PREVALENCE OF BOVINE CYSTICERCOSIS, TAENIASIS AND ASSOCIATED ZOONOTIC RISK FACTORS IN KAJIADO COUNTY, KENYA.

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A Thesis Submitted to the Graduate School in Partial Fulfillment for the Requirements for the Master of Science Degree in Medical Parasitology of Egerton

University

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NOVEMBER 2017

DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been submitted or presented in part or whole for an award in any other institution.

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DEDICATION

I dedicate this work to my late mum.

ACKNOWLEDGEMENT

My sincere gratitude goes to God for His grace that has been sufficient for me. I am grateful to Egerton University for giving me the opportunity to further my studies in this prestigious institution. I'm highly indebted to my supervisors Prof. C.I. Muleke, (Egerton University), Dr. R.S. Shivairo (Egerton University), and Dr.C.Njanja (Veterinary Research Institute, Muguga) for their advice, guidance and encouragement during proposal writing, project work and thesis writing. I am thankful to National Commission of Science, Technology and Innovation (NACOSTI) for the financial support they offered me that went a long way alleviate the project burden. I would like to thank lecturers from the Department of Biological Sciences Egerton University who reviewed my work to meet the required threshold. My gratitude goes to Dr. Jacktone Achola, County Director of Veterinary Services, Kajiado county, all Sub-County heads of veterinary services, and their counterparts in the Ministry of health for their support and cooperation. Thanks to Mr. George Omondi of Veterinary Research Institute, Muguga for his assistance during the laboratory analysis and lastly many thanks to all research assistants and volunteer pastoralists who cooperated and agreed to participate in this study.

ABSTRACT

Taeniasis is a common zoonosis whose epidemiology is estimated at 50 million cases of infestation worldwide with economic losses in Kenya amounting to $1.289 million by 2003. The infection has been grouped among the neglected tropical diseases thus its impact has been trivialized. A slaughter house survey was undertaken to determine the prevalence rate of bovine cysticercosis in carcasses slaughtered within selected abattoirs in Kajiado County and establish the viability of Cysticercus bovis. A retrospective study of bovine cysticercosis and taeniasis in Kajiado County was also undertaken and the risk factors associated with this zoonosis in this County determined. A total of 468 carcasses sampled from seven abattoirs underwent meat inspection in accordance with the Kenya meat control act Cap 356. These abattoirs receive animals from all over the County including neighboring counties. 12 macroscopically identified Cysticercus bovis isolated from the 468 carcasses were tested for viability by immersing them in 40% Ox-bile and observed under a microscope for scolex evagination. Data on bovine cysticercosis and taeniasis from January 2013-December 2015 was extracted from monthly reports of the ministry of agriculture, livestock and fisheries and ministry of health. A total of 91 pastoralists' households were interviewed in five sub-locations using a structured questionnaire. The SPSS version 20 was used to analyze data from the abattoirs and also the retrospective study. The Chi square was used to analyze the association of the zoonotic factors with the infection. The slaughter house prevalence rate of bovine cysticercosis was 2.56% (12/468) while the cyst viability was 80% (10/12). According to meat inspection reports out of 72,849 carcasses inspected between January 2013 and December 2015, 373 were positive translating to a mean of 124.3 with a standard deviation of 144.6. Zoonotic factors investigated showed a positive association with the prevalence of bovine cysticercosis with a p-value of 0.000. Out of 91 households, 68.1% households lacked toilets, 46.5% had 1:6-20 toilet-human ratio and 23% used dam, river or wells as their water sources. Another 42% did home slaughter yet 47.6% out of those who did home slaughters didn't inspect their meat. Evidence provided in this study showed that bovine cysticercosis was prevalent in Kajiado County and existing zoonotic factors exposed the animals and the pastoralists to bovine cysticercosis and taeniasis infection, respectively. Public health education and up scaling of existing medical laboratories are vital in the control of bovine cysticercosis and taeniasis while hospital based follow up research on human taeniasis is needed.

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LIST OF ABBREVIATIONS AND ACRONYMS

BESS T-base	Base Excision Sequence Scanning Thymine Base
CDC	Centers for Disease Control and Prevention
cDNA	Complementary deoxyribonucleic acid
Cox 1	Cytochrome C oxidase subunit1
DNA	Deoxyribonucleic acid
EC	European Commission
ELISA	Enzyme-Linked Immunosorbent Assay
EU	European Union
FAO	Food Agricultural organization
IgM	Immunoglobulin M
McAb	Monoclonal antibody
NDMA	National Drought Management Authority
OIE	World Organization for Animal Health
PCR	Polymerase chain reaction
SPSS	Scientific packages of social sciences
WHO	World Health Organization

CHAPTER ONE
INTRODUCTION

1.1 Background

Zoonosis are infectious diseases that are transmitted from animals to human or from man to animals, the latter being called reverse zoonosis or anthroponosis. Some of these zoonoses are given great recognition while others are treated with neglect. Taeniasis, a cestode infection is among the neglected tropical zoonosis in man that is of socioeconomic and public health importance. Tapeworm (cestode) infections have been recorded in history from 1500 B.C. and have been recognized as one of the earliest human parasites. *Taenia saginata* was differentiated from *Taenia solium* infection by the late 1700s (Cox, F.E.G., 2002). However, the exact life cycle of *T. saginata* was discovered around 1863 when the cattle were identified as the immediate host. Globally, it is estimated that 77 million human carriers exist; of which 40% live in Africa (Hussein *et al.*, 2011). Regrettably, the disease that is caused by adult worms in humans is estimated to cause 50,000 deaths annually while ill-health caused by the adult worms in human gives rise to high medical costs (Kumar and Tadesse, 2011). It is worth noting that in this zoonosis man is the definitive host, cattle being the intermediate host. The intermediate host gets infected by ingesting eggs or proglottids from contaminated pastures (WHO/DFID-AHP, 2015). The proglottid has a protective barrier which is acted on by enzymes and acids in the bovine gastrointestinal tract (GIT) releasing up to 100,000 eggs into the bovine's small intestines.

According to Tolosa 2009, regions with prevalence rates of *T. saginata* above 10% have been classified as highly endemic, between 0.1 and 10% as moderate prevalence while prevalence rates below 0.1% as low. The prevalence figures of bovine cysticercosis that have been published in the various European union (EU) member states vary between 0.01-6.8% while prevalence figures for taeniasis range between 0.1 and 15%. It is thus worth noting that the prevalence rate of both taeniasis and bovine cysticercosis in inspected carcasses is less than 1% in developed countries and as high as 36% in developing countries. More studies have demonstrated a prevalence rate of 3.09% and 1.23% of bovine cysticercus in Belgium and France respectively (Qekwana *et al.,* 2016*).* On the other hand studies have documented startling prevalence rates of bovine cysticercosis of 30-36% in Kenya, 20% in Guinea, 18% in Sierra Leone, 20% in Cameroon, 20% in Senegal, 0.2-9% in Nigeria, 0-27% in Tanzania, 19.7% in Ethiopia, and 0.2% in the North West province of South Africa (Tolosa, 2009; Teklemariam and

Debash, 2015). Subsequently, losses accruing from bovine cysticercosis from condemned and downgraded carcasses due to treatment of beef before human consumption in Kenya are estimated at $1.289 million annually (Wanzala *et al*., 2003). These results are from routine slaughterhouse inspection, which infact are an underestimation of the real prevalence by a 3-10 factor (Zdolec *et al.,* 2012). This is owed to the relatively low sensitivity of the visual inspection methods prescribed in EU directives and thus there is paucity of reliable data of prevalence figures in cattle (EC, 2000).

Attaining the one health concept in Kenya is far from reality largely due to numerous challenges and limitations arising from the continuously changing human, animal and environment interface (Gebreyes *et al.,* 2014; Desta, 2016). Since the animal and human interface is a very intimate and common event in the pastoral areas, it is very difficult to address the health of animals and humans separately necessitating their integration (Schelling *et al*., 2007; Zinsstag and Tanner, 2008). Although there are no effective dewormers or treatment drugs for bovine cysticercosis, effective control of taeniasis in the human host by deworming using either niclosamide or praziquantel may be the only approach. While there are various control measures for bovine cysticercosis in practice such as cooking of meat at 57°C, deep freezing of meat at −10°C for 10 days, pickling meat in 25% salt solution for 5 days and strict adherence to buying only officially inspected meat (OIE, 2017); elimination and control of the parasite is still far from being realized due to the public health concerns associated with it.

Kajiado County has undergone lateral changes due to the city expansion in geographic boundaries leading to sprawl and peripheral developments. The low density areas have gradually become subjected to intensive use and thus becoming high density or medium density use. Human population increase in the County was steady and strongly related to time (Figure 3). Although human population has increased in Kajiado County, a sharp increase occurred between 1999 and 2009. Rangeland, rocky and bare ground decreased while crop land built-up, woodlots and riverine vegetation increased by 1984. Built up area was confined to a small radius within urban centers but by 2010 it had spread along the road network near urban centers. The most drastic expansion occurred between 2004 and 2010 with more than 500% increase; while built up land increased by 1531.72%. Crop land increased throughout the period of 1984-2010 by 1024% (Morara *et al.,* 2014). This has dictated the habitat and distribution of population of pastoralists in the County.

Approximately 200 herds of cattle are slaughtered daily in Kajiado County with the pastoralists playing a crucial role in meeting the increase in demand for meat. Raw beef as well as drinking raw blood, cooked blood, and blood-milk mixtures is among delicacies of the Maasai as well as their traditional diet (Kenya Information Guide, 2014). Unfortunately, infested cattle do not usually show symptoms and therefore detection of infestation only occurs during meat inspection. Although meat inspection has 100% specificity and is the only slaughter house procedure relied upon in preventing *Cysticercus bovis* transmission to humans; it cannot eradicate the infection because of its low sensitivity which ranges between 11.5–15.6% (Meiry *et al.*, 2013). This study focused on establishing the prevalence of this zoonosis and its associated risk factors. Therefore there is need for a different approach to control this zoonosis which involves determining the associated public health concerns and how they can be addressed to control it.

1.2 Statement of the problem

Cattle production and marketing in Kajiado County is the main economic activity, with about 70% of the people depending on livestock and their products. However taeniasis and bovine cysticercosis negatively impacts on the performance of this sector because of down-graded and condemned carcasses. Very little information on prevalence of taeniasis and bovine cysticercosis in this County is available. This study investigated the prevalence rates of taeniasis and bovine cysticercosis and associated zoonotic risk factors in Kajiado County.

1.3 Objectives

1.3.1 General objective

To determine the prevalence rates of bovine cysticercosis, taeniasis and associated zoonotic risk factors in Kajiado County, Kenya.

1.3.2 Specific objectives

1. To determine the prevalence rate of bovine cysticercosis in carcasses slaughtered within seven abattoirs in Kajiado County.
2. To establish the viability of *Cysticercus bovis* isolated from carcasses slaughtered in seven abattoirs within Kajiado County.
3. Undertake retrospective study of bovine cysticercosis and taeniasis in Kajiado County.
4. Determine zoonotic risk factors associated with bovine cysticercosis and taeniasis in Kajiado County.

1.4 Null hypotheses (H^0)

1. There is no significant prevalence rate of bovine cysticercosis in carcasses slaughtered within selected abattoirs in Kajiado County.
2. There are no viable *Cysticercus bovis* from carcasses slaughtered in Kajiado County abattoirs.
3. Prevalence of bovine cysticercosis and human taeniasis in Kajiado County is not significant.
4. There are no significant zoonotic risk factors exposing human to taeniasis in Kajiado County.

1.5 Justification

Despite the fact that *T. saginata* is a cestode with an indirect life cycle revolving between man and cattle and its economic significance in the pastoral communities, the prevalence rates of bovine cysticercosis, taeniasis and the risk exposing factors to this disease in Kajiado County are unknown**.** This study determined the prevalence rates of bovine cysticercosis, taeniasis and investigated the associated risk exposing factors in Kajiado county. This information could be used to alleviate the notion that this zoonosis is under control, and also be used in public health awareness campaigns to control this zoonosis

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction on neglected zoonotic parasitic diseases

Neglected zoonotic diseases (NZDs) are found in communities of low-resource settings across the world, where they impose a dual burden on people's health and that of the livestock they depend upon. National governments are increasingly seeking to mitigate the impact of NZDs on their citizens by implementing control programmes to address these burdens. NZDs, such as taeniasis, rabies, hydatidosis, leishmanisis and human African trypanosomiasis are a subset of the neglected tropical diseases that are naturally transmitted from vertebrate animals to humans and vice-versa (Kulkarni *et al*., 2015). The World Bank has estimated that zoonosis cost global economies more than $20 billion in direct, and $200 billion in indirect costs between the year 2000 and 2010. Zoonotic disease risks are predicted to further increase as environmental changes continue (Webster *et al*., 2016). NZDs are grossly under-reported making their impact almost invisible in national statistics and thus receiving limited attention, despite the profound effect they have on those living in endemic areas (King, 2011).

