PREVALENCE, TREATMENT OPTIONS AND RISK FACTORS ASSOCIATED WITH RABBIT MANGE IN CENTRAL KENYA

A thesis submitted in partial fulfillment of requirements for Masters of Science degree of the

University of Nairobi (Applied Veterinary Parasitology)

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J56/82630/2015

University of Nairobi

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2020

DECLARATION

This thesis is my original work and has not been submitted for award of a degree in any other University.

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I dedicate this work to my family. My husband Cornelius K. and my children Coryden K. and Coretta C.

ACKNOWLEDGEMENT

First, I would like to thank God for the strength He gave me throughout my study period.

Secondly, I thank my supervisors Dr. R.M. Waruiru, Prof. P.K. Gathumbi and Dr. G.O. Aboge for the excellent guidance they gave me in proposal writing, data collection, article and thesis writing.

Many thanks to Dr. P.O. Okumu and Dr. K.O. Ogolla who devoted their time to support me in proposal writing, sample collection, processing and data analysis. I thank Mr. Josphat N. Gichure for his assistance during questionnaire development and administration and data analysis. Many thanks to Mr. R.O. Otieno, Ms. R.N. Gitari and Ms. E. Keya for their assistance in collection and processing of samples.

I am grateful to all the rabbit farmers from Kiambu and Nyeri counties and the Department of Animal Production (UoN) for allowing me to use their rabbits. Much appreciation to livestock and veterinary officers from Kiambu and Nyeri counties who took part in this study. Dr. Maina Karina and Mr. Eustace Muriithi were very resourceful in reaching farmers in Nyeri and Kiambu counties, respectively.

Much thanks goes to Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) for funding the project and University of Nairobi for providing the training infrastructure.

Lastly, I thank my guardian Mr. Peter Nyigei for the support he gave me throughout my education.

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LIST OF ABREVIATIONS AND ACRONYMS

ALP – Alkaline phosphatase

ALT – Alanine amino-transferase

CNS- Central nervous system

DVPMP- Department of Veterinary Pathology, Microbiology and Parasitology

GABA- gamma-aminobutyric acid

KPHC- Kenya Population and Housing Census

MoLD- Ministry of Livestock Development

UoN_ University of Nairobi

ABSTRACT

The rabbit is one of the major livestock kept by small scale farmers in many parts of Kenya mainly because of increase in awareness of the advantages offered by the enterprise. However, rabbit industry is constrained by many factors, diseases being major among others. Mange is the second most important disease affecting rabbits. Despite this, there are no records on prevalence and practices on control of rabbit mange in Kenya. Additionally, there are no specific drugs against rabbit mange in Kenya. The aim of the present study was to determine the prevalence, risk factors, control strategies of rabbit mange and efficacy of commonly used anti-mange drugs in Kiambu and Nyeri counties, central Kenya. A cross sectional study using semi-structured questionnaires complimented with observational data sheets and sample collection was undertaken in June and July 2016. A total of 97 rabbit farms were visited in both counties and 171 samples collected from rabbits with clinical signs of mange. The most common clinical signs of mange as reported by farmers were scratching (39.88%), wounds (25.51%), crusts (21.11%) and head tilting (13.49%). Ear scabs (36.3%), alopecia (24%), scratching (11.7%), crusts (8.8%), and dandruff (1.8%) and wounds on the skin (0.6%) were encountered during clinical examination. *Psoroptes cuniculi* was the only mite isolated from 49.5% of the farms during the baseline survey. The overall mange prevalence was 49.5%. Fleas (*Ctenocephalides canis*) were also isolated from 5 farms. Inappropriate use of treatment options by farmers, poor maintenance of hygiene in rabbit houses and sourcing of breeding stock from other farmers were identified as potential risk factors for mange mite infestation in rabbits. The most common treatment options used by farmers against mange were ivermectin (25%), carbaryl (16%) and liquid paraffin (12%). Controlled laboratory and field trials were done to determine the efficacy of anti-mange agents commonly used by farmers in Kiambu and Nyeri counties. In the controlled laboratory trial, a total of 24 rabbits were recruited for the study. Twenty were mange-infested while 4 were mange-free. The mange-infested

rabbits were randomly placed into 5 treatment groups (G1, G2, G3, G4 and G5) each consisting of 4 rabbits. The 4 mange-free rabbits formed the negative control group (G6). Rabbits in G1 were treated with ivermectin (0.4mg/kg) at an interval of 14 days, G2 were given a combination of carbaryl and liquid paraffin applied every other day until the lesions cleared. G3 were treated with 5 drops of liquid paraffin applied daily till the lesions cleared, G4 were treated with selamectin (6 mg/kg) applied once on the skin behind the neck. G5 served as positive control and were given 5 drops of distilled water applied topically on their ears while G6 served as negative control rabbits. Lesions were scored daily on a scale of 0-4. Ear scabs were collected weekly up to day 28 to check the viability of the mites. Rabbit weights were also taken weekly during the study period. The efficacy of anti-mange mite agents in a field trial were tested in 140 naturally infested rabbits. Results confirmed ivermectin, selamectin, liquid paraffin, carbaryl-liquid paraffin combination and carbaryl alone to be effective against rabbit mange as manifested by reduced lesion scores and lack of viable mites by the end of the trial. There was a significant difference ($p<0.05$) in lesion scores between positive control and other treatment groups. Mange is a major challenge to rabbit farming in Kenya, therefore, it is recommended that farmers and animal health workers be informed on methods of its control. Present study revealed that maintenance of hygiene in the hutches, isolation of newly purchased rabbits to observe for signs of mange and treatment of mange infested rabbits to be the best methods of controlling mange. Ivermectin, selamectin, liquid paraffin and carbaryl were confirmed to be effective against rabbit mange. Farmers are encouraged to use liquid paraffin as the first option as it is cost effective and easy to administer relative to other treatment option.

CHAPTER ONE

1.0 INTRODUCTION

Poverty levels in the African continent is very high (World Bank, 2008). This goes hand in hand with the rapid increase in population of Africa (Carl, 2012). With these, there has been a need to look for easy and cheaper means of producing food (Onifade *et al*., 1999). Rabbits have been identified as the most sustainable means of producing high quality animal proteins in developing countries (Onifade *et al*., 1999). This is because of the advantages of rabbits which include high rate of reproduction, early maturity, rapid growth rate, genetic diversity, affordable management cost, high efficiency in feed conversion and efficient utilization of space (Lukefahr and Cheeke, 1990). Additionally rabbit compete less with human for feed as they can be fed well on kitchen waste and excess from vegetable gardens and they adapt easily to various ecologocal environment (Onifade *et al*., 2008). Rabbit meat is highly nutritious. It is a fine grained meat with high protein level, low fat content, low cholestrol and is highly palatable. This is important in Kenya where there is rise in lifestyle related diseases (Borter and Mwanza, 2011).

Rabbit production has been demonstrated to alleviate poverty in developing countries including Kenya (Oseni *et al*., 2008). Rabbit industry in Kenya has grown markedly over the years unlike in the past where it was left to youth clubs, self help groups, women, government training centres and institutions (Hungu *et al*., 2013). According to the Directorate of Livestock Research and Marketing, the current rabbit population in Kenya is about 875, 465 (Hungu, personal communication, 2015). Previous studies have attributed this growth to government promotions of rabbit industry, decrease in land size holdings in high potential areas and increase in awareness of the advantages of rabbits among farmers (Borter and Mwanza, 2011; Serem *et al*., 2013). However, rabbit production in Kenya is faced by many challenges and diseases have been pointed as the

most important (Borter and Mwanza, 2011; Hungu *et al*., 2013; Serem *et al*., 2013; Okumu *et al*., 2015). Okumu *et al*. (2015), reported th at diseases of the digestive system as the most important cause of mortalities and morbidities in rabbit farms followed by ear canker (otic acarosis). The most important digestive tract disease is coccidiosis with prevalence of intestinal coccidiosis at 29.5% and hepatic coccidiosis at 11.48% while, prevalence of ear canker was 16.39% (Okumu *et al*., 2015). Sarcoptic and psoroptic mange have been reported as the most common skin conditions of rabbits in Kenya (Aleri *et al*., 2012). They cause economic losses in rabbit farming through weight loss and rarely mortality when complicated by secondary bacterial infections (Eshar, 2010). Recent study by Okumu *et al*. (2015) reported that farmers neither control nor treat rabbit mange in their farms but previously a retrospective study by Aleri *et al*., 2012 based on University of Nairobi Small Animal Clinic records reported it to be treated using ivermectin. This is an extrapolation from what is recommended for pets but the efficacy, safety and the most effective dosages of this drug has not been determined. This study was designed to address this gap through the following objectives.

1.1 Objectives

1.1.1 General objective

- The overall objective of the study was to determine available control strategies, prevalence and efficacy of commonly used treatment options against mange of domestic rabbits in Kiambu and Nyeri counties, Kenya

1.1.2 Specific objectives

The specific objectives of the study were:

- To determine prevalence and available control strategies against mange of domestic rabbits in small holder production systems in Kiambu and Nyeri counties
- To determine the efficacy of anti-mange agents against natural mite infestations of domestic rabbits under laboratory conditions
- To determine the efficacy of anti-mange agents against natural mite infestations of domestic rabbits under field conditions.

1.2 Hypothesis

The study was based on the null hypothesis that prevalence of domestic rabbit mange in Kiambu and Nyeri is low and currently used control strategies are not effective.

1.3 Justification

Micro-livestock species like rabbits have been used successfully in poverty alleviation programs in Africa (Oseni, 2012). Smallholder rabbit production units have contributed to food security in developing countries (Lukefahr and Cheeke, 1991a). In Kenya, rabbit industry is one of the fastest growing micro-livestock industry. However, it is constrained by challenges such as inadequate supply of breeding stock, management support systems, markets and disease burden. Diseases cause morbidities and mortalities of rabbits leading to economic losses (Borter and Mwanza, 2011; Hungu *et al*., 2013; Serem *et al*., 2013; Okumu *et al*., 2015). There are limited studies on diseases of rabbits and none has been focused on rabbit mange. According to Okumu *et al*., 2015, mange in general and psoroptic mange in particular is the second most important disease of rabbits with a prevalence of 16.39%. Sarcoptic mange is also frequently diagnosed in Kenya but its prevalence has not been documented. Past studies on disease of rabbits have not determined the efficacy of common treatments of rabbit mange in Kenya. Drugs currently used in treatment and control of

rabbit mange are borrowed from what is recommended for pets (Aleri *et al*., 2012). The efficacy, safety and exact dosages of these drugs have not been determined. This study aims at determining the prevalence of rabbit mange and the efficacy of commonly used therapeutic agents against mange mites.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Rabbit industry in Kenya

Rabbit farming in Kenya was introduced by missionaries in central Kenya but popularization in other parts of the country failed because of socio-cultural issues. For a long time, it was left to youth groups, women, self-help groups, schools and government training centres (MoLD, 2004). Over years this has changed and rabbit industry in Kenya has grown markedly (Borter and Mwanza, 2011; Hungu *et al*., 2013). Previous studies have attributed this to decrease in land size holdings in high potential areas as rabbits require less space and feed resources, vibrant rabbit production promotions by the government and rise in awareness of advantages of rabbit production among farmers (Borter and Mwanza, 2011; Hungu *et al*., 2013; Okumu *et al*., 2015). The advantages of rabbit production as described by Lukefahr and Cheeke (1990) include; high reproduction rate, early maturity, rapid growth rate, genetic diversity, efficiency in feed conversion and economic utilization of space. Rabbits also compete less with human being for food unlike other animals like chicken and pigs (Borter and Mwanza, 2011). Rabbit meat is highly nutritious, it is a white meat high in protein and low in fat content substituting easily chicken meat and fish in most recipes. It is also easy to digest, hence, good for babies, old people and people with digestive disorders. Additionally rabbits are highly adaptable animals. They are easy to manage and they require low capital investment (Oseni and Lukefahr, 2014). Apart from being kept for meat, rabbits can be used for research in laboratories, can be kept for fur which is used for making garments and they can also provide manure to be used in fertilizing farms (Moreki, 2007).

Despite the growth of rabbit industry in Kenya, there are many challenges facing it and the most important is disease.

2.2 Constraints of rabbit production in Kenya

Major challenges affecting rabbit industry in Africa are unfavorable policies hindering development of sustainable smallholder rabbit programs and unfavorable environmental conditions like heat stress, poor management which include poor nutrition and improper housing among others, diseases, parasites and socio-cultural issues of not eating rabbit meat in some regions of Africa (Oseni and Lukefahr, 2014). Heat stress is the major challenge in the tropics and arid areas. It lowers feed intake, reduces growth rate, reduces fertility and increases kit mortality (El-Raffa, 2004). According to previous studies by other workers (Mailu *et al*., 2012; Hungu *et al*., 2013; Serem *et al*., 2013; Okumu *et al*., 2015), challenges facing rabbit industry in Kenya include; diseases, lack of market for rabbits, poor husbandry practices and limited extension services on rabbit farming. Other constraints include: lack of quality breeding stock due to few multiplication centers making farmers to resort to sourcing their breeding stocks from neighbors which increases the chances of inbreeding, insufficient funds, high cost of rabbit feeds and poor record keeping by farmers. Due to this, farmers are unable to determine main production parameters like production costs, efficiency and performance. This leads to overpricing of rabbits which impact negatively on their competition with other meats like poultry (Mailu *et al*., 2012).

2.3 Diseases of rabbits

Rabbits are affected by parasitic, bacterial, viral, fungal and nutritional diseases and also diseases caused by miscellaneous agents like trauma and toxins (Martino and Luzi, 2008; Percy and Barthold, 2008).The most common rabbit diseases affect digestive, respiratory and cutaneous systems (McClure, 2011). In Kenya, diseases have been identified to be among the major constraints hindering rabbit production (Hungu *et al*., 2013; Serem *et al*., 2013; Okumu *et al*., 2015). A study by Okumu *et al*. 2015 reported coccidiosis, mucoid enteropathy and parasitic

conditions especially ear canker and mange as the major diseases of rabbits. Other conditions reported include; cheyletiellosis, abscesses, pneumonia, helminthiasis, flea infestation and sore hock (Okumu *et al*. 2015).

2.3.1 Parasitism of rabbits

Rabbits are affected by both endo- (helminths and protozoa) and ecto-parasites. Helminths affecting rabbits include nematodes like *Obeliscoides cuniculi*, *Nematodirus leporis*, *Trichostrongylus calcaratus, Passalurus ambiguus, Dermatoxys veligera,* and *Trichuris leporis.* Cestodes affecting rabbits include *Cittotaenia variabilis* in which rabbit is the definitive host, canine tapeworms *Taenia pisiformis* and *T. serialis* in which rabbit is the intermediate host and trematodes include *Fasciola hepatica* where rabbits serve as the intermediate host (http://netvet.wustl.edu/species/rabbits/rabparas.txt). Protozoan parasites affecting rabbits are *Eimeria* spp., *Toxoplasma cuniculi, Sarcocystis cuniculi, Encephalitozoon cuniculi, Chilomastix cuniculi, Giardia duodenalis, Monocercomonas cuniculi, Retortamonas cuniculi* and *Entamoeba cuniculi.* Most of these parasites are not pathogenic and only few cause clinical diseases in rabbits (http://netvet.wustl.edu/species/rabbits/rabparas.txt). Ectoparasites of rabbits include lice, fleas, ticks and mites among others.

2.3.1.1 Endoparasites

2.3.1.1.1 Taenia serialis and Taenia pisiformis

Rabbits are intermediate hosts of *T. serialis* and *T. pisiformis* whose larval stages are commonly found attached to mesenteries. Their young larvae leave white meandering subcapsular tracts as they migrate through the liver (Mayer, 2016). Infection of rabbits with *T. pisisformis* has been demonstrated by Betancourt-Alonso *et al*. (2011) to cause behavioural changes in rabbits. Infected

rabbits spent more time lying down and this predispose them to predation, a form of transmission induced by the parasite as it is transmitted to the definitive host to complete its life cycle (Klein, 2003). Additionally, *T. pisiformis* metacestodes have been reported by Anderson *et al*. (1981) to make large cavities in host tissues and organs hence making the host to require a lot of metabolic resources to survive and induce immune defense. *Taenia pisiformis* metacestodes are also located on abdominal and thoracic organs, hence interfering with their functions as they compress their muscles (Anderson *et al*., 1981).

Clinico-pathologically, infection with *T. pisisformis* leads to increase in leukocytes (mainly heterophils), total bilirubin, Alanine amino transferase and Alkaline phosphatase. At post-mortem, metacestodes and liver lesions are observed (Betancourt-Alonso *et al*., 2011).

2.3.1.1.2 Passalurus ambiguus

Passalurus ambiguus is the rabbit pinworm. It is a cosmopolitan parasite living in cecum or anterior colon and is transmitted through ingestion of contaminated feed or water. It is not economically important but is upsetting to rabbit owners (Mayer, 2016). They are diagnosed during fecal examination to find their eggs or during necropsy where adults can be seen (Mayer, 2016).

2.3.1.1.3 Baylisascaris procyonis

Is the common roundworm of raccoon but it has been reported to cause fatal central nervous system (CNS) disease in domestic rabbits by Kazacos *et al*. (1983). Affected rabbits show signs of torticollis, tremors, ataxia and loss of balance. White nodules representing larval granulomas are seen on the epicardium, endocardium and liver serosa. Multifocal myocarditis, hemorrhagic tracts, necrosis, inflammation of the liver, eosinophilic myositis, focal nephritis and mild interstitial

pneumonia are observed. In the brain, multifocal areas of necrosis and inflammation in the cerebrum, cerebellum, midbrain and medulla are seen. The parasite is thought to be transmitted through contaminated straw from a barn used by raccoons (Kazacos *et al*., 1983).

2.3.1.1.4 Coccidia

Rabbits are infested by coccidia of genera *Cryptosporidium, Toxoplama, Besnoitia, Sarcocystis* and *Eimeria* (Pakandl, 2009). Of these, *Eimeria* spp. are the most common cause of coccidiosis, a common and worldwide disease of rabbits (Mayer, 2016). There are two forms of coccidiosis in rabbits, hepatic coccidiosis caused by *E. stiedae* and intestinal coccidiosis caused by *E. intestinalis*, *E. magna, E. flavescens, E. media, E. perforans, E. coecicola*, *E. exigua,* E. *irresidua, E. piriformis* and *E. vejdovskyi* (Pakandl, 2009). These species of *Eimeria* are divided into five groups based on their pathogenicity as follows; nonpathogenic (*E. coecicola*), slightly pathogenic (*E. perforans*, *E. exigua* and *E. vejdovskyi*), pathogenic (*E. media, E. magna, E. irresidua* and *E. piriformis*), highly pathogenic (*E. flavescens* and *E. intestialis*) and lastly those whose pathogenicity depends on the infective dose (*E. stiedae*). Severity of coccidiosis depends on infective dose, parasite species, immune status and age of the animal (Pakandl, 2009). Clinical signs of the disease depends on localization of the parasite (Sivajothi *et al*., 2014). Intestinal coccidiosis is characterized by diarrhea, melena, weight loss, reduced feed intake and sometimes mortality (Pakandl, 2009; Sivajothi *et al*., 2014).

2.3.1.2 Ectoparasites

2.3.1.2.1 Lice

Lice are obligate ectoparasites of mammals and birds and are placed in two suborders orders Mallophaga (chewing lice) and Anoplura (sucking lice) (Price and Graham, 1996). They are highly

host specific and all their developmental stages (i.e., egg, 3 nymphal instars and adult) occur on the host and they can't survive off the host (Price and Graham 1996). Rabbits are infested by the hematophagous louse, genus *Haemodipsus* and seven species have been described in different parts of the world. These include: *H. africanus* in southern Africa, *H. brachylagi* and *H. setoni* in North America, *H. conformalis* in central Asia, *H. leporis* and *H. lyriocephalus* in Eurasia and *H. ventricosus* in Europe (Durden and Musser 1994; Durden and Rausch, 2007). Some of these species have been introduced in other regions i.e., *H. ventricosus* is now cosmopolitan, *H. lyriocephalus* has been introduced into New Zealand by European hare and is also present in scrub hares in South Africa. *Haemodipsus setoni* has been reported in South Africa and Eurasia (Durden and Rausch, 2007). Lice infestation in rabbits is manifested clinically as weight loss, pruritus, irritability, dermatitis, skin necrosis, secondary bacterial infection, and anemia in heavy infestations (Price and Graham 1996; Sant and Rowland, 2009). Healthy animals remove most of its lice by self-grooming (Murray, 1990). *Haemodipsus ventricosus* is a vector of *Francisiella tularemia* which is zoonotic and causes tularemia (Durden, 2002). Lice infestation is diagnosed by demonstration of eggs or adults on the skin or hair and can be treated with macrocyclic lactones like selamectin or ivermectin (Sant and Rowland, 2009).

2.3.1.2.2 Ticks

Ticks are obligate ectoparasites of mammals, reptiles, birds and amphipians and have a worldwide distribution. They belong to the Phylum Arthropoda, Class Arachnida, Sub-class Acari and Order Ixodida. Two families are important as vectors of diseases in both animals and humans namely, Argasidae and Ixodidae. They feed on animals leading to decrease in production, irritation, reduction in quality of hides and skins and anemia and sometimes death, when they feed in large numbers (Liyanaarachchi *et al*., 2013).

