PIG MANAGEMENT PRACTICES AND THEIR CONTRIBUTION TO OCURRENCE OF PORCINE CYSTICERCOSIS IN THIKA MUNICIPALITY AND ITS ENVIRONS, KENYA

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DECLARATION

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

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DEDICATION

This thesis is dedicated to my caring parents David Mwangi and Naomi Wangari, my loving wife Caroline Wanjiku and my son Maxwell.

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ABBREVIATIONS AND ACRONYMS

C. cellulosae	Cysticercus cellulosae
FAO	Food and Agriculture Organization
GoK	Government of Kenya
ILRI	International Livestock Research Institute
NACOSTI	National Commission for Science, Technology and Innovation
T. solium	*Taenia solium*

ABSTRACT

The pork tapeworm (*Taenia solium*) is an important parasite that causes disease in humans and pigs where humans host the adult worm in the small intestines and the larval stages are found in the muscles, brain and other tissues in humans and pigs (cysticercosis). Neurocysticercosisis (where the larva of *Taenia solium* is in the brain) is a major cause of epilepsy in humans. Humans can get the infection by consumption of infected pig meat while consumption of food and water contaminated with *Taenia solium* eggs can cause infection in both pig and human. Porcine cysticercosis causes loss to farmers through condemnation of carcasses during meat inspection and loss of market when pork eaters shy away due to fear of infection. The study was carried out to evaluate the Prevalence and risk factors in pig production management systems that can contribute to the occurrence of porcine cysticercosis in Thika municipality and its environs, Kenya in 2016. Cluster sampling method was used to randomly select farmers from four wards of Kamenu, Gatuanyaga, Township and Kimorori. Among the selected farmers, 81 pig farms were visited and structured questionnaires were administered to the pig farmers to collect data on management practices and awareness on porcine cysticercosis. A study sample of 1-5 pigs per farm was randomly selected based on the available number of pigs and criteria of selection. The study pigs were examined by lingual palpation for presence of cysts which appears as nodules on the ventral side of the tongue. Data was analysed using SPSS version 20 where means and percentages were calculated as well as logic regression to determine the relationship between prevalence of porcine cysticercosis and management practices. The farm and pig prevalence of cysticercosis was 6.2% and 1.8% respectively. Porcine cysticercosis was significantly associated with feed source: swill (P=0.001), neighbour's leftovers (p=0.001), home mixed feeds (0.006), and the frequency of de-worming pigs (p=0.027). The main risk factor for porcine cysticercosis was the feeding of swill (P=0.001). Majority (55.6%) of the respondents were females, the pig stock sizes were ranging from 1 pig to 78 pigs and with an average of 11. Majority (97.5%) of pig farmers in the study area practiced zero grazing system. In order of preference, the farmers reported to feed their pigs on manufactured feeds (55.6%), home mixed feeds (28.4%), swill from garbage (12.3%), household leftovers or waste (2.5%) and neighbours leftovers (1.2%). The main (71.6) source of water for watering livestock was tap water. Other sources were wells and borehole, reported by 27.2% and 1.2% of the respondents, respectively. On animal health practices, 88.9% of the pig keepers de-wormed their pigs while 97.5% sought veterinary services. There were 69.1% of the respondents who reported that they usually buy replacement pigs. All the respondents kept pigs for commercial purposes. This study showed that cysticercosis was present in Thika with a low prevalence and the main risk factor for the disease was the practice of feeding pigs on swill. The results of this study shows that there is need to create awareness on the occurrence of the disease in the study area, to give advice on improved pig husbandry practices and especially avoid feeding of swill or cook before feeding it to pigs.

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Pig production is one of the fastest growing livestock sectors in the world with accelerated growth in developing countries that are shifting from ruminant livestock production to mono-gastric production that have shorter life cycles (FAO, 2012). Pig production in the society has many values including income generation, source of food, storage of wealth that can be used in time of crisis and also serve as important assets used in some traditional ceremonies (Kagira *et al.,* 2010).

Pig production has major public and animal health concerns due to occurrence of *Taenia solium* taeniosis in humans and porcine cysticercosis which are prevalent in many parts of the world especially in countries of Latin America, Africa and Asia (Sarti *et al.,* 1992). The global prevalence of porcine cysticercosis stands at about 8% (Zoli *et al.,* 2003). *Taenia solium* taeniasis and porcine cysticercosis have been attributed to cultural practices of eating raw or undercooked pork, poor socio-economic factors and poor sanitation (Sarti *et al.,* 1992). Studies have demonstrated that in endemic areas, porcine cysticercosis and *T. solium* infections in human have been associated with poverty, absence of latrines and free access by scavenging pigs to human faeces as well as feeding of pigs on feeds which are contaminated with infected human faeces (Muller *et al.,* 1987; Mutua *et al.,* 2007).

Pigs acquire infection by ingesting human faeces containing either proglottids or the eggs of *T. solium* tapeworm. These eggs then hatch to oncospheres in the gastrointestinal tract of the pig. The oncospheres travel via the bloodstream and

lodge in any of the body organs where they develops into cysticerci called *Cysticercus cellulosae.* On the other hand, human acquire taeniasis by ingesting undercooked pork infected with *T. solium* cysticerci (Muller *et al.,* 1987).

Prevalence rates of 9%, 3% and 15% were reported in field investigations carried out in Township, Budalangi and Funyula divisions of Busia District respectively (Githigia, 2006). Poverty which may lead to poor sanitary services as well as backyard pig production system where pigs were allowed to access human waste was implicated in spread of Cysticercosis (Mutua *et al.,* 2007). About 20% of pigs in Central Kenya were raised by free range system (KNBS, 2009). The free range coupled with poor sanitation especially in the informal settlements in major towns characterized with poor human excreta disposal is a risk factor to *T. solium* transmission (Sarti *et al.,* 1992).

Thika municipality and its environs which includes Thika town is located in Kiambu County in central Kenya and borders Murang'a County. Thika town is the second largest in Kiambu and has a strong industrial subsector. Pork is among the popular meats consumed in Thika town and its environs. Propelled by the high demand for pork in both Thika and Nairobi, pig farming has emerged as one of the most popular livestock enterprises in Thika municipality and its environs hence its choice as the study area. There was no data on prevalence as well as risk factors of cysticercosis in Central Kenya and therefore the need to conduct this study.

1.2 Statement of the problem

Majority of porcine cysticercosis studies have been conducted in Western Kenya where pigs are reared on free range, partial confinement and tethering systems

which are known to be risk findings in studies elsewhere (Eshitera *et al.*, 2012). In some parts of Central Kenya, the free range system and partial tethering of pigs is also practiced. However, there was no studies and documentation on the prevalence of porcine cysticercosis in central Kenya. Hence there existed a knowledge gap which was filled by this study on estimation of the prevalence of porcine cysticercosis in Thika municipality and its environs and identification of pig management practices that may have contributed to cysticerci infection in the region.

1.3 Justification of the study

Pig production is a major economic activity in Thika municipality and its environs where it is preferred because of low space requirement and presence of ready market offered by both local consumption and Nairobi City County (FAO 2012). *Taenia solium* cysticercosis is major concern in pig industry not only because of its ability to cause serious disease in human but also the potential to cause loss of market for pork. Controlling the *T. solium* cysticercosis infections is therefore important (Sarti *et al.*, 1992). Several studies had been done in western parts of Kenya where the disease was found to be endemic (Mutua *et al.*, 2007). However, information on the disease and its risk factors in central Kenya has been scanty and therefore the need for this study. This study aimed to understand the status of pig production systems in Thika municipality and its environs in terms of management practices and the risk factors that may contribute to the occurrence of porcine cysticercosis.

1.4 The research questions

The study addressed the following research questions:

i. What are the current pig management practices in Thika municipality and its environs?

ii. What is the prevalence of porcine cysticercosis in Thika municipality and its environs?

iii. What are the management practices that may contribute to porcine cysticercosis in Thika municipality and its environs?

iv. What is the association between the risk factors in pig management practices and the occurrence of porcine cysticercosis?

1.5 Study hypotheses

The null hypotheses

Ho_1- There is no association between pig management practices and the occurrence of porcine cysticercosis.

Ho_2- There is no porcine cysticercosis in Thika municipality and its environs.

1.6 Study Objectives

1.6.1 Broad objective

The broad objective was to evaluate the risk factors in pig management practices and their contribution to the occurrence of cysticercosis in Thika municipality and its environs.

1.6.2 Specific objectives

The specific objectives of the study were as follows:

i. To characterize the pig management practices in Thika municipality and its environs

ii. To determine the prevalence of porcine cysticercosis in Thika municipality and its environs

iii. To evaluate the association between the risk factors in pig management practices and the occurrence of porcine cysticercosis

1.7 Conceptual framework

Socio demographics such as age of the respondent, gender, ward, education level and religion of the respondent, the management practices which include source of water, housing system, health management, feeding system, level of confinement and level of sanitation are the risk factors that may be associated with the occurrence of porcine cysticercosis and were therefore the independent variables in this study. The dependent variable was the prevalence of cysticercosis while intervening variable was the existing laws and policies which govern various aspects within the management and production systems of the pigs. While the risk factors were expected to increase prevalence of porcine cysticercosis, intervening variables either reduced their effect or eliminated it all together.

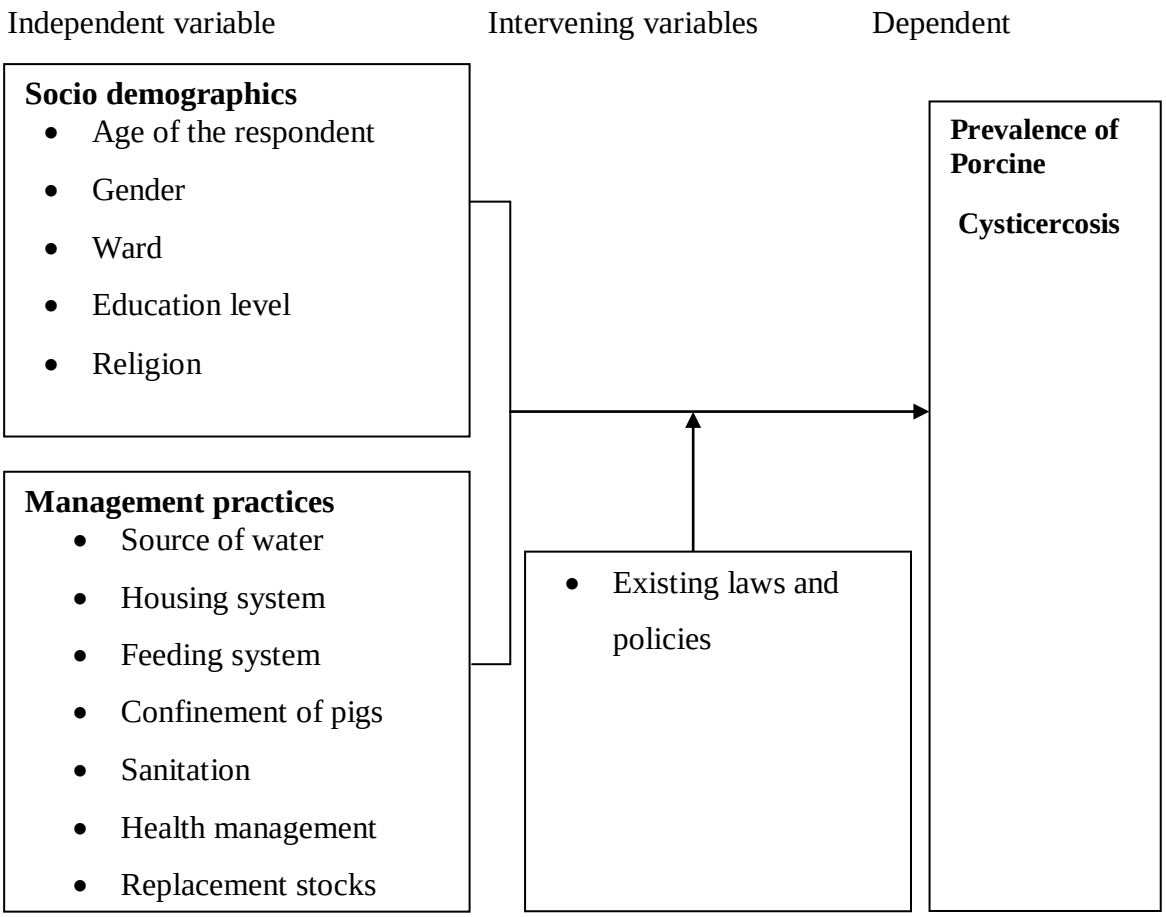

Figure 1.1: The conceptual framework

Source: Adopted from Krecek et al. (2012).