Data collected locally for instance in hospitals, more oftenly than not is never communicated up the administrative chain to give a national picture hence it doesn't demonstrate their impact on the affected population. Additionally, lack of adequately equipped diagnostic laboratories in the health centers caring for the affected communities may lead to misdiagnosis of the disease. Conversely from a larger scale perspective, lack of data about these diseases in an area means little resources are put in by an overstretched public service to follow-up investigations (Eric & Francos, 2012). The development of cheap and effective vaccines is no guarantee that these endemic zoonotic diseases will be eliminated in the near future. However, simply increasing awareness about their causes and how they may be prevented often with very simple technologies could reduce the incidence of many endemic zoonoses (Maudlin *et al.*, 2009).

2.2 Epidemiology of Neglected zoonotic parasitic diseases

The Food Agriculture Organization (FAO) estimates that, globally, there are between 500 million and 900 million food-insecure livestock keepers, and livestock contributes to the livelihoods of 70% of the world's rural poor (King, 2011). Additionally, increasing globalization, with persons, animals, and their products moving around the world has enabled unprecedented spread of infections at speeds that challenge the most stringent control mechanisms. Furthermore, continual encroachment of humans into natural habitats by population expansion or tourism brings humans into new ecologic environments and provides opportunity for novel zoonotic exposure (Cutler *et al.,* 2010). Moreover, climatic variation creates new ecological niches for vectors hence altering temporal and spatial distribution of disease.). FAO, World Organization for Animal Health (OIE) and World Health Organization (WHO) recognize a joint responsibility for addressing zoonotic and other high impact diseases. This is through working together for several decades to minimize the health, social and economic impact from diseases arising at the human-animal interface. Preventing, detecting, controlling, eliminating or managing disease risks to humans originating directly or indirectly from domestic or wild animals is the way to go (FAO-OIE-WHO, 2010).

Many helminth related infections are favored by rainy conditions. For instance, conditions such as heavy rainfall create increased vector capacity causing outbreaks if vertebrate reservoirs are available (McPhaden, 2006). Outstandingly, during floods helminth eggs are deposited and remain viable during periods of droughts and hatch when conditions are favorable (Lafferty, 2009). Additionally, soil moisture is also a factor in the developmental stages of helminthes, with high mortality related to dry conditions and soil evaporation. Moreover, soil composition determines the distribution of helminthes where optimal soil factors include humus rich, and alkaline pH (>6.1) coupled with a susceptible vertebrate hosts and immunity of human factors (Hugh-Jones and Blackburn, 2009. Taeniasis being one of these zoonoses has been neglected due to its mild nature of manifestation but the economic losses it causes are enormous. Subsequently, losses accruing from bovine cysticercosis from condemned and downgraded carcasses due to treatment of beef before human consumption in Kenya are estimated at $1.289 million annually (Wanzala *et al.*, 2003).

2.3 Epidemiology of bovine cysticercosis

Cysticercosis falls in the category of neglected zoonotic diseases; however much regard is given to swine neurocysticercosis due to its association with epilepsy (WHO and FAO, 2016). There is a significant variation in the prevalence of bovine cysticercosis in different countries, ranging from <0.01% to more than 20% (Meiry *et al.,* 2013). *T. saginata* has a cosmopolitan distribution, but the infection is more important in Africa, Asia and Latin America and in some

Mediterranean countries, (Fahmy *et al.*, 2015). In Kenya, Cheruiyot (1981) found prevalence to range from 0.74% in the Coast Province to 18% in Kisii District in Nyanza Province. There is immense evidence from studies showing that pastoral areas are particularly badly affected; for example 75.9% of calves in Samburu district were found to be infected with *T. Saginata* while 18.2% of cattle surveyed in Kenya were found to be infected with *Cysticercus bovis*. The worst affected areas being Nyanza, Rift Valley and North-Eastern Provinces. A sero-epidemiological survey of cattle in the Rift Valley, Eastern and North Eastern Provinces of Kenya, revealed that Rift Valley Province was the most seriously affected by *T. Saginata* (Asaava, 2009).

2.4 Life cycle of *Taenia saginata*

T. saginata is classified under the domain Eukarya; kingdom Animalia; phylum Platy-helminthes; class Cestoda; order Cyclophyllidea; family Taeniidae; genus Taenia and species *T. saginata (*Zeibig, 2013).

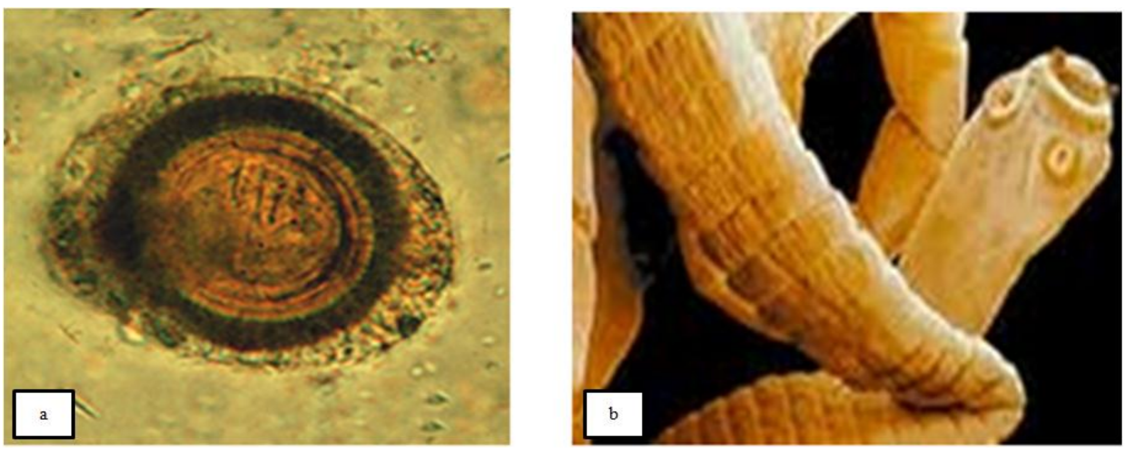


Figure 1a and b: *T. saginata* egg and a mature *T. saginata* as seen under a microscope **(**Source: http://www.cdc.gov/dpdx/taeniasis/index.html).

It is a flat segmented acoelmate with a characteristic head called the scoleces which has four suckers at the anterior end (Fig. 1b). The scolex forms the attachment terminal while the neck is unsegmented and poorly differentiated (Paniker and Ghosh, 2013). New segments or proglottids are formed in the neck region as older ones are pushed posteriad forming the strobila (body). As each proglottid is shifted posteriad its reproductive system matures with the most posterior being gravid or egg filled (Bogitsh *et al*., 2013). The adult taenia resides in the jejunum portion of the human’s small intestine where the scolex attaches to the epithelial lining of the gut. *T. saginata* produces many gravid proglottids which break off singly and are passed on to the environment in human feces where the intermediate host gets infected when they ingest infected herbage (WHO/DFID-AHP, 2015). Every proglottid has longitudinal and transverse muscles giving the adult both horizontal and vertical mobility (Dornet and Praet, 2007). The nervous system consists of nerves only, while in the scolex nerves end in a ganglia.

Adult *T. saginata* secrete molecules that deter other parasites from co-infecting the same host hence, increasing its survival without exerting too much stress on the host (Despommier *et al.*, 2000). The digestive enzymes and acids in the gastrointestinal tract will break the thick shell of the proglottid which is the protective barrier in cattle and release up to 100,000 eggs (Figure 1a) into the bovine's system. Studies have shown that the eggs develop into oncospheres (embryonated eggs) once ingested. The oncospheres move to the jejunum where they break releasing the larvae that consequently breaks through the intestinal epithelium and travel through the blood circulation of the bovine finding their way to the muscles and or specific organs such as the heart and liver (Figure 2a and b) (Soares *et al.*, 2011).

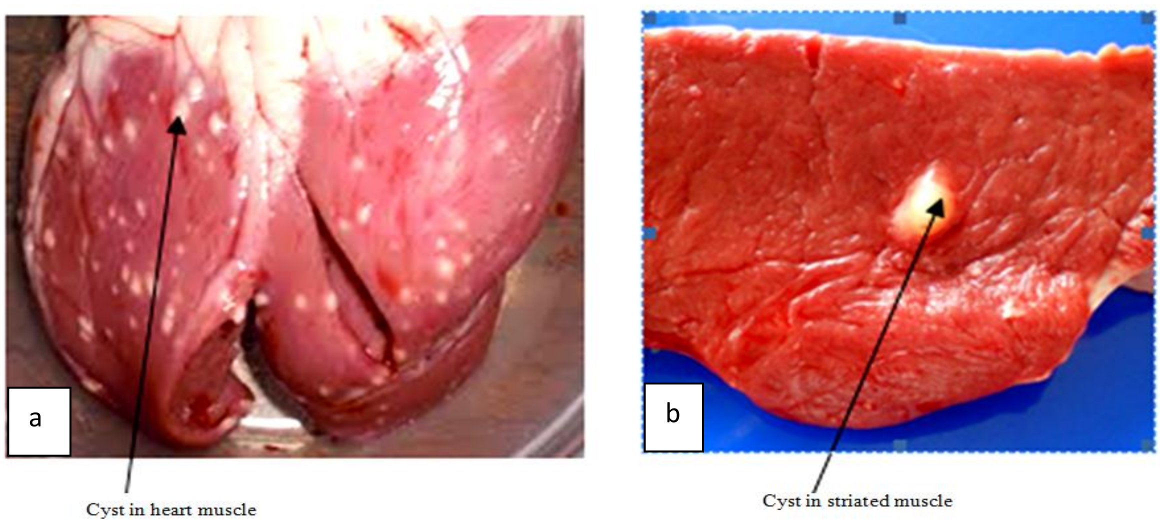


Figure 2a and b: *Cysticercus bovis'* cysts in the heart and in the striated muscle respectively (Source. http://www.idosi.org/apg/6%281%2915/4.pdf)

The larvae encyst, to form a pea-sized, fluid filled cyst called a "cysticerci" that can survive in the muscles for years and still remain infective. When undercooked beef is eaten by a human, the definitive host the cysticerci excysts with the evaginated scolex attaching to the intestinal epithelium where it develops to a mature tapeworm within 8-10 weeks. *T. saginata* doesn't have a developed digestive system instead it absorbs nutrients aided by its specialized tegument which has microfolds that increases its surface area (Markell *et al.*, 1999). Particularly, *T. saginata* can grow up to 5 meters long consisting 1000 to 2000 proglottids each carrying 1,000 eggs and can have a lifespan of 25 years in a hosts' intestine (WHO/DFID-AHP, 2005). Taenias are hermaphrodites with a round the year breeding and they are oviparous (sperm storing) enabling them to survive for a long time in a host.

