add to the family income (Patton *et al.*, 2008).

Even with the increasing interest, the industry is faced with several challenges. One of the most devastating and discouraging constraints to rabbit production is disease. The success or failure of a rabbit production program depends mainly on the ability of the farmer to control diseases through proper management (Cheeke *et al*, 1987), which includes proper feeding, housing, space and regular sanitation of the rabbit housing (Patton *et al.*, 2008). Poor husbandry practices influence the occurrence and outcome of disease in a rabbit colony. The rabbit diseases include enteritis and; pasteurellosis and pneumonia. Enteritis is a complex of several diseases which cause diarrhoea, dehydration and death of young rabbits. One of the most common causes of enteritis in rabbitries is coccidiosis. Endoparasites and ectoparasites also contribute to retarded growth of rabbits but rarely cause death. Rabbit production is also limited by inadequate availability of parent breeding stock, high cost of commercial feeds and limited access by farmers to technical information (Ministry of Livestock Development Sessional Paper 2, 2008).

1.2 OBJECTIVES:

1.2.1 *General objectives*

To determine the characteristics of the rabbit production system and common infections and other production constraints on rabbit farms in Nairobi and its environs.

1.2.2 *Specific objectives*

1. To determine the production characteristics and constraints of rabbit farming in Central, Rift Valley and Nairobi provinces in Kenya.

2. To estimate baseline haematology values of rabbits from Central, Rift Valley and Nairobi Provinces in Kenya.

3. To determine the prevalence and pathology of diseases in rabbits from Central, Rift Valley and Nairobi provinces in Kenya.

1.3 JUSTIFICATION

Studies based on disease and production systems in domestic rabbits in Kenya are few due to emphasis on larger livestock in the animal heath and production sector. Consequently, there are limited focused studies on rabbit production and diseases and therefore capacity to handle diseases of rabbits and other emerging food animals is inadequate (Ministry of Livestock Sessional paper 2, 2008).

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

The term micro-livestock refers to smaller breeds of domesticated livestock (National Research Council, 1991) such as the rabbit. This is an important sub-system in regions where there is scarcity of land, low income earning communities and women and children in particular, who may lack adequate resources to start income generating and nutrition supporting enterprises (Payne and Wilson, 1999). Micro-livestock are affordable, easy to maintain, have a low financial risk and rapid returns, they also provide a steady source of income and food security. Their small size and efficient use of space, low capital needs for housing, use of non conventional feeds, easy management and production of numerous by-products, make them beneficial to this system (Payne and Wilson, 1999).

2.2 THE DOMESTIC RABBIT

The domestic rabbit is an important source of meat for human consumption throughout the world and its meat is very rich in protein and low in fat and calories per gram, which make it a "health meat". Rabbit production is a significant agricultural enterprise in the USA and is also relatively important in several European countries such as France, Spain and Italy (Cheek *et al.*, 1987). At present, China ranks first in the world in rabbit hair and meat export (since 1979, rabbit hair export of China has accounted for about 90%), and 4,065 tons of rabbit fur and 32,998 tons of rabbit meat were exported in 2001 (Hanping *et. al.*, 2003). Several African countries - among them Ghana, Kenya, Malawi, Mauritius, Mozambique, Nigeria, Sudan, Tanzania, Togo and Zambia have national rabbit-raising programs (National Research Council, 1991).

Rabbit farming has advantages compared to that of other livestock because of the rabbit's small body size, high rate of reproduction, adaptability to inexpensive housing and useful by-products (Owen *et al.*, 1977). In the medical field, rabbits are used routinely in research work and it is also important for teaching purposes in anatomy and physiology, its by products including blood, plasma cells, complement liver and brain powder are used for laboratory purposes (Adams, 1976).

Inadequate food production is a critical problem throughout Africa and rabbit farming could make a significant contribution to human welfare in an area with inadequate food production (Karikari and Asare, 2009). In Kenya, the estimated rabbit population in 2005 was 472,100 and 13,400 of these constituting 2.8% of the country total were in Nairobi Province (Ministry of Livestock Annual Report, 2005) which shows that it is still a new enterprise. Surprisingly, the national livestock data in Kenya Census 2009 did not include rabbits. Livestock play important roles in Kenya's socio-economic development and contribute towards household food and nutritional security particularly among pastoralists and vulnerable members of the society such as women and children (Ministry of Livestock Sessional paper 2, 2008).

The stakeholders in the sector recognize the role that a vibrant livestock industry can contribute to reverse the poverty levels and the nation's economic growth. Like in many developing countries, Kenya is faced with a number of development challenges, including high levels of unemployment (particularly among the youth); climate change; increasing population; unfavourable terms of

trade; high cost of inputs; limited value addition and declining agricultural earnings (Ministry of Livestock Development Sessional paper 2, 2008).

In Kenya, as in many countries, commercial rabbit production is increasing and involves the use of large numbers of rabbits of improved breeds and strains, scientifically balanced and pelleted feeds, and strictly controlled environmental conditions. However, rabbit production on a small scale is still important in many countries (Owen *et al.*, 1977). Smallholder livestock productivity in Africa can be increased significantly given the growing demand for livestock products (Sere, 2004) and this calls for expansion and higher efficiency in the production of rabbits in many developing countries. There is also the need to move from self-sufficiency of meat consumption to cash income as the motive for production, if the expansion drive is to succeed. This is because a rabbit production program aimed at self-sufficient meat consumption may not be sustained as farmers are more interested in cash income than improving their nutritional status (Karikari and Asare, 2009).

2.3 BREEDS, DISTRIBUTION AND USES OF RABBITS

Rabbits belong to several genera in the sub-families Leporinae and Palaeloginae of the family Lepidae in the order Lagomorpha, super order Glives. Rabbits occur throughout the world and the true rabbit, *Oryctolagus cuniculus*, comprises several subspecies that were originally native to southwest Europe and North Africa (Payne and Wilson, 1999); with domestication came the development of different breeds and varieties (colours) (Meredith and Jepson, 2001).

O. cuniculus is prolific and adaptable, most of the fancy breeds were developed within the past 100 years, and only since the early 1900's have rabbits been raised domestically in the USA. In Kenya, rabbits were introduced by missionaries in the 19th Century (Ministry of Livestock Development Sessional Paper 2, 2008). Over the years, the breeds have been improved from the long, rangy, low meat yield type to the compact, blocky animal of today (Patton *et al.*, 2008).

The main meat species in China are the New Zealand White rabbit, Californian rabbit, Japanese white rabbit, Chinchilla rabbit, Belgian hare, checkered giant rabbit, lop-ear rabbit among others. Commercial rabbitries in the United States use white (albino) New Zealand rabbits, California rabbits or high-breed crosses of the two breeds for meat (United States Department of Agriculture, 2002), while some of the important breeds of meat rabbits in the Himalayan region are New Zealand White, White Giant, Gray Giant, Soviet Chinchilla (Jithendran, 2009). The common rabbit breeds in Kenya are New Zealand White, Californian White, Flemish giant, French Ear lop, Chinchilla, Angora, Kenya White and their crosses (Rudesat, 2009).

Rabbit skins can be used for several purposes (mats, rugs and clothes) while the manure is a valuable organic fertilizer for use in vegetable gardens (Schiere, 2004), its urine contains a lot of ammonia and uric acid which when applied on crops acts as a fungicide (Organic Farmer, 2007). Various breeds of rabbits are useful models in biomedical research (embryology, toxicology, virology, etc.), and are also widely used in safety testing (Kozma *et al.*, 1974). For commercial purposes, the most important differences between rabbits are their size, breeding ability and suitability to the climate. Utility breeds are producers of meat, either by a fast growth rate (needs good feeding) or large and frequent litters.

The breed categories can be classified as follows:

1. Light breeds (up to 2-3 kg adult weight)

2. Medium breeds (3-5 kg)

3. Heavy breeds (more than 5 kg) (Schiere, 2004)

For commercial meat production in Kenya, the New Zealand White (NZW) is the principal breed. They are large rabbits, with meaty haunches and wide, deep shoulders (Ministry of Livestock Development Sessional paper 2, 2008). It has a number of desirable traits including a rapid growth rate, good carcass quality, good prolificacy, and good mothering ability and in general possesses all the characteristics desirable for a meat producing animal (Cheeke et al, 1987). An adult buck weighs 4-5 kg, and an adult doe weighs 4.5-5.5 kg and have white fur (Ministry of Livestock Development Sessional paper 2, 2008).

Californian white is another major meat breed which is lighter than New Zealand, they are fairly large rabbits used often in the production of meat and are well fleshed on the back and haunches. An adult Californian rabbit weighs 3.6-4.8 kg. This breed has a white body with black markings on the nose, ears, feet and tail. Flemish Giants is also a very large rabbit which is used for meat production; it has very wide backs and weighs 5-6.5 kg.

Flemish Giant has potential as a sire breed in commercial meat production, the purebred giant does not have adequate reproductive performance for commercial production, and its large size results in high maintenance feed requirements. The high growth rate potential of the giant breeds may be exploited through cross breeding (Cheek et al, 1987). It comes in a variety of seven different colours, black, blue, fawn, light gray, sandy, steel gray and white.

The Checkered Giant breed may reach weight of over 5 kg, it is white with black or blue markings (along spine, body spots, cheek spots, coloured ears, eye circles and butterfly mark on nose) and have a long, hare-like body. Chinchilla has brown to grey fur, upstanding ears and brown eyes. The buck and doe attain maximum weight of 6-7 kg in 5 months; the meat yield is 4-5kg. The chinchilla is also produced for its fur and is also popular as an exhibition breed with excellent meat qualities (Rudesat, 2009). French Lop is a cross between English Lop and Flemish Giants. It has a heavy build and massive thickset appearance and weighs 4.5kg and above. The French Lop has a dense, soft coat that comes in two color varieties: solid and broken, and within these categories can be found a number of different rabbit colours, including agouti, black, broken marked, chinchilla and sooty-fawn.

2.4 HAEMATOLOGY OF THE RABBIT

Rabbits display differences in haematological parameters which have been published by various authors. These differences are due to the analytical techniques applied in different laboratories (Milas *et al.*, 2009). It is important to compare the blood parameters in male and female rabbits in different farming systems because this can help identify conditions of stress which can be due to environmental issues, nutritional and physical status of the rabbit (Archetti *et al.*, 2008). Low PCV and Hb values are due to anaemia and differences in leukocytes may indicate the host's reaction to infection, however unlike for other animals, rabbits do not usually develop a leukocytosis in bacterial infection; eosinophilia may be occur in chronic parasitism (Lester *et al.*, 2005). An important feature of rabbit diseases is an altered ratio of heterophils to lymphocytes (Milas *et al.*, 2009).

The rabbit erythrocyte is a biconcave disk whose average diameter ranges from 6.7 and 6.9 μm with the average thickness of 2.15 to 2.4 μm, there is marked anisocytosis of the erythrocytes of rabbits, polychromasia has also been observed as a normal finding in contrast to other mammals (Moore, 2006); reticulocytes are 2-5 % and the life span of the erythrocyte ranges between 45 to 70 days, with an average of 57 days. The range in RBC counts documented for males is 4.08 $x10^6$/μl-7.46 $x10^6$/μl whereas in females is 4.89 $x10^6$/μl -7.11 $x10^6$/μl (AML, 1999, Milas *et al.*, 2009).

Erythrocyte numbers and haemoglobin concentrations are slightly higher in male rabbits than in females (Moore, 2006). Rabbit platelets appear as small clusters of azurophilic granules surrounded by a pale blue cytoplasm. Heterophils are the counterpart of the neutrophil and measure 9 – 15 μm in diameter and possess distinct acidophilic cytoplasmic granules.

2.5 RABBIT PRODUCTION

Rabbit production is both a commercial enterprise and a hobby in many countries, being more of the former in Kenya. In commercial production, rabbits are used for meat, as pets and for laboratory purposes; whereas as a hobby, the rabbits are raised for the shows, home consumption, pet sales or as youth educational programs (USDA, 2002) for example in the 4K club in Kenya. In recent years in China, there are fixed processing enterprises for rabbit meat and fur, to produce semi-finished or finished products. In major rabbit farming areas of China, rabbit fur markets and meat fairs have been set up as the main market outlets for rabbit products and windows to provide information on markets, as well as link the farmers with the markets (Hanping *et. al.*, 2003).

The major world exporters of rabbit products include: France, Hungary, the Netherlands and Spain, which exported large quantities of rabbit meat in 2000 (USDA, 2002). In the U.S.A meat rabbits are sold live to processing plants who market them to retail groceries and restaurants, rabbit meat is also consumed in small quantities in India and wool production is also thriving (Jithendran, 2009).

In Africa, Nigeria, Uganda and other developing countries have adopted rabbit farming to meet the protein demands of growing populations (Mailafia *et al.*, 2010). The success situation in India, USA and Europe and other countries should be the benchmark for Kenya's rabbit industry by adopting strategies in place to address the current lack of information on rabbit farming enterprise.

2.5.1 Husbandry

Suitable environmental conditions, management, hygiene and adequate nutrition and feeding are vital in rabbit (Demeterova *et al.*, 1991). The term "environment" includes every factor that influences a rabbit's life. Some of these factors are the hutch size and location, proximity to other animals, moisture content, temperature, ventilation, amount of light, shelter design, availability of water, and general management. The backyard rabbitry is rabbit keeping on a small, family scale, a few does and one or two bucks are kept in a rabbitry just next to the house. The rabbits are fed on greens, weeds and vegetable kitchen waste. In order to obtain a good profit, farmers must consider sources and prices of rabbit feed, management techniques and markets (Huish, 2005).

2.5.2 Housing

The following considerations should be taken in housing:

Space: Sufficient room is important in rabbit house otherwise stress, fighting and injury will result. The standard requirement for does and bucks is 30 x 24 x 18 inches or 24 x 24 x 18 inches depending on the size or breed of rabbit. (Lukefahr *et al.*, 1995)

Suitable temperature: The temperature range in a rabbit is 10-20°c. Rabbits tolerate cold more easily than heat. However they may suffer from cold draughts or sudden changes in temperature. The hutch should be constructed to protect the rabbits from extremes of both heat and cold.

Ventilation: Movement of fresh air, which must be free from smoke and dust through the rabbitry, is essential, especially in hot weather. The hutches must also be rainproof.

Security: Rabbits are easily frightened by sudden noises and the presence of predators such as snakes, rats, dogs and cats can cause a considerable amount of stress. A rabbitry should be built in a quiet place and if necessary a fence should be built to keep predators away from the rabbits.

Cleanliness and hygiene: Disease is much more likely to occur under dirty conditions where there is risk of multiplication of bacteria and other parasites like worms and mites.

Food and water: regular feeding and plenty supply of clean water is necessary for rabbits to thrive. In the absence of these, even for short periods, they may suffer stress (Huish, 2005).

Breeding rabbits are kept in intensive husbandry systems, mainly in cages with wire nets or slated floors. The housing of rabbits and especially reproducing does is related to behavioural, hygienic, environmental and welfare considerations (Hoy and Verga, 2006). The main welfare indicators for rabbits are mortality, morbidity, physiology, behaviour and performance. Zero or low mortality is the most important welfare criteria, morbidity rate includes infectious diseases and injuries. The expression of abnormal behaviour may indicate the existence of problems (Schaeffer *et al.*, 2008).

Many different types of hutches can be used, however, all metal cages help prevent unsanitary conditions that can precipitate disease problems. The cages should be made of 1-by-2-inch mesh for the sides and top and 0.5-by-1-inch mesh for the floor. Hanging the cages from the ceiling in single layers makes management easier for the producer (Meredith and Jepson, 2001). In the U.S., modern commercial rabbitries are generally designed with rows of single tiered wire bottomed cages attached to walls or hung from the ceiling. Multi-tiered systems can still be found, but innovations from Europe indicate that single-tiered systems are more efficient (USDA, 2002). In a study by Oseni *et al* (2008) it was shown that single tiered caging system was used in most rabbit units due to low cost of construction and easy to design but was associated with farmers with smallholder farms. It should be noted that single tiered caging systems are more easier to manage because of the ease at which cleaning is done, therefore farmers with multiple tiered caging houses need to adhere to strict cleaning regimes (McNitt, 2009).

Mature bucks and does should have individual cages that are at least 30 inches wide, 30 inches deep and 20 inches high. Bedding must always be provided, in the form of a layer of newspaper or wood shavings (not sawdust) plus straw. A nest box should be placed in the hutch prior to kindling (birth) to provide seclusion for the doe and protection for the litter. Nest boxes should provide enough room for each doe and her litter but these should be small enough to keep the litter close together. Nest boxes can be made of non treated wood, wire mesh, or sheet metal. During cold weather, bedding such as straw or wood shavings is also recommended. The box should be enclosed except for a small opening on top for the doe to enter (Meredith and Jepson, 2001).

For the good welfare of rabbits the following considerations should be taken into account; no pain, suffering or injuries should be caused by floor, walls or equipment. There should be protection against predators and adverse climatic conditions, rabbits should be provided with food and water, regular sanitation of rabbit housing, careful handling of animals and enrich the housing system by providing platforms for exercise (Hoy and Verga, 2006).

2.5.3 Feeding

Rabbits are herbivores and hind-gut fermenters. Hindgut fermentation is a mode of digestion similar to rumination where bacteria actively ferment digested food and this occurs in the caecum and colon. The basic requirements of feed for rabbits include protein, fat, fibre, minerals, vitamins and water in varying portions according to their age or if they are pregnant or lactating (Hagen, 1974). However, unlike other hind-gut fermenters, the rabbit has a very rapid gut transit time and eliminates fibre from the digestive tract as soon as possible (Meredith and Jepson, 2001). The process of caecotrophy (re-ingestion of faeces) allows absorption of nutrients and bacterial fermentation products (amino acids, volatile fatty acids and vitamins B and K), and the re-digestion of previously undigested food (Meredith and Jepson, 2001).