CHAPTER TWO: LITERATURE REVIEW

2.1 Global overview of pig production and occurrence of porcine cysticercosis

Pig production is predominant in various parts of the world such as China, European Union, United States, Indonesia, India, Nepal and Korea, sub-Saharan Africa, Central America and parts of South America, (USDA/FAS, 2019). Worldwide pork production in year 2018 was 113,080 metric tons (USDA/FAS, 2019). China was the largest producer and consumer of pork and as shown (Table 2.1), China produces close to 50% of the pork produced worldwide. Other major pork producers are the European Union, United States, Brazil, Russia, Vietnam, Canada, Philippines, Mexico, Korea and Japan (USDA/FAS, 2019).

Globally, number of pigs are reducing (USDA/FAS, 2019). Increase in pork production as pig population reduce was because of improvement of individual pig productivity. While China had the largest stocks of pig, the trend of stock sizes closely followed pork production trend with European Union, United States, Brazil, Russia, Canada, Mexico, South Korea, Japan, Ukraine and Belarus having the largest stocks in the world (Table 2.2).

Table 2.1: Pork production in selected countries in Metric tonnes

Production	2013	2014	2015	2016	2017	2018
China	56,183	58,208	56,454	54,255	54,518	54,040
European Union	22,359	22,540	23,249	23,523	23,400	23,350
United States	10,525	10,368	11,121	11,320	11,611	11,942
Brazil	3,335	3,400	3,519	3,700	3,725	3,763
Russia	2,400	2,510	2,615	2,870	2,990	3,155
Vietnam	2,357	2,431	2,572	2,701	2,741	2,801
Canada	1,822	1,805	1,899	1,914	1,959	1,930
Philippines	1,388	1,402	1,463	1,540	1,563	1,602
Mexico	1,284	1,290	1,323	1,376	1,267	1,321
Korea, South	1,252	1,200	1,217	1,266	1,280	1,329
Japan	1,309	1,264	1,254	1,279	1,275	1,270
Others	4,636	4,234	5,330	5,646	5,781	6,577
Total Foreign	108,850	110,652	112,016	111,390	112,110	113,080
Kenya	**17**	**17**	**26**	**10**	**12**	**nr**

Key: nr- no record

Source: USDA/FAS, 2019.

Table 2.2: Swine stocks in selected countries in thousand heads

	2013	2014	2015	2016	2017	2018
China	475,922	474,113	465,830	451,130	435,040	440,600
European Union	146,982	146,172	148,341	148,716	147,240	150,260
United States	66,224	64,775	67,776	68,919	71,525	73,150
Brazil	38,577	38,844	39,395	39,422	39,223	38,830
Russia	18,816	19,081	19,405	21,345	21,888	22,940
Canada	12,610	12,940	13,180	13,575	13,760	14,170
Mexico	9,510	9,775	9,700	9,917	10,697	10,410
Korea, South	9,916	9,912	10,090	10,187	10,366	11,270
Japan	9,685	9,537	9,440	9,313	9,346	9,280
Ukraine	7,577	7,922	7,492	7,240	6,816	6,240
Belarus	4,243	3,267	2,925	3,205	3,152	3,160
Others	2,138	2,098	2,308	2,272	2,347	2,990
Total	802,200	798,436	795,882	785,241	771,400	783,300
Kenya	**432**	**430**	**462**	**504**	**554**	**500**

Key: nr- no record

Source: USDA/FAS, 2019.

The pig farming systems in the tropics as classified by Dick and Geert (2004) were: traditional small-scale subsistence-driven production systems, semi-intensive and intensive pig keeping system. Intensive pig keeping system is most common in industrialized countries where very few pigs kept under traditional system. In developing countries, half of the present pig population is still kept under traditional small-scale subsistence-driven production systems (FAO, 2009).

Free-range or scavenging system is usually practiced by small farmer mixed holdings who keep pigs as assets that can be sold to provide emergency fund (Dick and Geert, 2004). On the other hand, semi-intensive pig keeping is characterized by housing of animals, giving more care to health as well as feeding of pigs, modest inputs, higher production and the pigs are also marketed. In intensive pig keeping, meat is produced for the market efficiently and profitably, generally larger numbers of pigs are kept and need substantial inputs of time and money, with careful calculation of the expenditures and the subsequent benefits (Dick and Geert, 2004).

Taenia solium cystercosis and porcine cysticercosis complex is an emerging public health concern in many parts of the world with cases emerging in non-endemic areas due to international immigration and the changing pig production patterns due to an increase in the production costs (Zoli *et al.,* 2003). Infection with *T. solium* and its larvae is prevalent in human hosts in many developing countries in Latin America, Africa and Asia (Allan *et al.,* 2003; Sarti *et al.,* 1992). Taenia eggs have been found to be very resistant to various environmental conditions that allow them to survive in the environment where they can get mixed with fodder and consumed by the pigs (Schantz, 2002). The global prevalence of porcine cysticercosis stands at about 8% (Zoli *et al.,* 2003).

The cause of cysticercosis in human, domestic animals as well as wild animals is metacestodes of Taenia species (OIE, 2014*).* Cysticercosis in pigs is caused by metacestodes of *T. solium*. Adult *T. solium* have a scolex bearing double rows of hooks attached to gravid segments which have less than fourteen uterine branches (Lawson and Gemmell, 1990). The segments containing infective eggs usually

detach and leave the host passively with faeces. Animals acquire infection on consumption of such eggs in contaminated water and feed or consumption of faeces having *T. solium* segments (OIE, 2014*)*. Pigs may also acquire infection by coprophagy of faeces of pigs that had consumed contaminated feed (OIE, 2014*)*. Metacestodes of *T. solium* (*C. cellulosae*) occur in muscles and central nervous tissue of pig while in human, central nervous tissue, muscles, subcutaneous tissue and rarely the eyes are affected (Khalil, 1994). *Cysticercus cellulosae* is thought to be a leading cause of epilepsy in humans (OIE, 2014).

2.2 An overview of pig production and occurrence of porcine cysticercosis in Africa

In numerous parts of the Africa, pigs are kept in low-input systems where they wander freely to scavenge for food which permits underprivileged farmers to enter into pig farming without huge capital investments (Lian *et al*., 2013). Most pig farmers in Africa practice traditional pig production system although semi intensive and intensive piggeries have been increasing in highly populated areas (Kaufmann *et al*., 2000). Pig farmers in South-Eastern Botswana were mostly concentrated in the municipalities and big villages where the demand for pig products is high (Chabo and Babusi, 2000).

Pigs are an essential source of household revenue and food security in numerous countryside economies of unindustrialized countries (Ly, 2000). In line with this, pig farming plays a significant role in smallholder farming systems, as a source of revenue for use in emergency needs (Phengsavanh *et al*., 2010). Pig production can play the following essential roles in Africa: diversification of incomes and decrease of socioeconomic risks, advancement of linkages between systems and

resources (water, land, crops, and animals) and generation of value added products (for example, utilizing of crop residues to produce meat, and the making of manure) (Devendra, 1993).

Porcine cysticercosis is not well recognized in many developing countries of Africa especially those of central and western parts and very little epidemiological data are available (Tsang and Wilson, 1995). Surprisingly, these areas record a very high prevalence of about 6.8% to 18% and the infection reportedly occurs over most of the African continent with the exception of the strictly Muslim areas of the North and sub-Saharan areas (Garcia *et al*., 2002). In Tanzania, cases of porcine cysticercosis were first reported in Mbulu District by (Boa *et al.*, 1995) where the prevalence was estimated at 17.4%. In Uganda, 9.4% of pigs surveyed were found positive by lingual palpation for cysticercosis with most cases coming from the rural areas where absence of latrine was reported as the main risk factor (Kisakye and Masaba, 2002).

2.3 Overview of pig production and occurrence of porcine cysticercosis in Kenya

Agriculture is the main stay of Kenyan economy and its importance is highlighted by its enormous contribution to the countries industrial products and exports (65% of the exports) (FAO, 2012). Although pig sector contribution to the economy is small, it possesses a huge potential which can be exploited (Behnke and Muthami, 2011). Historically, growth of human population, urbanization and increase in income are the main drivers of livestock products demand while production response depends on technology and increase in number of animals (Thornton, 2010**)**. The main hindrances to pig production

sector in Kenya include poor infrastructures, unreliable feed availability and poor sanitation, inadequate veterinary services as well as poor husbandry practices (FAO, 2012).

There are three pig production systems in Kenya; Free range traditional systems, small scale intensive system and large scale intensive commercial systems.

2.3.1 Free range traditional system

Free range traditional system is also known as extensive system because pigs are allowed to roam freely and feed on a variety of feeds including crop residue, kitchen left over, by products of crops as well as grazing on grass (Eshitera *et al.*, 2012). Free range traditional system is mostly found in Nyanza, western Kenya and slums in urban areas (FAO, 2012). It is characterized by keeping of few animals, poor feeding system, disease challenges, few breeding boars, low profit, lack of skills and money to build houses as well as seasonal tethering of pigs during planting, growing and crop harvesting (Mutua *et al.*, 2011). The main decision makers on the husbandry practices and methods of pig keeping are either women or men and women together while the day to day care of pigs is done by women (Nantima *et al.*, 2015).

2.3.2 The small scale intensive pig keeping system

This system is mainly found in Central Kenya, the former Eastern Province, and the Northern and Central parts of the former Rift valley Province (Behnke and Muthami, 2011). The number of pigs kept range from fewer than 10 up to100 (Wabacha *et al.*, 2004). Most farmers in this system home mix their own feed

while in some areas farmers have formed cooperative societies with feed mills e.g. Meru Central cooperative society (FAO, 2012).

2.3.3 Large scale intensive commercial pig keeping systems

This system is found in the same regions as small scale intensive system. Large numbers of pigs are kept in this system at times more than 5000. These farms belong to the largest pork processers in Kenya, Farmers' Choice who raise and slaughter the pigs (FAO, 2012).