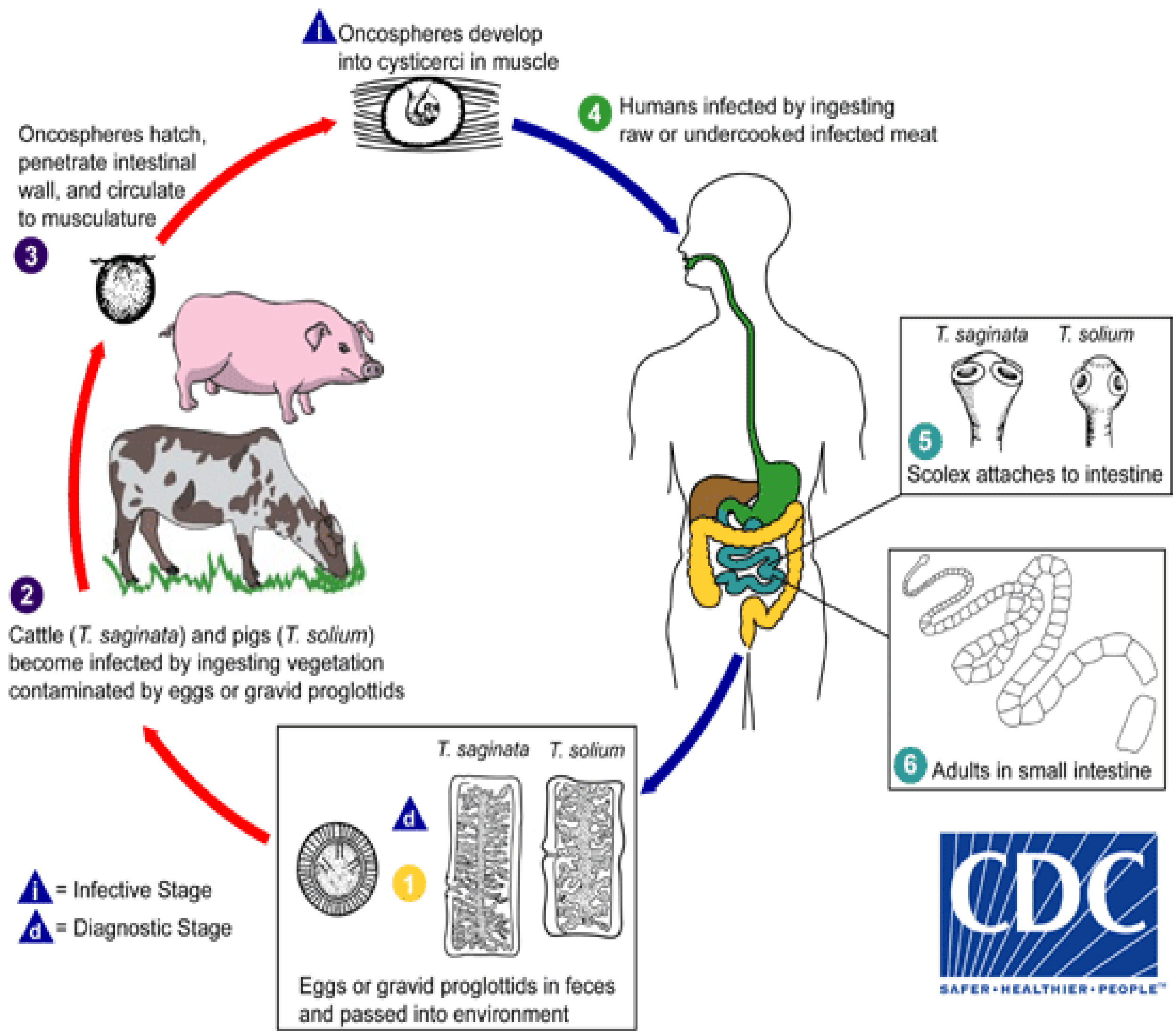


Figure 3: Lifecycle of *Taenia saginata*

(Source: http://www.cdc.gov/parasites/taeniasis/biology.html)

It is worth noting that increased numbers of cysts are found in the triceps muscle which is associated to the blood kinetics in the animal affecting the distribution of oncospheres to their predilection site (Nuraddis and Frew, 2012).

2.5 Predisposing factors of taeniasis.

According to Gebrie and Engdaw, (2015) prevalence of bovine cysticercosis is associated with consumption of undercooked, sundried or raw beef, poor waste disposal, poor sewage treatment system, low level of public awareness on its life cycle and presence of home slaughtering practices where meat is not inspected (Cabaret *et al.*, 2002). Furthermore, a tapeworm carrier on the farm, poor hygiene of farm staff e.g. handling of bovine feed with egg-contaminated hands, and defecation by man in places frequented by cattle are a common source of infection (Mwita *et al*., 2013). Additionally, application of night soils on pastures, contamination of surface water and drinking untreated water all add to infection (Nuraddis and Frew, 2012). Moreover, encouragement of defecation in open air due to lack of toilets in the parks by tourists and grazing in close proximity to a railway line exposes animals to human feces (Flutsch *et al.,* 2008). It's worth noting that streams carrying effluent from sewage treatment plants and their access by cattle increases infection (Calvo-Artavia *et al.,* 2013). Interestingly, eggs can survive in the environment for a few days in hay; a few months in ensilaged feed and 6-8 months on pasture especially in humid, shady places (CDC, 2013) and thus making it harder to break the cycle.

2.6 Symptoms of taeniasis

While most of the population remains asymptomatic to these tapeworm infections, children are highly susceptible showing mild symptoms. This has been attributed to the large size of the tape worm which leads to digestive problems such as abdominal pain, loss of appetite, weight loss, and stomach upset (Semie *et al*., 2015). The most visible symptom of taeniasis is the active passing of proglottids (tapeworm segments) through the anus causing anal pruritis. In rare cases, tapeworm segments become lodged in the appendix, bile ducts and or pancreatic ducts causing appendicitis and biliary obstruction (CDC, 2015). Patients heavily infected with *T. saginata* have also witnessed nasal expulsion (Figure 4) of the cestode which leads to obstruction and can result in fatalities, (Sheikh *et al*., 2007).

Figure 4: A 6.3 meter long *T.saginata* being expelled from the patient's nostrils
(Source: http://ispub.com/IJS/16/2/9449#)

2.7 Symptoms of bovine cysticercosis.

In cattle, the presence of cysticerci in the tissue could cause muscular stiffness, nervous symptoms and loss of body condition leading to downgrading and condemnation of the affected carcass (Rabiu and Jegede, 2010). Live cattle having *Cysticercus bovis* show no symptoms, however, heavy infestation by the larvae may cause myocarditis or heart failure (Kumar and Tadesse, 2011).

2.8 Methods of diagnosis of bovine cysticercosis.

2.8.1 Meat inspection

In bovine cysticercosis the only practical way to assess the cyst burden is by total dissection of carcass at specified predilection sites as per cap 356 of the Kenya meat control act cap. 356: 1973, 2012. The typical gross findings are normally one or more white to gray cysts, <1 cm in diameter, projecting from the surface of the heart, skeletal muscle or other tissue. However non-predilection sites such as neck, back, hind limbs, chest, pelvic, lumbar regions, lungs and liver also harbor high numbers of cysticerci (Wanzala *et al.,* 2005). Observations indicate that except for the dead, degenerate or calcified cysticerci a careless meat inspector could miss out quite a number of viable cysticerci, which blend the pinkish-red color of the meat and be passed on for human consumption becoming the source of taeniasis, (FAO and WHO, 2014). To effectively improve meat inspection procedures, there is need to increase the areas and number of incision sites observed during inspection and vary them according to the nature of the animals and their husbandry history (Wanzala *et al.*, 2003).

2.8.2 Immunological tests (The Mouse monoclonal antibody-based antigen detection ELISA)

This is of value for the diagnosis of naturally occurring, viable, bovine cysticercosis in live cattle and has an immediate application for field based epidemiological studies designed to determine prevalence (Onyango-Abuje *et al.*, 1996). Given the fact that serology is at lEast 3-10 times more effective than the classical meat inspection techniques, the risk of people getting infected by cysticerci would decrease by a factor 10, if serological tests were applied on a large scale (EC, 2000). Diagnosis of taeniasis can be through capture of coproantigen in feces using Ag-ELISA but this doesn't differentiate species (OIE, 2014).

2.8.3 Detection of viable metacestodes using HP10 assay

In contrast to antibody detection, the HP10 assay is a better tool of diagnosis because it detects viable metacestodes and thus cattle with the potential to transmit taeniasis to humans. The sensitivity in the HP10 assay depends on the number of viable metacestodes in an infected animal; the lower the number, the lower the signal (Giri and Parija, 2012). The HP10 assay uses a McAb (IgM) isotope that detects antigenic glycoprotein of viable *T. saginata* cysticerci in cattle sera giving better results considering cut-off under mild infection condition (Wanzala *et al.*, 2002).

2.8.4 Molecular diagnosis (Use of synthetic peptides as targets for the specific diagnosis of bovine cysticercosis)

Six peptides namely HP6-2, HP6-3, Ts45W-1, Ts45W-5, and TEG-1 derived from *T. saginata* oncospheres cDNA library have been evaluated as targets for the specific diagnosis of bovine cysticercosis (Abuseir *et al.,* 2007). Longitudinal studies indicated that *T. saginata* infected cattle respond to all the six peptides by 3^{rd} – 4^{th} week post-infection and that the antibody levels remain high for at lEast 12 weeks post-infection (Ferrer *et al*., 2003).

2.9 Diagnosis of taeniasis

2. 9.1 Self detection tool for tapeworm carriers

A common symptom associated with taeniasis is the expulsion of proglottids where carriers may report the presence of these proglottids in their feces or feel them in their undergarments (Mwape and Gabriël, 2014).

2.9.2 Laboratory diagnosis using microscopy

Stool specimens are collected on three different days and examined in the laboratory for taeniid eggs using a microscope (Figure 1a). Tapeworm eggs can be detected in the stool 2 to 3 months post-infection (CDC, 2013). *T. saginata* eggs measure 30-35 um in diameter and have radial striations. However morphologically they are indistinguishable from *T. solium* eggs (Chiesa *et al.,* 2010).

2.9.3 Differentiation of taeniid species in humans using histo-pathological specimens

It is rather difficult to differentiate *T. saginata* and *T. asiatica* species morphologically; although usually, mature proglottids of *T. saginata* have 12-30 lateral uterine branches and can be differentiated from *T. solium* which has 7-13 lateral uterine branches. Histo-pathological examination is still the gold standard to confirm absence of rostellar hooks and presence of suckers unique to *T. saginata* (Sako *et al.,* 2008).

2.9.4 Molecular identification of human taeniid cestodes by BESS T-base analysis

The differential diagnosis of all human taenia species, including two genotypes of *T. solium* has been developed. This uses the base excision sequence scanning thymine-base (BESS T-base) using mitochondrial Cox1 and cytochrome b gene (Yamasaki *et al.,* 2002). This method is for the detection of thymine "T" bases only and the identification of taeniid cestodes by comparing diagnostic "T" base peak profiles. Based on the nucleotide sequences of Cox1 from human taeniid cestodes, most "T" bases are well-conserved among taeniid species, but species or genotype-specific "T" bases are sparsely distributed over the gene. Sensitive BESS T-base profiles unique for *T. saginata, T. asiatica* and two genotypes of *T.solium* Cox1 have been identified. "T" bases at positions 189, 595, 603,612 and 618 of the Cox1serve as differential markers and it has been confirmed that bases at these sites are completely conserved among species. For example, in *T. saginata,* "T" base peaks appear at positions 189 and 612, but no "T" base peaks appear at positions 595, 603 and 618, because bases at these positions are not "T" base (Yamasaki *et al.,* 2003).

2.9.5 Differential diagnosis of human taenia tapeworms using multiplex PCR

Species-specific product with molecular sizes of 706 (base pairs) bp, 629 bp, and 474 bp are amplified from *T. asiatica, T. saginata*, and *T. solium* in regular PCR reaction, respectively. Three set of primers Ta7216F, Ts7313F, Tso7466F, and Rev7915 are combined in a single reaction using a mixture of template DNA of the 3 taenia tapeworms. A multiplex PCR is performed with a mixture of *T. asiatica*, *T. saginata*, and *T. solium*, template DNA; and the species-specific primer sets, PCR products of different sizes generate species-specific bands. The diagnostic, species-specific, PCR fragments derived using species-specific primers are similar to those obtained using multiplex PCR (Jeon *et al*., 2013).

2.9.6 Tests aimed at secretory products of live cysts or tegument antigen

Serum antigens from viable cysticerci or adult tapeworms have been shown to offer the advantage of indicating a current infection and thus have a prognostic value in terms of decisions of treatment with drugs (Brandt *et al.,* 1992). Attempts are being made to identify cDNA sequences encoding for potential diagnostic peptides but given the limitations of antibody detection assays, the use of immunoassays to detect the excretory/secretory products of live parasites would be of major advantage (Rostami *et al*., 2015).

2.10 Differential diagnosis:

The eggs of ***T. saginata,*** *T. asiatica* and ***T. solium*** are identical, but the gravid segments of ***T. saginata*** are more active than those of ***T. solium***, and there are more uterine lateral branches (15-32) in *T.saginata* compared to 7-13 in *T.solium* (Gonzalez *et al.,* 2000).