The genera of ixodid ticks affecting rabbits are *Rhipicephalus*, *Amblyoma* and *Haemophysalis* while argasids are *Otobius* and *Ornithodoros*. Different tick species infest different lagomorphs due to habitat preference of the host and preference of the tick (Horak and Fourie, 1991). Twenty five (25) species of ixodid ticks have been recovered from lagomorphs in South Africa (Horak and Williams, 1986; Horak *et al*., 1991) and in Sri Lanka, Liyanaarachchi *et al*., (2013) recovered *R. sanguineus, R. haemophysaloides, H. bispinosa* and *H. intermedia* in domestic rabbits.

The most common argasid tick affecting rabbits is *Otobius lagophilus*. All the stages are found on rabbits where they feed on lymph secretions. The ticks are mostly found on ears, the area between the ears, neck and dewlap of female rabbits (van Praag, 2010).

Treatment of tick infestation is done using ivermectin at 0.4mg/kg if infestation is severe but if ticks are few they can be removed carefully with forceps and killed by immersing in alcohol or acaricide solution (van Praag, 2010).

2.3.1.2.3 Fleas

Fleas are small, laterally flattened wingless insects who act as vectors of many pathogens like *Yersinia pestis, Rickettsia typhi* and *R. prowazekii* and *Bartonella* spp. which causes diseases in humans (Bitam *et al*., 2010; Eisen and Gage, 2012). Fleas can also transmit myoxomatosis virus to rabbits. *Ctenocephalides canis* is the intermediate host of *Dipylidium caninum* which can infect humans (Durden and Hinkle, 2009). Fleas infest a wide range of mammals and birds as they have low host specificity (Blagburn and Dryden, 2009). *Ctenophalides canis, C. felis, Spilopsyllus cuniculi, Pulex irritans* and *Echidnophaga gallinacea* have been reported to infest rabbits (Cooke 1990;Sant and Rowland, 2009 ; Frank *et al*., 2013). In Kenya, flea infestation in rabbits is rare and

the most common species reported are *C. canis* and *C. felis* and *S. cuniculi* by Okumu in his desertation. *Spilopsyllus* spp. infests outdoor rabbits (Sant and Rowland, 2009).

Fleas have a worldwide distribution and they are more important in tropical and subtropical regions where they are present throughout the year due to favorable environmental conditions (Cruz-Vazquez *et al*., 2001). Their distribution is favored by high humidity and moderate temperatures (Cooke, 1990). Flea larvae require more than 70% relative humidity for survival and growth while, adult fleas are intolerant to hot and dry air (Cooke, 1990).

Infested rabbits may show any of the following signs; scratching, licking, self-biting, visible bite marks or evidence of fleas (i.e., flea dirt, alopecia, scales, and pale mucous membranes in anemic rabbits). Fleas are controlled using imidacloprid or permethrin or selamectin (Sant,and Rowland, 2009). Phenylpyrozole (a pesticide that exert direct excitatory effects on the nervous system) is contraindicated in rabbits as it has been associated with death. Flea collars are not recommended as they irritate and cause burning on the skin (van Praag, 2010). Treatment of the environment with boric acid or acaricides is also important as eggs, larvae and pupae develop in the environment and some adults are found on the environment (van Praag, 2010; Sant and Rowland, 2009).

2.3.1.2.4 Mites

2.3.1.2.4.1 *Psoroptes cuniculi*

Psoroptes cuniculi is a non-burrowing mite in the family Psoroptidae and is also called ear canker mite. It causes ear canker (otic acarosis) in rabbits. It is the most common parasite of rabbits in the world and infests primarily the ears (Ulutas *et al*., 2005). *Psoroptes cuniculi* lives on the external auricular meatus where it feeds mainly on serous exudate, skin secretions and blood (Perruci *et al*., 2005). Their mouth parts are adapted for feeding on the surface of the skin; they

abrade the stratum corneum with their chelicerae ingesting lipids and other dermal substances. The host reacts to the mites by developing localised perivascular dermatitis and edema. Blood are ingested by mites as a result of small hemorrhages at abraided surfaces of the skin. In advanced cases or in older sick and untreated animals, the parasite colonizes other parts of the body like head, neck, legs, ventral abdomen and perianal region (Acar *et al*., 2007). All developmental stages occur in the host and the parasite lives its entire life under the margin of scabs formed at infested sites. They deposit their eggs there which hatch in 4 days and the life cycle takes about 3 weeks (van Praag, 2010).

Psoroptes cuniculi can also infest goats, sheep, horses and occasionally deer, antelope and laboratory guinea pigs. It has also been reported to be zoonotic by Swarnakar *et al.* (2014) in India. The researchers found *P. cuniculi* infestation had spread to the animal attendant, his family and the supervisor of the rabbit farm.

Psoroptic mange is highly contagious and can spread easily by direct contact between infested and uninfested rabbits or indirectly through formites as the mites can stay off the host for 21 days (Sant and Rowland, 2009).The disease is more prevalent during the cold season and subside during warmer seasons. Ear canker has been reported in many countries which include: USA (Yeatts, 1994), Italy (Fichi *et al*., 2007), Korea (Eo and Kwon, 2010) and Kenya (Aleri *et al*., 2012).

Lesions occur primarily on the ears and the clinical signs include: intense pruritus, head shaking, erythema and crusty lesions on the external ear canal and internal surface of the pinnae, ear drooping occur in extreme cases where crusty lesions are conspicuous in thickness. There is also malodorous discharges in the external ear canal and pain on palpation of the ear (Rowland and Sant 2009; Swarnakar *et al*., 2014). When the animal scratches the affected sites, blood oozes out

predisposing the animal to secondary bacterial infection complicating the situation further and can lead to death. Emaciation and deafness may also occur (Swarnakar *et al*., 2014).

The following lesions may be observed; papules, thickening ear auricle, hair cast and crusts of coagulated serum in the ear canal, hyperemia and ulcers on the skin. Hyperkeratosis and hair follicles hyperplasia are seen on histopathology (Tehrani *et al*., 2011).

2.3.1.2.4.2 *Sarcoptes scabiei*

Sarcoptes scabiei is a cosmopolitan burrowing mite inhabiting epidermal part of the skin causing sarcoptic mange in animals and humans (Eshar, 2010). It causes transient itching dermatitis in humans (Hengge *et al*., 2006; van Praag, 2010). Sarcoptic mange is an important disease of wild and farmed animals (Durdane *et al.,* 2010). It is a common skin condition in domestic animals in Kenya and this has been attributed to the favorable tropical climate (Aleri *et al*. 2012). The species affecting rabbits is *S. scabiei* variety *cuniculi* and spread rapidly from one rabbit to another through nymphs and larvae that live on the surface of the skin. Adult females make tunnels on the skin where they lay eggs, a maximum of 50 eggs in her life time (van Praag, 2010). The mites feed on lymph and slough epithelial cells (Eshar 2010). Affected rabbits show severe pruritis so they scratch themselves and this leads to alopecia and skin abrasions which can develop to serous encrustations and secondary bacterial dermatitis, scales can develop and erythema and in chronic cases there is anorexia, lethargy, loss of body condition and death may occur (van Praag, 2010). Lesions first appear on lips and nose then head and neck and sometimes around the genitalia. Eshar (2010) observed distal limbs and nasal hyperkeratosis, toe nail deformation and elongation and crustation on dorsal surfaces of the paws. Wounds can be complicated by secondary bacterial

infections. Clinical pathological changes include anemia, leucopenia and hepatic or renal amyloidosis in severe cases (Eshar, 2010; van Praaq, 2010).

Young animals of less than 1 year of age and immunosuppressed animals are more susceptible to the disease. Immunosuppression can be contributed by early weaning, relocation, sudden diet change, overcrowding and improper handling (Eshar, 2010).

2.3.1.2.4.3 *Notoedres cati*

Notoedres cati is a burrowing mite affecting cats but it occasionally infest rabbits causing mange like *Sarcoptes* spp. (van Praag, 2010). Clinically its infestation is characterized by pruritus, alopecia, scab and crust formation and lichenification (Panigrahi *et al*., 2016). The lesions first appear on the nose then later spread to frontal region, lips, eyelids, base of the ears, dorsal aspect of forelimbs, lateral aspect of hind limbs and external genitalia. Abdominal skin can be affected in extreme cases (Panigrahi *et al*., 2016). *Notoedres cati* var. *cuniculi* has been reported in India where Angora and New Zealand rabbits were infested concurrently by this mite and *S. scabiae* var. *cuniculi* (Darzi *et al*., 2007).

2.3.1.2.4.4 *Cheyletiella parasitovorax*

Cheyletiellosis is a common parasitic disease of rabbits (Mederle, 2010). *Cheyletiella parasitivorax* affects rabbits, dogs and cats and is zoonotic causing transient dermatitis in humans (Mederle, 2010). *Cheyletiella* spp. are large mites ranging from 270 - 540µm and are very mobile and hence can be seen moving on the skin hence the name ‘moving dandruff‘(Mellgren and Bergwall, 2008; Sant and Rowland, 2009). Adults have 4 pairs of legs with distal combs. They are non-burrowing and live in close association with the keratin layer of the skin where they feed on surface epithelia, debris and lymph. Development from egg to adult mite takes place on the same

host. Female lay eggs and stick them to the hair about 3-4mm above the skin. Life cycle takes about 5 weeks under optimal conditions (van Praag, 2010; Mederle, 2010). Females can live off the host for 10 days without feeding but larvae, nymphs and males can't live off the host for more than 2 days (Mederle, 2010). Clinical signs of the disease which include pruritus, scratching, crusting, scales on the skin and alopecia are manifested in immunocompromised rabbits (Mellgren and Bergwall, 2008; Mederle, 2010; Sant and Rowland, 2009). Lesions are mainly seen on withers but may extend to the back and ventral abdomen (Mellgren and Bergwall, 2008).

2.3.1.2.4.5 *Leporacarus gibbus*

Leporacarus gibbus formerly *Listrophorous gibbus* is a fur mite belonging to the family Listrophoridae, order Astigmata. All stages of its life cycle occur on the rabbit. It affect distal one third of hair shaft mainly on the dorsum, abdomen and ventral part of the tail where it feeds on sebaceous secretions and skin debris (Kirwan *et al*., 1998). It causes pruritic dermatitis in animals and has been reported to be zoonotic (Dario and Domenico, 2014).

2.3.1.2.4.6 *Trombicula automnalis*

Trombicula automnalis is found on fur of rabbits that have free access to a yard. Female mites lay eggs in the soil where they hatch into larvae which move into grass and wait till a susceptible host is found. Only larvae will attack a rabbit, cat, dog or human and the parasite suck body fluids to engorge then fall down to complete its life cycle (van Praag, 2010).

2.3.1.2.4.7 *Dermanyssus gallinae*

Dermanyssus gallinae (red mite) is a mesostigmatic poultry mite and may accidentally be hosted by rabbits living in presence of birds. Larvae are usually found on the head of rabbits, neck and

shoulder regions, between the toes and in the perianal region. Infestations lead to intense pruritus and formation of macules and pustules. Scratching may lead to self-mutilation, wound and development of secondary bacterial infections (van Praag, 2010).

2.3.1.2.5 Diagnosis of mange infestation

Diagnosis of mange is based on clinical signs like alopecia, crusts on the skin, dermatitis and thickened skin and the demonstration of mites or their developmental stages in host skin scrapings (OIE, 2013).

Skin scrapings are collected from the edges of lesions by holding the scalpel blade at right angle to the skin or using skin scraping spatula and scraping off the outer surface of the skin. For burrowing mites deep scrapping is done until some blood oozes from the site while for surface mites superficial skin scraping is done and a drop of mineral oil or glycerol may be placed on the blade to help hold the skin scrapings during the procedure. Surface mites can also be collected using a vacuum cleaner fitted with an in-line filter (OIE, 2013). Ear mites can be detected using otoscope or cotton-tipped applicator can be used to swab the canal when ear mites are observed or suspected. Skin scrapings are mixed with 10% potassium hydroxide, stirred, centrifuged and supernatant discarded and few drops of the solution placed on slide and examined under a microscope for mites. Potassium hydroxide digest debris leaving mites intact for identification. Vacuumed material with the filter and ear swabs are also observed under a dissecting microscope for presence of mites. Mites are placed into their genus based on morphological characteristics. *Psoroptes cuniculi* are oval in shape and have pointed mouth parts and jointed pedicles with funnel-shaped suckers which differentiate them from other mites (Acar *et al*., 2007).

Sarcoptes scabiei are circular in shape with long pretarsi which have long unsegmented pedicels. Their legs are short and the 3rd and 4th pairs do not project beyond body margins. The anal opening is terminal and have fingerprint-like striations on the cuticle. *Notoedres* resembles *Sarcoptes* but they have the anus on dorsal surface of the body and are smaller in size. *Cheyletiella* are elongate rhomboidal mites with big palpal claws, M-shaped peritremes on dorsal surface of the mouthparts and comb-like appendages (OIE, 2013).

2.3.1.2.6 Factors predisposing rabbits to mange

2.3.1.2.6.1 Age

Young animals are more susceptible to mange as compared to adults especially where adult animals are kept together with young ones hence getting infestation through direct contact (Eshar, 2010; Elshahawy *et al*., 2016). Other studies have attributed this high susceptibility to the underdeveloped immunity of young animals (Awol *et al*., 2014).

2.3.1.2.6.2 Sex

Males hosts have a higher prevalence of mite infestation than females (Elshahawy *et al*., 2016). Cowan (1987), as cited by Elshahawy *et al*. (2016) attributed this to the higher contacts the males have with other rabbits than females because they are in charge of territory defense. In some areas also rabbit owners use one male for many flocks of rabbits (Elshahawy *et al*., 2016).

2.3.1.2.6.3 Breed

Some breeds of rabbits are more resistant to parasitic infections than others (Elshahawy *et al*., 2016). Elshahawy *et al*. (2016) reported a higher prevalence of mange infestation in English breed (30%) compared to California and Belgicie breeds which had a prevalence of 20%. A study by

Sondararajan and Iyue (2005) in India reported an incidence of mange mite infestation in Soviet Chinchilla rabbits to be 17.6% compared with White Giant and New Zealand White which were free of mange mite infestation.

2.3.1.2.6.4 Body condition

Animals in poor body condition have been demonstrated by many studies to be more susceptible to mange compared to those in good body condition (Feyera *et al*., 2015; Seid *et al*., 2016).

2.3.1.2.6.5 Hygiene

Poor hygiene due to low frequency of cleaning of animal houses has been associated with high prevalence of mite infestation (Souza *et al.*, 2008).

2.3.1.2.6.6 Contact with other animals

Mange is highly contagious and can spread easily by direct contact between sick and healthy rabbits or indirectly through formites (Sant and Rowland, 2009).

2.3.1.2.7 Control of mange

Maintaining hygiene in hutches is the best preventive measure in controlling diseases. To control mange in rabbitaries, infested rabbits should be isolated and their hutches cleaned and disinfected to prevent the spread of the disease. Newly purchased rabbits should also be isolated for two weeks and observed for mange infestation. Rabbits exhibiting mange should be treated to prevent the disease from spreading to other rabbits in the hutch.

Mange has been controlled using both chemotherapeutic and non-chemotherapeutic agents which include pyrethroids, organophosphates, sulphur-based compounds, benzyl benzoate solution and herbal preparations (Ulutas *et al.*, 2005).

2.3.1.2.7.1 Non-chemotherapeutic control

Mange has been controlled exclusively using chemical drugs like avermectins but repeated use of chemical acaricides may induce resistance in mites and may cause environmental contamination and residues in meat (Traina *et al*., 2005). To avoid this, botanical acaricides and other non-chemical remedies like paraffin oil, garlic extract, lemon, hydrogen peroxide and yoghurt among others on mites have been identified.

2.3.1.2.7.1.1 Garlic extract

Garlic extract has acaricidal activity. It has been demonstrated by Seddiek *et al*. (2008) to be effective against *P. cuniculi* with effectiveness comparative to that of ivermectin when given orally and topically simultaneously. The acaricidal activity has been attributed to alicin substance on garlic extract on the parasite (Anthony *et al.,* 2005). Natural garlic extract is a cheap, efficient and safe alternative method of controlling mange (Seddiek *et al*., 2008).Treatment of rabbits with garlic extract leads to an increase in body weight of rabbits as garlic extract apart from being anti-mange, is also antibacterial, anthelmintic and antifungal (Seddiek *et al.,* 2008).

2.3.1.2.7.1.2 Plant essential oils

Essential oils have been shown to have acaricidal activity on *P. cuniculi*, and *Sarcoptes scabiei* (Hanafi *et al*., 2010). Linalool and terpenoids have the highest acaricidal activity (Walton *et al*., 2004; Perruci *et al*., 2005). The most common naturally occuring compounds in essential oils are limonene, α-pinene, p-cymene and geraniol with geraniol and limonene having the highest acaricidal activity (Traina *et al.,* 2005).

2.3.1.2.7.1.3 Paraffin oil

Paraffin oil has been used in controlling mange by applying topically on the affected part of skin. It acts by suffocating the mites (Desoky, 2015).

2.3.1.2.7.2 Chemotherapeutic control

2.3.1.2.7.2.1 Macrocyclic lactones

Macrocyclic lactones are the avermectins and milbemycins derived from a fungus, *Streptomyces avermitilis*. Rabbit mange has been reported in many studies to be treated successfully with macrocyclic lactones like ivermectin (Okerman, 1994; Aleri *et al*., 2012), eprinomectin (Ulutas *et al*., 2005), doramectin (Vovyoda *et al.,* 2005) and selamectin (Kurtedede *et al.,* 2007; Mc Tier *et al*., 2005), moxidectin (Mellgren and Bergwall, 2010). They are potent antiparasitic agents at low dose level. Although they are not ovicidal, they persist in tissues for a long time and kill larvae emerging from eggs (van Praag, 2010). They are well absorbed when administered per os or parenterally i.e., subcutaneously but topical administration varies. They act by blocking the transmission of electrical activity in nerves and muscle cells by stimulating the release and binding of gamma-aminobutyric acid (GABA) at nerve endings (Martin *et al*., 2013), hence, causing an influx of chloride ions into the cells leading to hyperpolarisation and subsequent paralysis of the neuromuscular system leading to death of the parasite. In Turkey, it was found that ivermectin and doramectin (given three times at a dosage of 400µg/kg after every 80 hours) were effective against mange with ivermectin having more rapid effect than doramectin (Durdane *et al*. 2010).

2.3.1.2.7.2.2 Other chemotherapeutic agents used against mange

In addition to the above, fur mites have been treated successfully with topical permethrin (Birke *et al*., 2009), carbamates, benzyl benzoate and sulphur based compounds i.e., selenium sulphide shampoo (Fayed *et al*., 2008).

Benzyl benzoate and permethrin have less ovicidal activity on arthropod eggs hence multiple applications are required to have cure (Roos *et al*., 2001). Permethrin is a pyrethroid insecticide which act by reacting with voltage-gated sodium channels causing paralysis of the insect (Dragon *et al.*, 2014). Carbamates are inhibitors of acetyl choline esterases. They do not accumulate in tissues of mammals, they are rapidly metaboilised to I-naphthol which is non-toxic.

2.3.1.2.7.2.3 Selamectin

Is a spot-on formulation which is colorless to yellow solution found in single dose tubes. It is effective for ectoparasitic treatment in animals. It has been licensed for use in dogs and is effective against ectoparasites of rabbits. Mac Tier *et al*. (2003) demonstrated it to be safe and effective in treatment of rabbit mange. Traditional routes of administration like injection, bathing or instillation of acaricide into ear canal is time-consuming, difficult, distressing and painful hence selamectin applied as a spot-on formulation (dosage: 6-18 mg/kg) in a single occasion for ectoparasite control is safe and effective way of treating animals with minimal stress and maximum owner compliance (Fisher *et al*., 2007).

CHAPTER THREE

3.0 MATERIALS AND METHODS

The study was done in three phases namely, baseline survey, laboratory trial and field trial.

3.1 Baseline survey

3.1.1 Study area

The study was done between June and July 2016 in Kiambu and Nyeri counties (**Fig. 1**).

3.1.1.1 Kiambu County

Kiambu County is in the former Central Province of Kenya. It borders Nairobi and Kajiado counties to the south, Machakos county to the East, Muranga county to the North and North East, Nyandarua county to the North West and Nakuru county to the West. It occupies an area of 2,543.5 km^2 and has a population of 1,766,058 people (KPHC, 2009). The main economic activity is agriculture (mixed farming). It is a warm county with average temperatures ranging from 12 to18^0c and an average rainfall of 1200 mm per year.

3.1.1.2 Nyeri County

Covers an area of 3,337.1 km^2 and has a population estimated at 693,558 people (KPHC, 2009). It borders Kirinyaga and Meru counties to the East, Laikipia county to the North, Nyandarua county to the west and Murang'a county to the south. The major industry in the county is agriculture and it receives an average rainfall of between 550 and 1500 mm per year. Its temperatures range from 12^0c to 27^0c.