Table 2.1 Composition of faeces and caecotrophs

	Dry matter	Crude protein	Crude fibre
Faeces	53%	15%	30%
Caecotrophs	39%	34%	18%

(Meredith and Jepson, 2001)

Correct feeding management that takes into account the stage of development of the rabbit gastro-intestinal tract will maximize rabbit meat production. A balanced diet that contains adequate fibre (20 to 25%), minimal starch, and optimum protein concentration is important for preventing gastrointestinal distress in rabbits. If allowed to consume a diet *ad libitum*, rabbits will daily eat an amount that approximates 5% of their body weight in dry matter and drink about 10% of their body weight in water (Irlbeck, 2001).

The best diet for a rabbit is grass and good quality grass hay with a small amount of a good quality high fibre content (18 to 24%), and commercial diet with protein levels around 15%. Alfalfa hay can be given, especially to growing animals, but care should be taken since alfalfa is high in calcium which if fed in large amounts in diet could predispose to urolithiasis, a condition which causes formation of calculi in the urinary tract. Fresh vegetables and small amounts of fruit can also be provided, but fruits that are high in simple sugars should be avoided (Meredith and Jepson, 2001).

Commercial rabbit mixes that consist of pulses, grains, grass pellets and biscuits should not be fed *ad libitum*, because they lead to selective feeding and obesity in the rabbit. A rabbit in good condition should have palpable ribs and vertebrae. The Hay is important in maintaining gastrointestinal and dental health of rabbits. Carrots or other root vegetables should be suspended from the cage roof to act as an edible toy and increase the time spent in eating. More importantly, sudden changes in diet should be avoided (Meredith and Jepson, 2001). Water bottles can be attached to the outside of the mesh front, while ceramic or metal feeding bowls can be placed on the floor of the hutch because they are hygienic and will not be gnawed at. Hay can be fed loose or dispensed from a rack or net (Meredith and Jepson, 2001).

2.5.4 Breeding

The domestic rabbit, *Oryctolagus cuniculus*, is noted for its high reproductive capacity, the doe is able to produce 25-50 live kits a year (Karikari and Asare, 2009). Onset of puberty depends on breed and nutrition of the rabbit (well fed rabbits mature faster than poorly fed ones) (Huish, 2005), but maturity is achieved at approximately 4-5 months in the female and 5-8 months in the male. Does tend to be more territorial than bucks and so the doe should be taken to the buck or to neutral territory for breeding, to avoid aggression (Meredith and Jepson, 2001). Does can be re-bred immediately after giving birth but this practice requires a high level of expertise and a well managed feeding program (USDA, 2002).

Rabbits are induced (reflex) ovulators and thus there is no definitive oestrous cycle. Periods of receptivity usually occur for 12-14 days and sexually mature bucks will mate at any time. Pregnancy can be detected by palpation two weeks after a successful mating. Normal gestation is 30 - 32 days, and litter size varies usually between 4 and 12 kits, with the larger breeds producing larger litters (Meredith and Jepson, 2001). An extensive approach is more commonly practiced in which does are rebred 14 to 28 days after the birth of the previous litter. Large litter sizes (8 plus) are desired in the commercial rabbitry, but excessive litter sizes (11 or more) are not manageable for does. The frequency of mating depends on whether it is a commercial rabbitry or backyard, where the latter targets 4 litters a year as opposed to commercial which targets 5-6 litters a year from one doe (Huish, 2005). One male can handle up to 10 or more does but this depends on the intensity of farming, 2 males can be used to prevent inbreeding, also breeding in turns can allow a farmer to detect infertility in a male (Schiere, 2004).

Fostering, the transferring of kits from one doe to another nursing doe, can be used to keep litter sizes manageable (USDA, 2002). A nest box is necessary for new born kits, a common size is 18 x 12 x 12 inches with one low side of 6 inches. Prior to kindling, the doe lines the straw filled box with fur pulled from her belly, dewlap and flanks. The kits remain in the nest box until they can survive without the body heat provided by their nest mates (15 days) and the nest box is usually removed by 21 days. Mortality can be up to 40 percent when the kits are in the pre-weaning stage. Once the kits are weaned, they are moved to grow-out cages where they are fed to market weight (USDA, 2002). The kits are weaned at eight weeks of age.

2.5.5 Sanitation

A constant sanitation program is important for prevention of diseases. Cleanliness is required to maintain a safe environment in which animals can live and reproduce. Unfavourable environmental factors lower rabbit's resistance to disease and facilitate the spread of infection; of particular importance are hutch and shelter construction and maintenance (Patton *et al.*, 2008). The hutch should be easy to clean and allow for proper drainage for water runoff from the rabbitry area. Water should be fresh, clean, and protected from contamination by urine, faecal matter, and feeds, water containers should be cleaned thoroughly to prevent infection. Good feed utilization and waste removal are important in disease prevention, feed scattered about the rabbitry attracts insects, rats, and birds, which are all potential carriers of disease (Patton *et al.*, 2008).

2.5.6 Constraints

Over the years, there has been no organized market for rabbits in Kenya. Farmers have had to identify their own markets locally and make arrangements with local consumers, hotels or other farmers for disposal of mature rabbits (Ministry of livestock Development, 2005). Limited market for rabbit products is a major constraint in rabbit production. Rabbit production is also limited by disease, inadequate availability of parent breeding stock, high cost of commercial feeds and limited access by farmers to technical information (Ministry of Livestock Development Sessional Paper 2, 2008).

In a study done in Nigeria by Oseni *et* al., (2008), the constraints identified were access to foundation stock of rabbits, capital needed to start rabbit farming, space, feed, ants and rats, theft of the rabbits, marketing and labour requirements. In another study by Mailafia *et al* (2010), the main limitations to rabbit production in developing countries are vulnerability of the rabbits to heat stress and lack of managerial skills, elsewhere in Uganda, Lukefahr (1998) noted that the high cost of inputs in this type of farming and in turn inflated sale prices limit market demand and also many Ugandans discriminate rabbit meat due to its resemblance to rats. In a case study done in Vietnam by Nguyen (2008), the two main constraints identified were lack of market organisation and little access to new technology which led to lower reproductivity. In yet another study done in Togo, lack of materials for constructing the cages, poor selection of breeding rabbits, and poor nutrition (Kangni,1979) were identified as the main limitations to rabbit production.

2.6 DISEASE

Disease is defined as a morbid process that has a characteristic number of symptoms which can affect the whole body or parts of it. Disease producing agents are in the environment and depend on how the rabbit interacts with them. Microbial contamination refers to the pollution of air, objects and soil by bacteria, parasites, viruses or fungi. While some rabbits are more resistant to disease agents, the concentration of these disease causing agents also depend on how well the rabbit can overcome disease (Cheeke et al., 1987).

Recognition of diseases and signs of health: In any disease, the sick animal shows certain abnormalities; signs of health are just as important to appreciate as signs of disease. Diseased rabbit can express varied clinical signs that include death and loss of condition (Hunter, 1996). Some of the most important diseases do not cause dramatic clinical signs but affect the animals' general condition and reduce their productivity (Hunter, 1996). Generally, healthy animals have a sleek appearance to their coat and are well muscled, the rib and pelvic bones should not be prominent, but well rounded. The fur should be smooth and free of any lumps, loose scabs flakes and debris and their eyes should be clear. The nostrils should be bright and moist with no discharges. Domestic animals are accustomed to people and should have no fear of them; a lack of healthy curiosity, when an animal is approached may indicate that something is wrong.

Gait of the animal is also an important aspect when examining for fractures and lameness (Hunter, 1996). Respiration in healthy rabbits is silent and barely noticeable except after physical exertion. The consistency and colour of faeces of healthy rabbits depends on their diet. Diseases and death of rabbits leads to loss of high quality protein and other products from the rabbit (Dijkhuizen and Morris, 1997). This causes a loss on incomes and food security for households especially in developing countries.

Disease is a major factor limiting rabbit production in rabbit farms (Licois, 2006). Two syndromes are commonly recognized in diseased rabbits: **digestive syndrome** occurs more frequently in growing rabbits and **respiratory syndrome** is more common in adults. According to statistics in France, in 2005, 26% of rabbits analyzed for pathology had respiratory problems.

The clinical signs and lesions varied from nasal congestion and rhinitis to pneumonia. Pasteurellosis is the major bacterial disease of the respiratory system in rabbits. Other non-specific diseases occur as secondary infections of the upper respiratory tract and cause nasal congestion.

Digestive disorders are responsible for mortality and significant morbidity that is characterized by reduced growth and poor feed conversion, which causes greater commercial losses than mortality (Licois, 2006). The aetiology of some gastrointestinal problems is difficult to establish because the causes are multiple and symptoms, clinical signs and intestinal pathology is often comparable. Diarrhoea is largely dominant in gastrointestinal problems and may be encountered in more than 95% of cases (Licois, 2006).

2.6.1 Gastrointestinal Tract Diseases of Rabbits

Enteritis

"Enteritis" is a group name describing any diarrhoeal type of disease that kills rabbits, it has often been called "enteritis complex," because many different symptoms are observed, but the one unifying factor is death as the final result of the syndrome (Patton *et al.*, 2008). Enteritis can be caused by infectious agents and occasionally toxic factors.

2.6.1.1 Mucoid Enteropathy

Mucoid enteropathy (ME) is a condition in rabbits characterized by the presence of thick mucous in the colon. Rabbits are depressed, dehydrated and exhibit abdominal pain and distension, grinding of the teeth (a sign of pain), and perineal staining. The caecum is often impacted; both diarrhoea and constipation can occur in ME. The constipation is caused by a build-up of mucous that causes intestinal obstruction. Changes in the normal flora of the intestines, hyperacidity of the caecum are some factors that predispose rabbits to ME (Meredith and Jepson, 2001). Mucoid enteropathy is a major cause of disease and death in young rabbits. Management factors such as abrupt change in feed that disturb the normal gut flora have been associated with ME. Diagnosis is made histologically by demonstrating goblet cells consistent with excessive mucous production in the intestines (Wilber, 1999).

2.6.1.2 Enterotoxemia

Enterotoxemia is an explosive diarrhoeal disease of young rabbits 4–8 weeks of age, which often are observed to be normal one day and dead the next with or without evidence of diarrhoea. This acute death is caused by a deadly toxin produced by common bacteria, *Clostridium spiroforme*, *C. perfringens* and *C. difficille* being less common. Young rabbits die in 24–48 hours; occasionally adult and young breeders are affected, and they may live as long as 96 hours. Prolonged use of Penicillin in rabbits may also predispose them to the disease by altering the gut bacteria (Patton *et al.*, 2008).

The typical lesions of enterotoxaemia at necropsy are occurrence of a fluid filled intestine and presence of petechial haemorrhages in the caecum. The causative agent, *C. spiroforme*, can be isolated on blood agar. Diagnosis of this disease is accomplished by demonstrating the iota-like toxin in the intestinal contents or by staining and microscopic examination for the distinctive bacteria in centrifuged ceacal content. It has been shown that rabbits do not have this organism as part of their normal micro-flora; the type of diet provided has been suggested as a factor in the development of the disease. Diets high in fibre may reduce the incidence of this disease and addition of hay or straw to a low fibre diet is normally very beneficial (Patton *et al.*, 2008).

2.6.1.3 Collibacillosis

Escherichia coli is a major cause of enteritis in rabbitries. The organism is not normally present within the gastrointestinal tract of suckling and weanling rabbits. When a change occurs in intestinal pH (potential of Hydrogen), there is a rapid proliferation of the bacteria, factors that promote this growth include intestinal coccidiosis and diets that require high hydrochloric acid content for digestion. (Wilber, 1999)

The disease mainly affects 4-7 week old rabbits and it occurs just after weaning. It is characterized by severe diarrhoea associated with dehydration (Licois, 2006). This enteric disease is associated with colonization and proliferation of Enteropathogenic *E. coli* (EPEC) in distal ileum, caecum and proximal colon which appear distended with watery yellow to brown contents. The surviving rabbits show retarded growth and at necropsy, the caecal content appears entirely liquid and are sometimes hemorrhagic (Licois, 2006).

2.6.1.4 Coccidiosis

Two forms of coccidiosis in rabbits have been described, an intestinal form, and a hepatic form. Coccidiosis is caused by Eimeria species and commonly affects young rabbits. Hepatic coccidiosis is caused by *E. steidiae*. The most important species of intestinal coccidia are *Eimeria perforans, E. magna, E. media* and *E. irresidua* (Meredith and Jepson, 2001).

In a study conducted by Wesonga and Munda (1992) in Muguga Kenya, coccidiosis complicated by mucoid enteritis was reported in 55% of the laboratory rabbits examined. Coccidiosis is also one of the most commonly reported diseases by rabbit farmers. The disease which is a highly contagious infection in rabbits has a low prognosis of healing. Intestinal coccidiosis commonly affects young rabbits from the age of 6 weeks – 5 months and it is often attributable to stress, transport or immuno-suppression (Patton *et al.*, 2008). Rabbits become infected by ingesting faeces containing the coccidian oocyst and this can happen when the rabbit cleans its feet or fur that has been contaminated with the faeces of other infected rabbits (Meredith and Jepson, 2001). The sporulated oocysts are ingested and sporozoites are released which invade the enterocytes and multiply further by schizogony, depending on the species, one or more cycles take place and gametogony occurs and oocysts are formed and passed in the faeces (Wilber, 1999).

Clinical signs of intestinal coccidiosis differ with rabbits depending on their age and the species of the Eimeria involved. Clinical signs are more often seen in young rabbits due to their immature immune systems and include weight loss, severe diarrhoea which may contain mucous or blood, and dehydration. Rabbits with severe diarrhoea may develop a blockage of the intestines.

Deaths caused by coccidiosis are most often attributed to dehydration and secondary bacterial infections (Meredith and Jepson, 2001). Clinical diagnosis is achieved through examination of faecal preparations and histological examination (Pakes, 1974).

Hepatic Coccidiosis *Eimeria stiedae* is one of the most pathogenic coccidia protozoans in domestic rabbits causing severe infections and increased mortality. There is a strong relationship between the infection of coccidiosis and the host age (Ebtesam, 2008); weanlings are mostly affected as the older rabbits have developed immunity (Wilber, 1999). *Eimeria* oocysts are ovoid in shape and measure 30 to 40 by 16 to 25μm (Pakes, 1974). Transmission is by ingestion of sporulated oocysts (unsporulated in freshly voided faeces). *E. stiedae* exists in the duodenum, travels to the liver via the bloodstream or lymphatics, and invades epithelial cells of bile ducts to begin schizogeny. Signs in young rabbits include anorexia, debilitation and pendulous abdomen with hepatomegaly on abdominal palpation. Mortality is low except in young rabbits (Mendlowitz, 2002).

Diagnosis is by examination of faeces by direct smear, flotation or concentration methods. It can be difficult to identify *E. steidae* oocysts in faecal specimens since they may not be readily shed in the bile. Lesions include presence of an enlarged liver with multifocal flat, sometimes coalescent, yellow-white lesions that contain yellow exudate and occasionally a distended gallbladder is occasionally distended with bile. Microscopic lesions indicate marked periportal fibrosis surrounding enlarged bile ducts that are lined with hyperplastic inflamed bile duct epithelium. *E. stiedae* macrogametes, microgametocytes occur in the bile duct epithelium and oocysts are present in the lumen of the bile duct (Mendlowitz, 2002).

2.6.2 Respiratory Diseases of Rabbits

Respiratory diseases are second only to gastro enteric diseases in importance in rabbits. Pasteurellosis is the primary respiratory disease affecting domestic rabbits, but other bacteria such as *Bordetella bronchiseptica*, *Staphylococcus* spp., *Klebsiella*, *Streptococcus* spp., *E. coli*, *Salmonella* spp. and *Listeria* spp. are also significant opportunistic respiratory pathogens. The primary manifestations include upper respiratory diseases such as rhinitis, sinusitis, conjunctivitis, and dacryocystitis (Deeb and DiGiacomo, 2000).

2.6.2.1 Upper respiratory disease

Rabbits are obligate nasal breathers; any obstruction of the nasal cavity will result in respiratory compromise. Open-mouth breathing in a rabbit is a very poor prognostic sign. Diagnosis of upper respiratory tract disease in rabbits is based on clinical signs and physical examination, followed by laboratory testing and diagnostic imaging (Hoefer, 2001). *Pasteurella multocida* is one of the most common bacterial diseases in commercial rabbitries. The disease is mainly characterized by lesions and symptoms referable to the respiratory system and often pyogenic changes on other organs and occasionally septicaemia (Coudert *et al.*, 2006). Transmission occurs by direct contact with infected animals shedding the organism from nasal secretion (Wilber, 1999). The upper respiratory tract is regarded as the primary nidus of infection which then spreads to other tissues in the lower respiratory tract via aerogenous routes and the middle ear and external genital tract by venereal spread (Wilber, 1999).

Pasteurellosis is a major cause of economic concern in rabbit production and it is responsible for atleast 50% of the major causes of breeding doe culling; these bacteria affect other animals besides rabbits and can be transmitted from one animal species to another (Coudert *et. al.*, 2006). The symptomatology is not very different from that observed with other bacteria such as *Staphylococcus, Streptococcus* and *Bordetella* species. Pasteurellosis in rabbits can be characterised by snuffles or pneumonia as described below.