2.4 Pig management practices

In developing countries, pig farming is done both extensively and intensively (Kagira *et al.*, 2010; Nsoso *et al*., 2006). Intensification of livestock production has largely contributed to economic growth of many developing countries (Bellaver and Bellaver, 1999). Pig farming requires smaller space and is therefore easier to intensify as compared to ruminants (Phiri *et al.,* 2003).

2.4.1 Pig housing systems

Poor housing is one of the major constraints to pig production in third world countries (Ironkwe and Amefule, 2008; Wabacha *et al.,* 2004). In developing countries, pig houses are characterized by poor wind protection, poorly constructed floor which are usually wet, improperly constructed waste disposal system that normally lead to high worm infestations (Lekule and Kyvsagaard, 2003). Ironkwe and Amefule (2008) observed that in Rivers State Nigeria, there were two types of pig houses; the mud-brick walls with thatched roof, and rammed earth floor type as well as the cement block walls with zinc roof and concrete floor type. The mud-brick wall type was used by most farmers as it was

easily build from locally available materials. In free range or extensive system, houses are constructed using locally available material and usually, pigs are housed at night and during crop growing period (Armenia *et al*., 2016).

2.4.2 Pig nutrition and feeding practices

According to a study conducted on 164 pig farmers in Busia District, Western Kenya, the most frequent feedstuffs used by small holder farmers are ground maize, ground fish and kitchen leftovers (Mutua *et al.,* 2012). Feed and feeding costs make 75 -80% of the total pig rearing cost (Smith, 2006). This is because the bulk of pig feeds (more than 55%) are composed of grains which also form part of human food basket (Smith, 2006). Pig digestive system, compared to other domestic animals, has the highest similarity to human (Haynes, 2001). High cost of feed was found to be one of the major constraints to pig farming in Kikuyu area of Kenya (Wabacha *et al.*, 2004).

Majority of small holder farmers in Kenya are on the lookout for cheaper ways to feed their pigs (FAO, 2012). It has been observed that in some developing countries farmers avoid commercial feeds made from grains and grain by-products which are expensive due to competition with human (Ironkwe and Amefule, 2008). Swill from household and hotel leftovers have been documented as a common alternative in many areas of developing countries (Ajala *et al*., 2007; Carter *et al.,* 2013; Kamuribo *et al.*, 2011; Kagira *et al.,* 2010; Ocampo *et al*., 2005; Phengsavanh *et al.*, 2010). Swill has been associated with spread of diseases especially *Taenia solium* cysticercosis between human and pig (Haynes, 2001). In India, cooking of swill was found to successfully reduce spread of diseases (Ajala *et al.,* 2007; Phengsavanh *et al*., 2010). Use of brewers' grain has

been documented in Nigeria and Namibia (Haynes, 2001; Ironkwe and Amefule, 2008).

2.4.3 Pig watering and water sources

Water is an important component in pig nutrition and is required in large amounts for physiological body functions. At birth, water forms 82% of a pig by weight and by the time a pig is 104 kilograms, 51% of the body is water (Shields *et al.*, 1983). Water has a number of physiological functions in pig which includes; regulation of body temperature, forms part of body tissue, takes part in tissue metabolism, maintains mineral homeostasis as well as helps in excretion of metabolic end products especially urea (Brooks *et al.*, 1989). Although pigs get most of their water requirement by drinking, part of water is ingested together with feeds. Drinking water requirement for pigs vary with age and physiological status as shown (Table 2.3) (Froese and Small, 2001). The lactating sows have the highest daily water requirement and consumption while the weaned pigs have the lowest requirement.

Worldwide, sources of water for pig use include tap water, dams, rivers, wells and boreholes (Peden *et al.*, 2003). The origin of most of Kenya's water is its five water towers namely; Aberdare range, Mount Elgon, Mount Kenya and the Cherengani Hills (NEMA, 2010). Thika and Murang'a counties get water from Aberdare range water tower. Drinking water for pig should be clean to avoid infections (Brooks *et al.*, 1989).

Table 2.3: Water requirements and daily consumption in litres per pig based on swine type

Swine Type	Weight Range(kg)	Water requirement range (Litres /day)	Average Typical Water Use (Litres /day)
Weaner	7-22	1.0-3.2	2
Feeder pig	23-36	3.2-4.5	3.8
	36-70	4.5-7.3	4.5
	70-110	7.3-10	9
Gestating sow/boar	≥	13.6-17.2	15
Lactating sow	≥	18.1-22.7	20

Source: Froese and Small, 2001

2.4.4 Pig stocking and herd sizes

According to 2009 Census, the Central Kenya with 91,977 pigs had the highest number of pigs followed closely by Western with 84,838 pigs (KNBS, 2009). While most of pigs, more than 90%) in Western Kenya, were kept under traditional backyard system, only about 20 % of pigs in Central, were kept under this system (KNBS, 2009). Pigs in Kenya are mainly kept in small scale extensive system, small scale intensive system and commercial system (Behnke and Muthami, 2011). Extensive system, normally referred to as free range pig rearing system, is found mostly in western parts of Kenya and in slums of the major towns while small scale intensive system and commercial system are found in central Kenya and parts of Rift valley (FAO, 2012). There is limited information on herd sizes in Kenya, however a study conducted in western Kenya

indicated that the number of pre-weaned, growing and adult pig/per farm was 5.0 (±3.4), 1.8 (±1.2) and 1.5 (±0.9) respectively (Mutua *et al.,* 2011).

2.4.5 Pig Health management

Health issues in pig that requires to be solved include treatment of various diseases, vaccination against certain diseases and parasite control (FAO, 2012). Internal and external parasite infestations have been reported most frequently by in some studies (Ajala *et al.,* 2007; Kagira *et al.,* 2003; Kamuribo *et al.,* 2011; Lekule and Kyvsagaard, 2003; Mutua *et al.,* 2012). Worm control has been hindered by misuse of anthelmintic which in some cases has resulted to resistance (Steinfeld, 2003).

Reported causes of early piglet mortality include piglet being squashed by their mother, worm infestation, mange, diarrhoea, lice infestation and nutritional deficiencies (Ajala *et al*., 2007; Kagira *et al.,* 2003; Mutua *et al.,* 2012; Mutua *et al.,* 2011). Cysticercosis has been reported as a disease concern for pig and a major public health concern in several rural pig husbandry (Kagira *et al.,* 2003; Mutua *et al.,* 2011; Mutua *et al.,* 2012; Veary and Manoto, 2008).

Remarkable effort to control diseases has been reported in some areas. More than 60% of respondents in a study conducted in Kaduna, Nigeria said they vaccinate their pigs against common diseases (Ajala *et al.,* 2007). In ability to describe diseases has also been reported in other studies where respondents had reported that they did not experience any disease problem (Mutua *et al.,* 2010).

2.5 Pig cysticercosis

2.5.1 Life cycle of T. solium

Cysticercosis in pig is a condition caused by infection with metacestodes of *T. solium* which occurs after a pig ingests embryonated eggs in feeds contaminated by faeces from persons suffering from Taeniasis (Richard, 2017). Human host adult *T. solium* in their intestines and these warms produce embryonated eggs called oncospheres in motile segments which are passed with faeces (WHO, 2017). Infection is spread to other human being when these oncospheres are consumed in contaminated food and then hatch in the gastrointestinal tract to larva which invades the mucosa where it develops further before migrating back to the intestines to mature (Murell, 2005*)*.

The larva stage may invade other tissues of the body causing human cysticercosis. Of great significance is neuro-cysticercosis is which occur when cysticerci invade nervous tissue (Ana *et al.,* 2006). Neuro-cysticercosis may cause conditions such as seizures and other neurological signs (Ana *et al.*, 2006*)*. If the oncospheres are consumed by pig, they do not develop to adult tapeworms but instead form tissue cystcerci (FAO, 2012). Human may get taeniosis following consumption of uncooked or undercooked infected meat (Richard, 2017). Neuro-cysticercosis is responsible for 30% of epilepsy in areas where *T. solium* is endemic and this explains why it is important to control pig infection in order to control taeniasis and cysticercosis in human (WHO, 2017).

2.5.2 Diagnosis of cysticercosis in pigs

Palpation of the tongue for *cysticercus cellulosae* cysts in pigs has been used in several prevalence studies (Phiri *et al*., 2002; Githigia *et al*., 2002; Ngowi *et al.,*

2004). This method was reported to have a sensitivity of 50% in Chitwan and Kathmandu valley (Joshi *et al*., 2006). Post-mortem meat inspection is usually done in slaughter houses and is more sensitive and specific and it involves palpation and incision of several parts of a carcass. Ag ELISA test which detects for presence of antibodies released by pigs immune system against *cysticercus cellulosae* is the most sensitive and has been used in several studies (Eshitera *et al*. 2012, Krecek *et al.,* 2012 and Sikasunge *et al.,* 2006)

2.5.3 Risk factors of cysticercosis

Taenia solium cysticercosis is found in both pig and humans in many third world countries of Asia, Latin America and Africa where conditions sustain its life cycle because of poor sanitary conditions, inadequate meat inspection as well as free range management of pigs (Garcia *et al.,* 1998; Gonzalez *et al.,* 2001; Flisser, 2002). Several studies have associated porcine cysticercosis with poor sanitation and hygiene (absence of latrines, poor disposal of human faeces, poor hand washing practices), poor methods of pig husbandry (poor feeding practices and free-roaming of pigs), lack of meat inspection, and inadequate awareness of the disease (Pondja *et al*., 2010; Sikasunge *et al*., 2006).

2.6 Summary of literature review and the gaps in the knowledge

Porcine cysticercosis complex is an emerging public health and animal production concern across the globe with cases emerging in non-endemic areas due to international immigration and the changing pig production patterns due to an increase in the production costs (Zoli *et al.,* 2003). The global prevalence is estimated at about 8% (FAO, 2012). Both human and pig infections have been reported in South Africa, Zimbabwe, Gambia, Togo, Rwanda, Burundi, Malawi,

Swaziland, Madagascar and DRC (Zoli *et al.*, 2003). In Tanzania, cases of porcine cysticercosis were first reported in Mbulu District (Boa *et al.*, 1995) where the prevalence was estimated at 17.4%. In Uganda, 9.4% of pigs surveyed were found positive by lingual palpation for cysticercosis with most cases coming from the rural areas (Kisakye and Masaba, 2002).

Most of the endemic areas especially in sub Saharan Africa lack proper documentation of this particular disease while the risk factors to its transmission are not documented. Thika Sub-County, being a major producer of pork in the country and the region, lacked any documentation of porcine cysticercosis and therefore, this study sought to provide current status on pig management practices in Thika Sub-County. The contribution of management practices to porcine cysticercosis infection will be evaluated as well as other risk factors for the association with porcine cysticercosis in the region.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study area

This study was conducted in Thika municipality and its environs, Kenya which lies between longitude 36.35^{o}N - 37.25^{o}N and latitude 1.45^{o}S - 3.53^{o}S and is one of twelve sub-counties in Kiambu County (Kiambu County, 2013). The headquarters of Thika municipality and its environsare located in Thika town which is approximately 40km from central business district (CBD) of Nairobi city. Thika municipality and its environshas five administrative Wards namely; Township, Kamenu, Hospital ward, Gatuanyaga and Ngoliba as shown in the map of study area (Figure 3.1). Kimorori ward of Muranga County was also included since it supplies a significant amount of pork to Thika Town.