2.11 Treatment of taeniasis.

Antihelmintic treatment is effective in killing adult tape-worms but does not kill eggs. Single doses of praziquantel or niclosamide can cure infections in definitive hosts while mebendazole and albendazole also appear to be effective against adult stages. Praziquantel opens membrane calcium channels of the worm causing its paralysis, aiding the body in expelling the parasite through peristalsis (Sheikh *et al.,* 2007). In cattle there is no treatment for bovine cysticercosis (CDC, 2013). Most people, especially rural inhabitants use different types of herbal drugs for self-deworming practices for instance; in Ethiopia traditional herbs used in treatment for the cestodes are listed in Table 1 (Semie *et al.*, 2015).

Table 1: Common herbs used against cestode infection in Ethiopia

No	Local name	Scientific name	Parts of plants used
1	Broad-leaved Croton	*Corton macrustachys*	Bark
2	Pumpkin/ Squash	*Cucurbita pepo*	Seed
3	Enkoko	*Embelia schimperi*	Fruit
4	Hagenia	*Hygenia abyssinica*	Flower
5	Lotus sweet juice.	*Glinus lotoides*	Seed

(Source: https://www.idosi.org/apg/6 (1)15/4.pdf)

2.12 Prevention and Control of Taeniasis in Man

Prevention of taeniasis is achieved by interrupting the life cycle at one or more points by proper cooking of meat, refrigeration, and radiation in order to destroy cysts in the muscles. Adherence to meat inspection rules which is captured in the Kenya Meat Control Act CAP. 356: 1973, Revised (2012) which recommends that carcasses with 0 cysts should be passed directly for human consumption, 1–5 cysts should be retained, frozen at −10°C for at lEast 10 days and released "unconditionally", 6–20 cysts should be similarly treated as above but released conditionally to schools/institutions where proper cooking is expected to be done, over 20 cysts the carcass should be totally condemned. In rural areas where the disease is more prevalent and electricity is unavailable, the carcasses should be sliced and boiled for 2 hours at 77°C under the supervision of the inspecting officer. Condemnation of infected carcasses, sanitary disposal of feces, prohibiting the use of night soils for fertilizing pastures, washing salad vegetables and strict personal hygiene are among the measures that can be employed to control this condition (CDC, 2013).

Sensitization campaigns to inform tapeworm carriers on source of infection to cattle, mass deworming, proper destruction of expelled worms through sewage treatment are key precautions that can be employed to reach pastoral masses (Dorny *et al.*, 2000).

In Canada, bovine cysticercosis is a "notifiable disease" under the “Health *of Animals Act*” meaning that all suspected cases must be reported to the Canadian Food Inspection Agency (CFIA) for immediate investigation by inspectors. The CFIA’s National Cysticercosis Program is aimed at preventing the spread of the disease to humans by detecting and eradicating infected cattle. The CFIA meat hygiene program directs the inspection of cattle carcasses at federally registered abattoirs while all non-federally registered abattoirs must report any suspicion of bovine cysticercosis to the CFIA for investigation (CFIA, 2015).

2.13 Prevention and Control of Bovine cysticercosis

Control measures for bovine cysticercosis include confining animals under zero grazing all their live, use of clean and uncontaminated feeds and having a healthy workforce. Where possible, certification of the herd through sero-surveillance as free from cysticercosis is recommended (Zdolec *et al.*, 2012).

CHAPTER THREE
MATERIALS AND METHODS

3.1 Study Site

Kajiado County is located in the Southern rangelands of Kenya at an altitude ranging from 600m at the floor of Rift Valley, to 1,100m above sea level around Lake Magadi; enclosed within longitude 36.0^0E – 37.8^0E and latitude 1.25^0S – 3.12^0S. It's divided into five sub-counties (Figure 5) namely Kajiado Central, Kajiado North, Kajiado South, Kajiado East and Kajiado West which are further divided in to five (5) Wards each. The county has a population of 687,312 and a surface area of 21,901km^2 with a population density of about 31 persons per km^2. The cattle population by 2009 was 246,829 heads (Kenya Open Data, 2013). Most of Kajiado County lies in the semi-arid and arid zones characterized by warm and hot climate with temperature mean of 25ºC. The rainfall pattern is bimodal, with high average of 1,250mm and a low average of about 500mm per annum (Bobadoye, 2014).

Over 200 herds of cattle are slaughtered daily for its market and the surrounding towns especially Nairobi city. Although there are several hospitals and health centers in Kajiado County, the state of healthcare in the rural areas is in deplorable state and residents walk for long distances to access medical facilities (Kenya Open data, 2013). Some of the notable healthcare facilities in Kajiado include Kajiado county hospital, Kitengela, Ngong, Loitoktok and Rongai sub-county hospitals among others with a doctor to population ratio of 1:76,000.

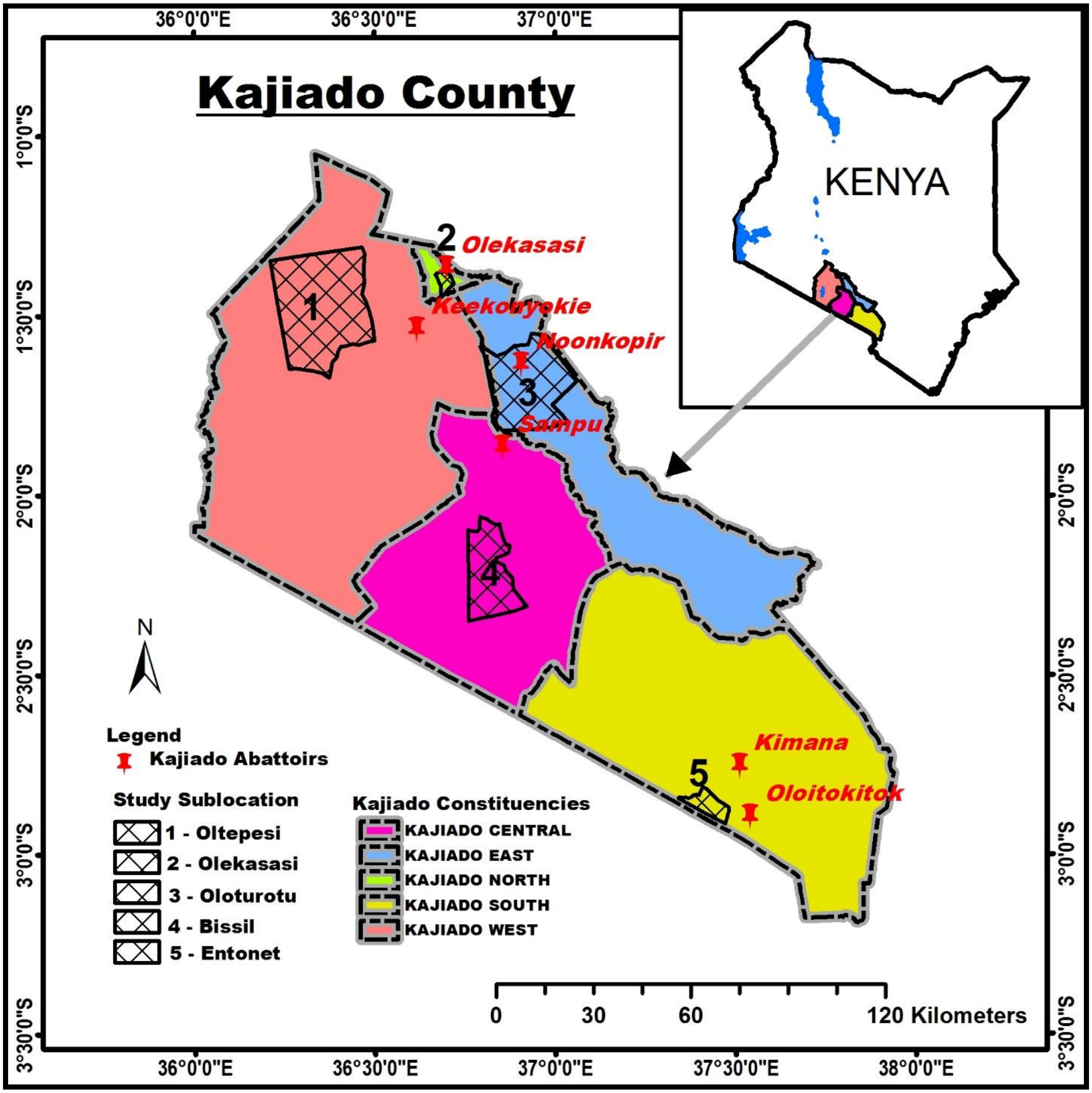


Figure 5: Kajiado county

3.2 Objective 1.Determination of prevalence rate of Cysticercus bovis in carcasses sampled from seven abattoirs within Kajiado county.

3.2.1 Study design and study animals

Seven abattoirs were selected across Kajiado County based on their daily slaughter and their distribution across the Sub-counties for a fair coverage of the entire county. Study animals were cattle presented for slaughter to seven abattoirs namely Kekonyokie, Bissil, Sampu, Olekasasi, Noonkopir, Kimana and Loitoktok.

3.2.2 Sample Size Estimation

Cattle brought to the seven abattoirs were chosen using random sampling and the sample size determined according to Slovin's formula (Galero-Tejero, 2011).

$$n = N / (1 + Ne^2)$$

Where:

n – Sample size,

N - Total population

e - Error of tolerance=0.0444

The total population N=6000, this means that the sample size is equal to;

$$N = 6000 / (1+6000 \times 0.0444^2)$$

$$n = 468$$

3.2.3 Ante-mortem examination

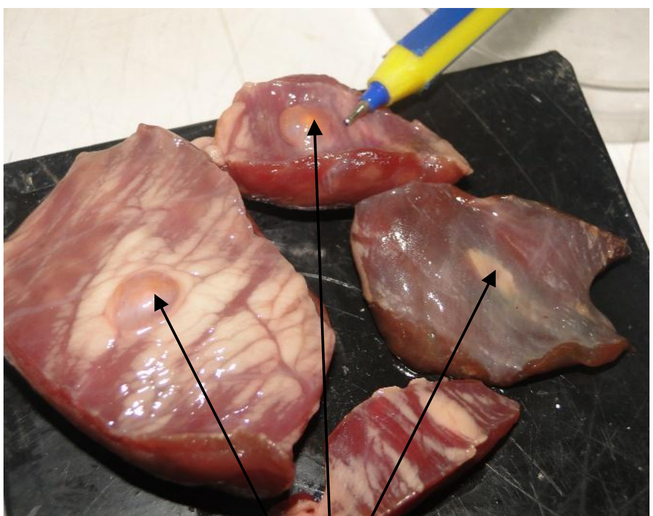
Sampled animals presented for slaughter underwent physical examination for any injuries and symptoms of helminth infections before slaughter.

3.2.4 Post mortem meat inspection

All the carcasses underwent meat inspection in accordance with the Kenya Meat Control Act Cap 356; 1973 (Revised, 2012). The tongue was examined by palpation and then opened lengthwise on the lower surface from the base to root, while the heart was opened from the base to the apex. For masseter muscles, deep linear incisions were made parallel to the mandible from its upper muscular insertion. Three deep, adjacent and parallel transverse incisions were made above the point of the elbow in the triceps brachii and examined before blood covered the sliced surface. Any macroscopically observed cysts were excised with at lEast 3grams of adjacent tissues, packaged in polythene sample paper bags, transported to the laboratory in a cool box before being stored at 4^0C in a refrigerator awaiting further analysis.

3.3 Objective 2. Viability of Cysticercus bovis isolated from carcasses slaughtered within seven abattoirs in Kajiado County.

A protocol according to Hussein *et al.*, 2011 was employed to test viability of the *Cysticercus bovis*. One gram of dried Ox bile which is equivalent to 8 grams of fresh bile was reconstituted in 100mls of normal saline ($NaCl_2$), and dissolved under gentle heat. The solution was further diluted to make 40% solution. The cysts were excisioned from the 3g beef sample collected from the abattoirs and immersed in 40% Ox-bile solution and incubated for 1-2 hours at 37^0C. The incubated slices were picked using a fine pair of forceps, placed on glass slides, covered with a cover slip and observed under a microscope at X100 objective lens. Evagination and presence of suckers on the scolex were used to confirm viability of cyst. Scolex was also observed for absence of the rostellum of hooks to differentiate *T. saginata* from other teania species.