2.6.2.1.1 Rhinitis/ Snuffles

Pasteurella multocida is a gram-negative, coccobacillus that varies in serotypes and virulence (Hoefer, 2001), it causes snuffles in rabbits. The mucous membrane of the nasal cavities becomes infected by bacteria from inspired air or by direct contact with infected animals or contaminated objects. The first symptoms include occurrence of a clear, fluid nasal discharge and frequent sneezing. The rabbit often rubs its nose with its forepaws, the fur of which becomes matted and dirty (Lebas *et. al.*, 1997). Snuffles is clinically characterized by manifestations of nasal sounds and nasal discharge which may be serous to mucopurulent. The infection may spread to the lower respiratory passages due to invasiveness of the bacteria and susceptibility of the animal to disease. Stress resulting from extremes of temperature, high humidity, and high ammonia levels in the rabbit house, travel, pregnancy and lactation are primary factors that encourage development of this disease (Patton *et al.*, 2008).

2.6.2.2 Lower Respiratory Disease

2.6.2.2.1 Pneumonia

Surveys on causes of rabbit mortality have revealed that pneumonia occurs in 25 percent of the animals and it is the greatest single cause of death in mature animals (Patton *et al.*, 2008). In the study by Wesonga and Munda (1992), pneumonia was found in 23% of the groups of rabbits examined. When upper respiratory disease (snuffles) spreads to the lungs, it causes pneumonia. Commonly observed signs include, depression, laboured breathing, bluish eye colour in albino rabbits and nasal discharge and high body temperature (normal: 38.5 – 40 °C). Gross lesions of the lungs appear as red consolidated areas, sunken purple areas and abscesses. *Pasteurella multocida* is the worst and most common bacteria isolated from the respiratory system of a sick rabbit and all production units are often contaminated with it and it is poses a constant threat (Patton *et al.*, 2008).

Microscopically, the affected organs are infiltrated by inflammatory cells, mainly granulocytes, a few lymphocytes and plasmocytes (Coudert *et al.*, 2006). Tentative diagnosis of pasteurellosis is based on clinical signs and gross necropsy findings of a mucopurulent exudate associated with inflamed body parts such as the respiratory tract, subcutis, middle ears, and reproductive tract. A presumptive diagnosis may be reached by making a smear or scraping from the affected area and doing a gram stain. Definitive diagnosis requires isolation of the bacteria by culturing from the affected site (Mendlowitz, 2002).

The best control for pasteurellosis is good husbandry techniques and culling of rabbits with clinical disease. Since most rabbits carry *Pasteurella multocida* in the nasal cavity, good management measures should be implemented to control the clinical disease. The rabbitry should have good ventilation, low ammonia levels, and low humidity to decrease incidence of this disease (Mendlowitz, 2002).

2.6.2.2.2 Staphyloccocosis

Staphylococcus aureus is a Gram-positive, hemolytic, coagulase-positive coccus. It infects the skin and causes purulent small lesions that may be initiated by injuries from poor quality cage wire floors or by bites or scratches between animals (Vancraeynest *et al.*, 2006). Staphylococci live in the nasal passages of rabbits, and the close contact associated with kindling and nursing offers opportunities for both direct contact and aerosol transmission (Patton *et al.*, 2008). *S. aureus* causes septicaemic infections and abscesses in numerous organs including the subcutaneous tissue, lungs, kidneys, and heart.

The *Staphylococcus* organism may also cause bronchopneumonia. The affected lungs are consolidated, with numerous necrotic lesions. The bronchi and trachea may contain a mucopurulent exudate. Focal suppurative necrotizing lesions with colonies of cocci are seen at histology. Diagnosis is made by demonstrating gram positive cocci in the affected lesions. Other bacteria that may cause subcutaneous abscesses include; *Pseudomonas aeruginosa*, a gram-negative opportunistic pathogen that lives in aerobic and poor nutritional conditions and produces characteristic blue-green pus in the skin lesions or abscess.

The dewlap and the abdomen are the most affected sites and lesions are localized and diffuse, while the affected skin is erythematous and moist. This type of moist dermatitis is also caused by other bacteria including *Streptococcus* sp. Diagnosis of this condition is achieved by use of clinical signs and bacterial culture and sensitivity tests to identify the bacteria and the most efficient antibiotic for treatment, the bacterium has acquired resistance to many antibiotics (Praag, 2009).

2.6.3 Endoparasites and Ectoparasites

2.6.3.1 Pinworm

Passalurus ambiguus is a fairly common worm in rabbitries and affected animals are usually asymptomatic but occasionally diarrhoea occurs (Mendlowitz, 2002). They often are seen on the surface of freshly passed faeces or through the wall of the caecum as glistening white worms, when rabbits are slaughtered. Pinworms cause little harm to the affected. These parasites are spread from animal to animal by ingesting feed and water contaminated with droppings of infected animals. Management methods that are used to control coccidiosis are also effective on pinworm control (Patton *et al.*, 2008). Diagnosis is achieved by demonstration of eggs by faecal floatation and subsequent culture to identify larva (Wilber, 1999).

2.6.3.2 Tapeworms

Tapeworms occur in rabbits either as adults in the intestine (rabbit as definitive host) or as larval forms in the liver and abdominal cavity (rabbit as intermediate host). The adult forms are very rare in hutch raised rabbits, but larval forms occasionally are observed. The rabbit tapeworm *Cittotaenia variablis* is uncommon in domestic rabbits.

Rabbits harbouring a few tapeworms show no signs of the disease, when many tapeworms are present, diarrhoea and emaciation might occur. It is proposed that rabbits acquire the tapeworm by ingesting the intermediate stages in oribatid mites. The larval forms of tapeworm most often found are those of *Taenia pisiformis*. They are found in the abdominal cavity and in the liver.

Rabbits acquire these tapeworms by ingesting contaminated feed and water containing tapeworm segments and eggs from the faeces of dogs. They form small, fluid filled cysts (cysticerci), which may be attached to the membranes holding the intestinal tract or may exist free in the abdominal cavity. Each cyst contains an embryonic tapeworm that, when consumed by a dog, will develop into a mature tapeworm. The tapeworm can be controlled by excluding dogs from the rabbitry (Patton *et al.*, 2008).

2.6.3.3 *Psoroptes cuniculi* (Ear Mites)

These mites are the most common ecto-parasite infection in rabbits. Transmission is by direct contact; the mite spends its entire life span in the external ear and may survive off the host for up to 21 days. This mite is a non burrowing parasite that chews and pierces the epidermis of the external ear. Gross lesions appear as light brown, thick crusty foul smelling exudates within the external ear canal and pinnae. The skin beneath the crust is alopecic and erythematous and may lead to secondary bacterial infections. Mites are easily demonstrable on scraping the material (Wilber, 1999) using 10% Potassium hydroxide solution (KOH) to clear the crusty material and microscopically reveal mites.

2.6.3.4 Sarcoptic Mange

Sarcoptes scabei and *S. cuniculi* and *Notoedres cati* rarely occur and when present cause alopecia and dermatitis on the face, nose, lips, feet and external genitalia (Wilber, 1999).

2.6.3.5 Cheyletiellosis (Fur mites)

Cheyletiella parasitovorax is a small, noninvasive fur mite, with low incidence of infection. Clinical signs include presence of partial alopecia and erythematous skin foci. Pruritis may often occur. The mite is commonly referred to as "walking dandruff". Diagnosis is by examination of the pelt to reveal small white mites with their eggs attached to hair shafts and examination of skin scrapings for mites (Mendlowitz, 2002).

2.6.3.6 Fleas and Lice

Rabbits are commonly infested with the fleas *Ctenocephalides* spp., especially *C. felis* and rarely *C.canis*. The infestation may be asymptomatic and may cause a mild pruritis and alopecia. Rabbits can be dusted and sprayed with pyrethrin products and the environment treated to control this parasitism (Mendlowitz, 2002).

CHAPTER THREE: CHARACTERISTICS OF RABBIT PRODUCTION ON FARMS FROM CENTRAL, NAIROBI AND RIFT VALLEY PROVINCES IN KENYA

3.1 INTRODUCTION

Livestock production has enormous untapped potential that if optimally exploited should contribute to sufficient food security and wealth in Kenya. In Nigeria however, a study by Onifade (1999) concluded that there was little awareness of the productive potential of the rabbit and there was ignorance to eating rabbit meat. Nigeria has potential to sustain itself and therefore rabbits bring no competition to feed resources, so to promote rabbit production in the country, marketing strategies were put in place. In Africa, the major stakeholders in rabbit production include Ghana, Nigeria, Kenya, Togo, Zambia and others, studies in these countries have centred on the production aspects of the rabbits. The rabbit as a potential producer of meat in these countries has not been fully realised like in other parts of the world like the USA, China and other developed nations.

The characteristics of rabbit production in most parts of Africa are comparable; the producers experience almost the same climatic conditions as well as challenges. Various authors have described these characteristics some of which are; rabbit farming is a small scale industry in most rural parts of Africa where the main reason for keeping them is to sustain the family's protein needs, the main housing used is hutch and material mostly used is wood and bamboo which are readily available, the most common breeds kept are New Zealand white and Californian, the feeds given in most areas are kitchen waste, hay, grasses and legumes and pellets where readily

available, breeding of bucks and does is done at a ratio of 1:2 or 1:3 in smallholder units, mortality of kits is greater at smallholder level due to inexperience of farmers, litters produced are on average 5-8 kits. (Lukefahr, 1998, Onifade, 1999, Oseni *et al.*, 2008, Mailafia, 2010)

3.2 MATERIALS AND METHODS

3.2.1 Study Area

The questionnaire study was conducted with some rabbit farmers from Central, Nairobi and Rift Valley Provinces, Kenya.

Nairobi lies at an altitude of 1,670 meters above sea level and occupies an area of 696 km^2. Due to its proximity to the equator, Nairobi climate has wet and dry seasons. The livestock sector in Nairobi comprises of dairy cattle, pigs, poultry, sheep and goats, bees and rabbits. The latter are adaptable to backyard conditions prevalent in the urban setup of Nairobi (NEMA, 2010).

Central Province borders Rift valley to the West and Eastern Province to the East and Nairobi to the South. Majority of farmers in the province practice mixed farming dominated by small holder livestock producers. As a result the livestock production systems in the province are intensive and semi intensive depending on the type of livestock kept and objectives of production. The types of livestock kept in these counties include dairy cattle, poultry, dairy goats, meat goats and meat sheep, wool sheep, pigs, beekeeping, rabbits, emerging livestock and to some extent beef cattle (NEMA, 2010).

Nakuru and Kajiado in **Rift valley Province** border Nairobi city to the North and Tanzania to the South. These areas experience very little rainfall and have semi-arid type ecology (desert bush and desert scrub) which supports mainly pastoral livestock farming system. Parts of Kajiado have agro-pastoral farming practices (NEMA, 2010).

3.2.2 Data Collection

3.2.2.1 Questionnaire Data

Data collection was done through interviews with the farmers using a questionnaire (Appendix 1) and group discussions (where I attended monthly meetings with rabbit farmers' groups). Fifty eight percent (58%) of those who were chosen were members of rabbit associations while the rest closely networked with rabbit farmers. The interviews and questionnaires were analyzed to document the common rabbit production practices and systems, while the group discussions by farmers focused on marketing of rabbit meat and its by-products, government support and breeding.

The questionnaires were administered to 72 farmers who attended monthly rabbit farmers association meetings in areas of Central, Nairobi and Rift Valley. A minimum of 30 questionnaires were needed in this study and therefore farmers were chosen randomly from the group meetings and included in the study. In general, the aspects covered in the questionnaire included: farmers' age, gender, level of education and number of years involved in rabbit keeping, the production aspect involved breeds kept, reasons for keeping rabbits, rabbit housing, feeds, breeding, sale and acquisition of rabbits, constraints and diseases.

3.2.2.2 On Farm Observations

An observation sheet (Appendix 2) was used to collect information from the farms which included aspects on housing conditions such as cleanliness of the hutches, feeding methods and housing space. General health of the herd (signs of sickness) and body conditions, diet of rabbits, as well as cleanliness and type of feeding equipment and disease presence using clinical signs and general behaviour of rabbits (active or dull).

3.2.3 Data Management and Analysis

Data were entered into MS Excel for Windows 2003 and tables and figures were created Descriptive statistics (frequencies and means) were analyzed using Statistical Package for the Social Sciences (SPSS) Predictive Analytics Software (PASW) version 18.

3.3 RESULTS

3.3.1 Study Farms and Farmers Biodata

The distribution of the 72 farmers who were interviewed in this study is shown in Table 3.1. The highest number of farmers interviewed in this study were from former Central Province, the least represented was Nakuru. The highest range in number of rabbits kept was in Nyeri County where Thika region recorded large herds of rabbits. Nairobi also had farms that kept many rabbits though lower than in Thika; 119 rabbits were recorded in one farm.

Table 3.1: Distribution of farmers in the questionnaire study and the rabbit population estimates on their farms.

Province	Number of farmers (n=72)	Range in numbers of rabbits kept per farm
Central Province	51	2-180
Nairobi Province	7	18-119
Rift Valley Province	14	9-41

The highest numbers of farmers in this study were from Central province. It should be noted that farmers who participated in the monthly meetings were from these three regions and that the handing out of questionnaires was randomised that no prior information of the farmers was obtained.

Majority of the farmers were males (68%); females were 32%. The rabbit farmers were aged between 23-78 years. Forty four percent (44%) of them were above 50 years of age, 41% between 36 and 49 years and 13% were 35 years and below, 2% was a no response (Figure 3.1). Eighty six percent (86%) of the respondents were the owners of the rabbitries, 2% were spouses, while 1% were children and employees respectively. All the rabbit farmers had undergone varied levels of formal education from primary school (7%), high school (51%), diplomas and other certificates 21% to University level (18%), (Figure 3.2).

Figure 3.1: Distribution of the age in years of 72 rabbit farmers interviewed in the study

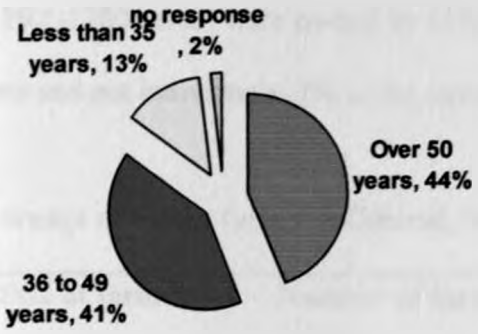
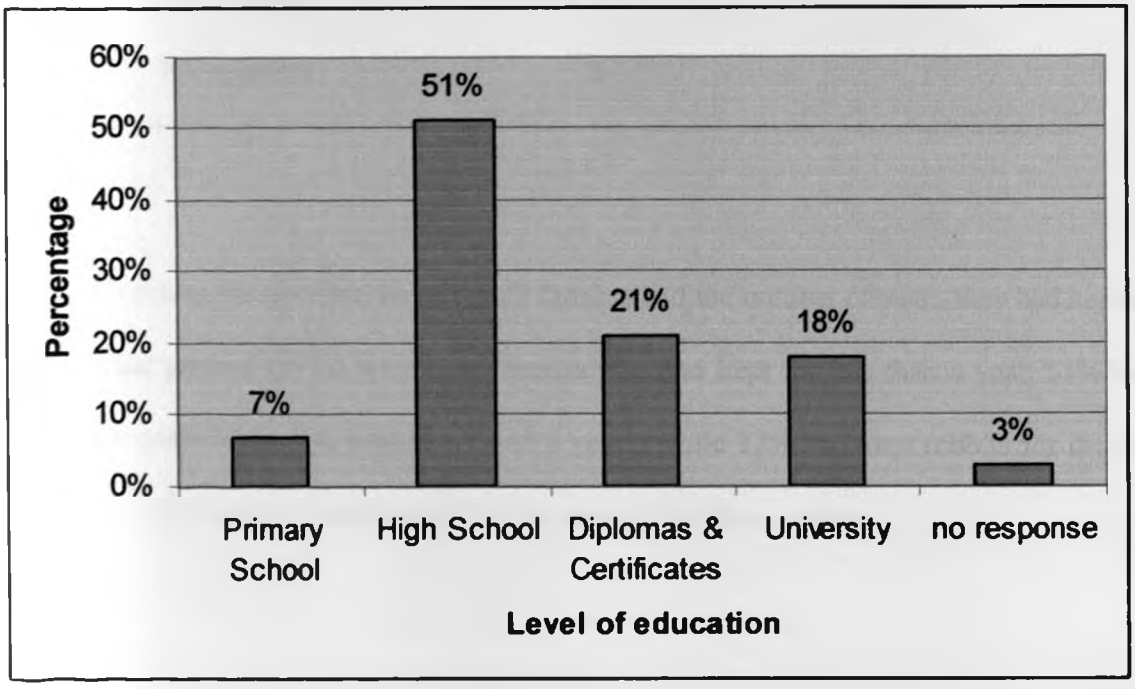


Figure 3.2: Distribution of the level of education for 72 rabbit farmers interviewed in the study



3.3.2 Farm Characteristics and Production System

Table 3.2 shows the frequency distribution of the study farms in terms of size. The largest proportions of farms measured 0.055 to 1.59 acres (54%), 1.6 - 3.9 (21%), 4 – 10 acres (13%) the larger farms 10.1-1280 acres were owned by (5%) of the farmers which were owned by groups and institutions and not individuals. 7% of the farmers did not respond.

