SEROPREVALENCE OF *TAENIA SAGINATA* CYSTS IN CATTLE, HUMAN HOSPITAL CASES OF TANIASIS AND RISK FACTORS FOR HUMAN TAENIASIS IN KAJIADO COUNTY, KENYA.

DR. RUPHLINE MARGARET ANYANGO (BVM UoN) J56/36035/2019

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF THE DEGREE OF MASTER OF SCIENCE IN VETERINARY PUBLIC HEALTH IN THE DEPARTMENT OF PUBLIC HEALTH, PHARMACOLOGY AND TOXICOLOGY IN THE UNIVERSITY OF NAIROBI.

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University and that all my sources of material used for this thesis have been duly acknowledged.

Sign…… …… Date 16/05/2023

Dr. Ruphline Margaret Anyango (BVM)

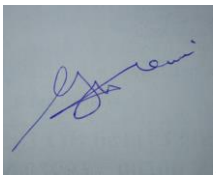
SUPERVISORS' APPROVAL

This thesis has been submitted with our approval as University Supervisors.

Sign …… …… Date…16/05/2023.

Dr. Timothy Wachira (BVM, MVSc, PhD)

Department of Public Health, Pharmacology and Toxicology

Sign…  …… Date 16/05/2023

Dr. Gerald Muchemi (BVM, MSc, PhD)

Department of Public Health, Pharmacology and Toxicology

DEDICATION

I dedicate this work to my parents, Mr. and Mrs. Ouma for their prayers and support. To all my siblings (Ken, Seline, Joseph, Vincent, and Josephine), and my dear friend Dr. Elvis Madara, this is for you!

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ABBREVIATIONS

T. saginata - Taenia saginata

C. bovis - Cysticercus bovis

ELISA - Enzyme Linked Immunosorbent Assay

PCR – Polymerase Chain Reaction

WHO –World Health Organization

WOAH[OIE]– World Organization for Animal Health

CDVS - County Director of Veterinary Services

CDHS - County Director of Health Services

COV – Cut off value

OD – Optical Density

ITS - Internal Transcribed Spacer

COI - Cytochrome c oxidase subunit 1

FAO – Food and Agriculture Organization of the United Nations

CDC – Centre for Disease Control

ES – Excretory-secretory

DNA – Deoxyribonucleic acid

RFLP – Restriction Fragment Length Polymorphism

ODK – Open Data Kit

DEFINITION OF TERMS

Taeniasis - food borne infection caused by consumption of raw or undercooked beef that contains viable cysticerci

Bovine Cysticercosis – parasitic infection of cattle with the larval stages (*Cysticercus bovis)* of *Taenia saginata*

Taenia saginata - a zoonotic tapeworm, commonly found in small intestine of man, causes human taeniasis.

Prevalence – Proportion of a population that have a given disease at a particular time.

Seroprevalence – Level of disease-causing pathogen in a population as measured by blood serum.

Risk factors – A variable that increases the chances of getting a certain disease or infection.

ABSTRACT

Taenia saginata is a zoonotic tapeworm that causes disease in cattle and human. A cross sectional survey was conducted between June and July 2021 in Kajiado County, Kenya to (i) estimate the seroprevalence of *Taenia saginata* cysts in cattle presented for slaughter in Kitengela, Kiserian and Keekonyokie slaughterhouses, (ii) to determine the annual hospital reported cases of *T. saginata* in humans that visited all level 4 hospitals in Kajiado county between 2015 and 2021 and (iii) to assess the risk factors for *T. saginata* in humans. Analyzed data in this study revealed that the seroprevalence of *T. saginata* cysts in cattle in the selected slaughterhouses was 2.67% (4/150). The meat inspectors recorded no cases of cysts during the study period and this confirms that Antibody ELISA is three times as sensitive as meat inspection. Data from hospital records showed that a total of 1,487,687 patients visited different facilities in Kajiado County between 2015 and 2021. Subsequently, 29 patients were diagnosed with human taeniasis between 2015 and 2021. The highest proportion (0.006%) was encountered in 2015 and the least proportion (0.004%) in 2020. From the risk factors assessed, uninspected home slaughter (75%), consumption of raw/improperly cooked beef (100%) and open defecation by herders (11%) still pose a risk to humans getting infected by *T. saginata* while presence and use of latrines (89%) and availability, accessibility and use of taenicides (89%) have significantly contributed to reduction of *T. saginata*. Considering the cultural practices of the local (Maasai) community, who are the main residents of Kajiado County, and since humans are the only definitive hosts of *T. saginata*, control of the infection should be centered towards continuous focused education coupled with regular deworming of human carriers, and especially the herders and school going children. This will gradually result in behavior and culture change that will ultimately reduce the prevalence and lead to elimination of the disease.