Thika is the largest town in Thika municipality and its environshas an industrial area with various processing industries dealing mainly in horticulture, fruits, coffee, cooking oils and animal feeds processing. Agriculture and livestock keeping is also predominant especially coffee, horticulture, fruits dairy farming, poultry and pig keeping. The sub-county has moderate tropical climate with average day time temperatures of 25 ^{0}C. The county has two rainy seasons with an average annual rainfall of 840mm. A “long” rain season which starts from March to June and a "short rains" season that starts from October to December. Thika municipality and its environsis located on gentle plains and is characterized by numerous valleys, rivers and is the home of Fourteen Falls.

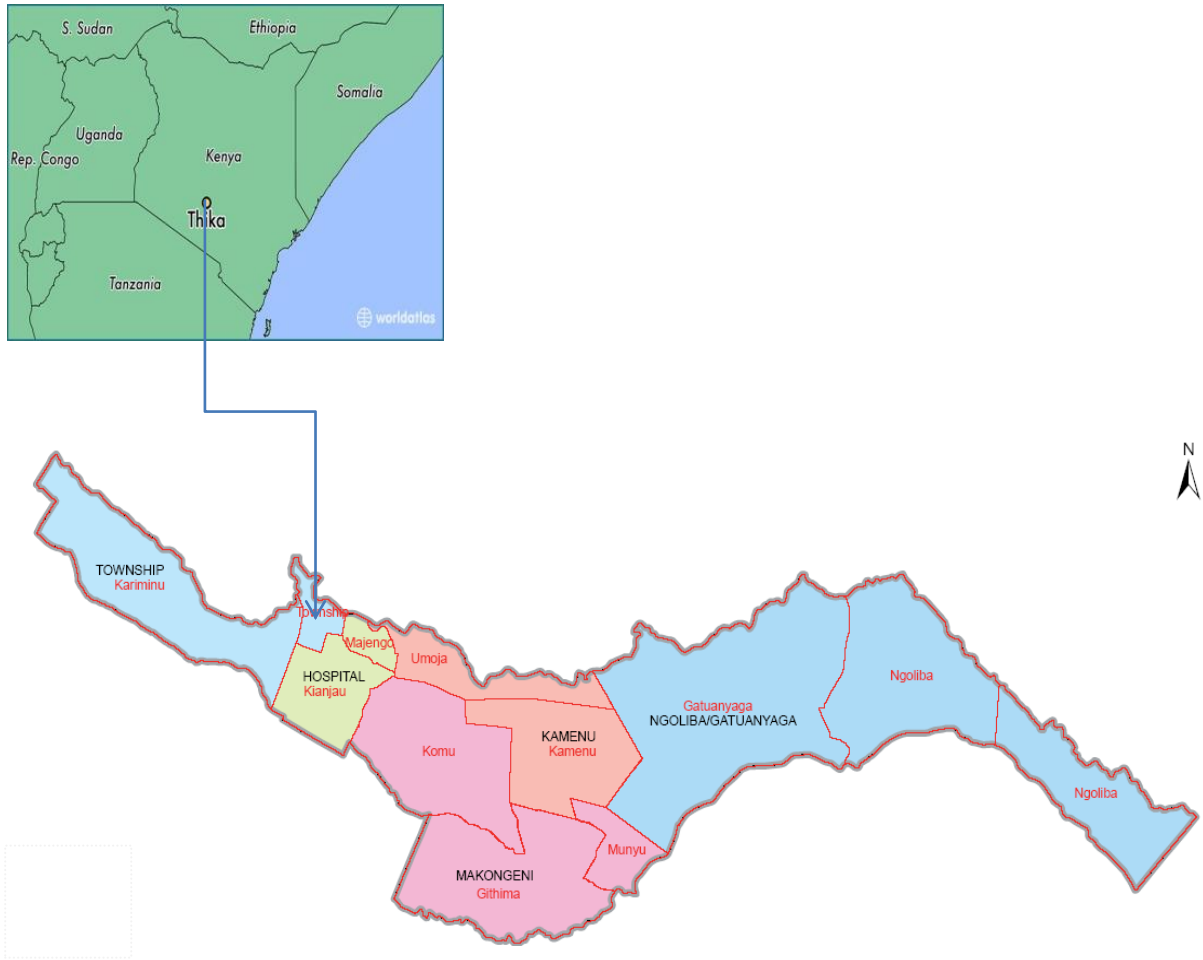

Figure3.1: Map of the study area

Source: Independent Electoral and Boundaries Commission, 2012

3.2 Study design

This study was a cross sectional survey where the pig farms, pig farmers and pigs were randomly recruited into the study for data collection and data collected at one point and time.

3.3 Study population

The study population included all pigs and pig farmers in Thika municipality and its environsand Kimorori ward of the neighbouring Murang'a Sub-County. According to 2009 Census, Thika municipality and its environshad a population of 165,342 people. Available records indicate that Kiambu County had 46,493 pigs in 2009 (KNBS, 2009). Most of the pig farmers are in Thika municipality and its environsas compared to other sub-counties in Kiambu due to proximity to slaughter houses and market (FAO, 2012). As per Kiambu County report the County produced 1803 tonnes of pig meat in 2013 (Kiambu County, 2013*)*. Current reports indicate that the County has 67,500 pigs in 300 households with an average herd size of 5 pigs (Kiambu County, 2013).

Target population were the pig farmers with pigs above 3 months old since younger piglets are less likely to have developed cysts, and pigs whose approximate weight was below 60 kilograms since heavier ones are not easy to restrain for examination.

3.4 Sample size determination

A previous study in western Kenya where lingual palpation method of diagnosing cysticercosis was used, the farm prevalence of porcine cysticercosis was reported at approximately 9.8% (Mutua *et al.,* 2007). Since cysticercosis is endemic in

western Kenya, the prevalence in Thika municipality and its environswas expected to be a bit lower and was therefore estimated to be 5%. The sample size of this study was based on random sampling of pig farmers and inflated by 20% to cater for rejection or non-responses. Sample size was calculated using the following formula (Daniel, 1999).

$$n=\frac{t^2 \times p\,(1-p)}{m^2}$$

Where n= required sample size

t= confidence level at 95% (standard value of 1.96)

p= estimated prevalence

m= margin of error at 5% (standard value of 0.05)

Substitution

T= 95%, P=5%, m= 5%

Therefore;

$$n=\frac{1.96^2 \times 0.05\,(1-0.05)}{0.05^2} = 73$$

With an expected prevalence of 5%, at 95% confidence interval and an error of 5%, the minimum number of households was 73. Seventeen farmers which was 20% of the sample size was added to take care of non-responses making a total of 90 respondents.

The same formula was applied to determine the minimum sample of pigs that were subjected to lingual palpation test for cysticercosis where pig prevalence was estimated to be 10% similar to the rest of the country as reported by Mutua et

al. *(*2007), at 95% confidence interval and an error of 5%, the minimum number of pig required was 138.

$$n=\frac{t^2 \times p\,(1-p)}{m^2}$$

Substitution

$$n=\frac{1.96^2 \times 0.1\,(1-0.1)}{0.05^2} = 138$$

In this study 273 pigs were examined which was double the minimum to increase the number of pigs subjected to lingual test so as to allow adequate sampling of pigs in all the sampled farms.

3.5 Sampling frame

3.5.1 Cluster sampling of the wards

Clusters were formed from the five administrative wards of the Sub-County. Two (2) - stage cluster sampling was used to form 3 clusters from the five administrative wards of the Sub-County based on; the geographic location, total population, pig keeping, pig husbandry practices and water and sanitation.

Cluster 1 comprised of Kamenu ward and the Hospital ward where Kamenu ward was randomly selected. Cluster 2 comprised of Gatuanyaga and Ngoliba wards. Gatuanyaga was randomly picked. Township ward harbours most of the pork eateries and the production was low unlike in the other wards where production was high and consumption low therefore it formed Cluster 3 due to these unique characteristics. Kimorori ward had unique characteristics in that it is the site of Kabati pig slaughter house (where most of pigs from Thika municipality and its

environs are slaughtered) and also supplies significant amount of pork to Thika town and was picked to form Cluster 4.

3.5.2 Recruitment of pig farmers

Identification of pig farmers was carried out with the help of county veterinary officers. Initially 178 farmers were identified and their contacts taken. Each farmer was given a random number. Every odd number was randomly picked where 90 farmers were selected (Table 3.1).

3.5.3 Identification of study animals

In each pig farm, lingual palpation test for cysticercosis was carried out in all the pigs in households with less than 2 pigs while 2 pigs were selected in households with 2-5 pigs and a maximum of 5 pigs selected in farms with more than 5 pigs.

Table 3.1: Number of pig farmers and number of farms sampled per Ward

S/no.	Ward	Number of farmers initially identified in each ward	Number of farmers targeted for sampling
1	Gatuanyaga	20	39
2	Kamenu	47	93
3	Township	5	11
4	Kimorori	18	35
	Total	90	178

3.6 Inclusion and exclusion criteria

3.6.1 Inclusion criteria

All the pig farmers in three wards of Thika municipality and its environsand Kimorori ward in the neighbouring Murang'a County who were randomly selected and voluntarily agreed to participate were recruited in this study. The head in each household was selected to voluntarily answer the questionnaire.

In each pig farm, all pigs aged three months and above both males and females were randomly selected for tongue examination by lingual palpation for cysticerci.

Stakeholders in the livestock sector who were selected to take part in a key informant interview were also included. The stakeholders included County veterinary officers in the study area, County community health officers, elite pig farmers, meat inspectors, private veterinarians and owners of pork eateries in Thika town.

3.6.2 Exclusion criteria

Pigs which were in third trimester of gestation period were also excluded to avoid stressing them during examination

3.7 Data collection tools and data collection

3.7.1 Primary data from pig farmers

Out of the 90 farmers targeted for sampling, 81 were visited and took part in this study. The remaining 9 farmers did not take part in this study as some refused to participate while others had stopped pig rearing by the time the farmers were visited. To all the 81 farmers who took part in this study, a semi-structured

questionnaire was administered to enquire about the bio data and background characteristics of each farmer as well as the various pig management practices in each farm (Appendix I). The questionnaires captured among others, socio-demographic data, water and sanitation, pig husbandry practices and awareness on porcine cysticercosis.

3.7.2 Procedure for lingual examination

Lingual examination to test for cysticercosis was also conducted by a veterinary surgeon to randomly selected pigs from each farm. Each pig was held using a pig snare and maintained in standing position during handling (Figure 3.2). A strong stick was used to keep its mouth open, by passing it across the mouth the tongues of the pigs were then examined for presence of *T. solium* cysticerci. Lingual palpation was done by gasping the tongue gently with one hand and palpating for the cysts. Where a cyst was identified as a firm nodule brighter in colour on the ventral part of the tongue as described by Eshitera et al., 2012 and Kagira et al., 2010.

Figure 3.2: Pig handling during lingual examination

3.7.3 Key stakeholder interviews

Key informant interview comprising the county agricultural extension officers, Sub-County veterinary officers, county public health officers and private veterinary practitioners was conducted to shed more light on pig husbandry practices and risk factors of cysticercosis in the study area.