Table 3.2: Acreage of rabbit farms in Central, Nairobi and Rift Valley provinces

Size of farm	Number of farms (n=72)	Percentage (%)
0.055- 1.59 acres	39	54
1.6 – 3.9 acres	15	21
4 – 10 acres	9	13
10.1 - 1280	4	5
No response	5	7

Figure 3.3 shows the distribution of the 72 farmers and the number of years they had kept rabbits. Twenty nine percent (29%) were new farmers who had kept for less than a year, 51% had kept rabbits for periods ranging between 1 and 5 years, while 17% had kept rabbits for more than 5 years, 3% of the farmers interviewed did not respond to this question.

Figure 3.3: Duration that the 72 farmers in the study had kept rabbits

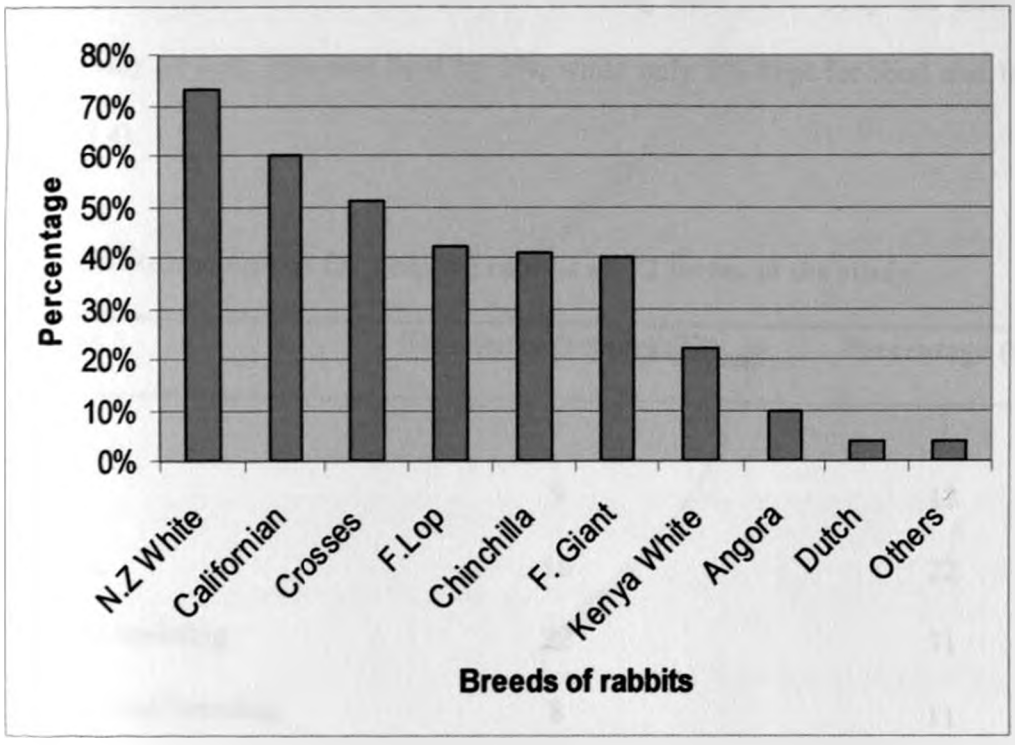
Seventy two of the rabbit farmers also kept other livestock with rabbits. The percentages are expressed separate in relation to rabbits. Most of the farmers interviewed kept chicken (78%), followed by cattle (52%) and other animals which were lower in percentage than chicken. Other birds (7%) were kept for commercial purposes (Table 3.3).

Table 3.3 The numbers and percentages of other livestock kept by rabbit farmers in the study

Animals	Number of responses on 72 farms	Percentage (%)
Chicken	56	78
Cattle	38	53
Sheep	15	21
Goats	22	31
Other birds (geese, doves and turkey)	5	7

The distribution of breeds of rabbits kept by the farmers is shown in Figure 3.4. The most common breeds kept were New Zealand white (73%), Californian (60%) and cross breeds (51%). Other popular breeds included French lop (42%), Chinchilla (41%) and Flemish giant (40%), Kenya white (22%) whereas Angora (10%), Dutch (4%) and others (4%) which included New Zealand red and New Zealand black rabbits, had the lowest percentages (Figure 3.4). These percentages were expressed as individual responses to give a cumulative response on each breed of rabbit kept.

Figure 3.4 Distribution of the breeds of rabbits kept on 72 farms in some parts of Central, Nairobi and Rift Valley provinces.



Key: N.Z White- New Zealand White, F. Lop- Frech Lop, F. Giant- Flemish Giant.

The responses by the farmers as to why they kept rabbits were varied and included combinations of the four choices: pets, food, fur/skins and breeding. Thirty one percent (31%) of the farmers kept the rabbits for food and breeding purposes, while 13% for food and 22% kept them for breeding alone. Those who kept for food, fur and breeding were 11%, while those who kept for all the given reasons, pets, food, fur and breeding were 10%. Only one farmer (1%) kept the rabbits only as pets. Pets and food by 3%, while only 1% kept for food and breeding purposes (Table 3.4).

Table 3.4 Reasons given for keeping rabbits on 72 farms in the study

Reasons	Number of farmers (72)	Percentage (%)
Pets	1	1
Food	9	13
Breeding	16	22
Food and breeding	22	31
Food, fur and breeding	8	11
Pets, food, breeding and fur	7	10
Pets and food	2	3
Pets, food and breeding	4	6
Pets and breeding	1	1
Food and fur	2	3

Figure 3.5 shows some types of housing used by the farmers in the study. Housing for the rabbits was mainly hutch (61%), of these 36% constructed a 2 by 2 feet (floor area) cage and 29% a 3 by 3 feet (floor area) cage (Fig. 3.5 A and B) another 14% constructed 2.5 by 2.5 feet cages for their rabbits, 1% built 10ft by 15feet cage, 12 by 12feet and 18 by 18feet cages respectively. Twenty five percent (25%) used indoor rabbitries while 14% used both hutch and indoor rabbitries. The measurements were based on the farmer's knowledge of the construction of each housing unit. Some of the housing units were poorly constructed (Fig. 3.5 C, D and F), where rabbits were exposed to weather extremes (Fig. 3.5D), others (multiple tiered cages) allowed waste to fall into food and water (Fig. 3.5E) and for some, faecal pellet could be found in feed (Fig. 3.5F)

Thirty six percent of farmers interviewed housed the mature bucks and does in separate hutches (singly), 13% housed the weaners together (4-5 kits in a cage), 33% housed in separate hutches for the mature and weaners together, 6% of the farmers did not respond. Of the 12% of farmers remaining indicated that the rabbits were housed together, sometimes 2 does in a cage, and 5 – 10 kits per cage.

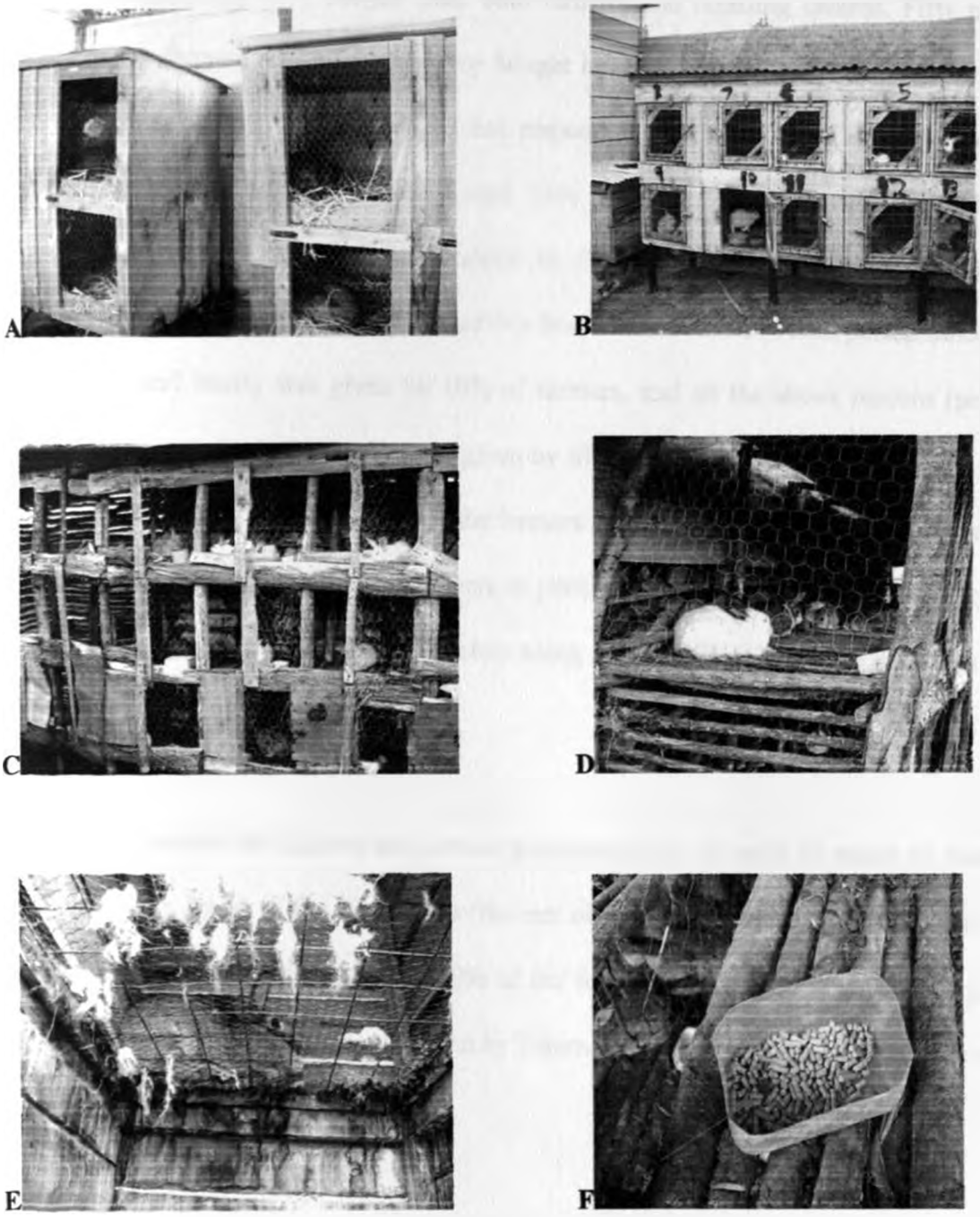


Figure 3.5: Examples of types of housing used by rabbit farmers in the study, showing A. Indoor rabbitry, B. Hutch, C. Poor housing, D. Rabbits exposed to weather extremes E. Waste from above cage falls into the cage below and F. faecal pellets in feed.

Sixty four percent (64%) of the farmers bought their rabbits from other farmers, 17% from breeding centres and 19% bought from both farmers and breeding centres. Fifty nine percent (59%) of the farmers responded that they bought in replacement stock while the 29% said they did not while 12% of the farmers did not respond to this question. Those who bought their replacement stock from other farmers were 29% and from breeders were 15%, 55% did not respond. The selection of stock at purchase by the farmers was influenced by breed (24%), performance of the rabbits stock (17%), advice from other farmers (14%), performance and breed (13%), size and beauty was given by 10% of farmers, and all the above reasons (performance, breed, advice and size and beauty) were given by 6% of the farmers. Advice and size and beauty was responded by 4% of farmers, 6% of the farmers did not respond to this question, performance and size and beauty in 3% of farmers where as performance, breed and size and beauty in 3% of farmers. The farmers identified their rabbits using cages (57%), breeds (33%), tags (4%) and tattoos (6%).

Table 3.5 represents the highest and lowest percentages of the ratio of males to females used during breeding, by 45 of the 72 farmers (the rest of the farmers did not consider male : female ratios). One male served 5 females in 29% of the farms, 1 male to 15 females was given by 1 farmer, 1 male to 2 females was only given by 2 farmers (4%), 1: 3, 1: 6 and 1: 10 were used by 3 farmers each (7%).

Table 3.5 Ratio of male to female rabbits used during breeding

Ratio (Male to Female)	Number of farmers (n= 45)	Percentage (%)
1 : 1	12	27
1 : 5	13	29
1 : 4	6	13
1 : 20	1	2
1 : 10	3	7
1 : 15	1	2
1 : 2	2	4
1 : 3	3	7
1 : 6	3	7
1 : 9	1	2

Sixty eight percent (68%) of farmers had an average litter size of 7 kits/ litter and above, 29% 4 – 6 kits, while 3% were no response. Fifty six percent (56%) of the farmers provided a nesting box for the female before birth while 32% did not, 12% of the farmers did not respond to this question. Sixty seven percent (67%) of the respondents indicated they had experienced death of new born kits, 18% did not experience this while 15% of them did not respond.

Sixty six percent of the farmers responded that most of their rabbits would reach market age (about 6 months), whereas only 13% of respondents said all their rabbits would reach, 7% indicated that very few rabbits would reach the age while 14% did not respond. Forty three percent (43%) of the 72 respondents said that rabbit farming was the main type of farming while the rest (57%) practiced rabbit keeping as a secondary source of income. The farmers in this study practiced commercial farming (31%), subsistence farming (29%) and both commercial and subsistence farming (38%), 2% of the farmers did not respond.

The range of weights of rabbits that farmers said were ready for market were 1 to 2.9 kgs (29%), 3 to 5.6 kgs (65%) and 6kgs and above (6%). Twenty one percent (21%) of farmers sold their rabbits at 2 to 3 months of age, 38% at 4 to 5 months while 20% at 6 months and above, 21% did not respond. It should be noted that rabbits were not sold before they were weaned which is at 2 months of age. The sale price of rabbits varied between farms with 25% of farmers selling at between 200 – 499 Kenya shillings (Kshs), another 25% of farmers sold at 500 – 1499 Kshs, a price range of KShs.1500 – 3000 was used by most farmers (50%). The prices of the rabbits varied due to individual costs in production by the farmers.

3.3.3 Farm Management Practices

Cleaning of the rabbitries was done daily on 42% of the farms to ensure no accumulation of waste, whereas 24% did the cleaning once a week. Sweeping was the main method of cleaning and it was done on 57% of the farms. A combination of both sweeping and disinfection was done on 40% of the farms (Table 3.6).

Table 3.6: Frequency and methods of cleaning rabbitries used by 72 farmers interviewed in the study

(A) Frequency	Number of farms (n=72)	Percentage (%)
Daily	30	42
Thrice weekly	13	18
Twice weekly	11	15
Once a week	17	24
No response	1	1
(B) Method of cleaning		
Sweeping alone	41	57
Disinfection	1	1
Sweeping & disinfection	29	41
No response	1	1

Fifty seven percent (57%) of the farmers used tap water, 17% from boreholes, 7% from rain water, while those who used wells as well as tap water were (4%) respectively, river water alone and river water and tap (3%) respectively only five percent (5%) of the farmers did not respond. The majority of farmers (63%) fed their rabbits on a combination of commercial pellets and vegetables (63%), while 19% fed rabbits on vegetables alone. Of the 19% who fed rabbits on

vegetables alone, 24% used wet vegetables. Only a small proportion (8%) of farmers fed rabbits on commercial pellets (11%) alone.

Table 3.7 Different types of feed given to rabbits by the farmers in the study

Type of feed	Number of farms (n= 72)	Percentage (%)
Pellets	8	11
Vegetables	14	19
Hay and grasses	5	7
Pellets and vegetables	45	63

Thirty five percent of the farmers who fed their rabbits pellets changed their feed suppliers often while, thirteen percent never changed, and thirty four percent rarely changed, eighteen percent of the farmers did not respond. Feeding of the rabbits was done in intervals, twice a day, by 78% of the farmers, while the rest (19%) fed the rabbits *ad libitum*, 3% of the farmers did not respond. Fifty four percent of the farmers took care of the rabbits themselves, 19% was by employed workers, 17% was by both farmer and employee, farmer and children (8%) while only 2% was by the farmer, employee and children.

3.3.4 Production Constraints

Eighty eight percent (88%) of the farmers sought advice on rabbit keeping, 9% did not while 3% of the farmers did not respond. Of the 88% of farmers who sought advice; thirty two percent (32%) was veterinary officers and 19% from farmers. 35% was obtained from both veterinary officers and other farmers while 14% did not respond.

Table 3.8 shows the number and percentages of farmers who experienced various constraints in rabbit production. Eighty three percent (83%) of the respondents noted that diseases of rabbits was a major constraint, 69% had problems of death of rabbits which was experienced from time to time; lack of commercial feeds was noted by 22% of farmers. Predators such as rats and cats were encountered in 29% of the farms with the farmers indicating that presence of thick bush encouraged these predators to stalk the rabbits. Other major constraints (19%) included marketing of rabbit and its by-products, expensive feeds, expensive caging of the rabbits, thieves.

Table 3.8 Constraints on rabbit production on 72 farms in Central, Nairobi and Rift Valley

Constraints	Number of respondents (n=72)	Percentage (%)
Disease	57	83
Predators	20	29
Death	50	69
Unavailability of feed	15	22
Others	13	19

Seventy one percent (71%) of the farmers interviewed could identify the symptoms of various conditions that affected their rabbits, 25% did not know, while 4% did not respond. The percentage that said they knew (71%), identified gastrointestinal problems; diarrhoea (39%) and bloat (21%) as major symptoms of rabbit diseases (Table 3.9). Other conditions that the farmers could identify were ear infection (8%) and pneumonia (7%).

Table 3.9 Symptoms of rabbit diseases that farmers could recognize in Central, Nairobi and Rift Valley Provinces of Kenya.