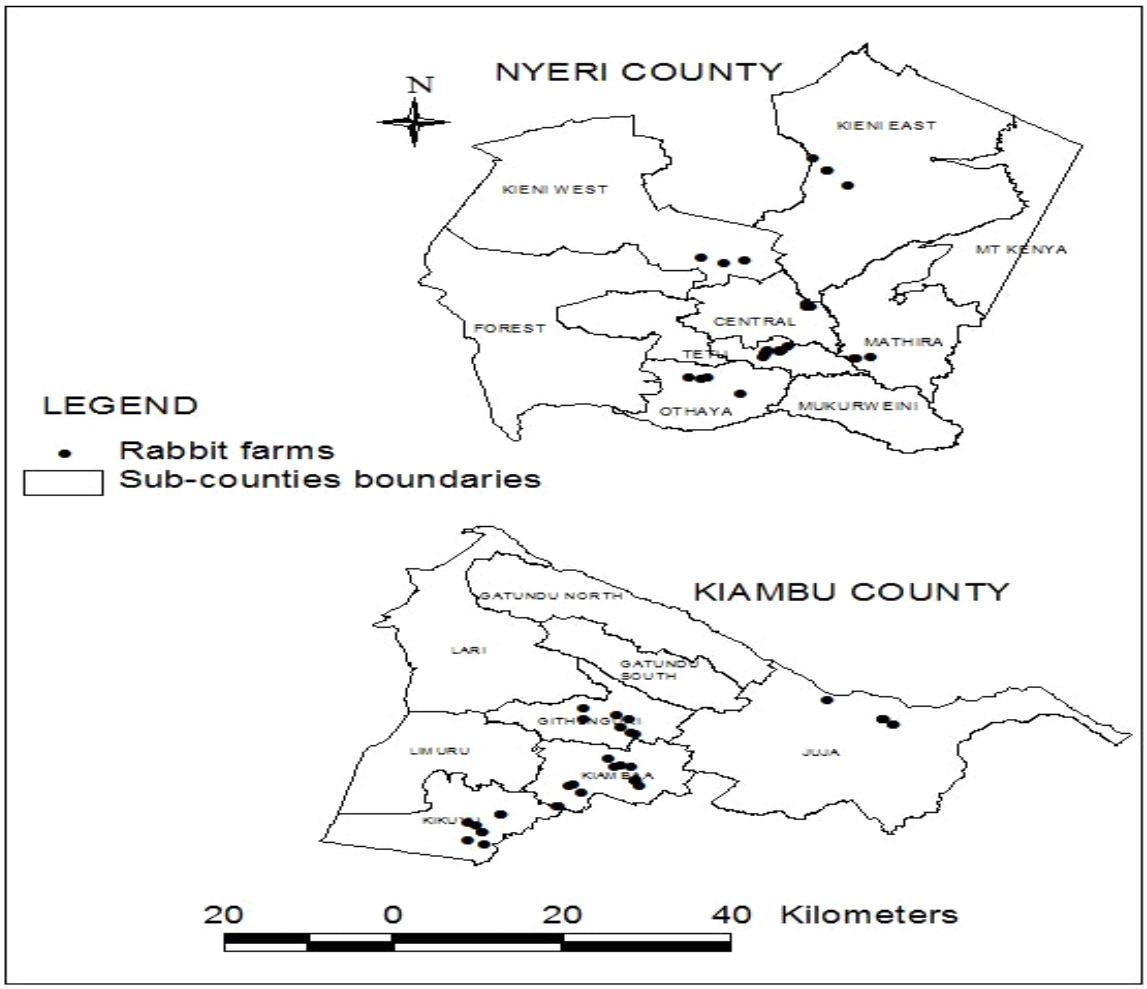

Figure 1: Map showing sub-counties and rabbit farms sampled in Kiambu and Nyeri counties

3.1.2 Selection of study farms

Ninety seven rabbit farms ,49 and 48 in Kiambu and Nyeri counties, respectively (**Fig. 1**) were selected randomly from lists of rabbit farmers maintained by directors of livestock and veterinary services in the two counties.

3.1.3 Selection of study rabbits

A minimum of 309 rabbits were to be examined from the selected farms calculated as described by Martin *et al*. 1987 based on rabbit population and established prevalence of mange in Kenya (Okumu *et al*., 2015).

$n=Z^2X\ PQ/L^2$

Where; n= number of rabbits to be examined

P= a priori estimate of disease prevalence (27.

Z= the value of Z that provides 95% confidence interval (1.96)

Q= 1-P

L= desired precision (allowable error) at 0.05

However, a larger number of rabbit (1768) were examined in the two counties because of the high number of registered rabbit farmers and the difference in number of rabbits kept in each farm.

3.1.4 Baseline survey on status of small holder production and available control strategies against rabbit mange infestation

This was done by undertaking a cross sectional study involving visits to the selected farms where semi-structured questionnaires (**Appendix 1**) were administered. The rabbit owner or attendant was interviewed on the farm and the information was recorded in the questionnaire. This was used to identify clinical signs of mange previously encountered in each farm, risk factors associated with mange and control strategies used by farmers against mange in their farms. The most common drugs used by rabbit farmers to control mange were determined using the semi structured questionnaire to farmers together with questionnaire to selected agroveterinary outlets (**Appendix 2**) in Kiambu and Nyeri counties. This was complimented by clinical observation data sheet (**Appendix 3**) in which clinical status of the rabbits and the hygiene status in the rabbit housing and the surrounding environment were recorded.

3.1.5 Clinical examination of rabbits and sample collection

Ten percent of the rabbits (bucks, does, weaners and kits) in each farm with many rabbits (>10) were randomly selected for examination for signs of mange and other ectoparasites, but where they were few (<10), which was the case in most farms across the two counties all were examined. Samples were collected from rabbits which had clinical signs associated with mange namely crusts, dandruff, ear scabs, hair loss, head tilting,pruritus and wounds on the skin. Both deep and superficial skin scrapings were taken using a sterile surgical blade and ear scabs were collected carefully using a pair of clean disinfected thumb forceps. Resulting wounds were disinfected with cotton swabs soaked in iodine.

3.1.6 Handling and transportation of collected samples

Skin scrapings and ear scabs were collected into disposable fecal pots with tight lids and other ectoparasites such as fleas and ticks were put in disposable universal bottles with 70% ethanol. Samples were labeled with farm and rabbit code numbers. All the samples were taken to the University of Nairobi (UoN) Parasitology laboratory in the Department of Veterinary Pathology, Microbiology and Parasitology (VPMP), for processing and analysis.

3.1.7 Sample analysis

Collected samples (skin scrapings and ear scabs) were digested in 10% potassium hydroxide to get rid of debris. Small amount of skin scrapings or ear scabs were put on a clean microscope slide using a pair of thumb forceps and 10% potassium hydroxide was added and left for few minutes. A mounting needle was used to spread the sample on the microscope slide and a cover slip was placed and observed under a light microscope (40x or 100x) for presence of mites. Mites were identified as described by OIE (2013). Other ectoparasites like fleas and ticks were identified under a microscope as described by Mathison and Pritt (2014).

3.2 Laboratory trial

3.2.1 Selection of study rabbits

The study was done in the Department of VPMP between June and July 2017. Before recruitment rabbit farms were visited and rabbits examined for signs of mange (presence of ear scabs, crusts, alopecia, dandruff). Samples (ear scabs and skin scrapings) were collected from rabbits with signs of mange and taken to the laboratory for confirmation of mite infestation. Irrespective of sex, age and breed, rabbits were recruited based on having clinical signs indicative of mange, mites

confirmed microscopically and they had not been treated with any acaricide in the last 30 days prior to the study.

3.2.3 Experimental rabbits

Twenty four rabbits, twenty (20) naturally infested with mange and four (4) mange-free were used. The mite infested rabbits were obtained from four rabbit farms in Ngong while the mange-free rabbits were obtained from the National Rabbit Breeding and Multiplication Center, Ngong. Recruited rabbits were transported to the Department of VPMP where they were housed in individual cages for males and females in groups of three. They were fed with commercial rabbit pellets from Unga Ltd. supplemented with hay. Water was given *ad libitum*. The twenty mange infested rabbits were placed randomly into 5 groups (G1, G2, G3, G4 and G5) of 4 rabbits each and the mange free ones were placed in group 6 (G6).

3.2.4 Animal welfare

The purchased rabbits for the controlled experiment were transported in plastic carriers, cages and crates to the Department of VPMP where they were allowed to acclimatize for three days. The carriage vehicle had a cabin fitted with sliding windows that allow aeration during transportation. The plastic carriers, cages and crates were secured with a rope to avoid sliding. In the animal house, rabbits were housed indoors in steel cages with galvanized sheet roof and spaced floor that allowed fecal material to collect into a receptacle at the bottom of the cage. Cages were fitted with a reticulated pipework for harvesting of urine. The house was cleaned and disinfected daily and fecal material disposed into a manure pit. Faculty of Veterinary Medicine Animal Welfare and Ethics Committee approved the study.

3.2.5 Handling and restraint of rabbits during clinical examination, weighing, administration of drugs and sample collection

Rabbits were lifted by slightly scuffing them and supporting the dorsum with the same arm while the other hand was used to support the body and the rear legs as described by Mitchel and Tully (2009). During clinical examination, sample collection and administration of drugs, a non-slip table surface was used to avoid sliding and injury and rabbits were restrained by applying a gentle downward pressure on the back. During weighing, the rabbit was lifted as described above and placed in a pre-weighed basket which was hanged in the weighing balance in order to take weight.

3.2.6 Examination of rabbits for mange mites

Before enrollment in the study, samples (ear scabs) were collected from the rabbits to confirm their infestation with *Psoroptes cuniculi*. They were collected carefully using a pair of thumb forceps for those with a lot of ear scabs and a sterile swab for those which had less ear scabs. Samples were collected on day 0, 7, 14, 21 and 28. Collected samples were taken to the laboratory where they were examined for presence or absence of mites and eggs.

3.2.7 Clinical examination

Examination of enrolled rabbits for signs of mange was done daily. They were allocated scores for severity of infestation on a scale of 0-4 as described by Arslan *et al*. (2014) whereby 0 was for ears that looked normal, 1 when lesions were within the ear canal, 2 where lesions were confined within the lower third of the ear, 3 when lesions were within the lower 2/3 of the ear and 4 for lesions that covers greater than 2/3 of the ear. Rabbits were weighed before treatment and weekly during the treatment period. Weight gain was calculated as weight at the end of experiment minus weight before treatment.

3.2.8 Treatment protocols

Three most commonly used anti-mange agents as identified from analyzed questionnaire data were ivermectin, carbaryl and liquid paraffin. The efficacy of these agents was determined using confirmed clinical cases of rabbit mange obtained from natural field infestations.

Group 1 were given ivermectin (Supermec®) 400µg/kg body weight sub-cutaneously twice at an interval of 14 days, group 2 were dusted with carbaryl (Dudu Dust®, Bayer, Germany) after applying 5 drops of liquid paraffin on the external ear canals after every 3 days for a period of 21 days, for group 3, 5 drops of liquid paraffin were applied on the lesions daily up to day 21, group 4 were given selamectin (Revolution®, Zoetis, USA) (standard drug) 6 mg/kg body weight topically at the base of the neck once. Group 5 served as positive control and were not treated but were given 5 drops of distilled water applied on the lesions daily while Group 6 were negative control and were mite-free and remained untreated.

Efficacy of the agents was based on disappearance of clinical signs of mange and absence of viable mites after microscopic examination. It was calculated as

$$\frac{\text{Number of infested animals before treatment} - \text{Number of infested animals after treatment}}{\text{Number of infested animals before treatment}} \times 100$$

3.3 Field trial

3.3.1 Study farms

The study was done in farms from Kiambu and Kikuyu sub-counties of Kiambu County between September and December, 2017. A total of eighteen farms which had positive cases of mange were selected with the assistance of livestock production officers in study sub-counties.

3.3.2 Experimental rabbits

A total of 140 rabbits were recruited irrespective of sex, age and breed. They were recruited based on having clinical signs indicative of mange, confirmed microscopically to have mites and had not been given any acaricide in the last 30 days before the study. The rabbits were placed randomly into 4 groups (1, 2, 3 and 4) of 35 rabbits each.

3.3.3 Clinical examination of experimental rabbits

Clinical examination of all enrolled rabbits for signs of mange (ear scabs, crusts, alopecia, dandruff) was done before treatment and after every three days after treatment up to day 28. They were given scores for severity of infestation on a scale of 0-4. Rabbits were weighed before treatment and weekly during the treatment period. Weight gain was calculated as weight at the end of experiment minus weight before treatment.

3.3.4 Parasitological examination of samples

This was done as detailed in the laboratory trial above and mites were categorized into their respective genera based on their morphological characteristics (OIE, 2013).

3.3.5 Treatment protocols

Group 1 were given ivermectin (Supermec®) 400µg/kg body weight sub-cutaneously twice at an interval of 14 days, group 2 were dusted with carbaryl (sevin) to cover the lesions after applying 5 drops of water on the external ear canals after every 3 days for a period of 21 days, group 3 was treated with 5 drops of liquid paraffin which were applied on the lesions after every three days up to day 21, Group 4 were treated with selamectin (Revolution®, Zoetis, USA) (standard drug) 6

mg/kg body weight topically at the base of the neck once. Effectiveness of the drugs was determined as described in the laboratory trial above.

3.4 Data management and analysis

Epidemiological data was entered into Ms Excel and exported to SPSS statistical software for determination of descriptive statistics (Andy, 2009). Means and frequencies were used to identify risk factors and farmer practices associated with mange and analysis of variance was used to test significance of risk factors on prevalence of mange. Prevalence was defined as the proportion of rabbits in a population which were positive for mage mites on sampling (Margolis *et al.*, 1982). Therapeutic data were analysed using Genstat. Analysis of variance was performed and significant differences of the means of the various treatment groups were illustrated by Bonferroni multiple comparison test. Results were given as mean ± SEM and significance levels of $p \leq 0.05$.

CHAPTER FOUR

4.0 RESULTS

4.1 Baseline survey

The study was carried out in 97 farms with 1768 rabbits, 49 farms in Kiambu County and 48 in Nyeri County. One hundred and seventy one skin samples were collected from rabbits examined.

4.1.1 Study farms' and farmers' information

Of the rabbit farmers visited, 80.4% were males and 19.6% were females (**Fig. 2**). Many of them were over 50 years old (69.1%) (**Fig. 3**) with main occupation being farming (59.8%) and business (19.6%) (**Fig. 4**). Over forty five percent (46.8%) of the study farms were more than one (1) acre in size, 30.9% were less than 0.25 acres, 6% range between 0.51 to 1 acres and 6% range between 0.26 to 0.5 acres (**Table 1**).

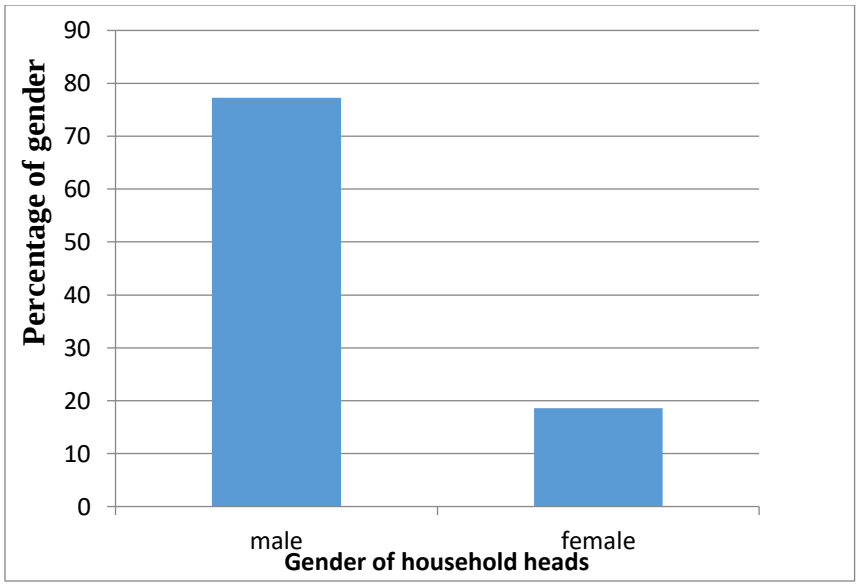

Figure 2: Gender of household heads of rabbit farms in Kiambu and Nyeri counties

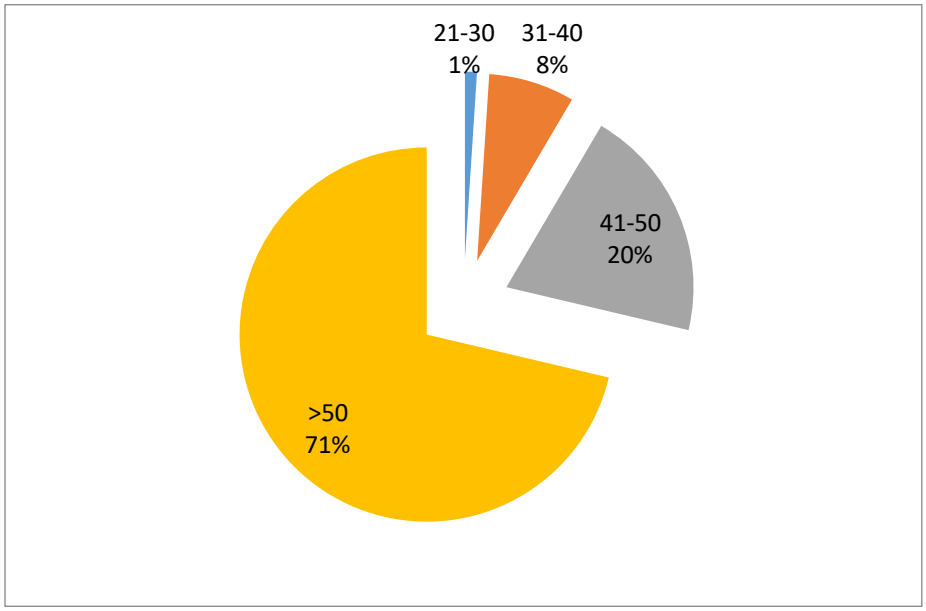

Figure 3: Age groups of household heads of rabbit farms in Kiambu and Nyeri counties

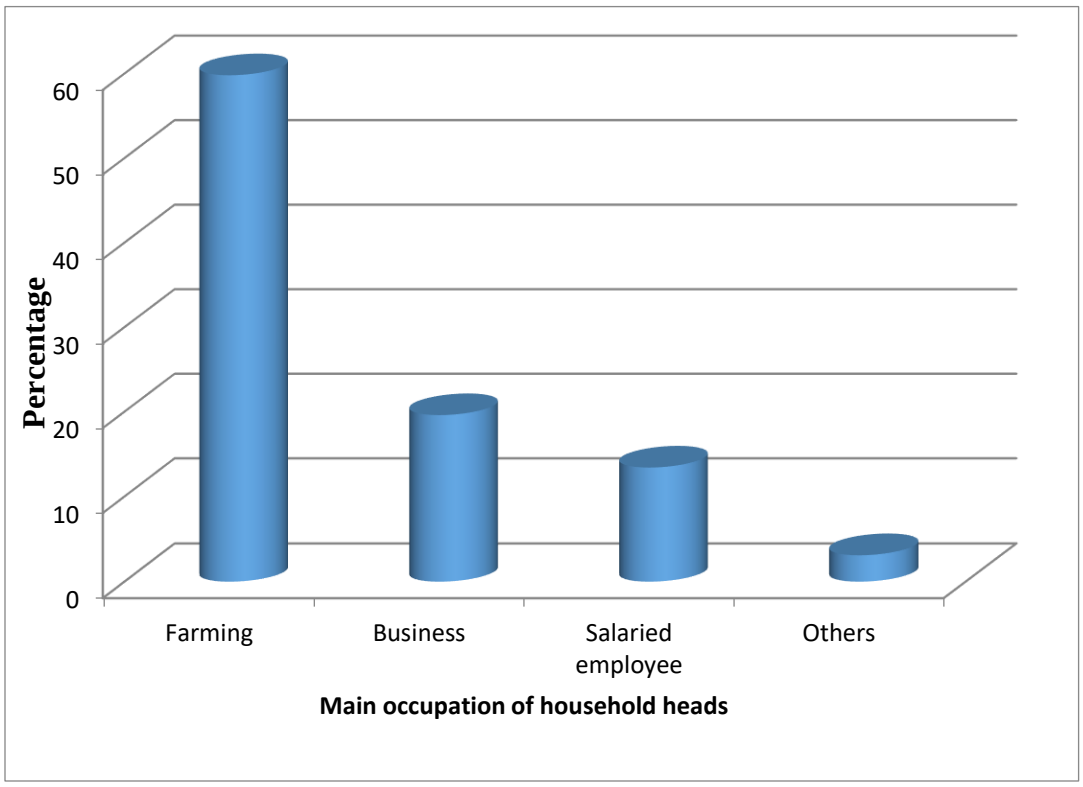

Figure 4: Main occupation of household heads of study farms in Kiambu

Table 1: Acreage of land owned by rabbit farmers in Kiambu and Nyeri counties

Acreage of farm	Frequency	Percentage (%)
Less than 0.25	29	30.9
0.26 - 0.5	6	6.4
0.51 - 1.0	15	16
More than 1.0	44	46.8

4.1.2 Rabbit production husbandry practices in Kiambu and Nyeri counties

4.1.2.1 Number of rabbits kept per farm

Over fifty percent (53.6%) of the farms had 1 to 10 rabbits, 18.6% had 11-20 rabbits, 13.4% had 21-30 rabbits, 8.2% had more than 40 rabbits and only 6.2% had 31-40 rabbits (**Table 2**). Most of these farms had mixed age groups of rabbits (kits (<1 month), weaners (1-4 months) and adults (>4 months)). Over ninety five percent (96.8%; 92/97) of the farms had does, 89.5% (85/97) had bucks, 48.4% (46/97) had weaners and 41.1% had kits (**Table 3**).

Table 2: Number of rabbits kept in study farms in Kiambu and Nyeri counties

Number of rabbits kept per farm	Frequency	Percentage
1 to 10	52	53.6
11 to 20	18	18.6
21 to 30	13	13.4
31 to 40	6	6.2
>40	8	8.2

Table 3: Age groups of rabbits kept by farmers in Kiambu and Nyeri counties

Age groups	**Number of farms (n=97)**	**Percentage**
Kits (<1 month)	39	41.1
Weaners (1-4 months)	46	48.4
Bucks (males>4 months)	85	89.5
Does (females>4 months)	92	96.8

4.1.2.2 Breeds of rabbits kept

The most common breeds of rabbits kept by farmers in the two counties were New Zealand White which was kept in 67 farms (25.4%) followed by cross breeds which were encountered in 64 farms (24.2%); California White (12.5%), Dutch (8.7%) and Flemish Giant (8.3%); Angora (2.3%) and French Earlop (2.7%). Less frequently kept breeds were categorized as others, which included; Rex, Kenya White and English breed among others (3.0%) (**Fig. 5**).