3.7.4 Observation in the pig farms

Observation techniques were also employed to identify various aspect of pig management as well as risk factors of porcine cysticercosis. Photographs were also taken using smart phone.

3.8 Data management and data analysis

The collected data was coded, entered into computer into Microsoft excel version 2013, checked for completeness and cleaned. The data was then analysed with Statistical Package for Social Sciences (SPSS version 20). The descriptive statistics analysed included proportions, means and percentages. The association of risk factors to occurrence of disease was tested by odds ratio (ratio of the odds of a disease occurring in one population to the odds of it occurring in another population), relative risk (ratio of the probability of a disease occurring in an unprotected population to the probability of it occurring in a non-exposed group) and attributable risk (the difference in rate of a disease between an exposed group and an unexposed group) were calculated at 95% confidence level and significant level was $P<0.05$.

Descriptive statistics was used to indicate the background characteristics of pig farmers. Various management practices were subjected to binary logistic regression analysis to test for association to occurrence of cysticercosis. The strength of relationship between management practices and cysticercosis was tested and management practices that may have high risk of infection were established.

Pig and farm prevalence of cysticercosis was calculated with the formulas below.

Pig prevalence = {(number of positive cases) / (number of pig tested) * 100}%

Farm prevalence = {(number of farms with a positive case) / (all farms) * 100}%

3.9 Ethical considerations

Clearance for research was sought from Kenyatta University Ethics Review committee and approval from Graduate school to carry out the research (Ref A149/OL/CTY/26895/2014, Appendix III). Clearance was also sought from the County directors of Public health and Veterinary services, Kiambu County (Appendix IV). Informed consent was sought from all the study participants. All data was collected using coded questionnaires using unique identifying numbers and was handled with confidentiality. Study participants were recruited into this study on a voluntary basis and there was no cash award but technical advice on improved pig husbandry, significance of cysticercosis and the risk factors for its transmission were shared with the pig farmers. Lingual palpation test was carried out humanely and all the pigs were handled gently. In pig farms where pigs were positive for cysticercosis, the County Director of Veterinary Services was made aware in order to treat the infected pigs and design control strategies and make a follow up interventions.

CHAPTER FOUR: RESULTS

4.1 Socio demographic data of the study participants

The results of socio demographic and hygiene data of the study participants are as presented in Table 4.1 and Table 4.2. The distribution of the farmers according to Ward was uneven where majority of farmers at 51.9% were from Kamenu, 22.2% from Gatuanyaga, 6.2% from Township, and 19.9% from Kimorori Wards respectively and this was in relation to the number of pig farmers in the study area. The respondents comprised of females (55.6%) and males (44.4%) with age range between 20 and 69 years and all were Christians. Among the households visited, 89% kept other livestock alongside the pigs. Majority of the respondents had formal education where only 1.2% lacked any formal education (Table 4.1).

All the respondents had other sources of income other than pig farming. The other sources of income as reported by the respondents included keeping livestock farming, salaried employment, casual labourers and business (Table 4.1).

Table 4.1: Socio demographic data of the study participants

Variable	Characteristic	Number of pig farmers (%)
Ward of residence	Kamenu	42 (51.9)
	Gatuanyaga	18 (22.2)
	Township	5 (6.2)
	Kimorori	16 (19.9)
Gender	Male	36 (44.4)
	Female	45 (55.6)
Marital status	Married	68 (84.0)
	Never married	11 (13.6)
	Divorced	2 (2.5)
Education level	No formal education	1 (1.2)
	Primary not completed	3 (3.7)
	Primary completed	27 (33.3)
	Secondary not completed	5 (6.2)
	Secondary completed	31 (38.3)
	College certificate	11 (13.6)
	University degree	3 (3.7)
Main source of household income	Salaried employment	20 (24.7)
	Business	11 (13.6)
	Casual labour	14 (17.3)
	keeping farming	30 (37.0)
	Crop farming	5 (6.2)
	Assisted/hand-outs	1 (1.2)

The main sources of water for domestic use in the study area as reported by majority of the respondents were tap water. Other reported sources of water for domestic use were wells, public tap and boreholes (Table 4.1.2). All households reported to own latrines with most respondent reporting that they had a pit latrine while only a few reported that they had a flush toilet. All the respondents reported that they usually washed their hands after using the latrine (Table 4.1.2).

Table 4.2: Sources of domestic water and latrine use

Variable		Number of pig farmers (%)
Source of domestic water	Tap in the compound	63(77.8)
	Public tap	2 (2.5)
	Well	15 (18.5)
	Borehole	1 (1.2)
Latrine ownership	Yes	81 (100)
Type of latrine	Pit latrine	61 (75.3)
	Flush	20 (24.7)
Washing hands after latrine use	Yes	81 (100)

4.2 Pig herd structure and pig management practices

4.2.1 Pig herd structure

The results of pig herd structure are presented in Table 4.2. The total number of pigs owned by all the households visited was 901 and their breakdown according to age and sex was as shown in the Table 4.3.

Table 4.3: Pig herd structure

Variable	Age category	Male	Female	Total
Age Group:	Breeders	66	185	251
Piglets		197	234	431
Fatteners		110	109	219
Total		373	537	901

The stock size in the house holds visited was ranging from 1 pig to 78 pigs with an average of 11 and a standard deviation of the mean of 14.12. A total of 58 (71.6%) households had less than 10 pigs while 13 (16.1%) had 11to 20 pigs and further 10 (12.3%) had 21 to 78 pigs.

4.2.2 Pig rearing system

The results of pig rearing system are presented in Table 4.4. All the farmers interviewed restricted the movement of their pigs throughout the year. The area Sub-County veterinary officer reported that the department had recently enforced the law that requires pig farmers to house their pigs. As a result of that enforcement, a majority of the farmers at 79 (97.5%) practiced zero grazing system while 2 (2.5%) kept their pigs under restricted grazing system. Small number (2.5%) respondents reported that they allowed their pigs to roam in a yard with one of them allowing them to roam sometime and the other one allowing them to roam always. No respondent reported that they allowed their pigs to roam outside the compound.

Table 4.4: Pig rearing systems

Variable		Number of pig farmers (%)
Pig ranging system	Zero grazing system	79 (97.5)
	Free ranging system	2 (2.5)
The place where pigs were kept	In a yard	2 (2.5)
	In a house	79 (97.5)

The pig housing structures observed in the study area ranged from well-built permanent houses to simple structures. (Figure 4.1, Figure 4.2).

Figure 4.1: Pig housing- a permanent house

Figure 4.2: Pig housing- a temporary house

4.2.3 Pig feeding systems

The results of pig feeding systems were as presented in Table 4.4. On the pig feeding, various feed sources were reported based on their importance to the farmers as shown in the Table 4.4. In order of importance the feeds reported included manufactured feeds, home mixed feeds, swill from garbage (Figure 4.3**)**, household leftovers or waste, neighbours leftovers and fodder from garden.

Table 4.5: Pig feeds and feed resources used in the study area

Variable		**Number of pig farmers (%)**
Manufactured feeds	Not a source	16 (19.8)
	Most important	45 (55.6)
	Second most important	7 (8.6)
	Third most important	3 (3.7)
	Least important	10 (12.3)
Home mixed feeds	Not a source	42 (51.9)
	Most important	23 (28.4)
	Second most important	4 (4.9)
	Third most important	1 (1.2)
	Least important	11 (13.6)
Swill from garbage	Not a source	63 (77.8)
	Most important	10 (12.3)
	Second most important	1 (1.2)
	Third most important	1 (1.2)
	Least important	6 (7.4)
House hold leftovers	Not a source	38 (46.9)
	Most important	2 (2.5)
	Second most important	1 (1.2
	Least important	40 (49.4)
Neighbours left overs	Not a source	59 (72.8)
	Most important	1 (1.2)
	Second most important	1 (1.2)
	Least important	20 (24.7)
Fodder from garden	Not a source	37 (45.7)
	Third most important	2 (2.5)
	Least important	42 (51.9)

4.2.4 Water sources

Majority of the respondents had access to clean sources of water for their livestock's. The study area is close to Thika town and farmers had access to piped water for both their livestock and domestic use. It was only in rural peri-urban areas with low population where there was no piped water and the farmers used wells and bore holes as source of water.

4.2.5 Stock replacement practices

The results of pig stock replacement practices are presented in Table 4.5. Most of the farmers out sourced their breeding stock especially the boar to avoid inbreeding. Some farmers reported that with the prevailing risk of African swine fever they preferred to raise their own boar rather than shared communal one.

A few farmers practiced fattening system where they bought weaned piglet, reared them to market weight and sold them to slaughter houses and practiced all in, all out system. For those who did not purchase replacement stock and did not have breeding boars, they would use neighbours boar to breed from selected gilts in the herd. Majority of the respondents kept pigs as a commercial enterprise while the rest reported they kept them for security purpose in case of emergency family needs.

Table 4.6: Pig replacement practices

Variables	Response/ source	Number of pig farmers (%)
Purchasing of replacement pigs	Yes	56 (69.1)
	No	25 (30.9)
Source of replacement pigs	Purchase from within the neighbourhood	49 (50.5)
	Purchase from outside the neighbourhood	6 (7.4)
	Given as a gift from neighbour	1 (1.2)
	Never purchase	25 (30.9)
Reason for keeping pigs	Commercial	49 (60.5)
	Security (as a bank) and commercial	32 (39.5)

4.2.6 Pig health management

The results of pig health management are presented in Table 4.6. Most of the farmers were keen on the health of their livestock in that they sought veterinary services and advice for their pigs. Thika municipality and its environsveterinary officer reported that the area boasted many private veterinarians and therefore veterinary services were readily available. Thika town also has many well stocked agro vets which are attended by veterinary surgeons and veterinary para-professional therefore improving access to de-wormers, other drugs and veterinary advices as well.

This was evident in the results of this study where a majority of the respondents reported that they de-wormed. The frequency of de-worming was varied with

most respondents reporting that they de-wormed their pigs every three months and the rest bi-annual or annually (Table 4.6).

Veterinary services were readily available where most of the respondents reported that their pigs were usually attended by a veterinarian. Further, a majority of the respondents reported that they sourced veterinary services occasionally (less than once a month) (Table 4.6).

On the perception of the veterinary services, a majority of the respondents felt that veterinary services are useful even when the pigs are not sick while the rest felt they are only useful when the animals are sick and a very small proportion felt they are not necessary at all (Table 4.6).

Table 4.7: Health management and worm control

Practices	**Frequency**	**Number of pig farmers (%)**
De-worming	Yes	72 (88.9)
	No	9 (11.1)
Frequency of de-worming	Rarely (once in a year)	8 (9.9)
	Occasionally (after six months)	22 (27.2)
	Often (after every three months)	42 (51.9)
	Never de-worms	9 (11.1)
Access to veterinary services	Yes	79 (97.5)
	No	2 (2.5)
Veterinary services frequency	Rarely (less than once a month)	31(38.3)
	Occasionally (two times in a month)	42 (51.9)
	Often (more than twice a month)	6 (7.4)
	Never gets vet services	2 (2.5)

4.3 Prevalence of porcine cysticercosis

The results of prevalence of porcine cysticercosis are presented in Table 4.7. Lingual palpation to examine for porcine cysticercosis was done on 273 pigs. Among these, 5 pigs were found to be positive while the rest were negative (Figure 4.3). Four of the positive cases were found in Kamenu ward while one positive case was found in Kimorori ward. The prevalence of cysticercosis was therefore found to be 1.83 %. Out of 81 farms that were evaluated for porcine cysticercosis, 5 farms had a positive case giving a farm prevalence of 6.2%.