Symptoms	Number of farmers (n=72)	Percentage (%)
Diarrhoea	28	39
Bloat	15	21
Lack of appetite	10	14
Dullness	8	11
Ear infections	6	8
Pneumonia	5	7

Sixty nine percent (69%) of the farmers sought treatment for their rabbits, 28% did not while 3% did not respond. Of the 69% who sought, 39% administered the medicine to the rabbits, while only 17% from veterinary officers, 18% from both veterinary officers and farmers, 26% did not respond. Eighty nine percent of the farmers had experienced death of rabbits on the farm, though 69% (Table 3.8) noted death as a constraint. Some of the major clinical signs associated with death of the rabbits were diarrhoea and bloat.

Farmers interviewed in this study were members of various rabbit groups that met to discuss solutions to problems they had encountered, some of the registered groups were; Rabbit Breeders Association Kenya (RABAK) of Thika with 800 registered members, Kigoro Rabbit Group, Rabbit Breeders Organization of Kenya, Gilgil Rabbit Farmers Group, Central Region Rabbit Breeders Organization.

3.3.5 On Farm Observations

The types of floor used in the rabbit housing were varied, 64% of farmers used wire mesh, 28% used wood and 8% of farmers housed the rabbits freely on the floor where they were free to move around (not restricted in cages). The spacing per cage was standard (2ft by 2ft by 2ft) in 84% of the farms and stocking density was (not more than 5 rabbits in a standard cage) in all farms. The rabbits were given fresh water on 22 (88%) of the 25 farms, while unclean water was used in 12% of the farms. Rabbits were fed mostly using clean containers (88%), commercial feeding equipment were used on (52%) and improvised equipment such as old containers and metallic cans accounted for 48% of feeding equipment used. Only 4% had unhygienic feed where pellets were seen to have dropped on the floor and those fed on vegetables had faecal pellets mixed with them. Thirty six percent of farms used substandard house cleaning methods, where the rabbits would go with unchanged beddings for more than a week. Dangers posed to rabbits on farms included poor air flow, darkness, poor housing structures, rotting wood and rust, rats and cockroaches and unusual smells.

3.4 DISCUSSION

3.4.1 Study Farms and Farmers' Biodata

Results of this study indicate that rabbit farming in Central, Nairobi and Rift Valley provinces is a small scale industry, 54% of farmers owned land between 0.055-1.59 acres (54%), 1.6-3.9 by 21% while those who owned larger pieces of land formed a small percentage 4-10 acres (13%) and 10.1-1280 acres (5%). This is in agreement with previous reports (Colins and Lebas, 1996; Lukefahr, 2007; Oseni *et al.*, 2008) that the rabbit industry in the developing world is dominated by small scale units. Kumar *et al.*,(2010), Oseni *et al.*, (2008) and Onifade *et al.*,(1999) have classified rabbit units by using the number of does and bucks housed in each where small holder housed less than 25 rabbits, medium holder between 25-150 rabbits and large holder more than 150. According to these classifications, the results from the study indicate that farming in Central, Nairobi and Rift valley provinces is small to medium rabbit holders. The small scale nature of the rabbit industry in Kenya implies that if well adopted, it can be practiced widely in the country since majority of Kenyans are small scale farmers and this should be taken into account in the design of intervention measures aimed at supporting rabbit farming.

The ages of the rabbit farmers in the present study ranged from 23 to 78 years, indicating that rabbit farming cuts across all age groups with 44% of them being above 50 years of age, 36-49 years were 41%. Earlier records indicate that a low population of adult farmers took up rabbit farming attributed to socio-cultural issues that associated rabbit keeping as a hobby for boys (Ministry of Livestock Development Sessional Paper 2, 2008). In the study however, those who practiced rabbit keeping below the age of 35 years was only thirteen percent. The advanced age

of the farmers captured in this study is a possible indicator that interest in rabbit farming among adults has risen in recent years due to the Government efforts in encouraging rabbit farming by establishing a rabbit breeding program in Ngong. The fact that majority of the farmers (68%) were males and this gender attributes should be considered in extension services and other interventions to the rabbit farmers. Though women farmers (32%) were fewer than the men, they typically have different opportunities and constraints in managing livestock than men. Rural women however are as likely to keep livestock, although the number of animals they keep tends to be lower and they are more likely to own poultry and small animals (FAO, 2009). Therefore, more women should be encouraged to take up farming. All the farmers in this study had undergone formal education. The medium to high levels of education among them would be expected to positively influence the uptake of information and technology and this will work in favour of efforts aimed at sensitizing for better practices in the industry.

3.4.2 Farm Characteristics and Production System

Forty three percent (43%) of the farmers interviewed indicated that rabbit farming was the main type of farming because they require less space than other types of livestock farm. This is consistent with reports from other parts of the world that rabbit is a suitable micro-livestock (Owen *et al.*, 1977). Most of the rabbit farmers (78%) kept chicken, another common farming enterprise in rural households. Chicken and other poultry require less space and can therefore be housed on the premises near rabbit hutches to improve income and provide animal protein for the households. Thirteen percent of the farmers kept rabbits mainly as a source of meat, while 31%

kept rabbits as a source of food and income. This is in line with the observation of Payne and Wilson, (1999) that in the tropics, the domestic rabbit is raised mainly for meat and as a pet.

Fifty one percent (51%) of the farmers had kept rabbits for periods ranging from 1 year to 5 years, indicating that sustained interest is increasing in this type of farming. Another 29% comprised of new farmers, indicating that rabbit farming was gaining popularity. This is in agreement with the Kenya Government, Ministry of Livestock Production Annual Report (2003) which indicated that interest in rabbit enterprise was gaining momentum countrywide, particularly in major towns and their environs. The rabbit is potentially one of the animals that could be used to solve the problem of low animal protein intake in the developing world (Karikari and Asare, 2009).

The observation in the study that New Zealand white (73%), Californian (60%) and crosses (51%) were the most represented rabbit breeds, was similar to that of Oseni *et al.*, (2008) in Southwestern Nigeria and Lukefahr *et al.*, 1995, USDA, 2005 in the USA. It is notable that the two breeds are suitable for meat production; which was the most frequently cited reason by majority of farmers for keeping and selecting the rabbits. It further supports the observation that rabbit meat production was the primary objective of the Kenyan rabbit farmers.

Sixty four percent (64%) of farmers bought their replacement stock from other farmers and 17% buying from breeding centres. This practice was also observed by Oseni *et al.*, (2008) to have disadvantages particularly because the practice denied the rabbit farmers access to a wide range of genetic material including imported ones.

The procurement of breeding stock from other farmers was seen as a major problem, most respondents believed that the rabbits were related because they bought their stock from each other. Some of the breeding centres also bought stock from farmers making the situation even more complicated because the centres would then act as distribution points of the offspring to other farmers. The Kenya Government's Sessional Paper 2 of 2008 identified inadequate breeding stock as a major limitation to rabbit production in Kenya. Oseni *et al.* (2008) noted several advantages for establishing rabbit multiplication centres including serving as information and coordination centres and as a service delivery points for the farmers. Such interventions require specific project planning with involvement of stakeholders. The selection of stock based mainly by breed (24%) and performance (17%) was consistent with other published reports that farmers need to consider these to ensure that good traits will be passed on to the offspring which eventually increases performance in the herd (Huish, 2005).

Poor construction of rabbit hutches was observed in the survey; rusty hutches, while others were hanging and required frequent replacement. The main problem reported by farmers, was the high cost of building material, which would required to be changed every 2 to 3 years (due to weather conditions). It was also observed that construction of multiple tiered cages often left little room for removal of waste. This often lead to waste contamination of adjacent cages and feed; which might have increased the risk of disease transmission. The poor construction of rabbit hutches could be a reflection of low capital investment in rabbit farming and cage design; similar to observations by Oseni *et al.*, (2008) in Southwestern Nigeria; or lack of technical expertise.

The findings in this study that sixty one percent of farmers housed their rabbits in hutches with 36% using a 2ft by 2ft (floor area) cage and 29% using a 3ft by 3ft (floor area) cage; confirm the previous reports that the FAO guidelines on the construction of rabbit hutches can be modified and adopted by local farmers (Lebas *et al.*, 1997). The observations that 36% of farmers housed mature rabbits individually and 33% housed 4-5 weaners per cage were consistent with previous recommendations of housing rabbits (Lukefahr *et al.*, 1995, Szendro and Luzi, 2006).

Identification of rabbits was done mainly by cage numbers (57%), a method that may be practical in small scale enterprises. As rabbit production expands more reliable methods such as tags and tattooing are required in order to improve management practices such as selection for breeding etc.

In this study, 1 male served 5 females on 29% of the farms, 1:10 was used in only 7% of farms while in others 1:1 (27%) was used., the recommended ratio in small scale rabbitries is one male to 10 females (Schiere, 2004; Schaeffer *et al.*, 2008) depending on the number of does available and the frequency of mating practiced. The average litter size of 7 kits observed in this study was comparable with litter sizes recorded by other researchers (Kpodekon *et al.*, 2004, Schiere 2004, Lukefahr, 1998). An important finding in this study was the high proportion of litters (66%) reaching the market which implied some financial contribution to the family revenue.

The comparatively high neonatal mortality rate (67%) recorded in this survey; which is high compared to a mortality rate of 19% in Benin (Kpodekon *et al.*, 2004), 27.9% pre-weaning age in Nigeria (Karikari and Asare, 2009) and 8.1% in Uganda (Lukefahr, 1998); justifies the need for farmers to provide nesting boxes (assuming that this is the only cause of neonatal mortality). Most farmers (38%) sold their rabbits at 4 to 5 months and at an average of 1000 to 2000 kshs, which is comparable to those sold in Ghana at 12 weeks of age at the sale price of Gh¢ 5 each which is approximately 400 Kshs (1 US$=80Ksh) (Karikari and Asare, 2009). It should be noted that, the farmers were selling rabbits at different prices, some sold at different ages and some by live weights; these prices were based on the cost of production of each rabbit. The cost of commercial feeds and building materials are some of the factors that influenced the prices of rabbits.

3.4.3 Farm Management Practices

Although the farmers cleaned the rabbitries on a regular basis by sweeping and disinfection, there was a wide variation in the frequency of cleaning; ranging from daily to once a week (which helped in minimizing contamination and risk of diseases). Sodium hypochlorite solution is reported to be an excellent disinfectant for small animal caging (Harkness and Wagner, 1983). Disinfection was further augmented by use of tap water on the majority of farms (57%), borehole water (17%) and rain water (7%). A small proportion of the farmers however used water from other sources such as wells and rivers which are likely to get contaminated.

Various types of feeds; pellets (11%), vegetables (19%) and pellets and vegetables (63%) were given to the rabbits. According to various sources of literature (Irlbeck, 2001; Samkol and Lukefahr, 2008), a balanced diet containing adequate fibre (20-25%), minimal starch and optimum protein concentration is important to prevent gastrointestinal distress and improve rabbit production (Irlbeck, 2001). It was also observed that some farmers did not trust feed companies because they did not indicate the ingredients on the packaging, others complained of high prices of pellets and in turn the farmers sought other alternatives to feeding for example chicken mash. Improper feed balances without prior testing of the feed components would lead to a decrease in production; for example, weight gain of the rabbits would be minimal and gastrointestinal complications increased (Irlbeck, 2001). Some of the dangers the rabbits were exposed to were; poor air flow which encourages respiratory diseases such as snuffles to be spread easily in the herd, poor lighting in the hutches, rotting wood and rust on hutches, rats and cockroaches which could harbour parasites (Huish 2005; Hoy and Verga, 2006).

3.4.4 Production Constraints and Diseases

The constraints the farmers faced included diseases (83%), deaths (70%), predators (29%) and unavailability and poor quality of feeds (22%). The high cost of commercial feeds was also a problem. These constraints are likely to have a negative effect on rabbit production in the country. The farmers may get easily discouraged and turn to other sources of income. In a study in India by Kumar *at* al., (2010) constraints rabbit farmers faced were grouped in categories such as production problems, financial, marketing and institutional problems; in another study by in

Nigeria by Oseni *et al.*, (2008) some of the constraints identified were lack of foundation stocks and capital, space, feed, ants and rats, thieves among others.

It should be noted that this study did not categorise the constraints as in previous literature (Kumar *et al.*, 2010), most of them fell under the production category. The constraints faced in this study were comparable to those in Nigeria as these rabbit industries are still developing however they cannot be ignored as potential constraints to these countries.

Although 88% of the farmers indicated that they obtained advice on rabbit production, 32% from Veterinary Officers and from Veterinary Officers and other farmers (35%), disease and death were reported to be a problem on many (or most) of the farms. Majority of the farmers (83%) had reported disease of rabbits on their farms. Despite the fact that most farmers could recognise the symptoms of ill health in their rabbits and the majority (69%) sought advice on disease and treatment for their rabbits, there appeared to be major problems in the management and control of the rabbit diseases.

3.5 CONCLUSIONS AND RECOMMENDATIONS

3.5.1 CONCLUSIONS

(i) This study identified that rabbit farmers in Central, Nairobi and Rift Valley provinces practice small scale farming due to small land space. Majority of the farmers involved are middle aged with a mean age of 49.6 years. The medium to high levels of education among the rabbit farmers will positively influence the uptake of technical information on rabbit industry.

(ii) Rabbit farming was the main type of enterprise in 43% of the households, while 57% relied on other types of farming, rabbit farming can therefore be combined with other farm enterprises as it requires less space and can provide an income as well as source of protein.

(iii) The New Zealand White, Californian white and Cross breeds of rabbits were the most frequently kept rabbit breeds; confirming their value in meat production.

(iv) Buying of breeding stock from other farmers was seen as a major problem by most farmers because the lineage was unknown and this could lead to inbreeding. The breeding ratios used by the farmers in this study were not consistent with those that are recommended.

(v) Rabbits on the study farms were mostly fed on pellets and vegetables.

(vi) Rabbit farming was characterized by low capital investment, poor cage design and inadequate access to technical information.

(vii) Farmers cleaned the rabbitries on a regular basis with sweeping as the most common method though cleaning frequencies varied on each farm.

(viii) The spacing of housing requirements of the rabbits was met on most farms.

(ix) High neo-natal mortality rates were noted in this study. Major constraints included disease, death which hinders growth of the rabbit industry.

3.5.2 RECOMMENDATIONS

- It is important to implement, in the design and communication of intervention measures aimed to support rabbit farming in Kenya.
- Comparative studies on breed performance under different management and feeding levels need to be undertaken on rabbit breeds in Kenya and any advantages exploited in cross-breeding programs. This will ensure that rabbits bred in Kenya will have good traits in production such as large litter sizes and heavy breeds which are a good source of protein.
- Poor housing can be addressed through the design of appropriate low-cost and durable prototype housing and materials which are readily available in the market, for use by rabbit farmers in the country. This service can be provided through the rabbit multiplication centres.
- Disease and pest problems need to be identified through research and appropriate measures taken by the Government and relevant institutions as has been done for other livestock.

CHAPTER FOUR: PREVALENCE AND PATHOLOGY OF DISEASES OF RABBITS FROM CENTRAL, RIFT-VALLEY AND NAIROBI, KENYA

4.1 INTRODUCTION

Disease is a major constraint that limits rabbit production on farms (Licois, 2006). The success or failure of a rabbit production program depends on the farmers ability to control diseases through proper management (Cheeke *et al*, 1987), which includes proper feeding, housing, space and regular sanitation of the rabbit housing (Patton *et al*., 2008). Major diseases in rabbits include enteritis which manifests a complex of several signs that include diarrhoea, dehydration and death of young rabbits. One of the most common causes of enteritis in rabbitries is coccidiosis. In a study conducted by Wesonga and Munda (1992) in Muguga, Kenya, coccidiosis with mucoid enteritis was reported in 55% of the rabbits examined. *Psoroptes cuniculi,* the common ear mite of rabbits, causes ear mange or canker and is very common in commercial rabbitries (Patton *et al*., 2008) and rabbits become susceptible to bacterial infection. Surveys on causes of rabbit mortality have revealed that pneumonia occurs in 25 percent of the animals and it is the greatest single cause of death in mature animals (Patton *et al*., 2008). In the study by Wesonga and Munda (1992), pneumonia was found in 23% of the groups of rabbits examined.

In a study by Musongong (2003) to determine haematological values in domestic rabbits in Nigeria, the PCV, Hb and WBC values were different from those reported in other rabbits. This can be explained by the difference in ecological zones from other rabbit values documented elsewhere by various authors. Burnett *et al.*,(2006) showed in a study in West Indies that males had higher Hb, PCV and RBC values than females. Cazabon *et al*., (2000) observed that all

reported parameters were within reference ranges given by various authors, however male and female monocyte percentage and monocyte absolute values were significant. A study by Milas *et al.*, (2009) observed a significant difference in Hb concentration between males and females. Hb values in female rabbits was higher than those in male, though the values were within reported values in literature.

Eosinophils of the rabbit have large cytoplasmic granules that stain dull pink- orange with conventional haematology stains. Lymphocytes are usually the predominant leukocyte in circulation and may contain a few azurophilic cytoplasmic granules. Basophils may be numerous and represent up to 30% of the circulating leukocyte population (Wilber, 1999).

In a review of post-mortem cases by Ngatia *et al.* (1988), 19.8% of rabbits examined died from respiratory conditions, pneumonia being the most prevalent among these. Gastro-intestinal conditions were observed in 18.5% of the rabbits examined, other conditions that were noted were hepatic coccidiosis and abscesses, subcutaneous abscesses as well as organ abscesses were also observed. Cooper (1976) also reported coccidia both clinical and hepatic as being responsible for disease and death.

The aims of the study were to obtain current information on diseases affecting domestic rabbits and to determine the normal haematological values and parasitological status of domestic rabbits in Nairobi, Central and Rift Valley Provinces, Kenya.