Cysts in bovine muscles

Figure 6: *Cysticercus bovis* in bovine muscles

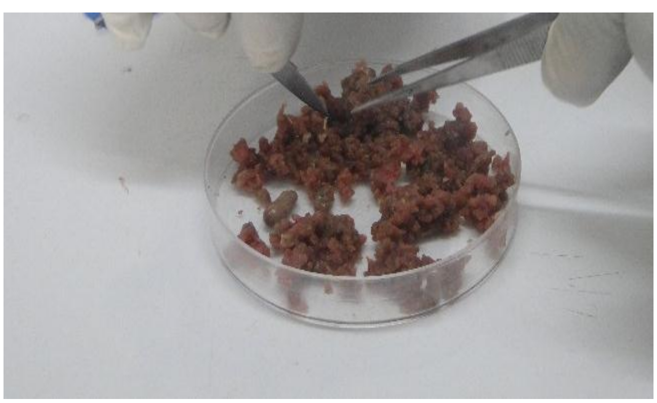


Figure 7: Sample preparation for emulsification and incubation of encysted muscles

3.4 Objective 3. Retrospective studies of bovine cysticercosis and taeniasis in Kajiado County.

Data on bovine cysticercosis and taeniasis was retrieved from the monthly reports of the Ministry of Agriculture, Livestock and Fisheries and Ministry of health respectively. This data covered a period of 3 years retrospectively (January 2013-December 2015), which was the duration when the county governments came into existence.

3.4.1 Retrospective data from Ministry of Agriculture, Livestock and Fisheries for the period, 2013-2015.

Retrospective data on cases of bovine cysticercosis in the entire County was extracted from meat inspection monthly reports of the Ministry of Agriculture, Livestock and Fisheries. The data included total number of carcasses inspected, the positive cases of bovine cysticercosis and negative cases recorded per month as per the sub-county. Data was entered in Microsoft Excel sheets and analyzed using SPSS version 20.

3.4.2 Retrospective data from Ministry of Health for the period, 2013-2015.

Retrospective data from Sub-county hospitals on cases of human taeniasis was extracted from monthly reports from the Ministry of health for a period of 3 years dating January 2013-December 2015. The data included total number of patients tested for taeniasis and the positive cases reported. Data obtained was entered in Microsoft excel and analyzed using SPSS version 20.

3.5 Objective 4. Determination of zoonotic risk factors associated with taeniasis in Kajiado County.

Questionnaire based interview with the pastoralists in Kajiado County was conducted in the five (5) sub-counties. From each Sub-county the sub-location with the highest population of pastoralists was selected because of their pastoral lifestyle (Table 2). Two pairs of permanent landmarks for example trading center, school, or river were identified and an imaginary transecting line was drawn across the sub-location using the landmarks. Volunteer pastoral households along the line transects were interviewed to establish the zoonotic risk factors associated with taeniasis (Bebe *et al*., 2000). The risk factors investigated included availability of toilets in the homestead, number of persons using a single toilet, sources of water for their animals, water treatment, home slaughters and emphasize on meat inspection.

Table 2: Sub-locations selected for questionnaire administration according to sub-county.

Sub-county	Sub-location
Kajiado North	Ole Kasasi
Kajiado East	Olturotu
Kajiado South	Entonet,
Kajiado West	Oltepesi
Kajiado Central	Bissil

(Source: https://kajiado.go.ke/kajiado_map.pdf).

CHAPTER FOUR

RESULTS

4.1 Objective 1. Prevalence rates of bovine cysticercosis from carcasses slaughtered in seven abattoirs in Kajiado County

The overall prevalence rate for the seven slaughter houses was 2.56% between May 2016 and June 2016 (Table 3). The prevalence rate of bovine cysticercosis was highest in Olekasasi in Kajiado North (9.090%) and loWest in Kajiado West and Kajiado South (0%) respectively. Bissil in Kajiado Central had the highest slaughter while Loitoktok in Kajiado South had the loWest. The calculated mean prevalence had a p-value of 0.000 which is $p<0.005$.

Table 3: **Prevalence rates obtained from various slaughterhouses as per sub-county.**

Sub-County	Slaughter House	Positive cases	Negative cases	Totals	Prevalence Rate
Kajiado Central	Bissil	3	145		
	Sampu			196	1.53%
		0	48		
Kajiado East	Noon-kopir	6	143	149	4.03%
Kajiado North	Olekasasi	3	30	33	9.090%
Kajiado South	Kimana	0	24	30	0%
	Loitoktok	0	6		
Kajiado West	Keekonyokie	0	60	60	0%
Total N.		**12**	**456**	**468**	**2.56%**

4.2 Objective 2. Viability of Cysticercus bovis isolated from carcasses slaughtered in seven abattoirs in Kajiado County.

Out of 468 carcasses that were sampled, 12 *Cysticercus bovis* were isolated from the various predilection sites (see table 4).

Table 4: **Distribution of cysts in carcasses**

Predilection site	No. of cysts
Heart	2
Triceps muscles	7
Masseter.	2
Liver	1
Total	**12**

Out of the 12 cysts that were obtained, 10 were viable while 2 were degenerated and calcified which translated to 80% viability. Figure 8a, b and c show photographs of both viable and degenerated cysts.

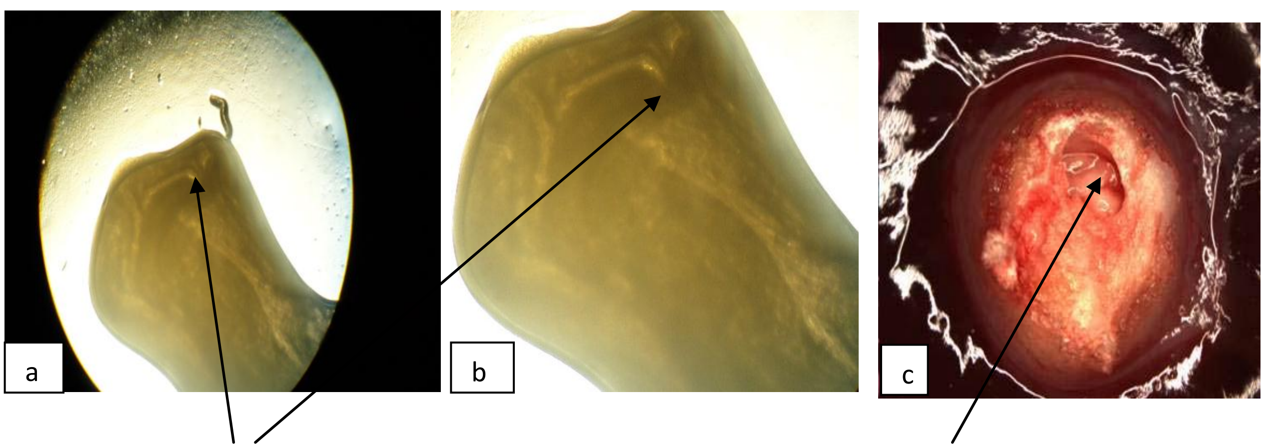


Figure 8a and b: Evaginated viable cysts **Figure 8c:** Degenerated cysticercus

4.3 Objective 3 Findings of retrospective study of bovine cysticercosis and taeniasis in Kajiado County.

4.3.1 Retrospective data of taeniasis in Kajiado County

Retrospective data of cases of taeniasis in the entire county was extracted from monthly reports from the Ministry of health (County director of health) for a period of 3 years (2013-2015) as described. There was no data for 2013 and 2014 while only 55 cases were recorded for

2015. A spot check within various medical laboratories (Rongai, Kitengela and Kajiado hospital) revealed that most monthly reports on taeniasis were vividly absent.

4.3.2 Retrospective data of Bovine cysticercosis in Kajiado County

Data from the Ministry of agriculture, livestock and fisheries showed that a total of 72,849 cattle were slaughtered between January 2013 and December 2015. The positive cases identified through meat inspection were 373; hence the mean of bovine cysticercosis cases was 124.3 with a standard deviation of 144.6. The t-value analysis gave 9.57 with a p-value of 0.000 which is less than the 0.05 significant level. Figure 9 shows that the positive cases of bovine cysticercosis increased exponentially in the county across the years from 2013 to 2015.

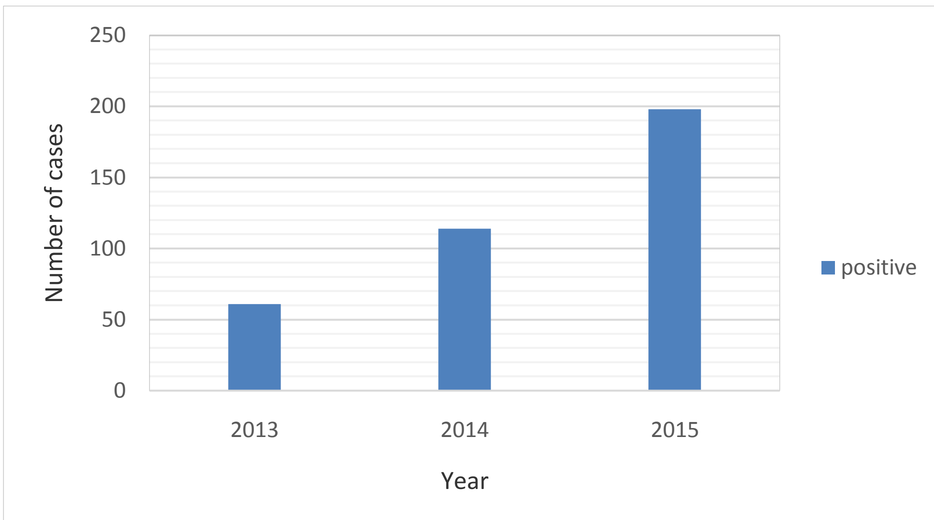


Figure 9: Bovine cysticercosis cases in Kajiado County, 2013-2015.

4.3.3 Prevalence rate of bovine cysticercosis in Kajiado Central sub-county.

In Kajiado Central (Figure 10), bovine cysticercosis was present throughout 2013 except in November and December where reports were missing. In the year 2014 cysticercosis was reported throughout the year except in the month of November. The highest prevalence was recorded in March 2014, June and August 2015 while July 2014 and April 2015 recorded the loWest prevalence rates in the Sub-county.

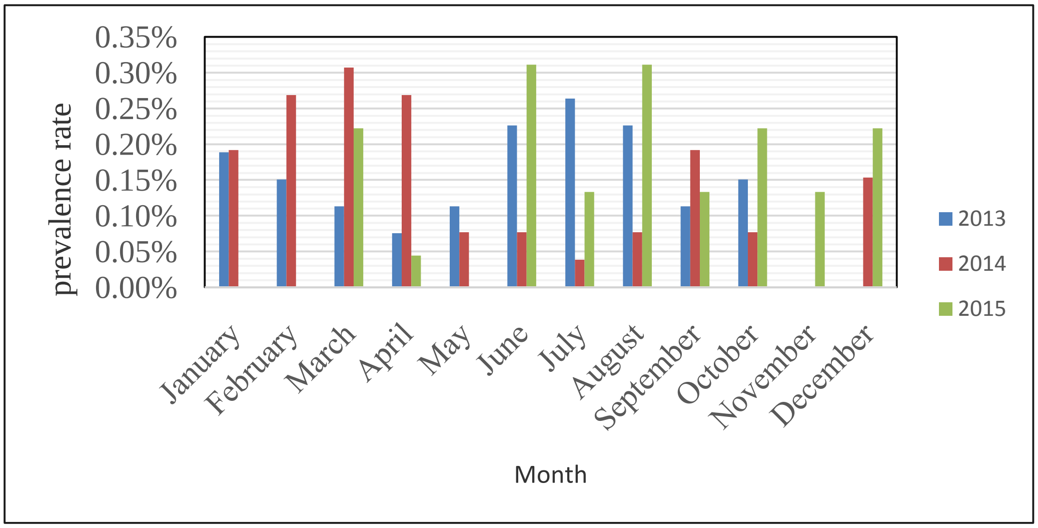


Figure 10: **Prevalence rate of bovine cysticercosis between 2013-2015, Kajiado Central.**

Results from Figure 11 show that in Kajiado West Sub-county bovine cysticercosis was present throughout the year from January to December 2015. Cases of bovine cysticercosis in 2013 and 2014 were scarce across the years from January to December. The highest prevalence rate was 0.09% in the month of September 2015 while the loWest prevalence rate was 0.01 in October 2013.