While three positive cases were found in pigs older than one year, two positive cases were found in pigs of approximately 5 months. All the five positive households had small stock sizes with the largest being 12 pigs and the smallest being 2 pigs. Although all the positive households practiced zero grazing, three out of the five (60%) fed their pigs on swill and none cooked swill before feeding. Kamenu ward hosted Kiganjo dump site where Thika Township and its environs' waste was dumped. The area's government veterinarian reported that most farmers got swill from the dump-site.

Table 4.8: Distribution of positive cases in the four Wards

	Gatuanyaga	**Kamenu**	**Township**	**Kimorori**	**Total**
Farms sampled	18	42	5	16	81
Pig in the sampled farms	307	488	77	29	901
Pig examined for cysts	77	145	34	17	273
Farms with a positive case	0	4	0	1	5
Positive cases	0	4	0	1	5
Farm prevalence	0	9.50%	0	6.30%	6.20 %
Point pig prevalence	0	2.80%	0	5.90%	1.83 %

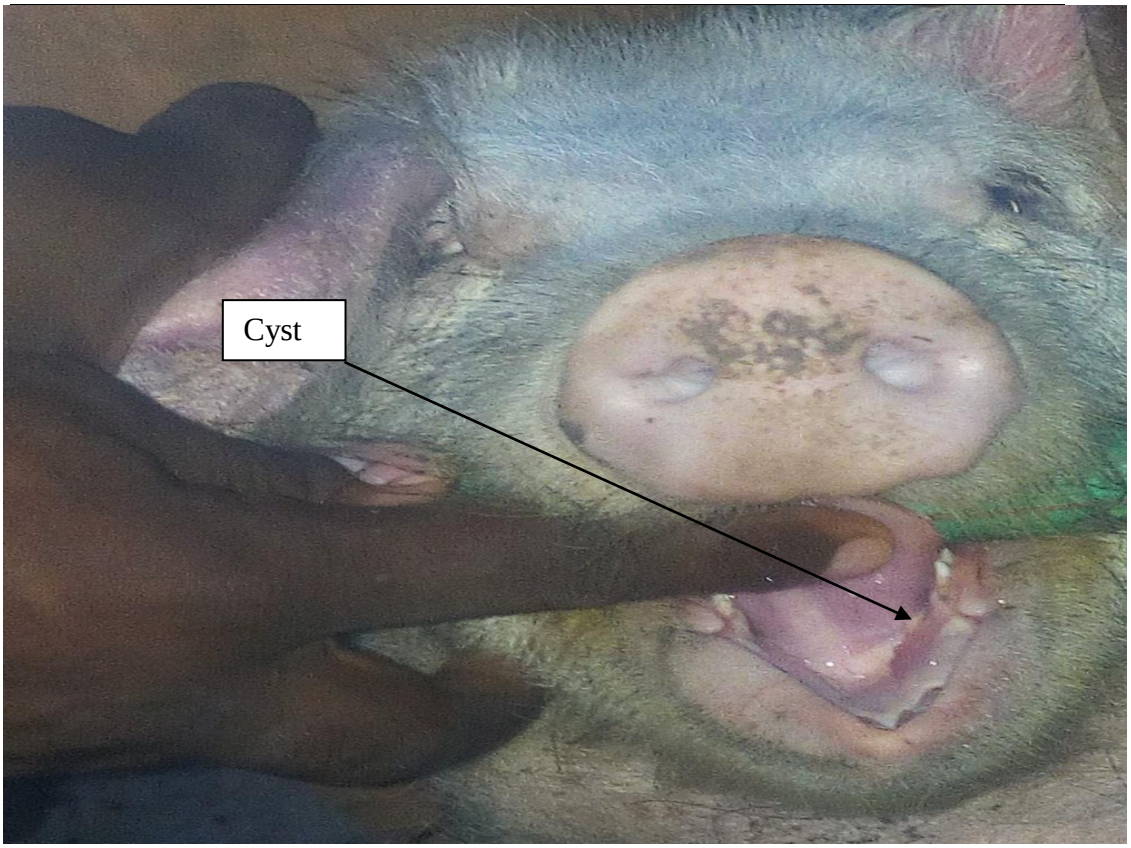

Figure 4.3: *Cysticercus cellulosae* cyst on the tongue of a pig

4.4 Risk factors in the management practices that may contribute to the occurrence of porcine cysticercosis

Binary logistic regression analysis was used to test dependence of porcine cysticercosis to various factors and management practices.

4.4.1 Socio-demographic characteristics of the respondents

The regression analysis of socio-demographic characteristics of the respondents to test for association to prevalence of cysticercosis is presented in Table 4.8. The regression analysis indicated that the main source of household's income was significantly associated with the occurrence of porcine cysticercosis.

Table 4.9: Association of socio-demographic characteristics of the respondents to occurrence of porcine cysticercosis

Variable	Score	df	p	Remarks
Ward of residence	2.328	3	0.507	Not significant
Gender of respondents	1.290	1	0.256	Not significant
marital of respondents	1.019	2	0.601	Not significant
Level of education of respondents	2.910	6	0.820	Not significant
Main source of households income	12.150	5	0.033	Significant
Source of water for domestic use	1.523	3	0.677	Not significant
Latrine type	0.063	1	0.802	Not significant
personal de-worming	0.871	1	0.351	Not significant

4.4.2 Management practices

The results of binary logistic regression analysis of various management practices to test for their association to prevalence of cysticercosis are presented in Table 4.9. Binary logistic analysis was also done to test the dependence of porcine cysticercosis to various management practices where significant association was found in the practices of feeding pigs on home mixed feeds (p=0.006), neighbour's leftovers (p=0.001), and swill (P=0.001) as well as frequency of de-worming pigs (p=0.027). The practices of feeding pigs on home mixed feeds, neighbour's leftovers and swill were found to increase risk of porcine cysticercosis infection while de-worming pigs every three months was associated with reduced the risk of infection.

Table 4.10: Association of pig management practices to the occurrence of porcine cysticercosis

Variable	Score	df	p	Remarks
Pig ranging system	0.135	1	0.713	Not significant
Feeding manufactured feeds	2.249	4	0.690	Not significant
Feeding on home mixed feeds	14.332	4	0.006	Highly significant
Feeding on fodder	0.237	2	0.888	Not significant
Feeding on house hold leftovers	7.643	3	0.054	Not significant
Feeding on neighbour's leftovers	16.561	3	0.001	Highly significant
Feeding on swill	17.637	4	0.001	Highly significant
Swill cooking	0.892	2	0.640	Not significant
Source of livestock's water	0.489	2	0.783	Not significant
De-worming of pigs	0.426	1	0.514	Not significant
Frequency of de-worming pigs	9.146	3	0.027	Significant
Access to veterinary services	0.135	1	0.713	Not significant
Frequency of veterinary services	1.328	3	0.722	Not significant
perception on veterinary services	0.743	2	0.690	Not significant
Purchase replacements	2.379	1	0.123	Not significant
Source of replacements	3.186	3	0.364	Not significant
Reason for keeping pigs	3.656	1	0.056	Not significant

CHAPTER FIVE: DISCUSSION CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Socio demographic data

Most of the respondents in the study were women who were usually left at home to take care of the livestock as their husbands did other jobs away from the homestead. This concurs with studies done in western Kenya which showed higher female than male respondents (Kagira *et al.,* 2010; Mutua *et al.,* 2012; Mutua *et al.,* 2011; Mutua *et al.,* 2007). In many parts of the world, labour for pig husbandry is mainly provided by women and this could be the case in this study as the respondent here majority of whom were women were left at home to take care of house chores including caring for the pigs. This study also concurs with various other studies by International Livestock Research Institute (ILRI) of who estimated that among about 600 million poor livestock keepers all over the world; around two-thirds of them are women (FAO, 2011; Thornton *et al.,* 2002).

A majority of the respondent had at least primary school education and above. The literacy level among farmers in the study area could be associated with the emphasis of Kenyan government for education for all. This enhances absorption of science and technology in pig faming in the study area and ease communication between farmers and extension service providers. This findings were similar to what Zanu et al. (2012) observed that there was high level of education among the pig farmers in Ghana. However, the current results differed with the report of Birhan et al. (2015), who observed that most of the pig keepers in Gonder, Ethiopia were uneducated.

A majority of the respondents were from Kamenu ward which is peri urban area and concurs with studies done in Thailand which reported that most of the pig farming was in peri urban areas due to proximity to the market and source of feed (Thanapongtharm *et al.,* 2016).

Majority of the respondents had tap water and latrines. This finding is different from other studies in Africa where the researchers reported that most of countries in sub-Saharan African lacks basic sanitation facilities such as latrines and do not have access to tap water (Ngowi *et al.*, 2004). Tap water is usually treated and therefore reduced transmission of cysticercosis and other water borne pathogens.

5.1.2 Pig management practices and ranging systems

Majority of farmers kept small herd sizes of less than 10 pigs, with a small minority having herd sizes of over 10 pigs. Most of the farmers had other sources of income and only kept a few pigs to provide extra income. These results were consistent with what Ironkwe and Amefule (2008) observed in Rivers State, Nigeria where all the farmers interviewed had less than 10 pigs with majority of the respondents having less than four adult pigs. However Ironkwe and Amefule (2008) only reported adult pigs while all pigs including piglets were counted in this study, hence the difference in herd size.

Small herd sizes were also observed in western Kenya where majority of pig farmers keep smaller herd size with an average of two pigs per household and with a sole purpose of supplementing their sources of income (Kagira *et al.,* 2010; Mutua *et al.,* 2012; Mutua *et al.,* 2011; Mutua *et al.,* 2007). With an average of 11 pigs, pig herd sizes observed in Thika were significantly higher than the average of 2 reported in western Kenya and that was possibly because

farmers in Thika were more motivated because of proximity to market as compared to those in western Kenya.

Most of the farmers practiced zero grazing system while only a few kept their pigs under restricted grazing system. The rearing system findings were not consistent with those of a study that was done in western Kenya where free range system was common (Mutua *et al.,* 2007). Pigs kept under zero grazing system have lower risk of coming in contact with pathogens and infective stage of porcine cyticercosis. Consequently, the prevalence of cysticercosis was found to be higher at as compared to Thika. This can be attributed to enforcement of ban on free range keeping of pigs in the municipality by Kiambu county government as reported by the sub-county veterinary officer.

In current study, pigs were confined in structures that ranged from temporary wooden houses with earthen floor and lacking roofing, to well-constructed permanent pig houses with good well drained easy to clean floor and good roofing. Those houses in their simplicity or complexity were used to permanently confine pigs. This concurs with findings of other researchers (Kagira *et al*., 2010; Mutua *et al.*, 2011; Mutua *et al.*, 2012; Mutua *et al.,* 2007) who found out that local available materials were used to construct pig houses in parts of Busia County in Kenya. Where earthen floor were used, pigs were at risk of cysticercosis and worm infection as cited by Lanada et al. (2003) that pigs on earth flooring were more vulnerable to parasites and diseases.