4.2 MATERIALS AND METHODS

4.2.1 Study Farms

The cross sectional survey of diseases and haematological parameters was conducted on 25 farms in Nairobi and parts of former Central and Rift Valley Provinces. These farms were selected randomly from the 72 farms and the number of farms (n) to be included in the study was calculated using the formula by Martin *et al.* (1987)

$$n = \frac{(z^2 \times p \times q \times N)}{e^2 (N - 1) + (z^2 \times p \times q)},$$

Where:

n = Sample size (being determined)

N = Population size (known)

p = Sample proportion (assumed to be 0.02, if not given)

q = 1 – p

e = 0.05

z = Standard deviation at a given CI (z = 1.96 at 95% CI) (Martin *et al.*, 1987)

4.2.2 Data Collection

The selected farms were visited once and the following samples collected and analyzed as indicated. During the study, blood, faeces, skin scrapings and sick / dead rabbits were collected from rabbits for haematology and Parasitology examination.

The ages of the rabbits were determined using records that farmers kept, while the breeds of the rabbits in the study were identified by their morphological features as well as farmers records. Sample collection was done during the period of September 2010 to April 2011.

4.2.2.1 Haematology

Eighty seven (87) adult rabbits (48 males; 39 females) were randomly selected from cages in the 25 farms located in parts of Central, Nairobi and Rift Valley provinces regardless of whether they were sick. Two millilitres of blood samples was aseptically collected into EDTA vacutainer tubes from the marginal ear vein of the rabbit (vasodilation of the ear vein was achieved by gentle stroking at the base of the ear) and stored at 4°C for transportation to the laboratory. The automated Coulter Counter (Haematology Vet Analyzer MS4 Vet.), was used to enumerate the Total Cell Blood Count (CBC) of the red blood cell (RBC), white blood cell (WBC), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC), hemoglobin (Hb) and thrombocytes, while smears were made for differential leukocyte count (Jain, 1986).

4.2.2.2 Parasitology

During the visit to the 25 farms, faeces for parasitological examination were collected from all the rabbit cages as described by Kaufmann (1996). The pelt was examined for ectoparasites such as fleas, mites and ticks and skin scrapings were collected for further identification (Kaufmann, 1996).

The McMaster technique as described in MAFF (1986) was employed to determine the number of worm eggs per gram (EPG) and coccidian oocysts per gram (OPG) of faeces and the oocysts sporulated using 2% potassium dichromate.

4.2.2.3 Pathology and Histopathology

Necropsies were performed on sick and dead animals during the survey, as described by Bivin and Timmons (1974) to detect the presence of gross abnormalities. All necropsies were performed by a pathologist and sixteen rabbits in total were studied. All the major internal organs were examined grossly during the necropsies, and tissues/ organs with lesions were histologically evaluated. Samples for histopathology were preserved in 10% neutral buffered formalin for 72 hours. Wax embedded tissues were cut at 5µ thick and stained with Haematoxylin and Eosin (H&E) and alterations in tissues and organs investigated as described in Culling (1974). Data was also obtained from records on post-mortem findings of rabbits submitted to the Department of Veterinary Pathology, Microbiology and Parasitology, University of Nairobi between January 2008 and April 2011.

4.2.3 Data Management and Analysis

Data from Pathology and Parasitology were entered into Ms Excel for Windows 2003 and analysed using descriptive statistics. Data for Haematology were entered into Ms Excel for Windows 2003 and analyzed using Instat v3.36. Mean values of the different parameters were compared between sexes within the same age group (adults) of the host using the student t-test. P values less than 0.05 were considered significant.

4.3 RESULTS

4.3.1 Haematology

The haematological data obtained from the rabbits sampled is shown in Table 4.1 and a summary of differential leukocyte counts is shown in Table 4.2. Raw haematological data for males and females is also given in Appendix 3.

Table 4.1 Haematological parameters of rabbits in Central, Nairobi and Rift Valley provinces, Kenya.

Haematological parameter	Male Rabbits (n=48)		Female Rabbits (n=39)	
	Mean ± SD	Range	Mean ± SD	Range
WBC (x 10^3/µl)	17.83±13.79	8.87-72.79	6.67±1.29	3.83-8.86
RBC (x 10^6/ µl)	6.24±0.89	4.62-8.68	6.143±0.77	4.9-7.82
PCV (%)	40.91±5.94	27.7-55	40.22±6.08	31.8-56.6
Haemoglobin (g/dl)	13.52±1.15	11.2-16.2	12.94±1.15	11.1-15.7
MCV (fL)	65.46±3.86	57.5-75.2	65.84±2.84	59.4-72.4
MCH (pg)	21.68±2.36	16.4-25.8	21.43±2.88	15.8-25.3
MCHC (%)	33.26±3.89	25.7-41.5	32.78±4.83	22.9-40.4
Thrombocytes (10^9/L)	89.9±54.96	20-209	85.77±75.3	13-279

Values are expressed as a mean value ± standard deviation.

Reference table for red blood cell count

Parameter	Males	Females
WBC x10 $m^3/\mu l$	4.2-12.3	4.4-13.2
RBC x10 $m^6/\mu l$	4.08-6.96	4.89-6.85
PCV %	30.7-46.2	32.1-45.6
HB g/dl	10.4-14	12.3-15.1
MCV fL	55-71	56-71
MCH pg	18-24	18.7-23.6
MCHC %	31.1-35	31.1-35.4
Thrombocytes (10^9/L)	108-678	109-841

Reference values: (Praag, 2011; Musongong, 2003; Milas *et al.*, 2009; AML, 1999):

Table 4.2 Differential leukocyte count in blood of rabbits in Central, Nairobi and Rift Valley provinces

Blood cells	Male rabbits (n=48)		Female rabbits (n=39)	
	Mean ± SD	Range	Mean ± SD	Range
Total Heterophils (%)	27.54±16.61	4-71	23.56±12.78	5-57
Lymphocytes (%)	69.54±16.27	31-96	73.72±13.34	42-94
Eosinophils (%)	2.479±4.92	0-23	1.333±3.19	0-19
Monocytes (%)	0.167±0.48	0-2	0.385±0.94	0-4
Basophils (%)	0.063±0.24	0-1	0.026±0.16	0-1
Nucleated RBC (%)	0.021±0.14	0-1	0	0

Values are expressed as a mean value ± standard deviation

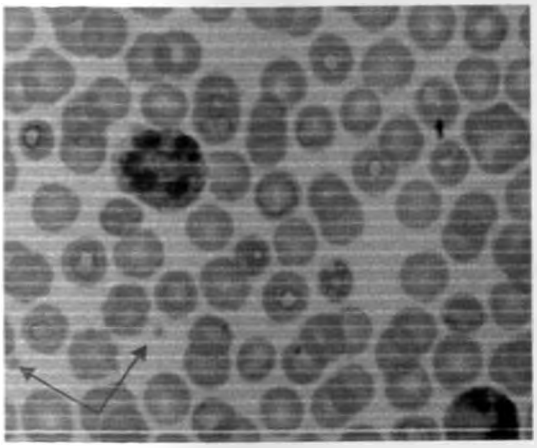
Reference table for white blood cell differential count

Parameter	Males	Females
Total Heterophils (%)	27-94	27-79
Lymphocytes (%)	16-70	20-69
Eosinophils (%)	0-2	0-3
Monocytes (%)	0-3	0-3
Basophils (%)	0-1	0-1

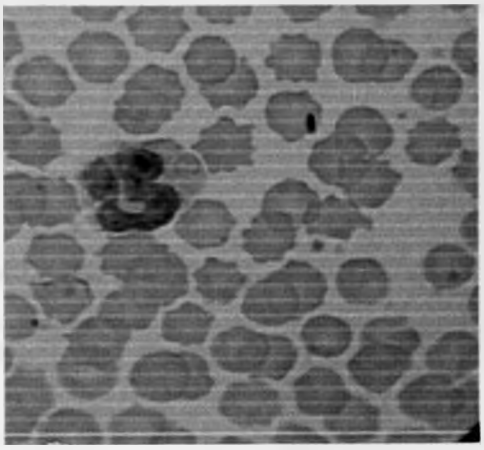
Reference values: (Milas *et al.*, 2009; AML, 1999):

The haematological values (Table 4.1) were within the reference ranges given by various authors except for the WBC which was significantly higher in the males (17.8 $x10^3/\mu l$) than females (6.668 $x10^3/\mu l$). Hb values were also significantly higher in males (13.52 g/dl) than females (12.94 g/dl) but were within the ranges reported for both sexes (Reference values p.71, 72).

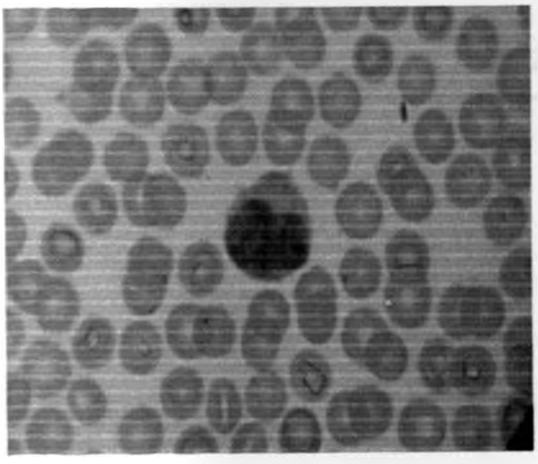
Heterophils (Figure 4.1B) were observed to be higher in the males than females (27.54 v 23.56 %) as well as eosinophils which had a mean of 2.479±4.92 % in males and 1.333±3.19 % in females were reported to be higher than those in published studies. In contrast monocytes were more in females (0-4%) than males (0-2%). Lymphocytes were the predominant group of circulating cells while basophils were the least represented group of leukocytes in the blood smears, their relative count was 0 to 1% in both males and females.



A. A Heterophil and arrows showing thrombocytes



B. Eosinophil



C. Lymphocyte

Figure 4.1 Some leukocytes of rabbits using Giemsa stain A. a heterophil, arrows pointing at thrombocytes B. an eosinophil C. lymphocyte (x40)

4.3.2 Parasitology

Coccidia were the main parasites observed in the faecal samples analysed and were recovered from 72% farms examined. Four farms had heavy infections (22%); Eleven (11) farms had mild infection (61%) whereas moderate infections were observed in 3 farms (17%) (Table 4.3).

Table 4.3 Prevalence of coccidia infections of rabbits in the study farms

	Number of farms visited (n=25)	Faecal samples analysed
Mild infection (+)	11	53
Moderate infection (++)	3	15
Heavy infection (+++)	4	33
No infection	7	105
Total	**25**	**206**

Key: (Niilo, 1967):

Mild infection (+): less than 10 oocysts per slide

Moderate infection (++): 10-100 oocysts per slide or section

Heavy infection (+++): more than 100 oocysts per slide

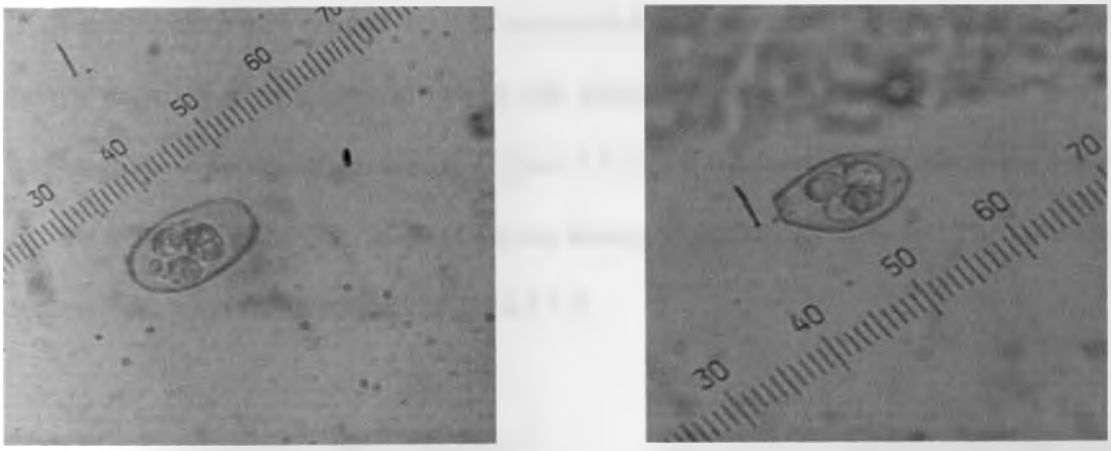


Figure 4.2 Eimeria spp. Isolated from rabbits in the study farms (x40 & x43)

From the samples with coccidia infections, Eimeria with different morphological features (shape, wall and micropyle) were observed (Figure 4.2).

Low numbers of Strongyle-type nematode eggs were observed in only 5 out of 206 faecal samples (2.4%) but no larvae could be obtained from cultures. The EPG of faeces in four of the farms was 100 and 200 in only one farm.

The level of infestation with mites varied from one farm to another and was reported in 10 of the 25 farms (40%). Two species of mites which are responsible for ear and skin infections were collected from rabbits in the study farms. *Psoroptes cuniculi* and *Sarcoptes scaibei* were both identified using clinical signs on host (Figure 4.4) and morphological features at microscopy (Figure 4.4). *Sarcoptes* spp were round in shape with short legs, while *Psoroptes* spp were oval shaped with legs projecting beyond the margins of the body (Urquhart *et al.*, 1996).

The rabbit with mange (Figure 4.3 A) had partial hair loss around the eyes and nose with white-yellow crust of dried epidermal debris, the mites (Figure 4.4A) was recovered from the skin scrapings. The rabbit with ear canker (Figure 4.3 B) had thick crusty material in the inner parts of the ear with the exposed surfaces of the ear having moist bloody material. The mite responsible for this infection was identified in Figure 4.4 B.

Figure 4.3 A. Rabbit showing partial loss of fur around nose and eyes, B. rabbit with severe inner ear infection with arrows (upper) showing exposed bloody surface and (lower) arrow showing crusty material

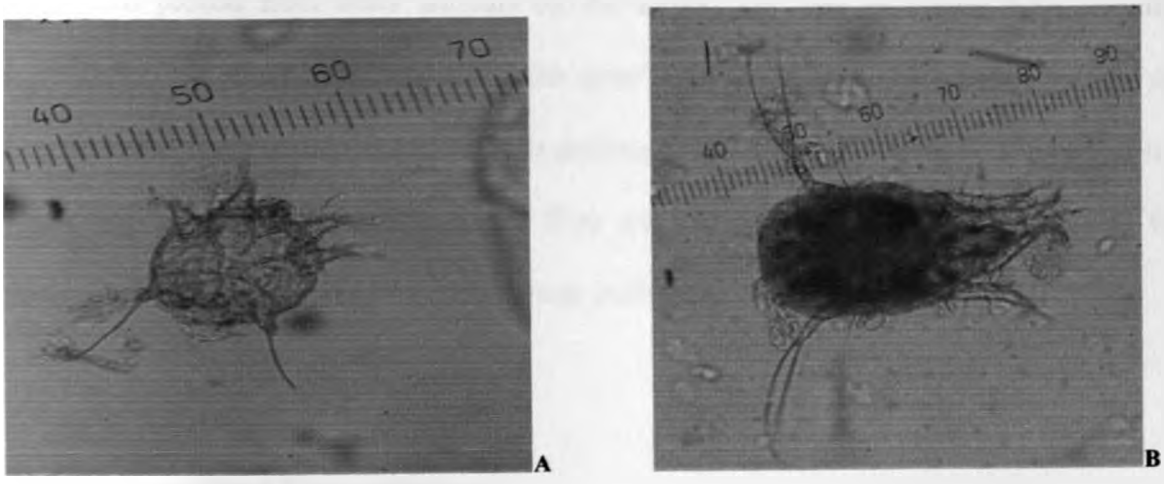


Figure 4.4 A. *Sarcoptes scabiei* (x10), mite recovered from a rabbit (fig. 4.3A) and *Psoroptes cuniculi* (x10), mite on a rabbit ear infection (fig. 4.3 B)

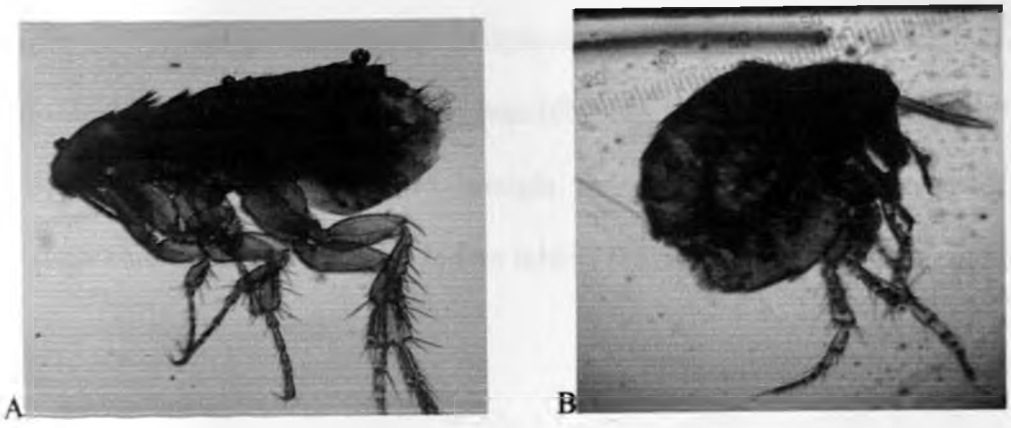


Figure 4.5 A. Ctenocephalides canis and B. Echidnophaga gallinacea (x10)

Fleas from different genera (Figure 4.5 A and B) were observed in 2 live rabbits, which could have been picked from other animals on the farms. The flea in Figure 4.5A identified as *Ctenocephalides canis*, had ctendia and the spine II on the genal comb was longer than spine I. One flea was identified as *Echidnophaga gallinacean.* It had no ctendia or combs and it had a contracted thorax (Coles, 1986). These fleas are commonly found on cats, dogs as well as domestic fowl as in the case of *Echidnophaga gallinacea.*

4.3.3 Pathology and Histopathology

The rabbit cases brought in for post-mortem studies (n=16) were sampled from the 25 study farms, and were recorded and tissues taken for further evaluation. A total of 95 cases were reviewed from the department's post mortem records from 2008-2011 (Table 4.4). The data on the 16 rabbit cases brought from the study farms in the period 2010/ 2011 are given below, 6 rabbits (38%) had gastrointestinal complications, 3 had mucoid enteropathy, 2 had coccidiosis and 1 had enteritis-clostridiosis. One case (6%) had ear canker and another one had malnutrition (6%). One of the rabbits cases brought for examination had suspected poisoning while subcutaneous abscesses occurred in two rabbits (13%). Three cases (19%) of aflatoxin poisoning were confirmed in the year.