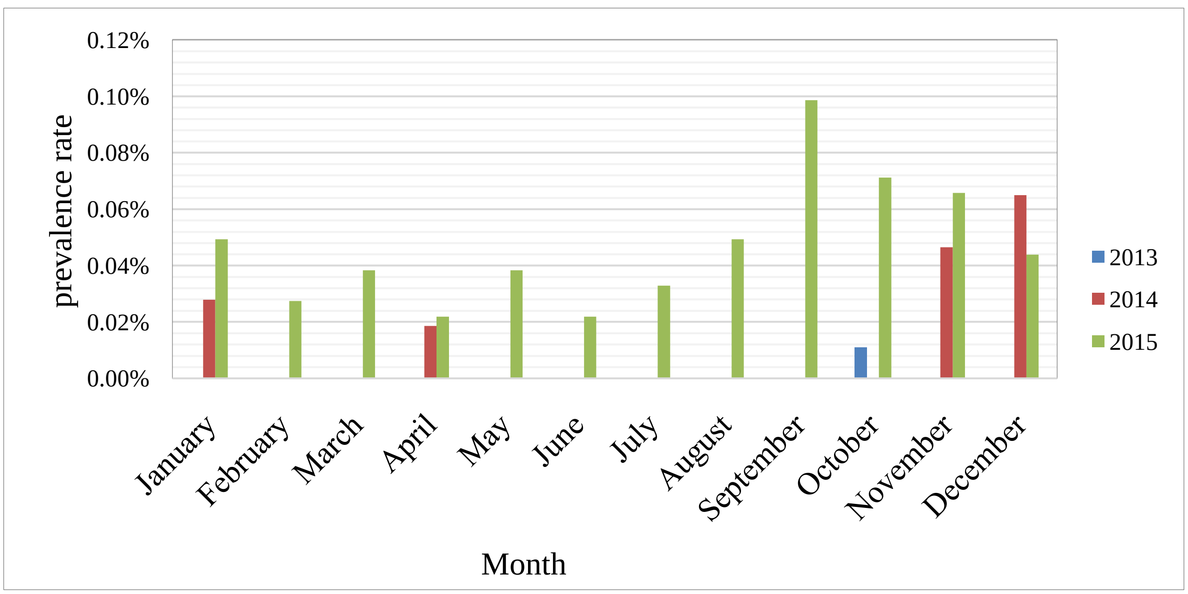


Figure 11: Prevalence rate of bovine cysticercosis between 2013-2015, Kajiado West.

Kajiado South only recorded bovine cysticercosis cases in July, August, October and November 2013 and February 2014 (Figure 12). This translated to prevalence rates ranging between 0.58-0.65%.

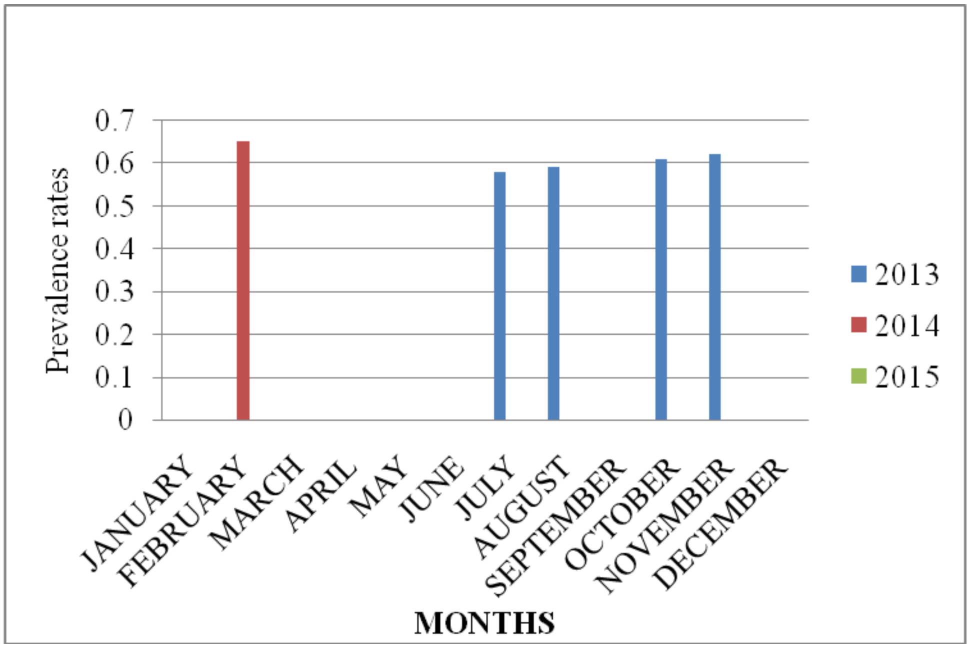


Figure 12: Prevalence rate of bovine cysticercosis between 2013-2015, in Kajiado South

In Kajiado North, prevalence rate of bovine cysticercosis was recorded throughout the three years and in all months of the year except January 2013, November 2014 and May 2015 (Figure 13). The highest prevalence rate (0.87%) was recorded in April, 2015 and the loWest prevalence rate was during the months of March, April, May, June and July 2014 (0.15%).

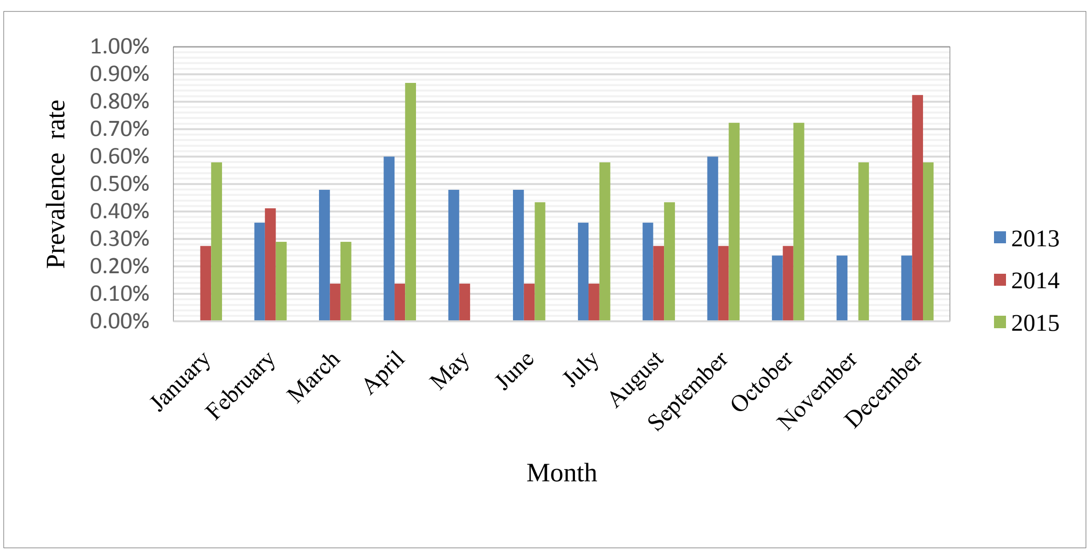


Figure 13: Prevalence rate of bovine cysticercosis between 2013-2015, in Kajiado North

In Kajiado East Sub-county (Figure 14) prevalence rates were reported throughout the 3 years except the month of May 2013, June 2013, June and November 2015. The highest prevalence rate was recorded in April, 2013 (0.086%) and the loWest prevalence rate was during the months of January, April, May, August, October and December 2015 (0.012%).

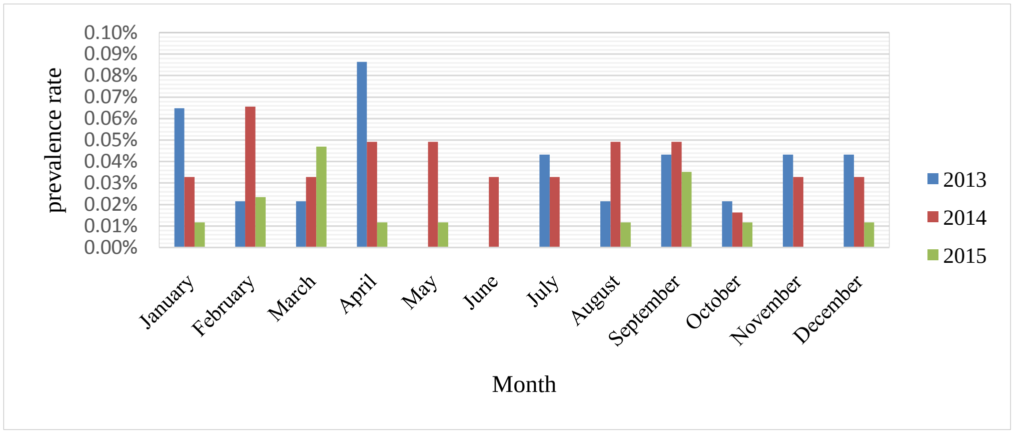


Figure 14: Prevalence rate of bovine cysticercosis between 2013-2015, in Kajiado East

4.4 Objective 4. Zoonotic risk factors associated with human taeniasis and bovine cysticercosis in Kajiado County.

Out of 91 households, 31.9% (29/91) households didn't have toilets, 65.9% (60/91) households had one toilet shared between 1-10 persons while the other 43.1% had 11 or more persons share a single toilet or lacked a toilet in the compound altogether (Table 5). Kajiado East and Kajiado North had the highest number of respondents who had toilets in their homesteads while Kajiado West and Kajiado South had the loWest number of households that owned a toilet. The p-value was 0.000 which was < 0.05 significant level implying that there was an association between availability of toilets and prevalence rate of bovine cysticercosis.

Table 5: Households owning a toilet and the number of persons using a single toilet.

Variable	Sub-County						Total	p-value
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	(%)		
Households owning a toilet								**0.000**
Yes	24	1	2	31	4	68.1	62	
No	1	14	10	0	4	31.9	29	
No of persons using a single toilet								
1-5 people	6	0	2	10	0	19.7	18	
6 -10 people	18	0	5	17	2	46.2	42	
11- 20people	1	9	5	4	4	25.3	23	
above 20	0	6	0	0	2	8.8	8	
Total							**91**	

Dam and borehole water were the two major sources of water in Kajiado County (Table 6) with 17.6%, 72.5%, 3.3%, 2.2%, 4.4%, using dam, borehole, river, well and rain water respectively. In Kajiado East, South, North and Central, boreholes were the major sources of water, while in Kajiado West dams were the major water sources. At lEast 51.6% used treated water either from source or they did treatment at home while 47.3% used untreated water. In total, 21 (23.1%) households used water sources that could be easily contaminated by ground run-off during heavy rains. A p-value of 0.000 was calculated which was < 0.05 significant level implying that there was association between source of water and infection with this zoonosis.

Table 6: Source and treatment of water

Variable	Sub-County						Total	p-value
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	(%)		
Source of water								**0.000**
Dam	0	15	0	0	1	17.6	16	
Borehole	19	0	12	30	5	72.5	66	
River	2	0	0	1	0	3.3	3	
Wells	0	0	0	0	2	2.2	2	
Rain	4	0	0	0	0	4.4	4	
Water treatment								
Yes	6	0	8	30	3	51.6	47	
No	19	15	4	1	4	47.3	43	
Sometimes	0	0	0	0	1	1.1	1	
Total households							**91**	

The percentage of households that bought beef regularly (45.1%) and always (13.1%) formed the bulk (58.2%) of the population (Table 7); only 17 households didn't use beef in their homes. In Kajiado East, Kajiado South, Kajiado North and Kajiado Central respondents bought beef more regularly than Kajiado West. A p-value of 0.000 was obtained which is <0.05 level of significance.

Table 7: Households that bought beef from butchery

Variable	Sub-County						Total	p-value
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	(%)		**0.000**
Households that bought beef from butchery								
Always	2	0	0	9	1	13.1	12	
Monthly	0	0	0	0	1	1.1	1	
Regularly	14	0	9	14	4	45.1	41	
Rarely	5	12	1	1	1	22.0	20	
Never	4	3	2	7	1	18.7	17	
Total							**91**	

A total of 42 households (46.2%) practiced home slaughter while 52.7% (48/91) didn't (table 8). Out of the 42 households that practiced home slaughter, 78.1% didn't involve a meat inspector. The respondents of Kajiado East, Kajiado South and Kajiado Central did home slaughters more oftenly while in Kajiado West and Kajiado North home slaughters were rare. A p-value of 0.000 which is <0.05 significant level was obtained indicating that there was a strong association between home slaughter and exposure to taeniasis.