4.1.2.3 Source of first and subsequent breeding stock

Over fifty five percent (59.4%) of the farmers interviewed reported to get their starting stock from other farmers and only 14.2% got from government farms while the remaining got them from research institutions, contractual agreements, as gifts or inheritance; only a few (0.9%) imported breeding stock (**Figure 6**). Most farmers (43.8%) obtained subsequent breeding stock from their neighbors while 41.6 % used their own stock (**Figure7)**.

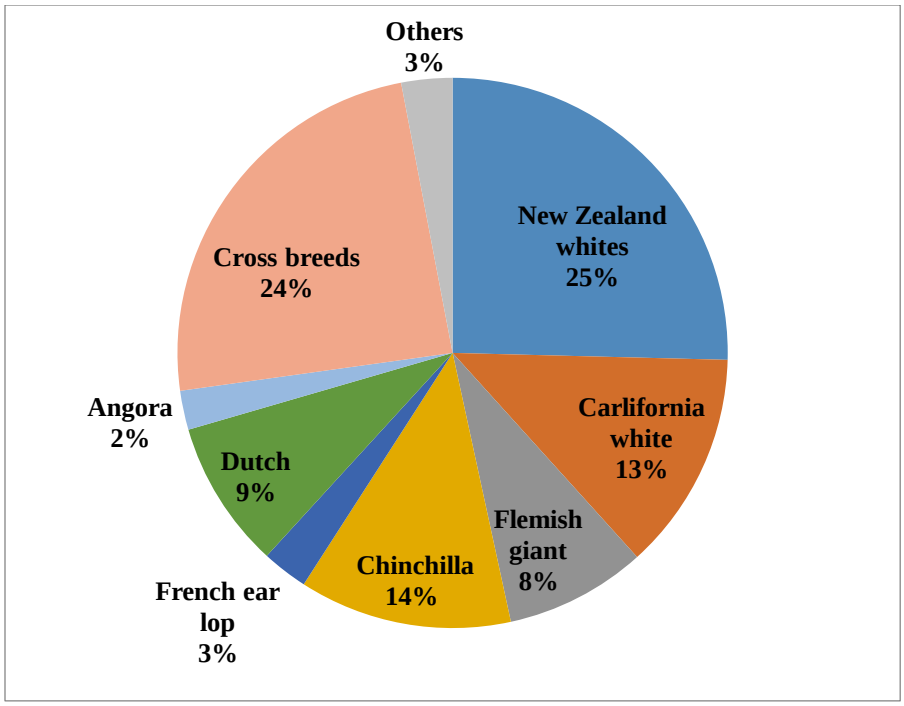

Figure 5: Breeds of rabbits kept by farmers in Kiambu and Nyeri counties

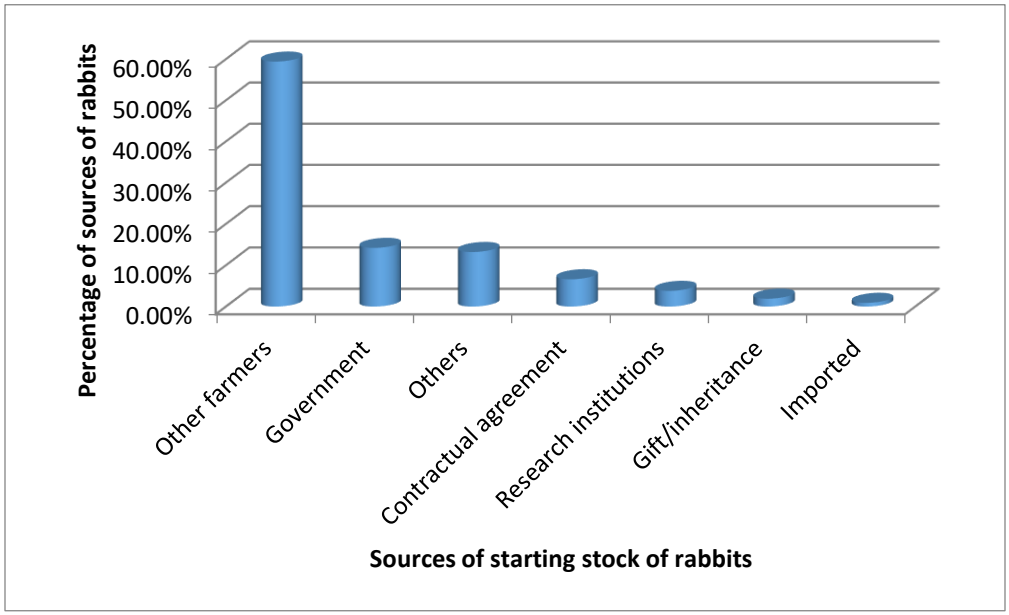

Figure 6: Sources of first stock of rabbits in Kiambu and Nyeri counties

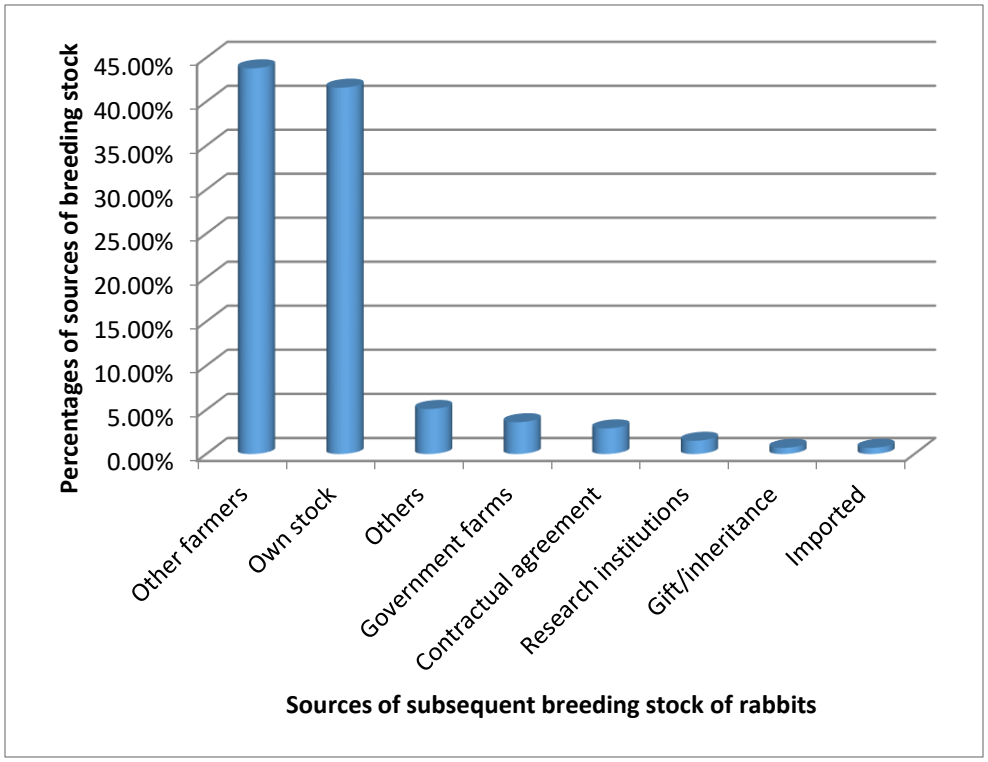

Figure 7: Sources of subsequent breeding stock of rabbits in Kiambu

4.1.2.4 Farmers' experience in rabbit keeping

Most farmers reported to have kept rabbit for more than 2 to 5 years (30 farmers, 30.9%) and more than 5 years (30 farmers, 30.9%), 29.9% of farmers had kept rabbits for 6 months to 2 years (29 farmers), and only a few 8.2% (8 farmers) had kept for less than 6 months (Figure 8).

4.1.2.5 Other animals kept by rabbit farmers

Majority of the farmers interviewed had other animals in their farms in addition to rabbit; 25.2% had chicken, 18.7% had cattle, 17.7% had sheep and goats, 16% had dogs, 14.6% had cats and 7.8% kept other animals which included ducks, geese, guinea fowls, pigs, bees among others (Figure 9).

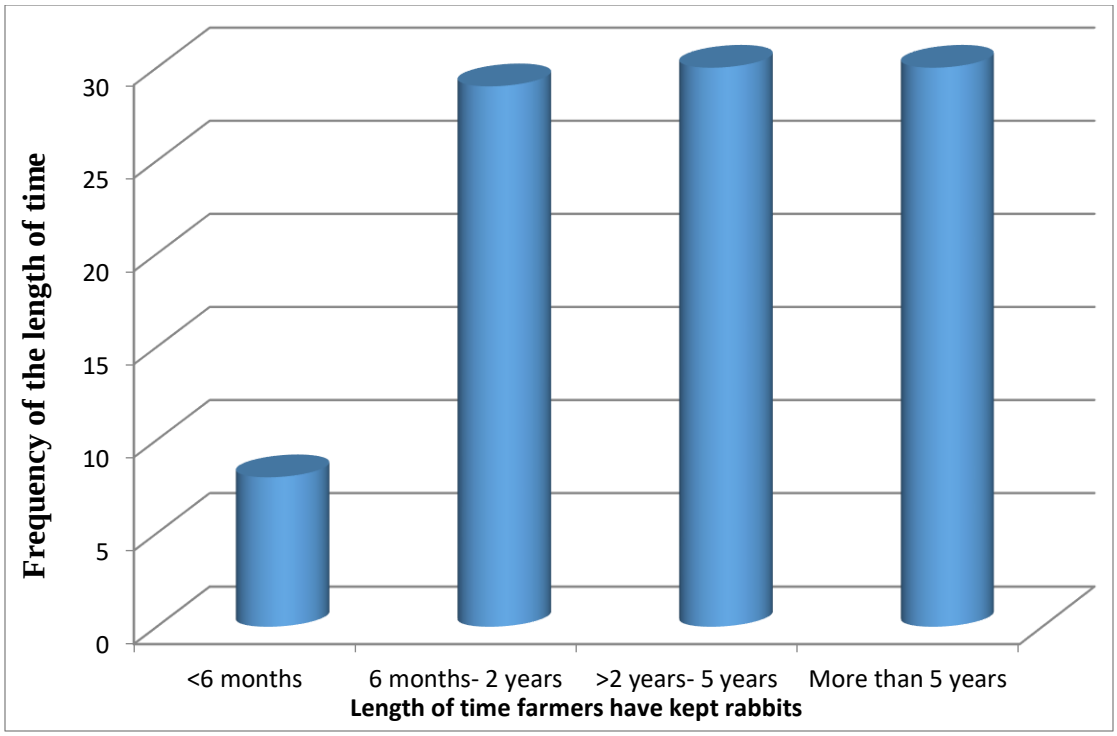

Figure 8: Duration farmers had kept rabbits in Kiambu and Nyeri counties

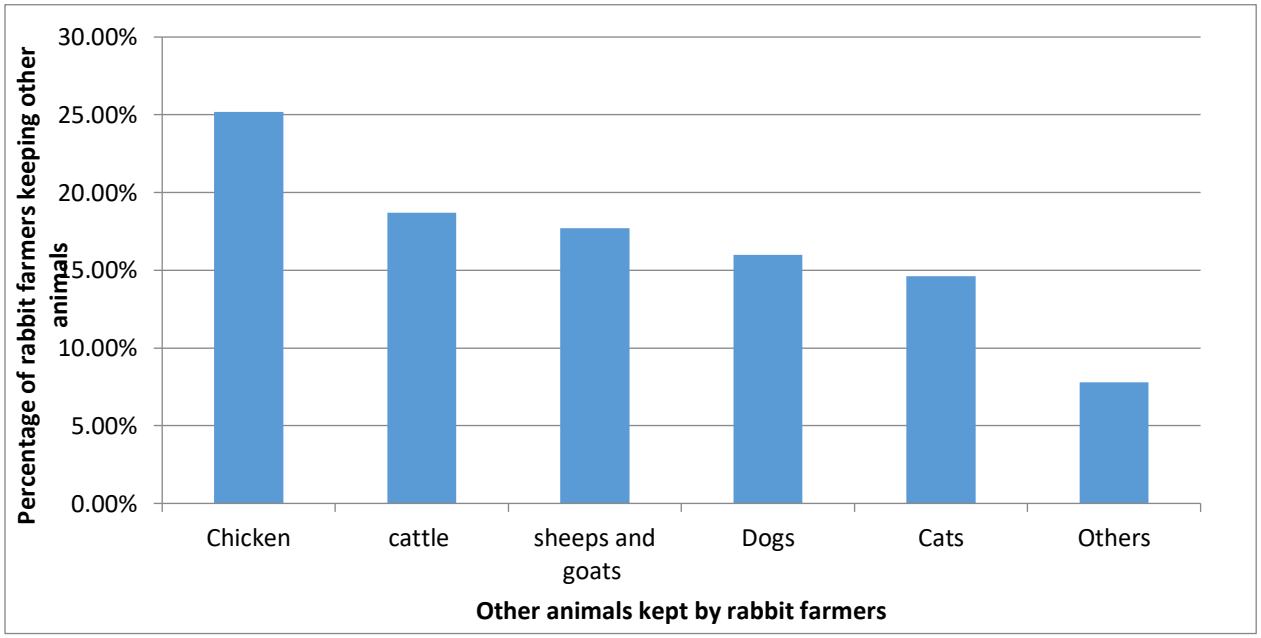

Figure 8: Other animals kept by rabbit farmers in Kiambu and Nyeri counties

4.1.3 Main reasons for keeping rabbits

Majority of the farmers (72%) in Kiambu and Nyeri counties reported to keep rabbit mainly as a source of income and food for their families (16%) and only 9% kept it as a hobby (**Fig. 10**).

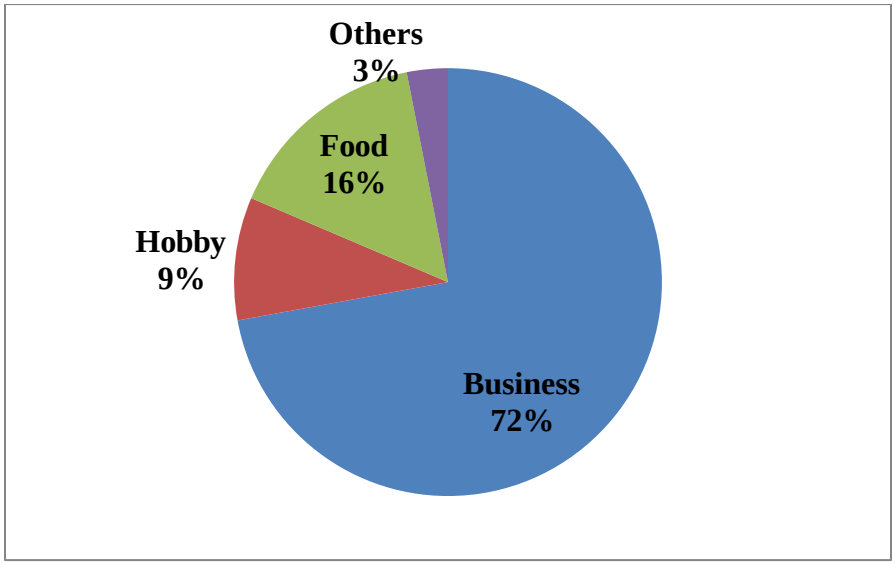

Figure 9: Main reasons for keeping rabbits in Kiambu and Nyeri counties

4.1.4 Housing

4.1.4.1 Type of housing units

Sixty six percent of the rabbit houses in the farms visited were outdoor while 34% were indoor. Rabbits were placed in individual cages or grouped according to age or sex and only few farmers were not grouping their rabbits. Most of the rabbits were reared outdoor in individual cages (23.3%), followed by those reared outdoor grouped according to age (18%) and outdoor grouped by sex (17.3%) Figure 11.

4.1.4.2 Type of floor in rabbit hutches

Over sixty percent (61.8%) of the rabbit hutches in the visited farms during the study had wooden floors and 33.3% had floors made of wire mesh. Only 3.9% and 1% had earthen and plastic floors, respectively (Figure 12).

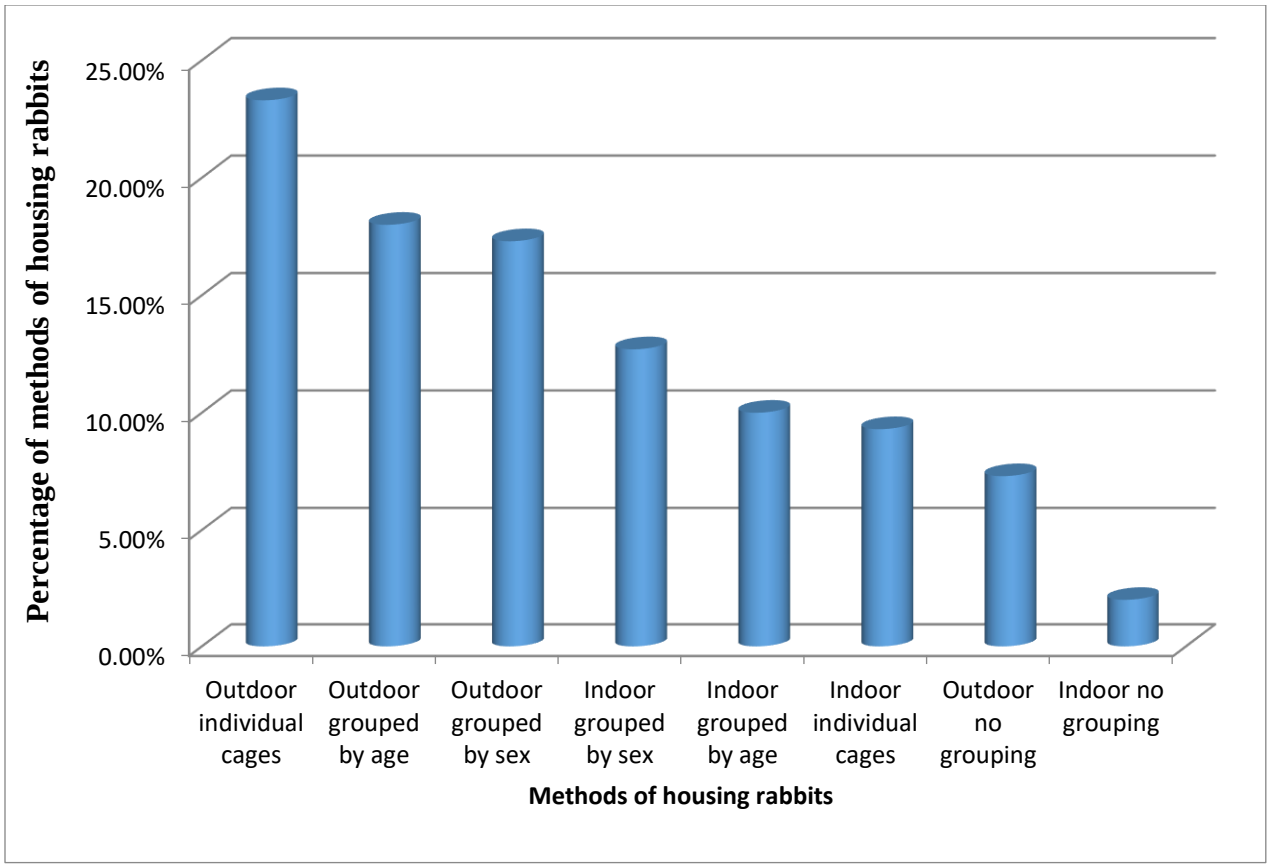

Figure 10: Methods of housing rabbits in Kiambu and Nyeri counties

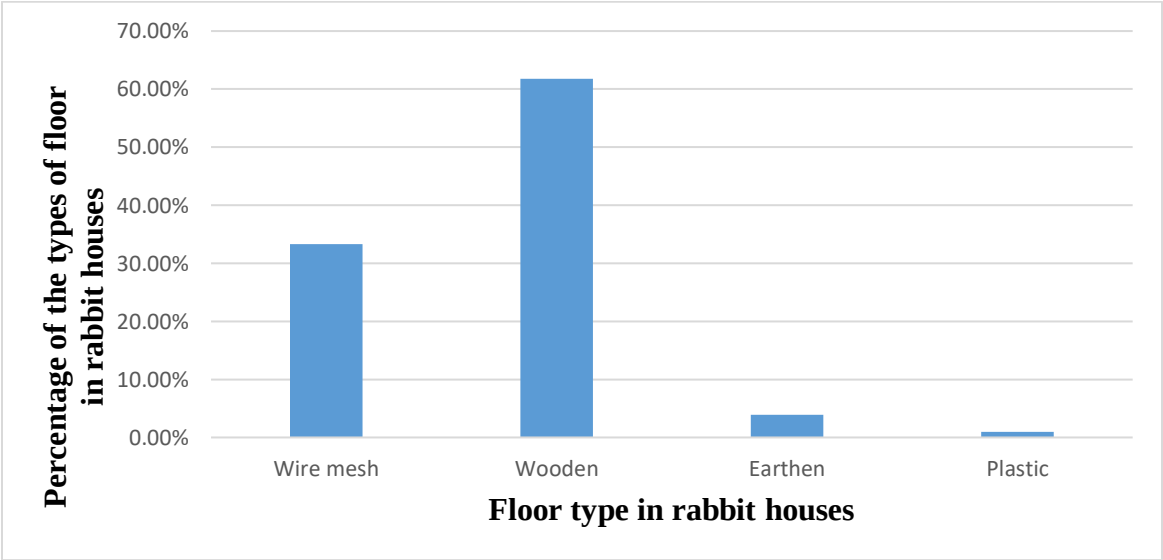

Figure 11: Floor types in rabbit hutches in Kiambu and Nyeri counties

4.1.4.3 Cleanness of rabbit houses

Majority of the farmers change beddings only in their rabbit hutches (74%) as a form of cleaning, 11% wash with water alone, 10% used water and disinfectants while cleaning and 5% fall under the category of others which include those who did not wash the hutches (Figure 13).