Three of the six cases with gastrointestinal complications were diagnosed with mucoid enteropathy. Gross pathology in all the three showed distended abdomen and intestines and a free flowing mucoid content occurred in the large intestines. Histological sections from these cases showed lesions consistent with mucoid enteropathy namely goblet cell hyperplasia in the intestinal mucosa. All these cases also showed congestion of the liver.

Coccidiosis was diagnosed in two rabbits. These rabbits had soiled perianal area and a distended abdomen and their stomachs were distended and full with ingesta and intestinal lumen contained mucoid fluid. Coccidian oocysts were demonstrated in the faecal contents.

The carcass of one rabbit brought for full post-mortem was in poor condition and its perianal area was stained with green to brown faeces; the caecum was distended and filled with watery contents and gas and haemorrhage occurred in the mucosa. The kidney, heart, liver and brain of this rabbit had no lesions but its lungs were congested and collapsed. A pure culture of *Clostridium* sp. was identified from intestinal contents of this rabbit at bacterial isolation in the department's Microbiology laboratory.

A three day old kit that had died the previous night on one farm was brought in for routine pathology. The farmer indicated that the kits were not suckling. At post mortem examination, blood tinged fluid occurred in the abdominal and peritoneal cavities. The liver, lungs and heart were congested, and bile was present in the duodenum, indicating that the kit was not feeding. Histological examination of the liver, lung, brain and heart showed congestion.

Ear canker was diagnosed in one rabbit, the rabbit was in good body condition, and the external ear canal had a thick crusty material. At histology, the ear canal in this case was inflamed and keratinised.

It was reported on one farm that rabbits would die suddenly without showing any signs of disease, 30 rabbits died during the period December 2010 to March 2011. The rabbits had good appetite and were active but the next day refused food and died. The farmer brought in tissues of liver and lung from one male rabbit for histopathology. The lungs had mild oedema, the heart was normal but liver showed widespread multifocal to diffuse necrosis, there was acute damage affecting hepatocytes at the peri-portal areas.

Two adult rabbits one with a subcutaneous abscess and the other with a submandibular abscess were brought in for post-mortem examination. The rabbit with the submandibular abscess was highly emaciated and the abscess was a cauliflower like mass and was located below the lower jaw and measured about 3cm in the largest diameter and with smaller accessory nodules. Incision of the abscess exuded dull pasty cream pus. Besides the abscess, the urinary bladder was distended, liver and mesenteric blood vessels were also congested. The rabbit with the subcutaneous abscess was in good condition (Figure 4.6), the abscess was located behind the scapula extending backwards along the spine and measured about 5cm by 4cm in the larger and smaller diameter, cut surface showed a creamy semi solid exudate with accessory swellings underneath.

Bacteriological isolation revealed that *Arcanobacterium* and *Pseudomonas* species were the primary cause of the abscesses while *Klebsiella* spp and *Streptococcus* spp were secondary infections. At histological examination, the skin overlying the abscess showed thick granulation tissue with pockets of pus on the subcutaneous surface, and this constituted the major part of the abscess wall.

Figure 4.6: Rabbit with abscess on scapular and abscess upon incision showing accessory nodules (arrows)

Three rabbits that were brought for full post mortem had a history of sudden death with no signs of disease, and they were all young rabbits below 2 months. The animals had similar lesions. Each carcass was pale and emaciated, urinary bladder was distended, liver was congested and the gall bladder was distended. Spleen was atrophied and the stomach mucosa was coated with a milky fibrin material. The duodenum and jejunum had a mucoid coating and had red (congested) serosa. The brain was pale. At histological examination, the liver had lesions that were consistent with aflatoxicosis. There was moderate reaction of bile ducts in the liver, fibroblasts were also present in the bile duct indicative that there was formation of new cells. Laboratory analysis confirmed the presence of high levels of aflatoxins in the feed and these cases were considered to have been positive for aflatoxin poisoning.

Two rabbits that were submitted by the owner for disposal were in good condition and showed no signs of illness. Routine post-mortem examination of two rabbits showed that the kidneys, heart, lungs, and intestines were normal at gross and at histological examination. The liver in one rabbit however, showed moderate periportal fibrosis consistent with a recovering case of hepatic coccidiosis. The bile ducts were atrophied and a reduced thickness of the epithelium. The bile duct sections were stained for parasites using PAS (Periodid Acid Schiff) stain but surprisingly were negative for coccidian oocysts. The histological demonstration of hepatic coccidiosis in a rabbit from records at the Department of Veterinary Pathology, Microbiology and Parasitology is presented in Figure 4.7.

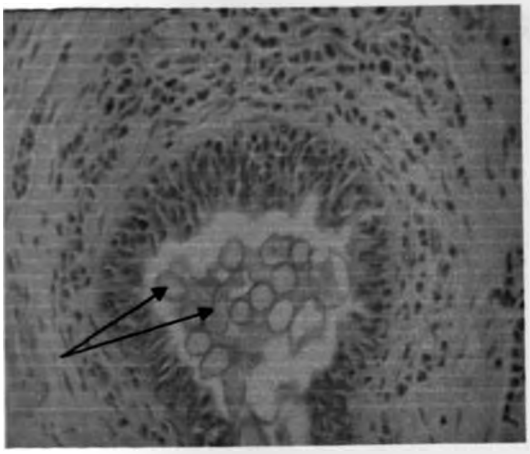


Figure 4.7: Hepatic coccidiosis in a rabbit: coccidian oocysts are present in the bile duct (H&E x40)

Data of rabbit (comprising 35 adults (375%) and 60 young (63%)) presented for post mortem examination at the Department of Veterinary Pathology, Microbiology and Parasitology from the year 2008 to April 2011 are summarised in Table 4.4.

Table 4.4: Diagnoses of cases presented for post-mortem in the Department of Veterinary Pathology, Microbiology and Parasitology in Nairobi from 2008 to April 2011

Diagnosis	Number of rabbits cases (n=95)	Percentage (%)
Enteritis complex		
i) Mucoid enteropathy	7	7
ii) Clostridiosis	1	1
iii) Colibacillosis	2	2
iii) Enteritis	29	31
Coccidiosis		
i) Hepatic	1	1
ii) Intestinal	10	11
Pneumonia and associated lesions	11	12
Acute brain swelling	3	3
Ear canker	2	2
Aflatoxicosis	3	3
Subcutaneous swelling	2	2
Malnutrition	2	2
Congestive heart failure & pericarditis	4	4
Endometritis	2	2
Other conditions	3	3
Inconclusive results/disposal	13	14

4.4 DISCUSSION

4.4.1 Haematology

The study revealed that a mean white blood cell (WBC) count of 17.8 $x10^3/\mu l$ in male rabbits was significantly higher than the normal range reported for laboratory rabbits in published studies ($P<0.05$) (Table 4.1) (Praag, 2011; Musongong, 2003; Milas *et al.*, 2009; AML, 1999). The mean WBC count for females (6.67 $x10^3/\mu l$) was within the reported normal range for female rabbits; this difference may indicate that male rabbits sampled could have been harbouring a silent disease that provoked a rise in WBC count. In published studies, rabbits have been shown to have high WBC counts, young rabbits at 3 months and also in adults over one year of age, another explanation could be due to lymphosarcoma (Harourt-Brown, 2002). Adult rabbits in this study were sampled and this could mean that the high WBC counts observed were due to this factor. There was a significant difference of WBC count between the values calculated between males and females in this study ($P<0.05$).

The red blood cell (RBC) values in both male and female rabbits were similar; male's 6.2 $x10^6/\mu l$ and female's 6.1 $x10^6/\mu l$ and this were consistent with previous reports. Other parameters of the erthron namely, PCV, MCV, MCH and MCHC were also within normal values in both male and female rabbits (AML, 1999; Milas *et al.*, 2009). However Hb values in males were slightly higher than females ($P<0.05$); male rabbits had a mean of 13.52g/dl and females 12.94g/dl. In an investigation on haematological values by Burnett *et al.* (1996), Hb values in males were higher than those reported in females within the same study; in a similar study by Cazabon *et al.* (2000) the Hb values were numerically higher in males than females though not significant.

Thrombocyte counts in males and females ranged within normal values. The differential leukocyte counts showed that lymphocytes were the predominant circulating leukocytes; this has been reported in literature (Lester *et al.*, 2005). The lymphocyte counts for male and female rabbits were in the normal range reported for rabbits, the mean count being 73.72% and 69.54% for female and male rabbits respectively. The morphology of the lymphocyte was similar to that of other mammals; they have a large nucleus which may be indented with a small amount of light blue cytoplasm.

The neutrophil count was higher in the male than female rabbits (27.54 v 23.56 %) but these counts ranged within the normal reference values for rabbits. Eosinophils ranged between 0-23% in males and 0-19% in females. This indicated that there was an eosinophilia in majority of rabbits and this may be attributed to coccidiosis that was found to be the most common parasitic condition in the rabbits examined. The eosinophil values of the mean in both male and female rabbits were within the reference ranges. Monocyte counts were higher in female (0-4%) than male (0-2%) rabbits but the difference was not significant. Cazabon *et al,*(2000), Burnett *et al,*(2006) and Milas *et al,*(2009) all reported monocyte values of males being higher than those of female rabbits, however in this study female rabbits had higher monocyte counts. This increased monocyte counts can be associated with chronic bacterial infection; studies have shown that monocytes can be increased with subcutaneous abscesses, mastitis and labyrinthitis (which is inflammation of the inner ear) (Harcourt-Brown, 2002).

Basophils were the least represented group of leukocytes in the blood smears; their relative count was normal (0 to 1%) in both male and female rabbits (Milas *et al.*, 2009). The results of blood values showed narrow standard deviations in males and females rabbits.

4.4.2 Parasitology

Rabbits are susceptible to a number of parasites few of which are of economic importance. The problems caused by these parasites are greatly influenced by methods of feeding, handling, and housing of rabbits (Patton *et al.*,2008). Coccidiosis is a common and widespread problem in commercial rabbit operations and research facilities. Coccidia were the main parasites observed in the faecal samples that were analysed in 18 of the 25 farms examined. Four farms had heavy infections. The heavy coccidiosis infections conform with the poor hygiene conditions that was observed in many rabbit farms that housed rabbits on solid floor pens.

The heavy coccidial infection on the 4 study farms could be attributed to; 2 farms had over 50 rabbits had sub standard housing and infrequent cleaning regime. In addition, 3 of the 4 farms with heavy coccidia infection had wooden hutches and lacked the wire bottomed cages which has been reported to minimize the incidence of coccidian parasite infections (Patton *et al.*, 2008).

The mild infection observed in 11 of the 18 farms is consistent with the fact that adults, mostly carriers of oocysts. It is also likely that on such farms, shed oocysts that infect the young kits. The absence of wire bottomed cages and lack of simple hygiene methods (including regular and frequent cleaning and disinfection of the pens as was observed in most farms in this study

(Wesonga and Munda, 1992). Many of the farms lacked single tiered caging systems that minimises infections and these are also recommended in rabbit houses (where resources permit) since they allow easy cleaning and removal of waste material (Meredith and Jepson, 2001; USDA, 2002).

Low numbers of Strongyle-type nematode eggs were observed in 5 out of 206 samples (2.4%). The low helminth worm load observed in this study has also been documented in Benin by Farougou *et al.*, 2004 who reported nematodes in 4.5% of the samples analysed. These results suggest that low prevalence of nematode infections occur in domestic rabbits in Central, Nairobi and Rift Valley, Kenya.

The level of infestation by ear mites varied from one farm to another and this was reported in 10 of the 25 farms (40%). *Psoroptes cuniculi* causes ear canker and their life cycle lasts less than 3 weeks and as many as 10,000 mites can colonise the ear of an infected rabbit (Wilber, 1999). In large rabbit populations, it is more difficult to control the levels of ear mite infestation but in smaller herds it is possible to control the infection. This was observed in one farm with over 200 rabbits where the farmer constantly complained about ear canker infection in the rabbit herd. The farm used wooden hutches and the farmer implemented quarantine procedures and often treated them with paraffin oil to control ear canker. It is noted in this study that most farms reported the presence of mites, but no clinical disease of ear canker. *Sarcoptes scabiei* was diagnosed in one farm only, it is noted that this infestation rarely occurs in rabbits and when it does it causes alopecia and dermatitis in the face, nose and lips (Wilber, 1999).

Other external parasites such as the flea, do not commonly occur on the rabbit but have occasionally been reported (Patton *et al.*, 2008). For example *Ctenocephalides canis* and *Echidnophaga gallinacea* were observed only on 2 live rabbits in this study, which shows that they are not problematic as such and may parasitize the rabbit due to presence of other animals such as dogs, cats and domestic fowl the known definitive hosts for these fleas respectively.

4.4.3 Pathology and Histopathology

The results obtained from pathology showed that gastrointestinal disorders in the rabbit are common and more complex in manifestation. In a study by Ngatia *et al.*, (1988) gastroenteric conditions were diagnosed in 18.5% of the cases examined. Infectious and non-infectious enteritis was the most important cause of impaction and rupture in the stomach. In the current study, rabbits showed similar clinical signs of gastrointestinal distress such as bloat, caecal impaction, mucoid intestinal content in different diseases whose causative agents were different. The enteritis complex commonly referred to as mucoid enteropathy, a major cause of gastrointestinal disease and mortality, was the most prevalent condition that affected 38% of the rabbits among the 16 sampled. Various factors play a major role in development of this disease, in the field. The significant changes that were associated with the enteritis complex were the manifestations of distended abdomen with fluid and gas, splenomegaly, soiled perianal areas and congestion of the intestinal mucosa. Histological features of mucoid enteropathy include goblet cell hyperplasia of ileum, jejunum and colon (Wilber, 1999).

In this disease bacteria occur in the caecum and oedema with pyogranulomatous cellularity occur in lamina propria of the intestines. Oedema or haemorrhage can also occur in the submucosa of intestines in the affected rabbit (Mendlowitz, 2002). Three out of six cases from the 16 rabbits had mucoid enteropathy. Published sources indicate Mucoid enteropathy may be associated with a combination of factors including bacteria, toxins, dietary irregularity, and obstruction (Wilber, 1999).

Available literature indicates that intestinal coccidiosis may be subclinical or overtly clinical with high mortality (Patton *et al.*, 2008). Coccidiosis was diagnosed in ten rabbits that clinically had soiled perianal area and distended abdomen. Several cases in which infection with coccidiosis were confirmed at parasitological examination of faecal samples had no clinical evidence of the disease. Hepatic coccidiosis however does not present gastrointestinal lesions except when it occurs as a mixed infection (Patton *et al.*, 2008). Cooper (1976) diagnosed coccidiosis in 13.2% of rabbits surveyed, which were responsible for disease and death.

Clostridiosis diagnosed in a rabbit with in poor body condition had lesions that were consistent with previously described clostridiosis (Praag 2003). *Clostridium* spp were identified from isolation of intestinal contents. It is established in published work that Clostridia toxins provoke local lesions in the intestine and occasionally in other organs such as the liver and kidney (Praag, 2003) though in this case the other organs besides the gastrointestinal system were normal.

Cases of mismothering occasionally occur in rabbits (Onifade, 1999). A three day old kit died because of failure to suckle due to refusal by the mother. Bile was present in the stomach of this rabbit confirming that the kit was not feeding well. In such cases, the kits may be abandoned by the inexperienced mother, sometimes when the litter size is high (more than 12 kits) competition by the kits during suckling can cause starvation of the weak ones (Huish, 2005).

Aflatoxicosis was diagnosed in 3 rabbits that had died suddenly with no signs of disease. The diagnosis was based on pathology and necropsy finding. The feed (pellets) were analyzed for toxins by the Kenya Bureau of Standards and results indicated the presence of high levels of aflatoxins in the feed. Aflatoxins are a group of naturally occurring fungal (mycotoxins) toxins which can be contaminants in human and animal foodstuffs. Pathological examination of these cases confirmed, as expected, the principal target organ for aflatoxins is the liver (Bommakanti and Waliyar, 2000).

The two cases that manifested subcutaneous and submandibular abscesses in this study were caused by *Arcanobacterium* and *Pseudomonas* species of bacteria, *Klebsiella* spp and *Streptococcus* spp were isolated as secondary agents in these abscesses. Abscess formation in rabbits is favoured by unhygienic housing conditions that allow accumulation of moisture and dirt. Prrag (2010) observed that abscesses of the skin are mainly caused by bacteria such as *Staphylococcus aureus*, *Streptococcus sp*, *Pseudomonas sp.* or *Fusiform.* These abscesses are found mostly on the head, neck and shoulders as well as other parts of the body.