Table 8: Households that did home slaughters and inspected meat

Variable	Sub-County						Total	p-value
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	(%)		**0.000**
Households that practiced home slaughters								
Yes	19	3	10	2	8	46.2	42	
No	6	11	2	29	0	52.7	48	
Rarely	0	1	0	0	0	1.1	1	
Households that involved meat inspectors in their home slaughters								
Yes	0	0	2	18	0		20	
						21.9		
No	25	15	10	13	8	78.1	71	
Total							**91**	

CHAPTER FIVE
DISCUSSION

Studies have shown that *Taenia saginata* eggs have to be passed on from a human host to the environment for bovine cysticercosis to occur in cattle. Otherwise the hefty losses caused by carcass degradation, condemned organs and millions lost on human treatment of helminthiasis would not occur. Despite the proven losses caused by bovine cysticercosis infections and the bodily harm that taenia causes less attention is given to human taeniasis. Most studies on bovine cysticercosis have dwelt majorly on improvement of diagnostic methods (Onyango-Abuje *et al.*, 1996) without weighing the enormity of this infection first. However this study endeavored to undertake the evaluation of prevalence rates of this zoonosis in Kajiado County and the underlying zoonotic factors.

The slaughter house prevalence rate for the period of two months (May 2016 and June 2016) was 2.56%. Results from this study concurred with previous results reported elsewhere; for instance; Nyagatare slaughter house in Rwanda recorded a prevalence of 3% (Stampston *et al.*, 2016) while 2.59% was recorded in Wolita Sodo (Dawit *et al.,* 2012). Tolosa *et al*., 2009 reported 2.93% in Jimma municipal abattoir, yet Bedu *et al.*, 2011 recorded 3% in Ziway. However these results were high compared to 2% prevalence rate recorded in Gondar ELFORA in Ethiopia (Adem and Alemneh, 2016). This was lower than 3.6% reported in Jimma municipal abattoir (Gomol *et al.*, 2011), 3.6% in Addis Ababa (Nuraddis and Frew 2012) and 4.6% in South West Shoa (Adugna *et al.*, 2013). Higher prevalence rates were recorded in other studies such as 4.8% in Ibi Nigeria (Karshima *et al.*, 2013), 7.5%, (Kebede *et al.*, 2009) in Addis Ababa, 5.2% was reported in Shire by Belay and Mekelle, 2014 and 6.7% at Kombolcha in North-Eastern Ethiopia (Endris and Negussie, 2011). In Hawassa, Regassa *et al.*, 2010 reported extremely high results (52.69%), yet in North West Ethiopia Kebede, 2008 reported 18.49%. This implies that bovine cysticercosis was present in Kajiado County, Kenya although the prevalence rate may not be as high as reported in earlier studies.

The variation in results recorded in different studies carried out in different countries and localities were associated with poverty levels which is more common in developing countries than in developed countries. For instance, very low levels were reported in Croatia (0.26%), 0.48-1.08% in Germany and 0.9% in Cuba (Teklemariam and Debash, 2015). It’s important to note that the distribution of cysts can be in most muscles; however the description of the sites of incision by various countries could lead to varying results. Kenya meat inspection act limits the number of incisions yet studies done elsewhere showed that cysts could be found in other sites such as diaphragm, liver, biceps, chuck, strip loin, full tenderloin, knuckle and back ribs which are not incised routinely (Lopez *et al.*, 2011).This may have lead to false negatives while in essence the carcass was infected. The limitation of sites is to protect gross mutilation of the carcass that predisposes it to bacterial infection. Beef traders are however opposed to inspection of the masseter muscles of the head citing the lowered quality of the head (Engdaw *et al*., 2015).

There were several limitations and factors that led to the low prevalence rates recorded in the current study. These include the short duration under which the study was carried out an observation also reported by Hajimohammadi *et al*., 2014. Additionally, the poor conditions and infrastructure in the slaughter house such as poor lighting immensely limited the scope of this study. It is worth noting that slaughter houses in which the study was undertaken lacked a back-up generator whereas most of these slaughter houses conducted night slaughters. Therefore in the event power outages occurred the procedure was undertaken using lanterns or spotlight. This could in itself jeopardize the results as noted by Qadeer, 2008. Moreover, the speed of the slaughter line and congestion in the slaughter houses also limited the inspector as a result of obstruction and poor visibility rendering the procedure less sensitive. Such a situation was observed in another study in Kombolcha Elfora meat factory, Ethiopia (Jemal and Haileleu, 2011). Another observation was that private ownership of slaughter house facilities brought conflict of interest between the business people and the management. The traders were opposed to head incisions citing lowering of quality of the head; a situation that reduced the sites of inspection which could lead to under-reporting as noted by Garedaghi *et al.,* 2011. The prevalence rate of bovine cysticercosis was highest in Olekasasi in Kajiado North (9.090%) and loWest in Kajiado West and Kajiado South (0%) respectively. The variation in prevalence rate between various slaughter houses was correlated to difference in meat inspectors and the daily slaughter of individual abattoirs.

Macroscopic identification of cysts doesn't in itself translate into an infection as some cysts may be calcified (degenerate) or viable (Gomol *et al*., 2011) thus necessitating the viability test. Viable cysts are the only ones that elicit an infection once consumed by a human host in undercooked or raw beef. This study reported a cyst viability of 83.3% which was high compared to other studies such as 68.35% in Kombolcha Elfora, North-Eastern Ethiopia

(Engdaw *et al.,* 2015), 62.5% in North Turkana (Asaava *et al*., 2009), 70% by Getachew and Kumar, 2013 while Emiru *et al*., 2015 reported a viability of 66.6%. The highest viable number was in Noon Kopir slaughter house which was associated with the high prevalence rate in that slaughter house. From these results it can be alluded that there are human subjects infected with taeniasis in this county and thus are the source of the bovine cysticercosis. It's worthwhile mentioning that a human to human or a bovine to bovine transmission is not viable.

The retrospective study demonstrated that all Sub-counties in Kajiado County recorded varying prevalence rates of bovine cysticercosis for the three years period under review (2013-2015). This study registered an overall prevalence rate calculated from county meat inspection reports at 0.51% notwithstanding the prevailing challenges experienced in the various slaughter houses and the low sensitivity of the method. These results are in agreement with the European data on meat inspection that showed prevalence ranges of 0.007% to 6.8% (Chiesa *et al*.,2010). In developed countries such as Spain, Denmark, Belgium and Australia the ranges from 0.06% to 0.21% were reported (Meiry *et al.,* 2013). However the marked rise in cases of bovine cysticercosis across the County in 2015 (Figure 9) was associated with improved data capture and reporting (Motbaynor and Terefe, 2015). Moreover, it has been observed that the accuracy of meat inspection data is not only a function of the number of cysts present in a carcass (Garedaghi *et al*., 2011) but also the differences in data capturing practices across the County (Opara *et al.,* 2006). This can be reflected in prevalence rates recorded in Kajiado West (Figure 11) where the records took a drastic shift in 2015, a shift that can only be attributed to lack of uniformity in data capture among the meat inspectors.

In Kajiado West and Kajiado South there were many months that were marked as zero prevalence. Accurate and reliable data capture at the inspection point requires time while poor capture and recording of data for bovine cysticercosis is of significance and practical use save for the visual inspection at the slaughter house (Hill *et al.,* 2012). This finding is in line with other results shown in reports conducted around the world including Europe, Africa, Australia and America where the prevalence rates differed greatly even in the same country (Pearse *et al.*,2010; Terefe *et al.*,2014). The distribution of the cases across the years in all the Sub-counties was in agreement with the findings of Sungirai *et al.,* 2014 and Dzoma *et al.,* 2011 who observed seasonal differences in the occurrence of bovine cysticercosis cases in Zimbabwe and North West province of South Africa respectively. Kajiado County enjoys a bimodal pattern of rainfall, therefore leading to the pattern of prevalence rate observed in the various Sub-counties (Figure 10, 11, 13 and 14). During the dry spell eggs and proglottids undergo desiccation faster due to lowered humidity and high temperatures and thus eggs die before they are picked by the intermediate host (cattle) as noted by Endris, and Negussie, 2011. This tends to lower the level of infection. On the other hand during rainy seasons eggs and proglottids especially in humid places can last for longer periods before desiccation hence extending their infective lifespan (Suvorov, 1965).

Predictions of future global demand for livestock products indicate considerable opportunities for African producers. However, many of the emerging challenges in livestock production lie in complexity in the areas of policy implementation and institutions. It was realized from the current study that livestock and beef trade are vital source of livelihoods of the communities found in the county where the study was carried out. This was well portrayed by the exponential increase in the number of slaughter animals from 2013 -2015. Coincidentally the increase in number of animals slaughtered also had a subsequent increase in positive cases of bovine cysticercosis (Figure 9). The differences in prevalence rates among Sub-counties were associated with cultural heterogeneity or diversity where some sub-counties were highly cosmopolitan in nature than others (Morara *et al*., 2014). This meant that the communities in such settlements were not entirely engrossed in pastoralism and their mixed farming lifestyle permitted access to toilets. Sub-counties with urbanized form of settlement could be less exposed than Sub-counties with pastoral settlements; for instance, Kajiado North and Kajiado East were more urbanized compared to Kajiado West.

It was regrettably noted that during Christmas there are many festivities that necessitate home slaughters. This consequently leads to the consumption of uninspected meat as noted in the questionnaire results (Table 8). The implication of this occurrence was an increase in human infection during the month of December which translates to shedding of eggs after 3 months and thereafter infection of the cattle. This scenario is later confirmed during meat inspection in the months of July to October after the cycle is complete (Mesfin and Nuraddis, 2012; Newell *et al*., 2010). This fact on bovine cysticercosis was demonstrated in the current study as shown in Figures 10 to 14. It is also evident from other studies that the nomadic lifestyle encourages slaughters in the bush where the standards of hygiene are very low in addition to there being no available meat inspectors (Birhanu and Abda, 2014*)*. The results of this retrospective survey imply that bovine cysticercosis is endemic in this county and should not be ignored or considered as stamped out.

Taeniasis is a condition caused by the mature *T. saginata* and occurs in the small intestines of man. Though it manifests in a mild nature it is known to cause 50,000 deaths annually not to mention the hefty losses it causes in beef industry (Kumar and Tadesse, 2011). Record keeping as noted earlier is a relevant baseline in any policy or decision making however, records on cases of taeniasis from the various Sub-county offices of health services in Kajiado County were not readily available because many reports were nonexistent. It was disappointingly noted that loss of data was linked with transition from national to County government where some districts were merged to form one Sub-county while others were split in the middle between two sub-counties leading to loss or misplacement of important data. Numerous studies have noted with nostalgia that lack or loss of appropriate records is a great hindrance to correct reporting. For instance in Europe a review on studies published on bovine cysticercosis from 1990-2014 showed that only 23 European countries had reports on prevalence data on bovine cysticercosis **(**Laranjo-González *et al.,* 2016).

A spot check on some major hospitals showed all stool samples were recorded as negative. There were no positive cases in Kitengela, Kajiado, Rongai and Ngong hospitals. The use of direct microscopy as a diagnostic tool for taeniid eggs was associated with false negative results. This is due to the low numbers of taeniid eggs and proglottids in a stool sample and therefore to be viewed under a microscope concentration method needed to be employed (CDC, 2013; Jimenez *et al.,* 2010). It's important to note that though few proglottids are seen under a microscope, a single proglottid can carry up to a thousand eggs (WHO/DFID-AHP, 2005). The prevalence rates of bovine cysticercosis recorded in the overall prevalence of the entire county was (0.51%). It can therefore be inferred that there are infected persons in the community who are the source of bovine cysticercosis. The greatest limitation in detection of taeniasis would be attributed to the diagnostic techniques and tools being employed. On the other hand the Maasai culture may also be a hinderance to diagnosis and treatment of the condition as shown by Froyd, 1965 who observed that elderly people among the Maasai view submission of stool samples as a taboo hence they opt to seek for herbal treatment. However, further research on the existence of taeniasis should be conducted by molecular methods such as ELISA, PCR among others.