In terms of frequency of cleaning of rabbit houses majority of the farmers fall under the category of others and this include those who do not clean, clean only when dirty, or clean monthly among others.

4.1.5 Feeding

Of the farmers interviewed, 49% (50) reported to feed their rabbits with forage only while 42.2% (43) of the farmers used forage and commercial feed and only 8.8% (9) used commercial feed alone (Figure 14).

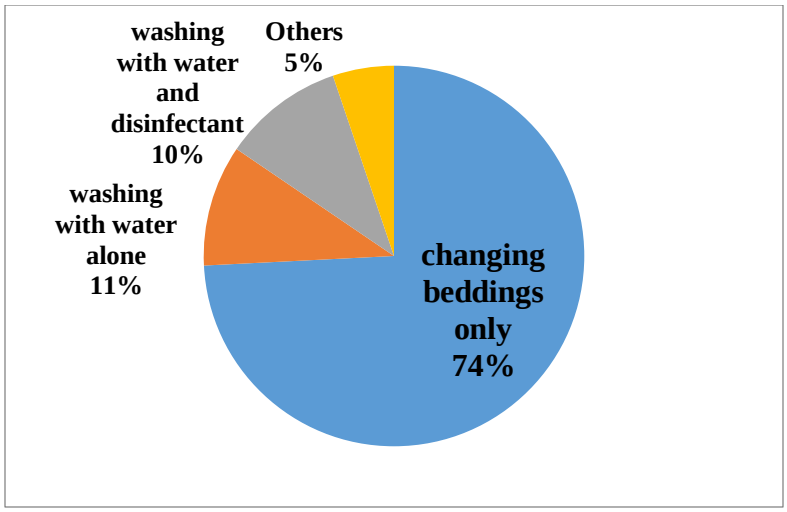

Figure 12: Methods of cleaning rabbit houses by farmers in study area

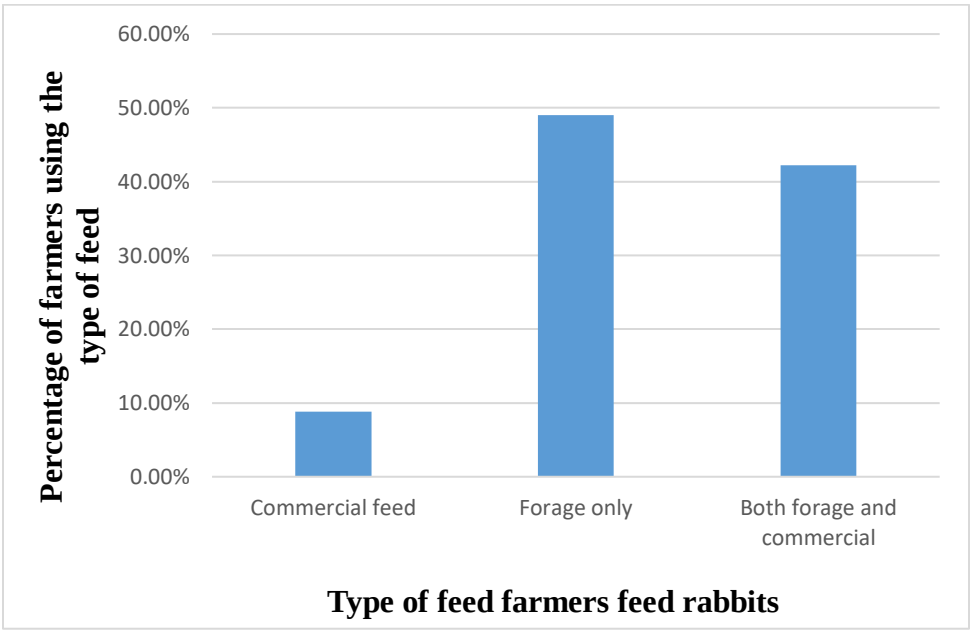

Figure 13: Types of feed used by farmers to feed rabbits in Kiambu and Nyeri counties

4.1.6 Clinical signs of ectoparastes of rabbits as reported by farmers

Majority of the farmers (79.4%) reported to have come across signs of ectoparasites in their rabbits which include; pruritus (39.9%), wounds (25.5%), crusts (21.1% and head tilting (13.5%) (Figure 15). They observed most of these signs in adult rabbits and in New Zealand White breeds.

4.1.7 Clinical signs of mange observed on clinical examination of rabbits

Mange was diagnosed in 66% of the farms visited. The most common clinical signs of mange encountered were presence of scabs on the ears (36.3%) (Figure 16) followed by hair loss (24%) (Figure 17), then scratching (11.7%), crusts (8.8%), dandruff (1.8%), head tilting (1.8%) and wounds on the skin (0.6%).

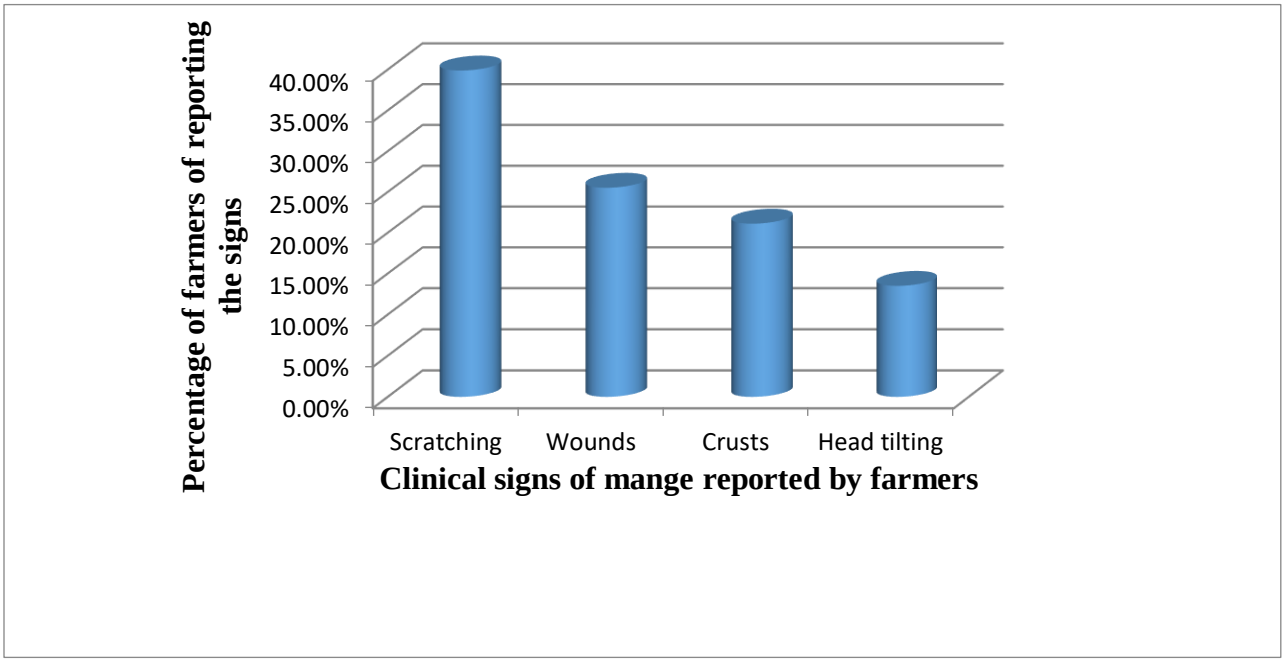

Figure 14 Clinical signs indicative of mange and other ectoparasites as reported by rabbit farmers in Kiambu and Nyeri counties

Figure 15: Ear scabs in a mange infested rabbit from one of the study farms in Kiambu County (arrow)

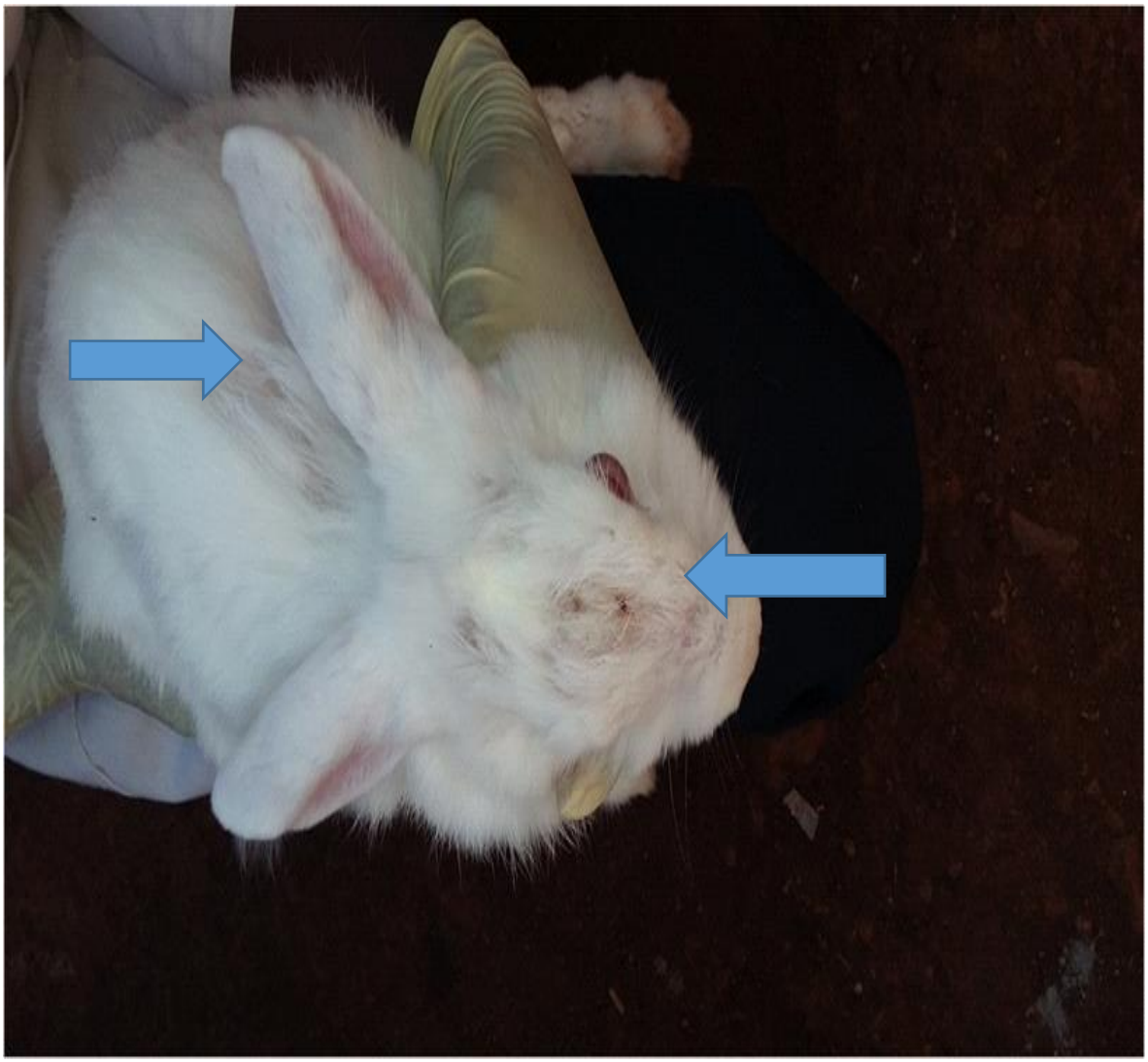

Figure 16: A rabbit from one of the study farms in Kiambu County with alopecia on the forehead and at the back (arrows)

4.1.8 Treatment and control of mange and other ectoparasites as reported by farmers

Majority of farmers reported to treat and a few 32.99% control mange in their farms. Many (42%) reported to treat for themselves rabbits when sick (Figure 18) with the majority (40%) relying on their own knowledge and information from others (21%) on use of therapeutic agents. Other farmers acquire information from veterinarians (19%), agrovets (11%) and 10% follow instructions from the manufacturer.

Farmers used chemotherapeutic and non-chemotherapeutic methods to control mites and other ecto-parasite infestations. Ivermectin (injection) (25%), carbaryl (16%) and tetracycline (14%) were the chemotherapeutic agents reported to be used commonly by farmers and mineral oil, liquid paraffin, used engine oil and ash were non-chemotherapeutic agents reported to be in use.

Many (50%) apply various options once, followed by those who apply once a month (26%) and few administer the regimes daily (5%), weekly (5%) and every two weeks (8%) **(**Figure 19**)**.

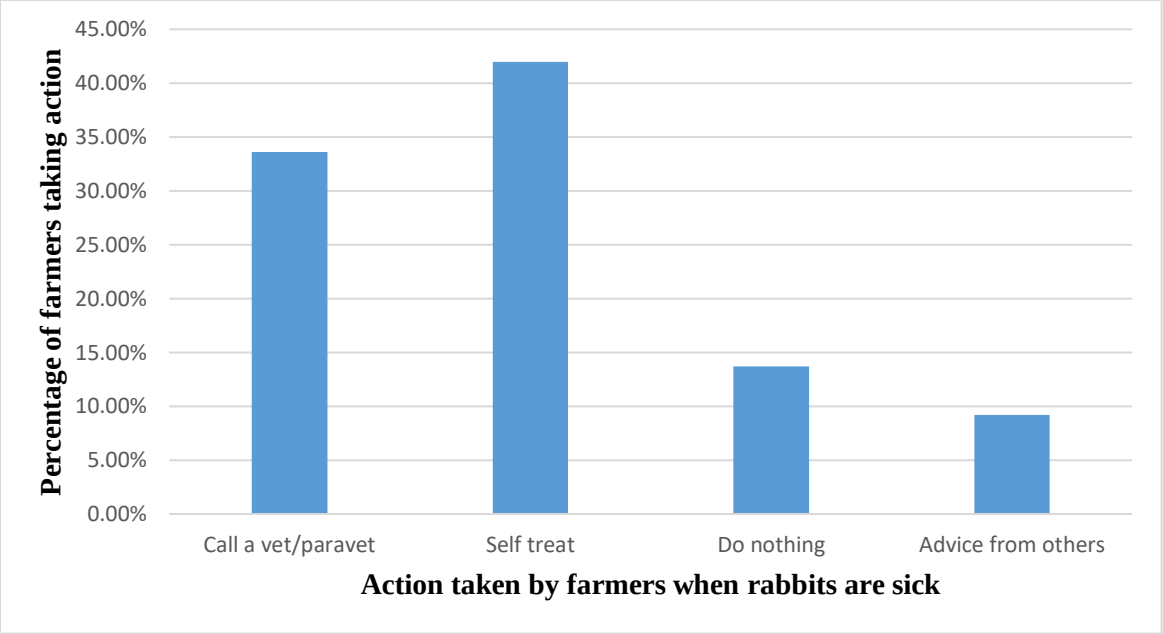

Figure 17: Management of sick rabbits by farmers in Kiambu and Nyeri counties

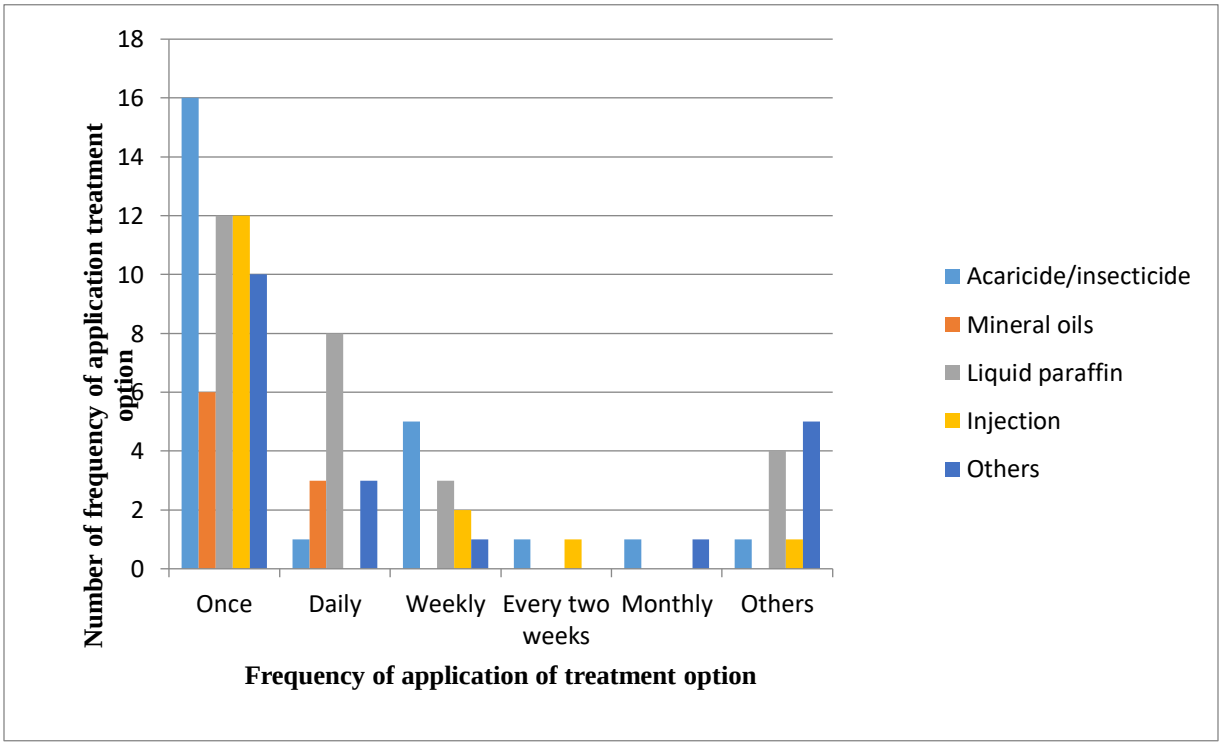

Figure 18: Frequencies of applications of various treatment options to revert clinical signs of mange and other ectoparasites as reported by farmers in Kiambu and Nyeri counties

4.1.8.1 Efficacies of treatment and prevention agents against mange and other ectoparasites as reported by farmers

Ninety four percent of farmers who used ivermectin reported it to be effective against mange mites and other ectoparasites and 81% of those who used carbaryl reported it to be efficacious. All those who use mineral oil reported it to be efficacious and 75% of those who control rodents reported it to be efficacious (Table 4).

4.1.9 Laboratory findings

4.1.9.1 Prevalence of rabbit mange in Kiambu and Nyeri counties

Psoroptes cuniculi was the only mite isolated from 49.5% of the farmers visited during the baseline survey. Regarding the number of samples 57.3% out of 171 samples processed for mites were positive for *P. cuniculi* (Figure 20). Prevalence was significantly ($p<0.05$) higher in Nyeri County (80%) relative to Kiambu County (41.6%).

Table 4: Percentage efficacy of various prevention options against mange as reported by rabbit farmers

EFFICACY STATUS	TREATMENT REGIMES				
	Carbaryl	**Liquid paraffin**	**Mineral oils**	**Ivermectin**	**Rodent control**
Efficacious	81	85	100	94	75
Not efficacious	3	6	0	0	13
Sometimes work	16	9	0	6	13
Total	100	100	100	100	100

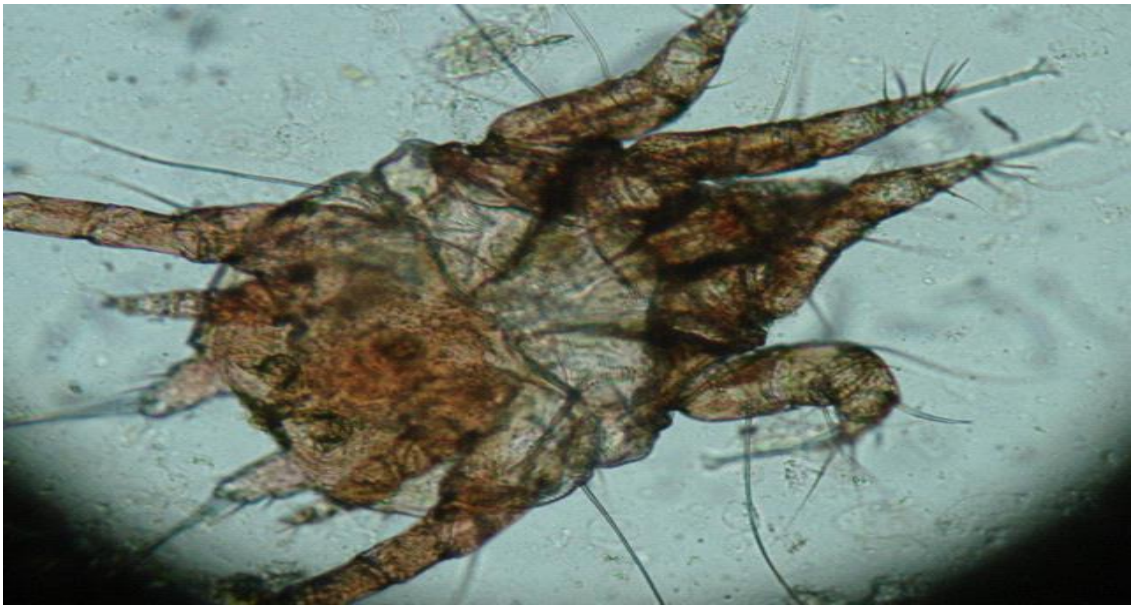

Figure 19: *Psoroptes cuniculi* isolated from ear scabs of a rabbit from one of the study farms

4.1.9.2 Risk factors for rabbit mange

4.1.9.2.1 Breed

Flemish Giant (71.4%) was the most susceptible breed to mange infestation during the study while Checkered Giant was the least susceptible (40%).