Although most farmers preferred feeds from manufacturers, the need to cut on cost of production has made them exploit other feed sources that cost less. The standard of feeding in Thika thought was much higher as compared to western

Kenya where previous study had shown that most farmers preferred locally available feed stuffs such as maize floor, dried fish and kitchen leftovers (Mutua *et al.,* 2012). The practice of using commercial feeds together with local feeds is not limited to Kenya only as Armenia et al. (2016) reported that most farmers in the Municipality of Surigao del Su, Philippine resorted to mixed feeding and in some cases fed only local feeds. Swine is an omnivorous animal. Being none selective eater, pigs consume diverse kinds of feeds and can survive on vegetable peeling, left over foods, wasted fruit and stem trimmings but it is the farmers concern to reduce the cost of feeds without upsetting the wellbeing and vigor of the animals (Armenia *et al*. 2016).

Water sources for the pigs were reported to be mainly from piped water from taps in the home compound. The findings of this study do not concur with findings by Eshitera et al. (2012) in a research done in Homabay County, Kenya which reported out that a majority of the respondents did not have potable water and relied on borehole and water from dams. In Homabay county, domestic water treatment was reported at 40.5% unlike in Thika where majority of the respondents have access to treated water which is unlikely to be contaminated with *T. solium* eggs and hence does not encourage the transmission cycle.

Most of the farmers reported that they have a good access to market due to the proximity of the Kabati slaughter house which is located within the Murang'a County. Pork sellers from Nairobi City and Thika town bought meat from the slaughter house creating demand. This does not concur with findings of studies done in western Kenya that found out that pig keepers were not in proximity to

the market and normally middlemen bought their pigs and transported them to the slaughter houses in Nairobi and Thika (Eshitera *et al.*, 2012; Kagira *et al.*, 2010).

In the present study, most of the farmers out sourced their breeding herd especially the boar to avoid inbreeding. Farmers in the study area had good access to veterinary advice and knew the importance of outsourcing breeding herd to avoid in breeding. Increased use of own stock give rise to inbreeding and consequently low productivity. Also most farmers were keen to own a boar and avoid outsourcing at the time of need due to the prevailing risk of African swine fever. Some of the farmers interviewed reported that they had previously experienced in their own farm or in a neighbours farm cases of African swine fever that acquired infection from a borrowed boar.

Majority of the respondents in this study reported that they usually de-worm their pigs and almost all farmers reported of seeking veterinary services for their herds. Thika municipality and its environsveterinary officer reported that most farmers purchase oral piperazine which they administer either in water or feeds. These findings were not consistent with findings from a study that was done in western Kenya that found out that disease control measures such as spraying for external parasites, de-worming and vaccination, were found to be rare (Mutua *et al.*, 2011). Mutua et al. (2011) also observed disease was a lesser challenge in peri urban areas than rural areas which was not consistent to the findings of this study. This can be attributed to the shift in market demand for pork that has called for increased production and the improved production systems coupled with pig keepers increased awareness and provision of quality veterinary services to meet the market demand for quality pork

5.1.3 Prevalence of porcine cysticercosis

This study investigated the prevalence porcine cysticercosis in Thika municipality and its environs and found it to be low as compared to other parts of Kenya and Africa at large. The study however confirmed that low numbers of pigs in the study area are infected by C. *cellulosae*. Majority of pig farmers in Thika confined their pigs therefore limiting their access to *Taenia solium* eggs. This is contrary to western parts of Kenya where pigs are left to roam either some periods of the year or throughout the year and consequently the prevalence (9.8%) of cysticercosis was found to be higher in those areas than in Thika (Mutua *et al*., 2007).

Presence and use of latrines in all the households visited ensured that human waste was well disposed. The main source of infection to pigs was therefore eliminated and therefore reducing infection rates. Eshitera *et al.* (2012) found that absence of evidence of latrine use was the main risk factor for pig infection with *cysticercus cellulosae* in Homabay district where prevalence by Ag ELISA test was 32.8% while examination by lingual palpation reported 5.6%.

In sub-Saharan Africa, studies on porcine cysticercosis reported a prevalence of 40.6% in Eastern Cape Province of South Africa (Krecek *et al.*, 2012), and 23.3% in the Eastern, Southern and Western provinces of Zambia (Sikasunge *et al.*, 2006), all using Ag-ELISA. Ganaba et al. (2010) reported prevalence of 38.4% in Burkina Faso using Ag-ELISA. Kiambu County reported prevalence that does not concur with prevalence in most parts of sub Saharan Africa. This can be attributed to the fact that the method used has lower sensitivity and does not

diagnose infested pigs at the onset of the infection unlike Ag-ELISA that detects antigens even before cyst formation.

The Ag-ELISA has been reported to have a sensitivity ranging between 76.3% and 86.7% and a specificity ranging between 84.1% and 98.9% in pigs in South Africa, Zambia and West Cameroon (Krecek *et al.*, 2012). Helen and Eric (2016) compared Ag-ELISA test and lingual palpation in 26 areas across Africa and reported that assessing the prevalence of lingual cyst-positive pigs to be a potentially quick way of detecting areas at high threat of cysticercosis.

5.1.4 Risk factors associated with porcine cysticercosis

This study found several pig management practices to be significantly associated with occurrence of porcine cysticercosis and these included; feeding (feeding pigs on swill from garbage, household leftovers and neighbours leftovers) failure to de-worm pigs and purchasing of replacement pigs. Feeding of uncooked swill was also found to increase the odds of cysticercosis infection. Thika was unique in that while porcine cysticercosis in many parts of Africa has been shown in many studies to be associated to absence of latrine and free range husbandry (Eshitera *et al.*, 2012; FAO, 2012; Krecek *et al.*, 2012), most farmers in the area had latrines and free range pig husbandry was non-existent.

Feeding of swill had the strongest association to cysticercosis and was therefore the main risk factor of the disease in the study area. The farmers who fed their pig on swill mainly got it from the dump site where risk of contamination with human faeces and consequently *Taenia solium* eggs was possibly high. Tin et al. (2015) also reported significant association of porcine cysticercosis to feeding of swill where they observed that most households in Nay Pyi Taw Area in

Myanmer collected swill which might have been contaminated with *T. solium* eggs from infected food preparers of swill collected houses. There was stronger ass/ociation on occurrence of porcine cysticercosis to feeding uncooked swill as compared to feeding swill in general. A study by Pondja et al. (2010) in Mozambique reported that cooking of swill kills tapeworm eggs reduced the risk of pig infection.

Cysticercosis infection was also associated to failure to de-worm pigs. Cases of cysticercosis in Busia district of Kenya were found to be fewer by Eshitera. (2012) where de-worming was done regularly after every three months. This concurs with the findings of the current study which reported a significant association between the frequencies of de-worming to the occurrence of porcine cysticercosis. Studies have shown that low doses (5-10 mg/kg/day) of praziquantel have some activity against cysts and pigs can tolerate high doses of up to 50 to 70 mg/kg/day (Garcia *et al.*, 2002) and therefore deworming may have reduced transmission and prevalence of cysticercosis.

5.2 Conclusions

The study aimed to to evaluate the risk factors in pig management practices and their contribution to the occurrence of cysticercosis in Thika municipality and its environs.

The following conclusions were drawn from the study:

Majority of pig farmers in Thika kept small herd sizes of less than 10 pigs. The pigs were zero grazed with restricted movement throughout the year. The pig houses were simple temporary structures although few of the farmers with higher

pig numbers housed there animals in structures with concrete floors, stone walls and iron sheet roofed. The production system in the study area was commercial small holder producers where pigs were fed in confinement throughout the year and were for commercial purposes. Most farmers preferred feeds from commercial manufacturers for their pigs, although a few used non-commercial feeds such as swill, household leftovers, home mixed feeds and neighbours' left over.

This study reported the presence of porcine cysticercosis in Thika with a low pig prevalence (1.8%) as compared to other endemic areas in Kenya and East Africa countries and farm prevalence (6.2%) is comparable with that reported in other studies in Kenya.

The risk factors for the occurrence of porcine cysticercosis in the study area was the feeding of pigs on swill (p=0.001). Other factors that were found to have some bearing on porcine cysticercosis prevalence were feeding pigs on home mixed feeds (p=0.006), neighbour's leftovers (p=0.001), and frequency of de-worming pigs (p=0.027).

5.3 Recommendations

The following recommendations were drawn from this study:

1. Some of the houses were poorly made and there is need that extension officers educate farmers on the need to improve pig houses and therefore welfare of their pigs.

2. This study reported the presence of porcine cysticercosis in Thika with a low pig prevalence and therefore it is necessary that all stakeholders (farmers, extension

officers, private veterinarians, county veterinarians) are made aware that the disease is present in the area in order to be vigilant.

3. The main risk factor for the occurrence of porcine cysticercosis in the study area was the feeding of pigs on swill and therefore it is necessary that extension officers educate the farmers on the risk of feeding their pigs on swill and encourage them to recook swill if they must feed it to their pigs.

5.4 Further research

The following areas were recommended for further research and drawn in line with the findings of this study

1. Studies on the sources of the swill and prevalence of Taeniasis of garbage and swill collectors
2. There is need also to expand this study to cover the entire central Kenya
3. Studies on prevalence and risk factors of *T. solium* in human in the area are also needed.

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APPENDICES

Appendix I: Study questionnaire

A STUDY ON PIG MANAGEMENT PRACTICES AND WORM CONTROL IN THIKA, KIAMBU COUNTY, KENYA

Hi. My name is Samuel Njogu Mwangi. I am a student from Kenyatta University. I am interested in understanding pig husbandry in Thika municipality and its environsin terms of how you feed them; construct their houses as well as other management practices. I would also like to understand worm control in human. The survey will take approximately 30 minutes.

Consent (*accepted or rejected*)…….

House hold number.....

Lingual test result.....

Accepted 1

Declined 2

Name of the interviewer Date

…… …….

Wards *(Circle appropriate)*

Kamenu 1

Gatuanyaaga 2

Township 3

Kimorori 4

……

Section A: Demographics

Indicate the following;

1. Contact of the respondent…….
2. The gender of the respondent *(Circle appropriate)* Male1 Female 2
3. Date of birth of the respondent (*day/ month/ year)*……. *(Indicate age in years)*……..

4. Marital status of the respondent *(Circle appropriate)*
   Married1 Never married 2 Divorced 3 Separated 4
   Widowed 5 Widower 6 Other
   (specify)……

5. Highest level of education attained by the respondent *(Circle appropriate)*
   No formal education 1 Primary not completed 2 Primary completed 3 Secondary not c

6. Religion of the respondent*(Circle appropriate)*
   Christian 1 Muslim 2 Hindu 3
   Adventist 4

   Not Religious 5 Others (**specify**) ……

Section B: Socio economic data

7. What is the main source of house hold income? *(Circle appropriate)*
   Salaried employment 1 Business 2 Casual labor 3 Animal husbandry 4 Crop farming5Assistance/Handouts 6 No reliable source of income 7
   Other 8 *(specify)*…….....

8. What is the main housing material for the household? *(Circle which apply)*

   Floor

   Earthen 1 Cement 2 Wooden 3 Other 4 *(specify)* ……

   Walls

   Earthen 1 Cement2 Wooden 3 Mud 4 Iron sheets5

   Other 6 *(specify)* …….