Traumatic injuries from sharp objects or bites by littermates predispose to abscess formation (Praag, 2010). Ngatia *et al.,* (1988) also diagnosed subcutaneous abscesses in the rabbits examined. The results from this study show that subcutaneous abscesses occur in Central, Nairobi and Rift valley provinces though they are not a common occurrence.

The retrospective data collected from the Department indicate that gastrointestinal disorders are the most commonly occurring disease conditions in rabbits in Nairobi and its environs. These conditions enteritis complex (39) and intestinal coccidiosis (10) occurred in 52% of the rabbits examined. Digestive syndromes occur more frequently in growing rabbits, and are responsible for mortality and significant morbidity in rabbit colonies (Licois, 2006). Ngatia *et al.,* (1988) also documented that the major conditions affecting rabbits are those affecting the digestive tract. In this study, the cases with respiratory disease were only 12% of the rabbits examined but were the second highest cause of death in the rabbits. The causes of gastrointestinal conditions of rabbits are multiple and symptoms are comparable. Diarrhoea is largely dominant and it may be encountered in 95% of gastrointestinal cases. Enteritis was confirmed in 29 cases (31%); intestinal coccidiosis was recorded in 10 cases (11%) and hepatic coccidiosis in 1 case (1%). Pneumonia and associated lesions was diagnosed in 11 cases (12%) and other findings included aflatoxicosis in (3%) of cases and ear canker in 2% of the cases. The lesions and diseases observed in retrospective study were consistent with those recorded in published reports (Wilber, 1999; Mendlowitz, 2002; Huish, 2005). The inconclusive results were mainly given due to decomposition of the carcass upon pathology. This implies that the Department should increase its capacity to effectively respond to the expectations of the rabbit farmers.

4.5 CONCLUSIONS

i. The haematological parameters of the domestic rabbit in Central, Nairobi and Rift Valley provinces were within the reported normal ranges with narrow standard deviations in males and females. The high WBC count in the male rabbits was suggestive of an underlying disease and advanced age of the rabbits sampled as well. Eosinophil counts in the male and female rabbits was indicative of chronic parasitism.

ii. Results of the parasitological examination indicated that *Eimeria* and Ear mite infestations are common parasites in rabbits in Central, Nairobi and Rift Valley provinces, Kenya. There was a low prevalence of nematode infections which occurred in domestic rabbits in this study while fleas from dogs and chicken were encountered in only two rabbits.

iii. Post mortem and histopathological findings of the study indicated that gastro intestinal disorders enteritis, coccidiosis and respiratory syndromes like pneumonia are important diseases affecting rabbits in the study area.

CHAPTER FIVE: GENERAL CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL CONCLUSIONS

a) This study has established that rabbit production is growing in Central, Nairobi and Rift Valley provinces.

b) The results obtained from the questionnaire study on rabbit production characteristics complements those from the prevalence and pathology of disease highlighting the main factors influencing the occurrence of disease on the farms.

c) The main issues observed in the questionnaire study include feeding of the rabbits, breeding, housing and constraints like disease and marketing of rabbits.

d) In the second aspect of the study, diseases of the gastrointestinal tract and respiratory system were the common cause of poor health and death of rabbits.

e) The overall study provides useful information that can be applied to support rabbit farming in Kenya.

5.3 GENERAL RECOMMENDATIONS

1) Strengthening and expanding the breeding centres and educating farmers through workshops on rabbit production as well as popularising of rabbit meat through advertising and investigating suitable production systems are essential for the development of rabbit industry in Kenya.

2) Research and training on rabbit diseases, feeds marketing and the compounding socio-cultural aspects, is needed to support the growth of rabbit industry in Kenya.

3) The farmers should also liaise with both the Government and universities for support. Increasing productivity of the rabbits would therefore go a long way in raising household incomes for the rabbit keepers and alleviate poverty.

4) Production and distribution of booklets and manuals on best practices in rabbit production is essential for effective training of rabbit farmers.

5) Supply of subsidized building materials for the construction of ideal rabbit hutches and technical support to ensure hutches of proper quality and size are used in rabbit production is recommended.

6) A comprehensive economic assessment of the rabbit industry in Kenya is needed so as to assist in determining the current status of the industry with a view to addressing the constraints that limit its enhancement.

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7.0 APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR CROSS -SECTIONAL STUDY ON RABBIT PRODUCTION IN CENTRAL, NAIROBI AND RIFT VALLEY PROVINCES

A. Farm identification

Date of interview.....

Location of the farm .....

Size of the farm in acres.....

GPS reading.....

B. Farmer's biodata

1. Name of farmer.....
2. Gender ☐M ☐F
3. Age in years.....
4. Level of education:

☐ No formal education ☐Primary school ☐ High school ☐ University

☐ Other.....

5. What is your relationship to the owner of rabbitry?

☐ Self ☐Spouse ☐Daughter/son ☐Worker ☐ Other (specify)

C. Farm characteristics and production system

6. What type of livestock do you keep?

☐Cattle .....

☐Sheep .....

☐Goats .....

☐Rabbits .....

□Chicken .....

□Others (specify).....

7. What number of livestock do you keep as specified above?
8. Is rabbit keeping the main type of farming? □Yes □No
9. Why do you keep rabbits?

□Pets

□Food (meat)

□Fur / Skins

□Breeding purposes

10. For how long have you been keeping rabbits?

□ < 1 year □ Between 1- 5 years □ > 5 years

11. Which breed(s) of rabbits do you keep? (use table)

12. How many of each breed do you keep (please specify below)

Breed	Sex		Total
	Male	Female	
New Zealand White			
Californian White			
Chinchilla			
French Ear lopped			
Kenya white			
Cross breeds			
Checkered Giant			
Others (specify)			
Total			

13. How do you identify the rabbits you keep?

☐ Ear tags

☐ Tattoo

☐ Cage number

☐ Breeds

14. How do you house the rabbits you keep?

☐Hutch

☐Indoor rabbitry

☐Both

15. a. What is the size of the rabbit house

☐ 2 ft by 2 ft (24 inch x 24 inch)

☐ 3 ft by 3 ft (36 inch x 36 inch)

Please specify.....

b. How many rabbits do you keep per house?

☐ Individually for mature rabbits

☐ 4-5 weaners per hutch

Please specify.....

16. Where do you source your rabbit stock?

☐ Local farmers/ breeders

☐ Breeding centres

☐ Other sources (please specify).....

17. How do you select your breeding stock?

☐ Performance

☐ By breed

☐ Advice from farmers

☐ Size and beauty

18. How many males are there to a female for breeding purposes?.....

19. Do you provide a nesting box for the female before birth? □Yes □ No

20. Have you ever experienced death of new born kits □Yes □ No

21. Approximately how many young ones do you get per female rabbit?.....

22. Approximately how many of these rabbits reach the market age?.....

23. Do you buy in replacement stock? □Yes □ No

If yes, from where do you buy? .....

24. What type of farming do you practice?

□Subsistence

□Commercial

□ Both of the above

25. Where do you sell your rabbits? □Markets □Individuals □Institutions/hotels □ Others.....

26. What is the average weight in kg's of a mature rabbit at market.....kg's

27. At what age do you sell your rabbits? .....

28. What is the sale price of rabbit per kg in kshs?.....

D. Management and farm practices

29. How frequent is the rabbit housing cleaned?

□Daily

□Thrice weekly

□Twice weekly

□Once a week

30. What cleaning regime do you use?

□ sweeping alone

□ Disinfectant/ bleach

□ Both the above

31. What is the major supply of water to your farm

□ Tap water/ Nairobi water services

□ Other (please specify).....

32. What type of feed do you give your rabbits

□Commercial Pellets

□Vegetables

□Left over foods

33. Do you give your rabbits wet vegetables □Yes □ No

34. Where do you get your rabbit feed

□ Agro-Vet suppliers

□ farm produce

35. How often do you change the feed suppliers?

□ Often

□ Rarely

□ Never

36. How often are your rabbits fed? □ Continuous / ad libitum □Intervals

37. Who takes care of your rabbits (feeding, house cleaning)?

□ Farmer □ Employee □Children

38. Do you get advice on rabbit keeping? □Yes □No

If yes, from who? □Vet officers and extension officers □Other farmers □ both

E. Production problems and diseases

39. Have you ever encountered any of the following problems on your farm concerning the rabbits? (tick as appropriate)

☐ Disease

☐ Predators /thieves

☐ Mortality of the rabbits/ sudden death

☐ Unavailability of rabbit pellets/feed

☐ Others (please specify).....

☐ .....

40. Do you know about the symptoms that affect your rabbits? ☐Yes ☐No

If yes, list the symptoms

.....

.....

41. Do you give medicine to your rabbits? ☐Yes ☐No

42. Who administers drugs to your rabbits? ☐ Farmer ☐ Vet ☐ Both

43. Do you seek advice on diseases and treatment? ☐Yes ☐No

If Yes, from who? ☐ Vet ☐ Other farmer ☐ Agrovet suppliers ☐ Others

44. Have you experienced death of rabbits on your farm? ☐Yes ☐No

If yes, what was the cause(s)/symptoms? .....

.....

Are you a member of a rabbit group organization? ☐YES ☐NO

If yes, which one.....

Appendix 2: Examination sheet for cross-sectional study on rabbit production in Central, Nairobi and Rift Valley provinces

Observation sheet

Farm identification..... GPS coordinates.....

Date..... Time.....

Location.....

Name of farmer.....

Environment	**Status**
Housing floor (wire mesh, wood, ground)	
Water Fresh/ brackish/ ground	
Watering method (stand pipe/containers); clean/ dirty	
Dangers posed to rabbits Chemicals (others)	
Cleanliness of housing & environs	
Unusual smells	
Housing space (small/std/large)	
Rabbits health	
Breeds	
Stocking density (normal/ overcrowded)	
Litter size	
Diet	
Feed (commercial/ vegetables/others)	
Recent changes in diet (Y/N)	
Quality of feed	

Feeding equipment (commercial/improvised containers/others) (clean/dirty)	
Feces	
Character (Quantity, color, odor, consistency)	
Disease	
Feeding (Y/N)	
Active/dull	
Soiled perineum (Y/N)	
Fur coat alopecic (Y/N); Canker (Y/N); Itching (Y/N)	
Eye / nasal discharge (Y/N)	
Coughing / sneezing (Y/N)	

Complaint: Duration _____ (hrs/ days/ weeks)

Other observations made;

Samples taken;

- Swabs (nasal/ conjuctival).....
- Blood.....
- Fecal samples.....
- Skin scrapings.....
- Carcass.....
- Live for screening.....

Appendix 3: Haematological parameters for male and female rabbits in Central, Nairobi and Rift Valley provinces

Haematological parameters for male rabbits

	WBC	RBC	PCV	Hb	MCV	MCH	MCHC	THROMB
1	8.87	6.16	40.6	14.5	66	23.5	35.7	29
2	8.9	4.62	27.7	11.5	60	24.8	41.5	40
3	8.97	6.32	43.1	13.5	68.3	21.3	31.3	97
4	9.22	5.52	35	12.2	63.5	22.1	34.8	116
5	9.26	7.01	45.7	13.5	65.3	19.2	29.5	197
6	9.39	5.67	35.8	11.2	63.3	19.7	31.2	34
7	9.4	5.88	38.4	13.1	65.4	22.2	34.1	86
8	9.47	6.13	40.2	14.1	65.7	23	35	40
9	9.52	5.59	34.3	13.2	61.5	23.6	38.4	34
10	9.71	5.78	38.3	14.3	66.4	24.7	37.3	27
11	10.05	5.55	38.2	13.2	68.9	23.7	34.5	107
12	10.08	4.85	37.6	12.5	65.4	21.7	33.2	42
13	10.9	6.09	36.5	12.7	65.7	22.8	34.7	35
14	10.94	7.09	49.2	13.8	69.5	19.4	28	162
15	10.95	6.04	37.9	12.2	62.8	20.1	32.1	146
16	11.46	7.04	47.1	16.2	67	23	34.3	180
17	11.52	6.14	40	13.9	65.2	22.6	34.7	96
18	11.76	6.27	43	13.5	68.6	21.5	31.3	119
19	11.92	6.08	39.2	14.3	64.6	23.5	36.4	50
20	12.32	5.84	41.8	15	71.7	25.6	35.8	184
21	12.49	7.19	49.5	14.6	68.9	20.3	29.4	138
22	12.99	7.06	48	14	68	19.8	29.1	128
23	13.39	5.94	38.7	14.8	65.2	24.9	38.2	42
24	13.4	5.56	37.6	14.5	58.7	22.5	38.5	36
25	13.57	5.76	34.1	12.8	57.5	21.5	37.5	33
26	13.91	5.17	36	12.3	69.8	23.7	34.1	138
27	14	4.96	37.2	12.3	75.1	24.7	33	209
28	14.24	6.42	39.6	13.7	61.8	21.3	34.5	45
29	14.37	6.31	39.4	15.6	62.5	24.7	39.5	35
30	14.91	5.24	36.1	12.3	69	23.4	34	127
31	15.02	4.83	32.3	14.4	67	23.6	35.2	20
32	15.03	5.99	38.6	13	64.5	21.7	33.6	92
33	16.12	7.61	51.3	13.2	67.5	17.3	25.7	59
34	17.18	8.68	54.7	15.2	63.1	17.5	27.7	131
35	17.78	5.94	34.7	12.1	60.3	21	34.8	44
36	17.97	6.18	39.5	11.8	64	19	29.8	89
37	18.47	5.73	37.2	13.6	65	23.7	36.5	29
38	19.86	7.49	46.8	15.6	62.6	20.8	33.3	65
39	20.77	5.26	39.5	13.6	75.2	25.8	34.4	124
40	24.04	5.76	33.9	13.6	58.9	23.6	40.1	26
41	28.17	7.2	47.4	13.4	65.9	18.6	28.2	131

42	40.25	6.46	40.2	12	62.7	18.5	29.6	39
43	45.58	6.54	39.6	13.9	60.7	21.2	35.1	31
44	51.23	7.52	50.9	13.6	67.7	18	26.7	163
45	58.1	6.07	43.9	11.4	72.4	18.7	25.9	179
46	72.79	7.01	45.2	14.4	64.5	20.5	31.8	99
47	113.11	7.25	47.1	14.5	65	20	30.7	118
48	141.6	8.61	55	14.2	63.9	16.4	25.8	125

Haematological parameters for female rabbits

	WBC	RBC	PCV	Hb	MCV	MCH	MCHC	THROMB
1	3.83	5.08	31.8	11.1	62.6	21.8	34.9	34
2	4.76	5.54	31.9	12	65.9	24.7	37.6	33
3	4.81	5.08	33.1	11.9	66.2	23.4	35.9	38
4	5.13	5.9	39.5	14.4	67	24.4	36.4	24
5	5.19	5.51	37.7	13.3	68.6	24.1	35.2	51
6	5.28	6.06	39.5	12.7	65.3	20.9	32.1	141
7	5.37	5.48	35.1	13	64.2	23.7	37	19
8	5.39	5.98	35.2	13	63.6	23.4	36.9	31
9	5.45	4.9	32.5	11.2	66.4	22.8	34.4	22
10	5.46	5.78	38.4	13.6	66.6	23.5	35.4	27
11	5.56	5.45	38	13.2	69.9	24.2	34.7	25
12	5.71	7.02	47	11.1	67	15.8	23.6	69
13	5.96	5.35	32.1	12.3	60	22.9	38.3	34
14	6.05	6.18	38.3	14	62.1	22.6	36.5	194
15	6.07	7.25	46.8	12.3	64.6	16.9	26.2	117
16	6.11	5.68	36	12.9	63.4	22.7	35.8	22
17	6.31	6.75	45.4	13.2	67.4	19.5	29	205
18	6.37	6.86	45.2	12	65.9	17.4	26.5	114
19	6.42	6.21	42.1	11.8	67.8	19	28	211
20	6.59	5.62	38.8	12.8	66	21.4	32.9	37
21	6.77	5.76	38.8	13.4	63.8	22	34.5	13
22	6.85	6.42	33.9	12.5	68.9	25.3	36.8	37
23	6.91	7.35	51.2	12.3	69.7	16.7	24	279
24	7.12	5.49	32.6	13.2	59.4	24	40.4	26
25	7.28	6.68	43.6	11.6	65.3	17.3	26.6	247
26	7.48	7.82	56.6	14.7	72.4	18.7	25.9	181
27	7.51	4.93	37.9	13.8	67.5	24.5	36.4	32
28	7.56	6.48	44.6	15.7	68.9	24.2	35.2	65
29	7.64	5.84	37.6	13.2	64.5	22.6	35.1	38
30	7.7	7.54	47.5	13.6	63.1	18	28.6	96
31	7.89	7.16	46.3	13.4	64.8	18.7	28.9	50
32	8.07	5.82	39.1	14.7	67.2	25.2	37.5	43
33	8.09	6.04	38.5	14.2	63.8	23.5	38.8	27
34	8.12	6.96	48.7	11.2	70.1	16	22.9	256
35	8.49	5.52	35.4	12.1	64.3	21.9	34.1	107
36	8.53	5.97	40.6	13.5	68.1	22.6	33.2	103

37	8.66	7.23	50.1	12.4	69.3	17.1	24.7	98
38	8.7	5.96	36.5	11.9	61.4	19.9	32.6	68
39	8.86	6.92	44.8	15.6	64.8	22.5	34.8	131