4.1.9.2.2 Sex

Prevalence of mange in females was slightly higher than that of males which were 60% and 61.2%, respectively. However, this difference was not statistically significant (**p>0.05**).

4.1.9.2.3 Age

The prevalence of mange in young rabbits (< 4 months) was higher (62.5%) than that of adult rabbits (>4 months) (55.1%). However, this difference was not statistically significant (**p>0.05**).

4.1.9.2.4 Source of breeding stock

Many farmers acquire their starting stock of rabbits (59.4%) and subsequent breeding rabbits (43.8%) from other farmers and had a high prevalence of mange in their rabbits. They had a mange prevalence of 47.6 % and 46.7%, respectively. Farmers in this study practiced borrowing of breeding bucks from neighbors.

4.1.9.3 Flea infestation

Out of 177 rabbits sampled for ectoparasites from 97 farms, 5 (2.82%) had fleas from 5 (5.15%) different farms. The fleas were seen below the abdomen, around the neck, at the back and ears.

The isolated flea was identified as *Ctenocephalides canis* **(**Figure 21**).**

Figure 20: *Ctenocephalides canis* isolated from rabbits in Kiambu and Nyeri counties

4.1.9.4 Tick infestation

Ticks of the genus *Rhipicephalus* formerly *Boophilu*s were isolated from one rabbit from one farm (1.03%).

4.2. Laboratory trial

4.2.1 Pre-treatment clinical state of infested rabbits

Clinical examination before treatment of infested rabbits revealed that they had overt signs of ear canker. They had scabs on their ears, were pruritic and had scratch marks and wounds on the affected areas. Out of twenty mite infested rabbits, four (20%) had severe infestation and were allocated a score 4, four (20%) had lesions within 2/3 of the auricle corresponding to a score 3, nine (45%) had lesions within the lower 2/3 of the ear and were allocated a score 2. Three rabbits (15%) had lesions confined to the ear canal and were allocated a score 1. One of the rabbits had pus and bad odour on the infested ears which is a sign of secondary bacterial infection and was treated with oxytetracycline injection and selamectin to combat the bacterial infection and mite infestation, respectively. One of the rabbits whose ears were full of scabs and were drooping also had scabs on the perianal area.

4.2.2 Effects of treatments on clinical signs of mange

Two (50%) out of four rabbits treated with ivermectin by day 14 and all of them (100%) by day 28 had no mange clinical signs. Those in group 2 were. By day 14, 3 (75%) out of four rabbits given carbaryl and liquid paraffin together and all of them (100%) by day 28 had recovered completely and had no mange clinical signs. By day 14, 3 (75%) out of four rabbits treated with liquid paraffin and all of them (100%) by day 28 were free from mange clinical signs. Three (75%) out of four rabbits treated with selamectin by day 28 had no clinical signs of ear canker. Those

which were given distilled water by day 28 all of them still had ear scabs on their ears. There was no reduction in the ear scabs and none of them showed self-cure. Those in the negative control group were free from mange clinical signs up to end of the trial. All the agents tested lead to a great improvement in the clinical scores compared to pre-treatment scores (Table 5). This was shown by the fading of scabs on the ears and other parts of the body of infested rabbits. Liquid paraffin combined with carbaryl was the fastest in clearing the lesions. By day 21 all the rabbits treated with this combination were free from mange clinical signs. There was a significant difference between mite infested groups and the negative control group ($p<0.05$) before treatment and by day 7 the difference was not significant ($p>0.05$) with the exception of positive control group. A significant difference in lesion scores between the positive and negative control groups was observed throughout the study period ($p<0.05$). There was a significant difference in lesion scores between the treated groups together with negative control group relative to the positive control group ($p<0.05$) at the end of the experiment.

4.2.3 Parasitological findings

Psoroptes cuniculi was the only mite isolated from samples collected from experimental rabbits. On day 0 (before treatment) all enrolled rabbits except those in negative control group had live mites (adults and eggs). Ivermectin, liquid paraffin, selamectin and carbaryl combined with liquid paraffin were effective against rabbit psoroptic mange. No mites were recovered on day 28 from all the rabbits treated with these agents. On day 21 all the rabbits treated with liquid paraffin and combination of liquid paraffin and carbaryl were negative for mites and only 25% (1) of those treated with ivermectin and selamectin were still positive for mites as shown in Table 6. All rabbits in the positive control group remained positive while those in the negative control group remain negative up to the end of the trial.

Table 5: Mean lesion scores of ears of rabbits in controlled laboratory trial before treatment (day 0) to day 28 post treatment

Group	**No. per group (N)**	**Day 0**	**Day 1**	**Day 7**	**Day 14**	**Day 21**	**Day 28**
Ivermectin	4	3.25 ± 0.48^{b}	3.25 ± 0.48^{b}	0.75 ± 0.25^{ab}	0.5 ± 0.29^{ab}	0.25 ± 0.25^{ab}	0.0 ± 0.0^{a}
Carbaryl with liquid paraffin	4	2.0 ± 0.0^{ab}	2.0 ± 0.0^{ab}	0.5 ± 0.29^{ab}	0.25 ± 0.25^{a}	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}
Liquid P	4	2.0 ± 0.71^{ab}	2.0 ± 0.71^{ab}	0.75 ± 0.25^{ab}	0.25 ± 0.25^{a}	0.25 ± 0.25^{ab}	0.0 ± 0.0^{a}
Selamectin	4	3.0 ± 0.41^{b}	3.0 ± 0.41^{b}	1.0 ± 0.0^{ab}	0.75 ± 0.25^{ab}	0.5 ± 0.29^{ab}	0.25 ± 0.25^{a}
Positive control	4	1.75 ± 0.48^{ab}	1.75 ± 0.48^{ab}	1.75 ± 0.48^{b}	1.75 ± 0.48^{b}	1.5 ± 0.5^{b}	1.75 ± 0.48^{b}
Negative control	4	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}
p-value		<0.001	<0.001	0.007	0.006	0.011	<0.001
Values within a column with different superscript are significantly different at p<0.05							

Table 6: Efficacy of ivermectin, carbaryl with liquid paraffin, liquid paraffin and selamectin on rabbit psoroptic mange based on presence or absence of viable Psoroptes cuniculi on ear scabs

Group	**Number per group (N)**	**Day 0**		**Day 7**		**Day 14**		**Day 21**		**Day 28**	
		Number of rabbits in which mites were present or absent									
		Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent
Ivermectin	4	4	0	3	1	3	1	1	3	0	4
Carbaryl with liquid paraffin	4	4	0	2	2	1	3	0	4	0	4
Liquid paraffin	4	4	0	4	0	2	2	0	4	0	4
Selamectin	4	4	0	2	2	2	2	1	3	0	4
Positive control	4	4	0	4	0	4	0	4	0	4	0
Negative control	4	0	4	0	4	0	4	0	4	0	4

4.2.4 Effect of therapeutic agents on body weights of experimental rabbits

Treatment with any of the four agents did not led to significant change in body weights of study rabbits compared to their weights before treatment (Table 7).

Table 7: Body weights of experimental rabbits from day 0 to day 28 post treatment with four anti-mange agents

Group	**Mean body weight during the treatment**				
	Day 0	**Day 7**	**Day14**	**Day 21**	**Day 28**
Ivermectin	3.25±0.43[a]	3.38±0.43[a]	3.63±0.32[a]	3.75±0.25[a]	3.75±0.25[a]
Carbaryl	4.0±0.20[a]	3.5±0.20[a]	3.88±0.13[a]	3.63±0.13[a]	3.63±0.13[a]
Liquid paraffin	4.13±0.55[a]	3.75±0.35[a]	3.75±0.35[a]	4.0±0.35[a]	4.0±0.35[a]
Selamectin	4.75±0.48a	4.75±0.48[a]	4.5±0.54[a]	4.63±0.47[a]	4.63±0.47[a]
Positive control	4.63±0.52[a]	4.625±0.52[a]	4.5±0.46[a]	4.5±0.46[a]	4.75±0.48[a]
Negative control	3.38±0.83[a]	3.38±0.83[a]	3.25±0.78[a]	3.5±0.65[a]	3.63±0.55[a]
p-value	0.291	0.227	0.405	0.328	0.214

Values given are mean ± SEM (standard error of mean); n (number of animals in each group) = 4. There was no significant difference(P>0.05) in weight gain between treatment groups

4.3 Efficacy of selected treatment options in the field

4.3.1 Pre-treatment clinical examination results

Clinical examination of study rabbits in the field before treatment revealed clinical signs of mange (sarcoptic mange, ear canker and cheyletiellosis). Those which had sarcoptic mange showed signs of pruritus, presence of crusts, alopecia, erythema and scratch marks. Crusts and alopecia were seen around the eyes, nose, limbs, paws, on the chin and in severe cases they were seen around external genitalia (Figure 22). Those which had ear canker showed signs of pruritus, scabs on the ears, erythema and scratch marks on the ears (Figure 23). One rabbit had signs of cheyletiellosis. It was scratching itself, had alopecic areas and dandruff on the back and was in a poor body condition (Figure 24).

Figure 21: One of the study rabbits with crusts and alopecic areas around the eyes, nose, on the limbs and paws (arrows)

Figure 22: One of the study rabbits with scabs and erythema on the ears (arrow)

Figure 23: A rabbit with cheyletiellosis manifested by dandruff and alopecic areas at the back (arrow)

4.3.2 Effects of treatments on lesion scores

Ivermectin, liquid paraffin, selamectin and carbaryl led to the clearance of mange lesions (ear scabs, crusts, dandruff, alopecia) in the treated rabbits (**Figs. 25, 26, 27 and 28**). Results revealed that liquid paraffin was faster than ivermectin and selamectin in clearance of mange lesions. From the day 3 to day 21 post-treatment, effects of ivermectin was statistically different from liquid paraffin in clearance of mange lesions. On day 9, 12 and 18 post-treatment effects of selamectin was statistically different from that of liquid paraffin. In the entire study period there was no statistical difference ($P>0.05$) between the effects of ivermectin and selamectin, ivermectin and carbaryl and carbaryl and liquid paraffin, respectively in clearance of mange lesions (Table 8).

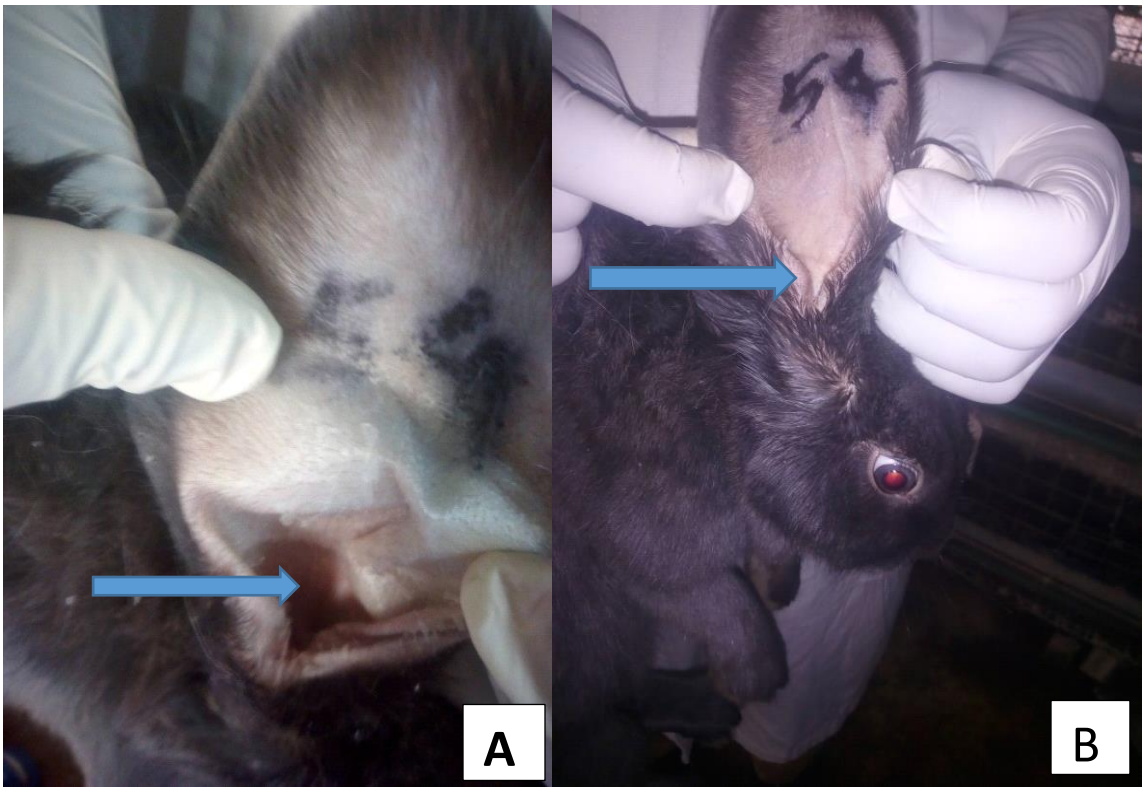

Figure 24: A rabbit with mange before treatment (A) and after treatment with liquid paraffin (B) during the field trial (arrows)

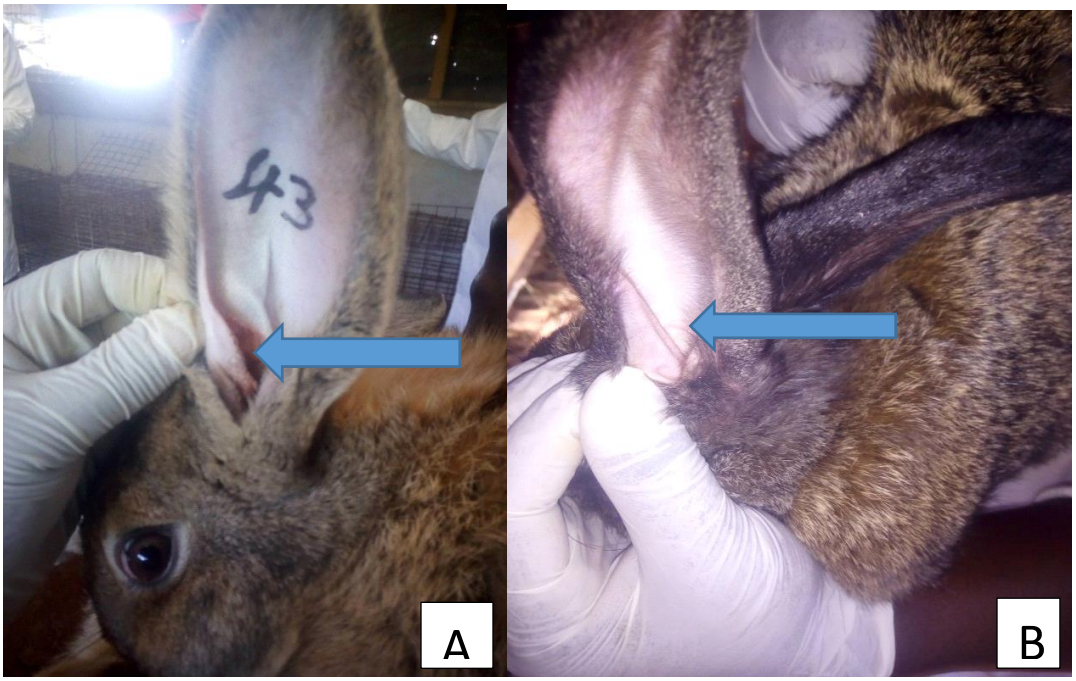

Figure 25: A rabbit with ear canker before treatment (A) and the same rabbit after treatment with ivermectin during the field trial (arrows)

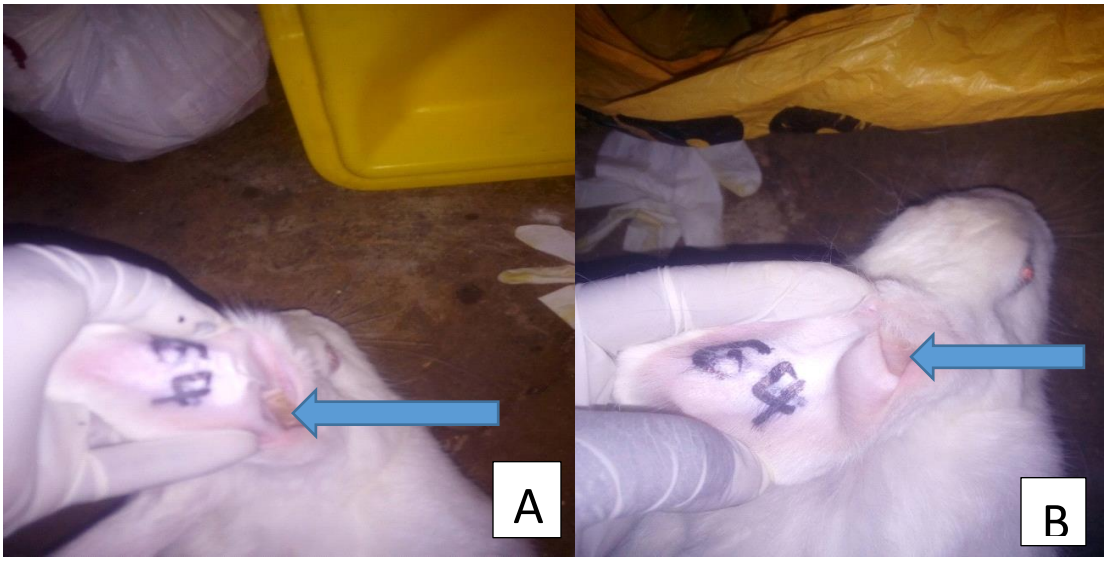

Figure 26: A rabbit with ear canker before treatment (A) and the same rabbit after treatment with carbaryl (B) during the field trial (arrows)

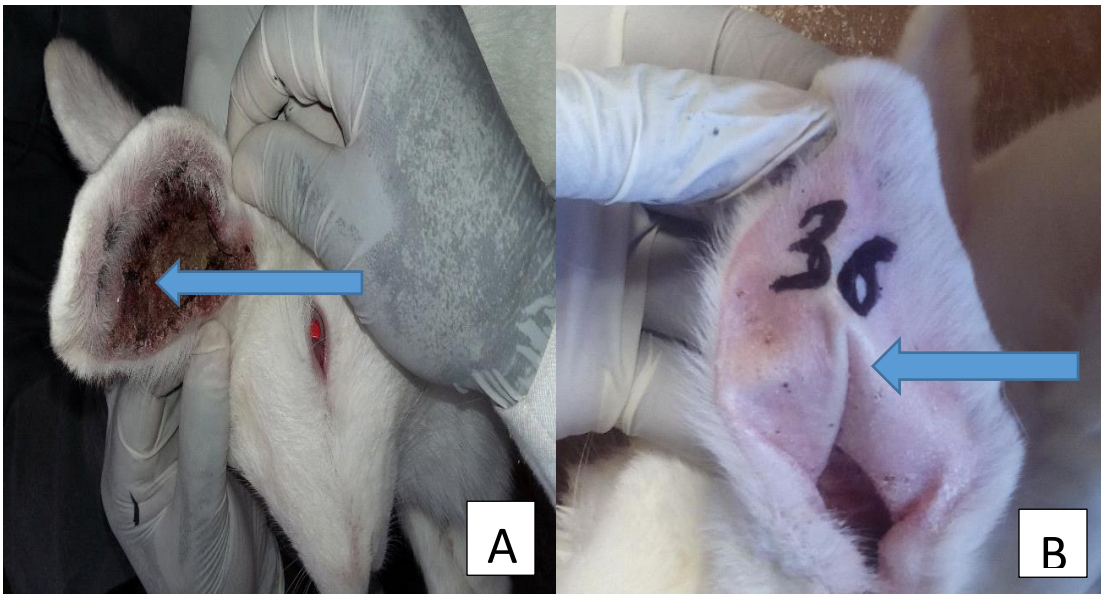

Figure 27: A rabbit with ear canker before treatment (A) and the same rabbit after treatment with selamectin (B) during the field trial (arrows)

Table 8: Efficacy of ivermectin, liquid paraffin, selamectin and sevin in clearance of mange lesions in trial rabbits

Group	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15	Day 18	Day 21	Day 28	Day 56
Ivermectin	2.171± 0.151^{a}	1.571± 0.131^{b}	1.229± 0.117^{b}	1.088± 0.122^{b}	0.971± 0.116^{b}	0.706± 0.108^{b}	0.706± 0.108^{b}	0.500± 0.114^{b}	0.235± 0.0851^{a}	0.125± 0.0915^{a}
Liquid paraffin	1.886± 0.121^{a}	1.086± 0.095^{a}	0.743± 0.111^{a}	0.543± 0.103^{a}	0.382± 0.104^{a}	0.265± 0.0973^{a}	0.206± 0.0704^{a}	0.114± 0.0546^{a}	0.0286± 0.0286^{a}	0.2000± 0.117^{a}
Selamectin	2.000± 0.148^{a}	1.353± 0.111^{ab}	1.000± 0.0917^{ab}	0.971± 0.0894^{b}	0.912± 0.0882^{b}	0.655± 0.103^{ab}	0.594± 0.0882^{b}	0.294± 0.0793^{ab}	0.171± 0.0646^{a}	0.0455± 0.0455^{a}
Carbaryl	2.000± 0.13^{a}	1.286± 0.0968^{ab}	0.971± 0.104^{ab}	0.743± 0.0948^{ab}	0.647± 0.102^{ab}	0.500± 0.0967^{ab}	0.382± 0.0945^{ab}	0.314± 0.0896^{ab}	0.229± 0.0286^{a}	0.429± 0.130^{a}
p-value	0.536	0.020	0.018	0.001	<.001	0.011	<.001	0.022	0.125	0.050

Values given are mean ± SEM (standard error of mean); n (number of animals in each group) = 35. Values in a column with different superscripts are significantly different at p-value <0.05

4.3.3 Effects of treatments on mite infestation

Psoroptes cuniculi, *Sarcoptes scabiei* var. *cuniculi* (Figure 29) and *Cheyletiella parasitovorax* (Figure 30) were recovered from the experimental rabbits. Out of 140 study rabbits 125 (89.29%) had *P. cuniculi* and 14 (10%) had *S. s.* var. *cuniculi* and 1 (0.71%) had both *C. parasitovorax* and *S. s.* var *cuniculi*.