   Roofing

   Grass 1 Makuti 2 Iron sheets 3 Tiles 4

   Other 5 *(specify)*……..

9. Does the household own livestock? *(Circle appropriate)*

   Yes1 No 2 *(If No skip to 5)*

10. If yes in question 9 above, which ones do your household own? *(for each livestock owned indicate their number)*

   Poultry 1 numbers ……
   Cattle 2 numbers…….
   Goat 3 numbers ……
   Sheep 4 numbers ……
   Pig 5 numbers ……...
   Rabbit 6 numbers ……...
   Other 7 *(specify)*……

11. What is the household water source for domestic use? *(Circle appropriate)*

Tap in the compound 1 Public tap outside the compound 2 Dam 3

River 4 Well 5 Borehole 6 other 8 *(specify*)…….

12. Does your household have a latrine?

Yes 1 no 2

If yes which type?

Pit latrine 1 flush 2

13. Do you wash hands after using the latrine?

Yes 1 No 2

Section C: Pig keeping practices (The respondent should own or be from a household that owns a pig)

14. Give the current number of pigs in the household by age and sex

Class:	Male	Female
Breeders	_____	_____
Piglets	_____	_____
Fatteners	_____	_____

15. What ranging system do you use for you animals? *(Tick appropriate)*

Species	Zero grazing	Restricted grazing	Free ranging	other *(specify)*
Cattle:	_____	_____	_____	_____
Sheep:	_____	_____	_____	_____
Pigs:	_____	_____	_____	_____
Poultry	_____	_____	_____	_____

16. Where do you keep your pigs? *(Circle one)*
In the yard 1 In a house 2 Outside the compound 3
Other 4 ***(specify)***……
17. Do you allow your pigs to roam freely? (*Yes/ No*) _____
18. If yes where and how often do you allow them to roam? *(Circle appropriate)*
In the yard: always 1 sometimes 2 never 3

Outside the compound: always 1 sometimes 2 never 3

19. If no how do you keep your pigs from roaming? *(Circle appropriate)*

Keep in house 1 Tie with rope 2 keep within fenced area 3 Let pigs roam 4 other 5 *(specify)*……

20. Rank in order of importance the sources of your pig's feeds:
    (1 = Most important; 2, 3, 4 = less important; 0 = not a source)
    Feed from manufacturers _____
    Home mixed feeds _____
    Fodder from the garden _____
    Household leftovers or waste_____
    Neighbors' leftovers _____
    Swill from garbage _____
    Scavenges widely _____
    Other *(specify)* _____

21. If swill is used do you re-cook? (*Yes/no*) _____

22. Do your pigs have access to human faeces in anyway? (*Yes/no*) _____
23. Where do the pigs get water from? *(Circle all those which apply)*

    Tap in the compound 1 Public tap outside the compound 2

    Dam3 River 4 Well 5 Borehole 6 Water vendors 7 Other 8 (specify)……

24. Do you normally deworm your pigs? (*Yes/No*) _____ (*If No skip to 9*)
25. If yes in question 7 above, how often do you de worm them?

    Rarely (once in a year) 1 occasionally (after six months) 2

    Often (after every three months) 3

26. Do your animals get inspected by a vet? (*Yes/No*) _____ *(If No skip to 11)*
27. If yes in question 9 above, how often do the animals get inspected? *(Circle appropriate)*

    Rarely (less than once a month) 1 occasionally (two times in a month) 2

    Often (more than twice a month) 3

28. What is your opinion (view) on the inspection of animals by a vet? *(Circle appropriate)*

    It is useful 1

    Useful only when the animals are sick 2
    Other 3 (specify)……

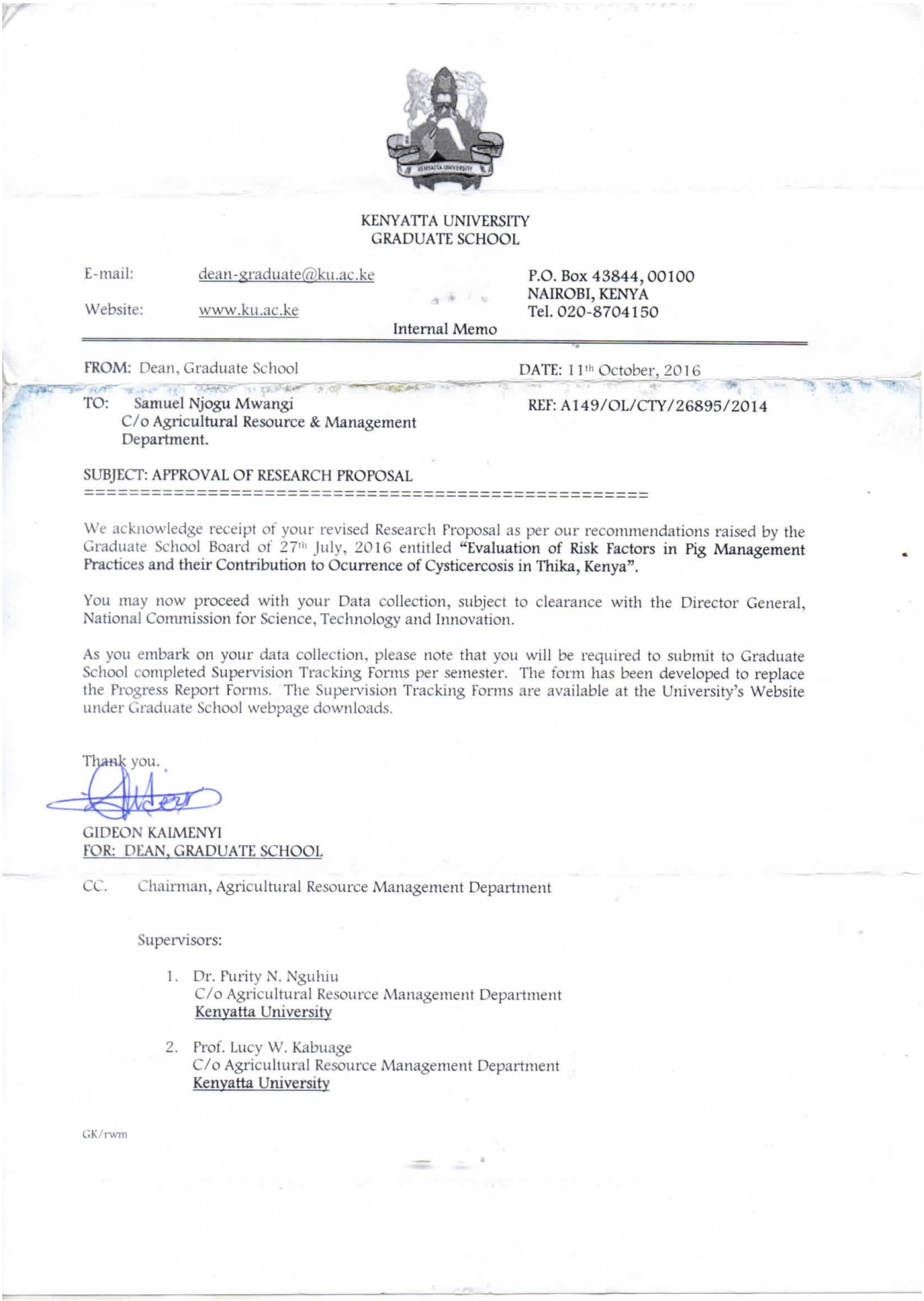
29. Do you ever purchase replacement pigs? (*Yes/ No*) _____

30. If yes, from where? *(Circle all those that apply*)
    Purchase from within the neighbourhood 1
    Purchase from outside the neighbourhood 2
    Given as a gift from neighbour 3
    Given as a gift from outside the neighbourhood 4
    Any other 5 (specify) _____

31. Reasons for keeping pigs (*circle all those that apply*):
    Home consumption 1
    Commercial 2
    Security (as a bank) 3
    Other 4 (specify) _____

Thank you for participating!

Appendix II: Approval of research proposal by Kenyatta University graduate school



KENYATTA UNIVERSITY
GRADUATE SCHOOL

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Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Dean, Graduate School

DATE: 11th October, 2016

TO: Samuel Njogu Mwangi
C/o Agricultural Resource & Management
Department.

REF: A149/OL/CTY/26895/2014

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your revised Research Proposal as per our recommendations raised by the Graduate School Board of 27th July, 2016 entitled **"Evaluation of Risk Factors in Pig Management Practices and their Contribution to Ocurrence of Cysticercosis in Thika, Kenya".**

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology and Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

GIDEON KAIMENYI
FOR: DEAN, GRADUATE SCHOOL

CC. Chairman, Agricultural Resource Management Department

Supervisors:

1. Dr. Purity N. Nguhiu
   C/o Agricultural Resource Management Department
   Kenyatta University
2. Prof. Lucy W. Kabuage
   C/o Agricultural Resource Management Department
   Kenyatta University

GK/rwm

Appendix III: Research authorisation by Kenyatta University Graduate School

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Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: A149/OL/CTY/26895/2014

DATE: 11th October, 2016

Director General,
National Commission for Science, Technology
& Innovation
P.O. Box 30623-00100,
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR SAMUEL NJOGU MWANGI – REG. NO. A149/OL/CTY/26895/2014

I write to introduce Mr. Samuel Njogu Mwangi who is a Postgraduate Student of this University. He is registered for M.Sc degree programme in the Department of Agricultural Resource Management.

Mr. Mwangi intends to conduct research for an M.Sc. Proposal entitled, "Evaluation of Risk Factors in Pig Management Practices and their Contribution to Ocurrence of Cysticercosis in Thika, Kenya".

Any assistance given will be highly appreciated.

Yours faithfully,

MRS. LUCY N. MBAABU
FOR: DEAN, GRADUATE SCHOOL

GK/rwm

Appendix IV: Clearance to conduct research by County government of Kiambu

COUNTY GOVERNMENT OF KIAMBU
DEPARTMENT OF HEALTH SERVICES

All correspondence should be addressed to
HEAD HRDU – HEALTH DEPARTMENT
Email address: mndiritu@gmail.com
mkwasa@live.com
Mobile: 0721641516
0721974633

HEALTH RESEARCH AND DEVELOPMENT UNIT
P. O. BOX 2344 – 00900
KIAMBU

Ref. No: KIAMBU/HRDU/AUTHO/2016/08/30/Nguhiu PN Date: 30/08/2016

TO WHOM IT MAY CONCERN

RE: CLEARANCE TO CONDUCT RESEARCH IN KIAMBU COUNTY

Kindly note that we have received a request by Dr P. N. Nguhiu of Kenyatta University to carry out research in Kiambu County on *"Emergence of Cysticercosis, a neglected meat-borne notifiable zoonosis in Thika Sub County of Kiambu County, Kenya"*.

We have duly inspected her documents and found that she has been cleared by Kenyatta University ERC and National Commission for Science Technology and Innovation until 18th August 2017. She thus does not need any further clearance with another regulatory body in order to conduct research within the county of Kiambu.

However, it is incumbent upon the institution where she is carrying out research to ensure that she receives adequate supervision during the process of conducting the research. This note also accords her the duty to provide a feedback on her research to the county at the conclusion of her research.

DR. M. NDIRITU NDIRANGU
COUNTY HEALTH RESEARCH DEVELOPMENT UNIT
KIAMBU COUNTY