The presence of taeniasis in a community is associated with various zoonotic factors such as poverty and poor hygiene that is indicated by lack of important basic amenities. In the current study, it was observed that 66.1% of the households sampled didn't have toilets in their homesteads (Table 4). Instead, these families used the bush or the area around the cattle shed (boma) for defecation especially for the young children. If the person was infected, then the forage became contaminated and the grazing animals picked the taeniid eggs while they foraged which is in agreement with Fahmy *et al.*, 2015. It was observed during this study that Kajiado County lacks a functional sewage system and many residential estates depend on septic tanks. Consequently, there is usually an overflow of sewage to the pastures exposing cattle to infection with taeniid eggs especially during dry weather when animals roam in residential places searching for pastures. This is in line with Girma, 2012 who noted that pit toilets tend to overflow especially in commercial housing and human waste is washed to pastures during rainy season. The other factor that causes contamination of the pastures is the encroachment to land formerly meant for pastures. This increased interaction between animals and human waste opening more avenues for infection of the animals (Kebede *et al.*, 2009).

This is in agreement with a report from CDC which shows that there is a close association between human beings and animals interactions with disease spread (CDC, 2013). Where eggs were not picked directly from the pastures, the eggs are swept by ground run-off to open water sources and they could be ingested by animals with water. It is important to note that taeniid eggs can survive in water for a month without losing their viability and therefore raw sewerage is a health risk to grazing animals. The highest numbers of households with toilets were recorded in Kajiado North; which was associated with urbanization in the Sub-county and the proximity to the city. It can therefore be inferred that the level of awareness of the population was higher in Kajiado North Sub-county. Kajiado South and Kajiado West had the largest number of households that didn't have toilets in fact most of them were in manyattas, hence poor hygiene. Such a phenomena was also observed by other scholars (Assefa *et al*., 2015; EU, 2011; EU, 2014 and EU, 2015) as a risk factor for taeniasis and bovine cysticercosis (Bedu *et al.*, 2011).

Many zoonotic parasites use water as a vehicle for transmission to their definitive or intermediate hosts either directly or via forage (Oryan and Alidad, 2014). The current study showed that the toilet: human ratio was very low where 47.2% of the people shared a single toilet between 6-20 persons. This implies that during peak hours for instance in the morning a given proportion of the family used the bush or thickets as an alternative toilet (Table 4). The fecal matter in the open contaminates the forage and eggs are picked by the animals as they graze while the rest is swept to open water sources during heavy downpours by the ground run-off water causing contamination of water sources with taeniid eggs *(*Hill *et al.,* 2012; Oryan and Alidad, 2015). These eggs are ingested by the animals while taking water opening up further infection with bovine cysticercosis (Kyvsgaard, *et al.*, 1991; Torgerson, 2013). The association between water contamination, poor hygiene and the transmission of infection is indisputable and can be traced back to 1946 where six out of seven human helminth infections could be prevented if humans are isolated from their own waste products (Goldsmid *et al.*, 2002).

According to Dupuy *et al.,* 2014 the reason for disease cluster in some areas can be attributed to factors such as grazing in areas with access to risky water sources and proximity to areas with high demographic pressure as was witnessed in Kajiado County which has diverse water sources as shown in Table 5. It was observed that out of 91 households 17.6% used dam or wells as source of water. Subsequently, Kajiado North and Kajiado East had the largest number of households that had tap or borehole water hence accessed clean drinking water while Kajiado West and Kajiado South had the largest number of households without clean water and either depended on dams, water pans or seasonal rivers that were shared between animals and man. It was therefore concluded that water contamination and access to untreated water contributed to exposure with infection a phenomenon linked to poverty or poor planning within a community (McCarthy and Moore, 2000).

Studies have shown that there is a direct association between consumption of beef and infection with *Cysticercus bovis* cysts a phenomena that allows the cycle of *T.saginata* to be complete (Gajadhar *et al*., 2006). An interesting observation was that 59.3% households in the County used beef as their source of protein as presented in table 6. Most of them sourced it from butcheries while others did home slaughter. Startlingly 47.6% of those who practiced home slaughters didn’t involve a meat inspector in their slaughter. Despite their level of awareness, professionals such as veterinarians and medical professionals often consumed raw meat to enjoy with their relatives and friends during home slaughters for cultural festivals (Firew and Moges, 2014). This was attributed to the engraved community value to their customs and traditions of consuming raw, and inadequately cooked beef dishes (Hirpha *et al.*, 2016). According to Taylor *et al.,* 2007 the most frequently affected organs were heart, lung, diaphragm, and masseter which are consumed raw or undercooked posing a potential public health hazard in contracting taeniasis, (Bedu *et al.,* 2011). This favored infection in case the meat was containing viable cysticercus as noted by Assefa *et al.,* 2015. Kajiado East Sub-county recorded high prevalence rates of bovine cysticercosis which was associated with home slaughters and lack of involvement of meat inspectors in the procedure (Table 9). Other studies have demonstrated that poor or lack of meat inspection was a good predisposing factor to bovine cysticercosis infection (Tesfay and Assefa, 2014).

WHO recommends that infected meat has to be boiled to at lEast 60^{o}C for several hours or be frozen for 10 days at -8^{0}C to -10^{0}C to kill the cysts (WHO/FAO/OIE, 2005). Although meat inspection is the only method that is readily available to diagnose *Cysticercus bovis* in beef, it was noted in this study that households ignored meat inspection during their home slaughter. Some respondents however cited lack of the service in their neighborhood. Some scholars observed that people who ate uninspected meat were highly vulnerable to diseases than people those who were strict on hygiene and meat inspection (Komba, 2012; Cooleman, 2002). *Cysticercus bovis* only gets diagnosed at postmortem and thus assuming that meat is fit for human consumption by visual examination at ante-mortem is erroneous and misleading (Swai and Schoonman, 2012). Due to the mild form in which the disease manifests both in man and cattle little attention is given to the disease as compared to the neurocysticercosis, (Bekele *et al*., 2013). Results from this study have demonstrated that the various zoonotic factors investigated significantly affected its morbidity in this County.

CHAPTER SIX
CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The following conclusions were drawn from this study:

- The results of this study established that bovine cysticercosis is present in Kajiado County. Though slaughter house prevalence rate was low, a longer study period would yield a higher prevalence.
- The high viability results demonstrated the potency of isolated *Cysticercus bovis* to cause taeniasis infection.
- The exponential increase in bovine cysticercosis cases in the retrospective study from 2013-2015 meant there was improvement on meat inspection and data capture.
- The zoonotic factors portrayed a public health education concern and the level of awareness was still wanting.

6.2 Recommendations

- Public awareness education on bovine cysticercosis and associated zoonotic factors should be undertaken by both the department of public health and the Ministry of Agriculture, Livestock and Fisheries.
- Better equipped laboratories and emphasis on correct diagnosis for example use of molecular techniques such as detection of antibodies by Ab ELISA, detection of antigen by Ag ELISA and the use of Polymerase Chain Reaction (PCR) assay.
- Improve further on data capture methods for example soft copies should be retained as back-up for the manual records.
- Discourage night slaughters because of poor visibility which lowers the sensitivity of the meat inspection method.

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LIST OF APPENDICES

APPENDIX 1

PARTICIPANT CONSENT FORM

ANNE MWIHAKI KIMARI is a student from Egerton University undertaking a course in Medical Parasitology and she will be undertaking her project entitled; "**PREVALENCE OF BOVINE CYSTICERCOSIS, TAENIASIS AND ASSOCIATED ZOONOTIC RISK FACTORS IN KAJIADO COUNTY, KENYA".** The study will involve an abattoir survey, analysis of monthly reports on the case records of both taeniasis in man and bovine cysticercosis in cattle in the County and also questionnaires to the various pastoralists. This study is aimed at generating information on prevalence of the two conditions i.e. taeniasis and bovine cysticercosis and the risk factors associated with this zoonosis.

Voluntary participation: Participation in this study is completely voluntary and there is no monetary benefit that shall be expected in return. By signing this form I'm consenting that I have read and understood the above information and I freely consent to participate in the project.

Thank you

Signature…………………………………………………….……….

Date…………………………………………………..………………

APPENDIX 2

QUESTIONNAIRE TO VOLUNTEER PASTROLISTS

Please tick √ the correct answer.

1. Do you have a toilet in your compound/manyatta? Yes [ ], No [ ].

2. About how many people use this toilet? 0-5 [ ], 6-10 [ ], 11-20, More than 20 [ ].

3. What is the source of your water? Dam [ ], Borehole [ ], River [ ], Well [ ], Others [ ].

4. Is the water normally treated? Yes [ ], No [ ].

5. How often do you buy beef from the butchery? Always [ ], Regularly [ ], Monthly [ ], Rarely [ ], Never [ ].

6. Do you slaughter cattle at home oftenly? Yes [ ], No [ ], Rarely [ ].

7. Do you call a meat inspector to inspect your meat at home? Yes [ ], No [ ].

APPENDIX 3

ETHICAL APPROVAL

EGERTON UNIVERSITY

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EGERTON UNIVERSITY

P. O. BOX 536-20115
EGERTON

RESEARCH ETHICS REVIEW COMMITTEE

Ref: EU/RE/DVC/009 **4th February 2016**

Anne Mwihaki Kimari
Dept. of Biological Sciences
EGERTON UNIVERSITY

RE: APPLICATION FOR ETHICAL APPROVAL OF RESEARCH PROJECT
Reference is made to your application for Ethical clearance of your research project entitled: ***"Occurrence of Bovine Cysticercosis and associated zoonotic risk factors in Kajiado County".*** The Egerton University Research Ethics Committee met on 2nd February 2016 and considered your application.

It was observed that:

1. That the procedure that will be used for this study is standard and has been used elsewhere.
2. That there is no mention of how carcasses found to be having too many cysts will be treated.
3. That the researcher should ensure confidentiality and data protection.
4. That the researcher needs to clearly articulate to the participants the nature of the study before obtaining consent.

Your proposed research was approved subject to addressing the above issues

Please further note that the Standard Operating Procedures (SOPs) requires that you submit progress reports of your study to the Committee. You are also required to obtain Research Permit from NACOSTI.

Prof. J. K. Kipkemboi
CHAIRMAN – RESEARCH ETHICS COMMITTEE
JKK/lm

FACULTY OF SCIENCE ★ EGERTON UNIVERSITY-NJORO ★ BOX 536-20115 EGERTON

1

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APPENDIX 4

RESEARCH PERMIT

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 8514

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MISS. ANNE MWIHAKI KIMARI
of EGERTON UNIVERSITY, 536-20115 egerton ,has been permitted to conduct research in *Kajiado County*

on the topic: *OCCURRENCE OF BOVINE CYSTICERCOSIS AND ASSOCIATED ZOONOTIC RISK FACTORS IN KAJIADO COUNTY, KENYA*

for the period ending:
2nd April,2017

Permit No : NACOSTI/P/16/16413/9755
Date Of Issue : 11th April,2016
Fee Recieved :ksh 1000

Applicant's Signature

Director General
National Commission for Science, Technology & Innovation

APPENDIX 5

RESEARCH PUBLICATION

www.ijird.com February, 2017 Vol 6 Issue 2

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Retrospective Study of *Cysticercus Bovis* and the Associated Zoonotic Risk Factors in Kajiado County, Kenya

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Abstract:
Bovine cysticercosis is a common zoonosis whose epidemiology is estimated at 50 million cases of infestation worldwide with economic losses from condemned and downgraded carcasses in Kenya amounting to £1.0 million by 2003. A retrospective study was conducted in Kajiado County, Kenya from January 2013 to December 2015 to determine the prevalence of Cysticercus bovis in the County and the associated zoonotic factors. Data on cases of bovine cysticercosis was extracted from monthly meat inspection reports of the County Director Ministry of Agriculture, Livestock and Fisheries from January 2013 to December 2015 and entered in excel spreadsheets. One sub-location was picked per a sub-county and a total of 91 households were sampled for a questionnaire interview according to Bebe et al., 2000. Prevalence rates were analyzed using descriptive statistics, while the Chi-square was used to analyze the association of the zoonotic factors with the cases of bovine cysticercosis. The mean of bovine cysticercosis obtained from the retrospective study was 150.9 with a P-value of 0.000 which is less than the 0.05 significant levels. Zoonotic factors investigated showed a positive association with the prevalence of bovine cysticercosis e.g. availability of toilets, source of water and its treatment, backyard slaughters and meat inspection had a P value of 0.000. The study showed that bovine cysticercosis is prevalent in Kajiado County and there were factors exposing the residents to this zoonotic infection. Public awareness on spread and implication of this zoonosis is important and also emphasis on hygiene is of necessity.

Keywords: Bovine cysticercosis, Cysticercus bovis, Kajiado, Zoonotic