Figure 28: *Sarcoptes scabiei* var. *cuniculi* recovered from skin scrappings collected during the field trial

Figure 29 *Cheyletiella parasitovorax* recovered from skin scrappings collected during the field trial

All the four agents tested were similarly effective against rabbit mange as shown in Table 9. Ivermectin was used to treat the rabbit which had cheyletiellosis and by day 56 the rabbit was negative for *C. parasitovorax*. Out of 35 rabbits which were treated with ivermectin twenty nine (82.86%) had ear canker and most of them were negative for *P. cuniculi* on day 28. Only three (10.34%) remained positive by day 28 post-treatment. On day 56, during follow up four (13.79%) rabbits were positive for psoroptic mange and three (10.34%) were relapses and one was positive throughout the experiment as shown in Table 9. Six (17.14%) rabbits which had sarcoptic mange and were treated with ivermectin all were negative by day 21 and no relapse was observed on day 56.

Out of 35 rabbits which were treated with carbaryl, thirty three (94.29%) were infested by *P. cuniculi* and by day 28 only three (9.09%) rabbits were positive. On day 56, seven (21.21%) rabbits were positive for *P. cuniculi* and 5 (15.15%) were relapses and two were positive throughout the experimental period. Two (5.71%) rabbits which were treated with carbaryl had *S. scabiei* var. *cuniculi*. One of the two rabbits responded to treatment and was negative by day 7 but the other rabbit remain positive throughout the study period.

Out of 35 rabbits treated with liquid paraffin, 31 (88.57%) had psoroptic mange and four (11.43%) had sarcoptic mange. On day 21 all the rabbits were negative for both sarcoptic and psoroptic mange. Only one rabbit which had sarcoptic mange was found positive during the follow up on day 56.

Thirty two (91.43%) of the rabbits which were treated with selamectin had psoroptic mange and three (8.57%) had sarcoptic mange. On day 14 all rabbits which had sarcoptic mange were

negative. Three (9.38%) of those which had psoroptic mange were still positive on day 28 and one of them was still positive on day 56.

All the four agents were effective in clearing of mange mites in the experimental rabbits. There was no significant differences when the four agents were compared against each other throughout the study period as shown in Table 9. Neither adverse reactions nor death related to the treatment was observed during the laboratory and field trial.

Table 9: Efficacy of ivermectin, liquid paraffin, selamectin and sevin against ear canker, sarcoptic mange and cheyletiellosis of rabbits

Group	**Day 0**	**Day 7**	**Day 14**	**Day 21**	**Day 28**	**Day 56**
***Cheyletiella* infestation**						
Ivermectin	1.971±0.01429[a]	1.971±0.01429[a]	1.971±0.0294[a]	1.971±0.0294[a]	1.971±0.0294[a]	2.000±0.000
Liquid Paraffin	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000
Selamectin	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000
Carbaryl	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000
p-value	0.395	0.395	0.419	0.386	0.381	
***Psoroptes* infestation**						
Ivermectin	1.171±0.0646[a]	1.429±0.0849[a]	1.618±0.0846[a]	1.848± 0.0634[a]	1.912±0.0494[a]	1.917±0.0576[b]
Liquid Paraffin	1.171± 0.0765[a]	1.371±0.0829[a]	1.676±0.0814[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[b]
Selamectin	1.086±0.0480[a]	1.400±0.0840[a]	1.759±0.0809[a]	1.824±0.0664[a]	1.914±0.0480[a]	1.955±0.0455[b]
Carbaryl	1.057±0.0398[a]	1.400±0.0840[a]	1.647±0.0832[a]	1.857± 0.0600[a]	1.914±0.0480[a]	1.667±0.105[a]
p-value	0.397	0.972	0.680	0.093	0.362	0.002
***Sarcoptes* infestation**						
Ivermectin	1.829±0.0646[a]	1.886±0.0546[a]	1.971±0.0294[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.00[a]
Liquid Paraffin	1.886±0.0546[a]	1.943± 0.048[a]	1.971±0.0294[a]	2.000±0.000[a]	2.000±0.000[a]	1.950± 0.05[a]
Selamectin	1.914± 0.0480[a]	1.971± 0.0286[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]	2.000±0.000[a]
Carbaryl	1.943± 0.0398[a]	1.971± 0.0286[a]	1.971±0.0294[a]	1.971± 0.0286[a]	1.971± 0.0286[a]	1.952±0.0476[a]
p-value	0.462	0.371	0.837	0.404	0.399	0.525

Values given are mean ± SEM (standard error of mean); n (number of animals in each group) = 35. Values in a column with different superscripts are significantly different at p-value <0.05

4.3.4 Effect of ivermectin, liquid paraffin, selamectin and carbaryl on body weights of experimental rabbits during field trial

Treatment with any of the four agents did not led to significant change in body weights of experimental rabbits compared to the weights before treatment as shown in Table 10**.**

Table 10: Effect of treatments on body weights of experimental rabbits during field trial

Group	**Day 0**	**Day 7**	**Day 14**	**Day 21**	**Day 28**
Ivermectin	3.003±0.135[a]	3.160± 0.138[a]	3.276±0.149[a]	3.321± 0.142[a]	3.309±0.155[a]
Liquid paraffin	2.886± 0.150[a]	2.963±0.163[a]	2.963±0.165[a]	3.077±0.162[a]	3.163±0.163[a]
Selamectin	2.814±0.177[a]	2.906±0.172[a]	3.071±0.184[a]	3.517±0.184[a]	2.994±0.167[a]
Carbaryl	3.191± 0.154[a]	3.294±0.157[a]	3.349±0.147[a]	3.349± 0.150[a]	3.454±0.151[a]
p- value	0.338	0.283	0.290	0.137	0.207

Values given are mean ± SEM (standard error of mean); n (number of animals in each group) = 35. There was no significant difference (p>0.05) in weight gain between treatment groups.

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 DISCUSSION

Among 97 respondents interviewed, 80.6% were males and 19.4% were females. The proportion of sex of respondents in this study differ significantly from what was found by Serem *et al*. (2013). This shows that males are more than before showing interest in rabbit industry unlike in the past where they saw it as an activity for boys and women. This reflects what was found by Hungu and her team in 2013. Adults have started to show interest in rabbit farming as depicted by the current study whereby 69.1% of farmers of rabbits were more than 50 years old while only 1% were young farmers between 21 and 30 years. This is similar with the findings of Hungu *et al*. (2013) and Serem *et al*. (2013). These authors have accredited this to the support the government has given to rabbit farming.

Farming (59.8%) and business (19.6%) were the key occupations of rabbit farmers and only 13.4% were salaried employees. This shows that rabbit keeping is practiced by people of different occupations including farmers and other careers, meaning that it is now a widely accepted economic enterprise in Kenya. Most of them keep rabbits as a source of income (72.2%) and food (15.5%). This is in agreement with what was found by Hungu *et al*. (2013) and Serem *et al*. (2013). However, this differs with what was found by Oseni *et al*., 2008 in Nigeria whereby majority of the farmers kept rabbits for subsistence food. Similar to previous findings (Serem *et al*. 2013; Hungu *et al*. 2013), majority of rabbit farmers (53.6%) were small scale farmers who kept 1 to 10 rabbits; only a few (8.2%) had more than 40 rabbits. Serem *et al*. (2013) cited inadequate capital to start and run rabbit farms, inadequate technical knowledge on rabbit management and limited access to market as the major factors making farmers to be small scale.

Carlifornia white, cross breeds and New Zealand white were the most popular breeds of rabbits kept by farmers in Kiambu and Nyeri counties. This is tallies with results from previous study by Oseni *et al*. (2008).

Most farmers (61.8%) reported to have kept rabbit for more than 2 to >5 years showing that there is sustained interest in rabbit farming. This is similar to what was found by Hungu *et al*., 2013. However, only a few (8.2%) had kept rabbits for less than 6 months; this shows that uptake of rabbit farming by new farmers is declining. This is in contrast to what was found by earlier workers. Most of the interviewed farmers reported that lack of market is a major challenge facing the enterprise and this probably could have made rabbit farming less attractive to new farmers.

The study observed that some farmers housed their rabbits in groups; this may facilitate rapid spread of ectoparasites as they are spread through contact, hence the high prevalence of mites reported in this study. Prevalence of mange is influenced by the hygiene of rabbit hutches. High prevalence (80%) was seen in farms using water without disinfectant to clean rabbit hutches followed by those which change beddings only (48.6%). High amount of moisture and low temperature in animal houses is thought to increase the prevalence of mange in animals (Blood *et al*., 2002). This is supported by the present study which was done during the cold season (June and July) in the study area and a high prevalence of 80% was seen in farms using water without disinfectant in cleaning rabbit houses. Washing with water only increases the amount of moisture in the houses. Farmers who reported not to clean their rabbit hutches or clean only when dirty had a high prevalence of mange (58.6%). This lower frequency of cleaning of animal houses has been associated significantly with mite infestation (Souza *et al*., 2008).

Majority of farmers interviewed (49%) reported to feed their rabbits with forage only. Over forty percent (42.2%) reported to feed both forage and commercial feed while only 8.8% used commercial feed only. Most farms which fed commercial feeds had their rabbits infested with mites. This was attributed to the presence of rats in rabbit hutches feeding on spilled rabbit pellets. Rats are known to be carriers of *P. cuniculi* which causes ear canker in rabbits.

Like what was found by Okumu *et al.*, 2015, farmers reported to have come across clinical signs of mange (pruritus, head tilting, crusts, wounds presence of parasites on the skin). The number of farmers reporting to have seen these clinical signs of mange in their rabbits was higher (79.4%) compared to what was reported by Okumu *et al.*, 2015 (60.4%). Similar to earlier findings by other workers on rabbit mange (Eshar, 2010; Ayodha, 2013; Swarnakar *et al*. 2014), presence of scabs on the ears, head tilting, hair loss, pruritus, crusts, dandruff and wounds on the skin were the clinical signs of mange encountered in 66% of the farms during clinical examination.

Fleas and ticks were also seen on some rabbits. The prevalence of flea infestation of rabbits in the visited farms was 5.15%. This was slightly higher than what was found (3.28%) by Okumu. In his desertation. The isolated fleas were *Ctenocephalides canis* (dog fleas); fleas have low host specificity. Fleas act as vectors of many pathogens like *Yersinia pestis*, *Rickettsia typhi* and *R. prowazekii* and *Bartonella* spp. which causes diseases in humans (Bitam *et al*., 2010; Eisen and Gage, 2012) and also can transmit myoxomatosis virus to rabbits. *Ctenocephalides canis* is the intermediate host of *Dipylidium caninum* which can infect humans (Durden and Hinkle 2009). Thus, there is need to control fleas in rabbit farms.

49.5% of the study farms had *Psoroptes cuniculi*. This prevalence was significantly ($p<0.05$) higher than what was reported (16.4%) by Okumu *et al*. (2015). The high prevalence seen in this

study can be accredited to the improper use of the treatment regimens by farmers, acquisition of breeding rabbits from neighbours and improper cleanliness of rabbit hutches. The high prevalence of *Psoroptes cuniculi* observed in the present study agrees with the previous study by Aleri *et al.* (2012) which reported *P. cuniculi* as one of the most common ectoparasite of rabbits in Kenya.

Flemish Giant was found to be the most vulnerable breed to mange with a prevalence of 71.4% as compared to Checkered Giant which was the least vulnerable with a prevalence of 40%. Elshahawy *et al*. 2016 accredited this variation in breed susceptibility to variations in resistance to parasitism.

Females had slightly higher prevalence (61.2%) than males (60%). Lloyd, 1983 as cited by Awol *et al*., 2014 attributed the higher prevalence of infections mange included in females to physiological processes of pregnancy and lactation which lead to increase in progesterone and prolactin respectively. These hormones lower immunity. However, the prevalence in this study was not statistically significant ($p>0.05$). This is similar to was observed by Elshahawy *et al*. 2016.

With regard to age, young rabbits (< 4 months) (62.5%) had slightly higher prevalence than adult rabbits (>4 months) (55.1%). This could be due to rearing together of rabbits of different age groups as it was seen in some farms in the study area, thus facilitating infestation through direct contact. The difference in prevalence was however, not statistically significant ($p>0.05$). This was in agreement with observations of Eshar (2010) and Elshahawy *et al*. (2016).

With regard to the source of breeding rabbits, many farmers acquire their starting stock (59.4%) and subsequent breeding stock (43.8%) from other farmers. Farms that acquire their starting stock and subsequent breeding stock had mange prevalence of 47.6% and 46.7% respectively. Additionally, most farmers in this study borrowed breeding bucks from their neighbors which is

in agreement with observations of Hungu *et al*. (2013) and Serem *et al*. (2013). These practices encourage the spread of mange as it is a contagious disease.

Most farmers (42%) reported to treat their rabbits themselves when sick. Forty percent depend on their own knowledge and information from other farmers (21%) on administration of the treatment. Most of them use treatment options that differ from farm to farm. Furthermore, the frequency of administration of these treatment options differ between farmers as most of them applied treatment depending on their own knowledge. This exercise of treating rabbits for themselves is likely to lead to drug resistance (Currie *et al* 2004).

The most common drugs used by farmers against mange in their rabbits were ivermectin (injection) (25%), carbaryl (16%) and tetracycline (14%). In Kenya, ivermectin has been reported to be in used to treat mange of rabbit (Aleri *et al*., 2012) but, no study has been done to confirm its efficacy. Mineral oil, liquid paraffin, used engine oil and ash were non-chemotherapeutic agents also used by farmers to treat clinical signs associated with ectoparasites of rabbits. Non-chemotherapeutic agents which includes garlic extract (Anthony *et al*., 2005; Seddiek *et al*., 2008), plant essential oils (Traina *et al.,* 2005, Hanafi *et al*., 2010) and paraffin oil (Desoky, 2015) have been confirmed to be effective against mange.

Farmers reported ivermectin (94%) and carbaryl (81%) to be effective against ectoparastes of rabbit. The efficacy of ivermectin has also been reported in other studies done in Kenya and in other parts of the world (Kurtdede *et al.,* 2007; Aleri *et al*., 2012). Concerning, the prevention of clinical signs of mange, carbaryl, liquid paraffin and ivermectin were reported to be effective.

Rodents were known by many farmers to be carriers of mange mites and stated that control of rodents was important in control of rabbit mites.

Ivermectin, liquid paraffin, selamectin, carbaryl combined with liquid paraffin and carbaryl combined with water were similarly effective against rabbit mange during laboratory and field trials. This was shown by the fact that no mites were recovered on day 28 from all the rabbits treated with these options in the laboratory trial. In the field trial some rabbits were still positive by day 28 but the mites were dead. All the rabbits in the control group remained positive up to study termination. Treatment with all the anti-mange agents led to a significant improvement in the scores of clinical signs compared with the scores before treatment and that of rabbits that were infested and not treated (positive controls). Statistically significant differences were observed from the third week after treatment to end of the experiment. All treated rabbits showed high rate of recovery as shown by smoothening of skin texture and disappearance of crusts and scabs on the ears. However, the positive control rabbits did not show any improvement in clinical appearance compared with the treated groups.

Reinfestation with mites mainly *P. cuniculi* was seen in some rabbits during follow up on day 56 in the field. For ivermectin, 3 (10.34%) rabbits that initially became negative were found to be positive for *P. cuniculi* on day 56 and, for carbaryl reinfestation with *P. cuniculi* was seen in 5 (15.15%) rabbits. Only one rabbit was found to be re-infested with *S. scabiei var cuniculi* after treatment using liquid paraffin and no reinfestation was observed in rabbits which were treated with selamectin. Re-infestation in the field could be attributed to the failure to isolate the infested and treated rabbits from others as mange is a highly contagious disease. Again the environment where the treated rabbits stayed was not treated and this could have acted as a source of reinfestation. The efficacy of ivermectin, liquid paraffin and carbaryl on rabbit mange confirmed the report made by farmers during the baseline survey that these options are effective against rabbit mange.

Efficacy of ivermectin against rabbit mange in this study agrees with what has been done by earlier workers (Curtis *et al*., 1990; Okerman, 1994; Durdane *et al*. 2010; Aleri *et al*., 2012). Durdane *et al*. (2010), in their study found that ivermectin given three times at a dosage of 400µg/kg after every 80 hours were effective against rabbit mange. In the present study a dosage of 400µg/kg of ivermectin given twice at an interval of 14 days was effective against cheylletiellosis, psoroptic and sarcoptic mange of rabbits.

Selamectin at a dosage rate of 6mg/kg once was found in the present study, to be effective against rabbit sarcoptic and psoroptic mange. This confirms earlier findings by Mc Tier *et al*. (2005) and Kurtedede *et al.* (2007). Kurtedede *et al.* (2007) recommended repeated application of selamectin for control of ectoparasite infestations. Selamectin was also found to be effective against fleas during the study in rabbits which had both mange and flea infestation. The fleas were found dead after one week and rabbits remained free from fleas throughout the study period (Kurtedede *et al* (2007). Ivermectin and selamectin are avermectins and they act by blocking the transmission of electrical activity in nerves and muscle cells by stimulating the release and binding of gamma-aminobutyric acid (GABA) at nerve endings (Martin *et al*., 2012), hence, causing an influx of chloride ions into the cells leading to hyperpolarisation and subsequent paralysis of the neuromuscular systems and death of the parasite.

Efficacy of non-conventional treatment options like plant essential oils (Perucci *et al.*, 1997; Fichi *et al*., 2007a; b), garlic extracts (Seddiek *et al.*, 2008), liquid paraffin (Desoky, 2015) among others have been demonstrated to be effective against mange of rabbits. In the present trial, liquid paraffin-cabaryl combination treatment recorded the fastest action in clearing mite infestations and associated lesions relative to use of cabaryl alone (wetted with water) and other test options. The labour-intensive nature of this treatment option in addition to the extra cost of cabaryl may limit

its adoption compared to the cheaper use of liquid paraffin alone. However, if the manufacturer of cabaryl, a broad spectrum insecticide makes the drug to be in liquid form by adding oil, it will be a good option against mange in not only rabbits but also other animals. Additionally, carbamates do not accumulate in tissues of mammals, they are rapidly metabolised to I-naphthol which is non-toxic. Hence, it is a good drug in food animals (Fukuto, 1990). Cabaryl inhibits the action of acetyl cholinesterase enzyme which controls chemical reaction that transforms acetylcholine into choline thus disrupting smooth transmission of nerve impulses (Pope *et al*., 2005). The effectiveness of cabaryl against mites in laboratory and field trials agrees with similar findings reported by Ebrahimi *et al*. (2015).

Studies have postulated that the oils act by blocking the opening to tunnels within stratum corneum through which the buried mites breath thereby suffocating the parasites (Ellse and Wall, 2014).

5.2 Conclusions

- Prevalence of rabbit mange was high in Kiambu and Nyeri counties, Kenya
- The most common treatment options used by farmers against rabbit mange was ivermectin, carbaryl and liquid paraffin
- Inappropriate use of conventional and non-conventional treatment options by farmers, poor maintenance of hygiene in rabbit houses and sourcing of breeding stock from other farmers were the potential risk factors for mange mite infestations of rabbits in the study area
- Ivermectin, selamectin, cabaryl and liquid paraffin were effective against rabbit mange in the laboratory trial and field trial.

5.3 Recommendations

- Dissemination of findings of present study to stakeholders (i.e., animal health providers and rabbit farmers) in other counties is indicated
- Farmers should be trained on proper husbandry practices of rabbits
- Farmers should use liquid paraffin as first line of treatment against rabbit sarcoptic and psoroptic mange due to its availability, ease of application and affordability
- Ivermectin and selamectin should be used as drugs of last resort to minimize development of resistance

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APPENDICES

APPENDIX 1: STUDY QUESTIONNAIRES FOR RABBIT FARMERS

UNIVERSITY OF NAIROBI

COLLEGE OF AGRICULTURE AND VETERINARY SCIENCE

Date of interview ……Tel. No. ……..Code……..

QUESTIONNAIRE ON ASSESSMENT OF THE EFFICACY OF COMMONLY USED DRUGS IN THE CONTROL OF COCCIDIOSIS AND ECTOPARASITISM OF DOMESTIC RABBITS IN SMALLHOLDER PRODUCTION SYSTEMS IN KENYA: *TO BE ADMINISTERED TO RABBIT FARMERS*

- **Background information**
- County ---------- Sub-county .....Ward ---------- Village.....
- GPS READING: Eastings……Northings ……. Elevations ----------
- Acreage of the farm ……..
- Note the type of farmers house (tick appropriately)

  (1) Stone (2) Timber (3) Mud (4) Iron sheets (4) Others (specify)

- **Biodata of owner**
- Name of household head ……
- Age of household head?

  [1] 21-30 years [2] 31-40 years [3] 41-50 years [4] > 50years

- Gender of the household head? [1] Male [2] Female

- Main occupation of household head:

  (1) Farming (2) Business (3) Salaried employee (4) Other …… (specify)

- Education level of household head……..

  [1] No formal education [2] Primary level [3] Secondary level [4] Tertiary level

- Name of respondent: ……
- Relationship of interviewee to household head.....

  (1) Owner (2) Spouse (3) Daughter (4) Son (5) Worker (6) Other (specify)…….

- Who is responsible for the day to day management decisions of the farm?

  1) Owner (2) Spouse (3) Daughter (4) Son (5) Worker (6) Other (specify)……

- What is the education level of the person responsible for day to day management decisions?

  (1) No formal education (2) Primary level (3) Secondary level (4) Tertiary level

- **Management**

  - Number of rabbits kept currently ……..……

  - Age groups of rabbits kept currently……..(tick as appropriate)

Age	Kits (< 1 month)	Weaners (1-4months)	Bucks (males > 4months old)	Does (> 4 months old)

  - Breeds kept? (tick appropriately)……..

Breed	NZW	CW	FG	CH	FLP	DU	ANG	Cross breeds	Others (specify)

- How long have rabbits been kept on the farm?

  [1] <6 months [2] 6 month-2yrs [3] >2yrs- 5yrs [4] Others specify…….....

- What is the main reason for keeping rabbit? (tick one) ……...

  [1] Business [2] Hobby [3] Food [4] Others specify……

- Where did you source your first stock? .....

Source of first batch	Other farmers	Government	Research institutions	Imported	Contractual agreement (specify group)	Gift /inheritance	Others (specify)

- What is the source of your breeding stock in the farm? (tick as appropriate)

Source of stock	Own stock	Other farmers	Government farms	Research institutions	Imported	Contractual agreement (specify group)	Gift /inheritance	Others (specify)

- After how long do you change your breeding stock for BUCKS?

  [1] After 1 yr [2] After 2 yrs [3] After >5 yrs

- After how long do you change your breeding stock for DOES?

[1] After 1yr [2] After 2 yrs [3] After >5 yrs

- What other animals/ livestock do you keep in the farm? (Tick appropriately)

Animals kept	Cattle	Sheep and goats	Chicken	Cats	Dogs	Others (specify)

- How do you clean rabbit houses?

  [1] Changing beddings only [2] Washing with water alone [3] Washing with water and disinfectant [4] Other (specify)……

- How frequently do you clean rabbit houses?

  [1] Daily [2] Once a week [3] Every 2 weeks [4] Others (specify)…….

- Rate the challenges you face as a rabbit farmer (tick appropriately).

	Tick appropriately		
Challenges faced	**Major**	**Minor**	**Not**
[1] Marketing			
[2] Diseases			
[3] Availability of feed			
[4] Cost of feed			
[5] Availability of veterinary services			
[6] Availability of drugs			
[7] Cost of drugs			
[8] Breeding stock			
[9] Knowledge on husbandry			
[10] Others (specify)			

- Note the type of housing used in the farm and tick appropriately. How are the rabbits housed in the farm?

Housing type	**Housing system**			
	[1] Individual cages	[2] No grouping	[3] Grouped by age	[4] Grouped by sex
Indoor				

Outdoor				

- Note the type of housing structures in the farm and tick appropriately the No. of tiers in each structure.

No of housing tiers	**Housing type**	
	Indoor	Outdoor
[0] No tier		
[1] 1		
[2] 2		
[3] 3		
[4] 4		
[5] >4 specify		

- Note the floor type in the farm and tick appropriately

[1] Wire mesh [2] wooden [3] Earthen [4] Others (please specify) ……

17. Observe the hygiene status of rabbit housing and (tick appropriately)

Hygiene	***Tick appropriately***		
	Plenty	**Less**	**Not present**
[1] Fecal matter in cage floor			
[2] Hatch odour			
[3] Presence of feed on cage floor			
[4] Presence of water on cage floor			
[5] Soiled rabbits			

B. Ectoparasites, coccidiosis and mucoid enteropathy

- Please note the breeds CURRENTLY KEPT by the farmer and then ask the following question(s) to fill in the table below as necessary. Has the breed ever shown the following clinical signs in the last six (6) months?

  Yes = 1, No = 0 N/A=9

Symptom/breed	NZW	CW	FG	CH	FEL	DU	ANG	Other	Cross
	☐	☐	☐	☐	☐	☐	☐	specify	Specify
Scratching/loss of hair									
Wounds on the skin									
Crust /Dandruffs									
Head tilting									
Presence of parasites on the skin (specify)									
Diarrhea/ Mucus in feces									
Distended abdomen									
Sudden death									
Lack of appetite									
Others specify									

- Which age groups are frequently affected by the symptoms below?

Symptoms	**Kits**	**Weaners**	**Adults**
Scratching/loss of hair			
Wounds on the skin			
Loss of weight			
Head tilting			
Presence of parasites on the skin (specify)			
Diarrhea/mucus in feces			
Distended abdomen			
Sudden death			
Lack of appetite			
Other specify			

- What do you do when your rabbits are sick? tick as appropriate

  [1] Call a Vet/ Paravet [2] Self treat [3] Do nothing [4] Advice from others [5] Others specify……

- If self-treat, what do you use? (Indicate the trade name if possible).

Symptoms	Antibiotics	Acaricides / Insecticides	Mineral oil/liquid paraffin	Withdraw/change feed	Multivit	Herbs	Injection	Other (specify)
Scratching/ Loss of hair								
Wounds on the skin								
Loss of weight								
Head tilting								
Presence of parasites on the skin								
Diarrhea/ mucus in feces								
Distended abdomen								
Sudden death								

Lack of appetite								
Other specify								

- How frequently do you apply the following to treat *external parasites*?

Method of control	**Frequency of application**					
	Once	Daily	Weekly	Every two weeks	Monthly	Others (specify)
Acaricide / Insect ides (specify)						
Mineral oils (specify)						
Liquid paraffin						
Injection						
Others (specify)						

- How do you control external parasites in the farm? How frequently?

Method of control	**Frequency of application**					
	Once	Daily	Weekly	Every two weeks	Monthly	Others (specify)
Acaricide/Insect icides (specify)						
Paraffin and oils (specify)						
Mineral oils						

Injection						
Controlling rodents						
Others (specify)						

- How do you apply the treatment regimes used?

  [1] Manufacturer's instructions [2] Vet advice [3] Advice from Agrovet [4] Advice from other farmers [5] Own experience

- Do the treatments work? Yes [ ] No [ ]

- If No what do you do?

  [1] Increase the dose [2] Increase frequency of application [3] Dilute [4] Others (specify) ……..

E) Coccidiosis & mucoid enteropathy

- What type of rabbit feed do you use? .....

  (1) Commercial (2) Forage only (3) Both

- What commercial rabbit feeds do you use?

Commercial feed	**Tick appropriately**
[1] Unga	
[2] Pembe	
[3] Isinya	
[4] Naku modern	
[5] Sigma	
[6] Pwani	
[7] Royal	
[8] Belfas	
[9] Don’t know	

[10] Other (specify)	

- Have you associated any of these symptoms with the following feeds? Tick appropriately

FEED	Unga	Pembe	Isinya	Nak.	Sigma	Pwani	Royal	Belfas	Forages	Other
[1] Diarrhea										
[2] Mucus in feces										
[3] Dullness/Rough hair coat										
[4] Bloating										
[5] Sudden death										
[6] Lack of appetite										
[7] Stunting										

- Of the clinical signs identified in (**29)** above, do you associate them with the following feeding practices. (tick appropriately)

Clinical signs	Sudden change in diet	Overfeeding	Poor quality feed	Fresh forages (Not wilted)	Others (specify)
[1] Diarrhea					
[2] Mucus in feces					
[4] Bloating					
[5] Sudden death					
[6] Lack of appetite					

[7] Stunting					

- Which forages do you feed the rabbit? How do you feed them? Tick as appropriate

Type of Forage	**Fresh**	**Wilted**
[1] Kales		
[2] Cabbages		
[3] Weeds		
[4] Carrots		
[5] Corn stalks		
[6] Grass		
[7] Hay		
[8]Sweet potato vines		
[9] Other (specify)		

- Do you associate commercial feeds and or forages with occurrence of any of the following symptoms in the age groups of rabbits shown below? (tick appropriately)

AGE	Kits<4 wks	Weaners>4wks	Growers >12wks	Pregnant doe	Lactating doe	Other (specify)
[1] Diarrhea						
[2] Mucus in feces						
[4] Bloating						
[5] Sudden death						
[6] Lack of appetite						
[7] Stunting						
[8] Other(specify)						

- Which of the following do you use to prevent the listed *clinical signs*? tick as appropriate against all applicable methods. If possible, give trade names.

PRACTICES	Antibiotics	Multi Vitamins	Herbs	Not changing feed	Vet visits	Nothing	Others
[1] Diarrhea							
[2] Mucus in feces							
[4] Bloating							
[5] Sudden death							
[6] Lack of appetite							
[7] Stunting							
[8] Other (specify)							

- Rate the importance of the following animal management methods in rabbit production?

	Tick appropriately		
Management practice	**Very important**	**Less important**	**Not important**
[1] Proper selection of breeding stock			
[2] Timely feeding			
[3] Quality feeds			
[4] Providing kindling nest boxes			
[5] Timely breeding			
[6] Separating sexes at time of weaning			
[7] Removing the doe to another cage when weaning instead of kits			
[8] Good housing/cages			
[9] Provision of clean water with clean watering equipment			

[10] Using clean feeders raised above the floor (crocks or cans)			

D) Identification of actual value chain actors

- Are you organized in groups with other farmers? 1) Yes___ 2) No___.

- If the answer is yes, what are the main reason for being grouped

Reasons		**Tick appropriately**		
		Very important	Less important	Not important
1	For marketing			
2	For trainings on rabbit keeping			
3	For finance			
4	Social benefits e.g. welfare			

- In relation to rabbit keeping and marketing, which information do the following resources provide you with? Tick all that apply

	Feeding	**Breeding**	**Housing**	**Disease management**	**Rabbit meat products**	**Marketing**	**Other reasons (specify)**
County Extension officers							
NGOs/private agents							
Internet							
Radio, TV and newspaper							
Agricultural shows/field days							
Neighbors and family							
Banks/credit institutions							
Rabbit farmers association							

- Which rabbit products do you sell? At how much? Indicate the cost

Product	Tick appropriately	Cost per quantity
Adult rabbits		
Young rabbits: Kits/ weaners		
Rabbit meat		
Rabbit urine		
Rabbit manure		
Rabbit fur		
Rabbit skin		
Other product e.g. sausages, samosas, cooked meat		

- Indicate the challenges that should be addressed in the rabbit value chain with regard to the following.

Production	Processing	Marketing
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.

- Do you have a production/market contract with any organization/ farmer? 1) Yes___ 2) No___.
- If yes, name the organization/s you have contracts with
- What costs do you incur on commercial feeds for your rabbits?

Item	Amount of feed given/per day	Cost of feed per kg
Commercial feed given to weaners		
Commercial feed given to adult rabbits		

- Which other feeds do you use (e.g. weeds, grass, hay, kitchen waste, any other)

	Do you buy/pay for the feed product? (yes or no)	At what cost per week
Weeds		
Grass		
Hay		
Kitchen waste		
Any other		

- In the table below give the age and weight that your rabbits are ready for market?

Product	Market weight in kg	Age in months
Rabbit for meat		
Weaners		
Breeding does		
Breeding bucks		

- What other cost do you incur under the following categories?

Cost items	Specify (where appropriate)	Approximate cost	How frequently paid
Feed supplements			
Labour			
Paid Extension			
Training cost			
Marketing			
Others (specify)			

.....**Thank You**.....

APPENDIX 2: STUDY QUESTIONNAIRE FOR AGROVETS

UNIVERSITY OF NAIROBI

COLLEGE OF AGRICULTURE AND VETERINARY SCIENCE

Date of interview .....Tel. No. .....Code.....

QUESTIONNAIRE ON ASSESSMENT OF THE EFFICACY OF COMMONLY USED DRUGS IN THE CONTROL OF COCCIDIOSIS AND ECTOPARASITISM OF DOMESTIC RABBITS IN SMALLHOLDER PRODUCTION SYSTEMS IN KENYA: *TO BE ADMINISTERED AT AGRO-VETERINARY OUTLETS*

NOTE: Information given will be treated with full confidentiality

- **Background information**

County ---------- Sub-county .....Ward ----------

Village..... Shopping center ……..

GPS READING: Eastings……Northings ……. Elevations ----------

- Name of Agrovet ……

2. Main occupation of the owner of Agrovet:

[1] Farming [2] Business [3] Salaried employee [4] Other (specify)……

3. Education level of the owner of Agrovet

[1] No formal education [2] Primary level [3] Secondary level [4] Tertiary level

4. Age of the owner of Agrovet?

[1] 18-30 years [2] 31-40 years [3] 41-50 years [4] > 50years

5. Gender of the owner of Agrovet? [1] Male [2] Female

6. Name of respondent: ……

7. What is the education level of the respondent?

[1] No formal Education [2] Primary level [3] Secondary level [4] Tertiary

8. Are you the owner of Agrovet: Yes [1] No [2]

- Gender of the respondent..... Male [ ] Female [ ]
- Has the respondent attended training in animal health? [1] Yes [2] No
- If yes, what level? .....

  [1] Certificate [2] Diploma [3] Higher diploma [4] Degree [5] Postgraduate
- How long ago did you attain the level of training above? ……..

  [1] <1 year [2] 1-5 years [3] 6-10 years [4] > 10 years
- How long have you worked in the Agrovet?

  [1] <6 months [2] 6 month-2 yrs [3] >2 yrs- 5yrs [4] >6 years

B. Information on drugs

- What are the sources of your veterinary drugs and feeds? (tick as appropriate)

	Direct import	**Wholesalers/distributors**	**Government institutions**	**Research institutions**	**Others (specify)**
Source of stock					

- Do you stock specific drugs for treatment of rabbit diseases? [1] Yes [2] No
- How frequently do you get clients enquiring about drugs for treatment of rabbits?

  [1] Never [2] Every week [3] Every month [4] Every 6 months [5] Every year
- What do you do when a client reports a case of sick rabbits? (tick as appropriate)

[1] Call a Vet/ Paravet [2] Prescribe a drug [3] Visit the farm and treat [4] Others …… (specify)

- Rate the frequency that clients have reported any of the following symptoms in rabbits in the last six (6) months? (tick as appropriately).

Symptoms	**Very often**	**Less often**	**Never**
Scratching			
Loss of hair			
Wounds on the skin			
Loss of weight			
Head tilting			
Presence of parasites on the skin			
Diarrhea /mucus in feces			
Distended abdomen			
Sudden death			
Lack of appetite			
Other (specify)			

- What do you sell to your clients to treat the following **clinical signs**? Give trade names where applicable

Symptoms	Antibiotics	Acaricides / insect ides	Mineral oil	Withdraw/change feed	Multivit	Injection	Other(specify)
Scratching							
Loss of hair							

Wounds on the skin							
Diarrhea /mucus in feces							
Head tilting							
Presence of parasites on the skin							
Diarrhea							
Distended abdomen							
Sudden death							
Lack of appetite							
Mucus in feces							
Loss of weight							
Other specify							

- What options do you have for control of external parasites in rabbit farms? Give trade names if possible?

Method of control	**Trade names**
Acaricide / Insecticides (specify)	
Mineral oils (specify)	
Injection	

Others (specify)	

- How frequently do you apply the control methods named above?

Method of control	**Frequency of application**					
	Once	Daily	Weekly	Every two weeks	Monthly	Others (Specify)
Acaricide / Insecticides (specify)						
Mineral oils (specify)						
Injection						
Others (specify)						

- How do you apply the treatment regimes used?

  [1] Manufacturer's Instructions [2] Vet advice [3] Advice from agrovet [4] Advice from other farmers [5] Own experience

- Do the treatments work for farmers? Yes [ ] No [ ]

- If No what do you advice the farmers?

  [1] Increase the dose [2] Increase frequency of application [3] Others (specify) ……..

- Which Options do you have to prevent occurrence of the following sickness/symptoms? Give trade names as appropriate

PRACTICES	Antibiotics	Multi vit.	Herbs	Not changing Feed	Vet visits	Nothing	others
[1] Diarrhea/mucus in feces							
[2] Bloating							
[3] Sudden death							

[4] Lack of appetite							
[5] Stunting							
[6] Other (specify)							

- Over the last 6 months, what commercial rabbit feeds have you stocked in your Agrovet? (Tick appropriately)

Unga	Pembe	Isinya	Nak.	Sigma	Pwani	Royal	Belfas	Hay	Others (specify

- Has your client associated commercial feed with any of the following clinical signs? (Tick appropriately)

Clinical signs	**Unga**	**Pembe**	**Isinya**	**Nak**	**Sigma**	**Pwani**	**Royal**	**Belfas**	**Hay**	**Other**
[1] Diarrhea										
[2] Mucoid feces										
[3] Dullness/Rough hair coat										
[5] Bloating										
[6] Sudden death										
[7] In appetence										
[8] Unthriftiness										

……..Thank You…….

APPENDIX 3: CLINICAL EXAMINATION DATA SHEET CLINICAL SCORE CARD AND OBSERVATION SHEET

Name of Household Head……

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

GPS READING (Latitude……) Longitude (……)

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

ENVIRONMENT
Fecal characteristics pellets ☐ watery ☐ Mucoid ☐ blood tinged ☐ ☐
Housing type Outdoor cages ☐ Indoor cages ☐
No of tiers 1- 3 ☐ 3-5 ☐ more than 5 ☐
Cage Elevation Tiered ☐ One level ☐
Housing floor wire mesh ☐ wood ☐ ground) ☐
Housing group cages ☐ Individual ☐
Odour bad ☐ normal ☐
Housing density crowded ☐ Not crowded ☐
Housing structure neat ☐ old ☐ poorly ☐ maintained ☐
Hygiene clean ☐ dirty) ☐

(b). Clinical case

1. Total number of rabbits…….. Number sick ……. Number dead……
2. Age…….. Sex …… breed…….
3. Identity……..
4. Farm questionnaire number…….
5. History……

   ……

6. Any treatment given……

   ……

7. Clinical signs observed……

   ……

8. Clinical diagnosis…….

9. Confirmed

diagnoses……

……

10. Post mortem

diagnosis……

……

Samples collected

Live rabbit for screening ……

☐ wabs (nasal/conjuctival) ……..

Age…….. sex …… breed…….… clinical signs……

History……

Rabbit identity……

☐ Carcass……

Age…….. sex …… breed…….… clinical signs……

History……

Rabbit identity……

☐ Fecal samples…….

Age…….. sex …… breed…….… clinical signs……

History……

Rabbit identity……

☐ Blood smear……

Age…….. sex …… breed…….… clinical signs……

History……

Rabbit identity……

☐ Skin scrapping……

Age…… sex …… breed…… clinical signs……

History……

Rabbit identity……

APPENDIX 4: GEOGRAPHICAL COORDINATES AND ELEVATIONS OF STUDY SITES VISITED DURING FIELD TRIAL IN KIAMBU COUNTY

Farm no.	Farmer's name	Farmer's contacts	Location	Latitude	Longitude	Elevation
1	Kiambu Institute of Technology	0718 410 425	Kiambu Sub-county	$01^{0}10.825'$	$036^{0}50.323'$	1568m
2	St. Joseph CAFASSO	0723 970 942	Kiambu Sub-county	$01^{0}10.544'$	$036^{0}53.451'$	1589m
3	Youth Corrective Training Centre-Kamiti Prison	0713 207 590	Kiambu Sub-county	$01^{0}10.729'$	$036^{0}53.979'$	1571m
4	Charity Irungu	0721 173 234	Kiambu Sub-county	$01^{0}10.618'$	$036^{0}53.898'$	1580m
5	Kamiti Medium Prison	0715 342 906	Kiambu Sub-county	$01^{0}10.622'$	$036^{0}53.763'$	1591m
6	Stephen Maina	0722 643 885	Kiambu Sub-county	$01^{0}10.033'$	$036^{0}52.001'$	1628m

7	Kiambu Prison	0725 859 920	Kiambu Sub-county	$01^0$10.465’	$036^0$49.793’	1675m
8	Simon Ndung’u	0723 232 388	Kiambu Sub-county	$01^0$09.749’	$036^0$48.148’	1793m
9	Joyce Maina	0724 336 102	Kiambu Sub-county	$01^0$08.935’	$036^0$49.135’	1801m
14	Peter Njoroge		Kikuyu Sub-county	$01^0$13.559’	$036^0$42.944’	
15	Peter Gitau	0720 473 835	Kikuyu Sub-county	$01^0$13.657’	$036^0$42.912’	
16	Simon Mrangi	0721 793 761	Kiambu Sub-county	$01^0$05.734’	$036^0$44.278’	
17	Marvin Kiondo	0726 858 793	Kiambu Sub-county	$01^0$05.258’	$036^0$05.215’	
18	Nafiazi Mugendi	0725 982 690	Kiambu Sub-county	$01^0$09.911’	$036^0$49.321’	
19	University of Nairobi-Animal Production Department		Kabete Campus			