Keywords: *Taenia saginata*, bovine cysticercosis, taeniasis, risk factors, prevalence.

CHAPTER ONE: INTRODUCTION

1.1 Background

Eighty percent of Kenya is Arid and Semi-arid land where livestock keeping is the main economic activity. Livestock keeping contributes to the economy of the Country by earning foreign exchange through export of livestock and livestock products. Livestock also contributes to food and nutrition security and improvement of livelihoods (Livestock policy, 2020).

Neglected zoonotic diseases have remained a great public health threat to livestock productivity, food and nutrition security in the 21st century. *Taenia saginata*, despite its economic and public health importance, is ignored probably because the parasite causes a minor health condition in human and have no major clinical signs in cattle (Dermauw *et al*., 2018).

Taenia saginata, commonly known as beef tapeworm of man, causes cysticercosis in cattle and taeniasis in humans. The disease has a global distribution in both developed and developing countries (Dermauw *et al*., 2018). Both the adult worm and the larval stage affect the health of their respective host, and cause losses.

The tapeworm has the bovine as its intermediate host and the human as the definitive host. The humans get the infection when they ingest raw or undercooked beef that contain viable cysticerci. The cattle get infected when they drink water or ingest pasture that is contaminated with parasite eggs or proglottids from human feces (Jorga *et al*., 2020). A high prevalence has been recorded in Africa due to breach of sanitary measures and because most small scale households keep bovine as a source of livelihood, source of food and source of manure (Murrell, 2005). The cysts can be detected during routine meat inspection by visual inspection, palpation and incision of the predilection sites (Meat Control Act, 2012)

The disease is a very important cause of economic and public health losses due to its consequences on economy, food security and nutrition and public health (Food and Agriculture Organization, 2005). Economic losses in cattle are due to downgrading, freezing and condemnation of organs or the entire carcass depending on the number of cysts (Laranjo-González *et al*., 2017). In rare occasions, heavy infestations with *Cysticercus bovis* have been known to cause heart failure or myocarditis in cattle especially as a result of heavy infections of the heart muscles (Kumar *and* Tadesse, 2011).

In humans, it causes fear and distress as a result of pruritus, nausea, abdominal discomfort, weight loss, mild diarrhoea. Serious gastrointestinal tract disorders like intestinal blockage and peritonitis have also been reported (Jorga *et al*., 2020). Economic losses are as a result of the expenses associated with carcass management retained in abattoirs.

According to Meat Control Act of Kenya (2012), it is recommended that no carcasses with cysts should directly be passed for human consumption. Carcasses with 1-5 cysts should be retained, frozen at −10°C for at least 10 days and released unconditionally, those with 6-20 cysts, should be treated in the same manner as above but released conditionally, and those with over 20 cysts should be totally condemned (Meat Control Act, 2012).

Bovine cysticercosis occurrence is worldwide especially in places where beef consumption is high, and depending on levels of meat inspection. The disease mostly occurs in areas where there is inadequate meat inspection, poor sanitation, lack of, and/or inadequate latrines, primitive animal husbandry practices, and in communities that practice uninspected home slaughter of cattle (Jorga *et al*., 2020).

Routine meat inspection has been reported to underestimate prevalence rates, according to previous studies (Dorny *et al*., 2000 ; Onyango-Abuje *et al*., 1996b), and the most recent study in Belgium(Jansen *et al*., 2017 ; Jansen *et al*., 2018). Different serological diagnostic tools that detect either antigens or antibodies have been developed and used for detection of *T.saginata* cysts in meat (Harrison *et al*., 1989 ; Onyango-Abuje *et al*., 1996b ; Ogunremi *and* Benjamin, 2010). Emphasis should therefore be put on prompt diagnosis and subsequent prevention and control of *Taenia saginata* cysts to ensure health of cattle is improved, quality and quantity of beef improves leading to increased revenue from local and international trade.

1.2 Problem Statement and Justification

Zoonotic diseases pose a great threat to human and animal health. Understanding the prevalence, risk factors and status of surveillance of *Taenia saginata* would be a prerequisite for enhanced prevention and control strategies.

Taenia saginata directly and indirectly impacts on livestock keeping, which is the main economic activity of residents of Kajiado County. Most recent study (Kimari *et al*., 2017), using meat inspection, revealed moderately high prevalence of bovine cysticercosis and human taeniasis and recommended use of serological and molecular techniques for advanced diagnosis.

Previous studies (Dorny *et al*., 2000 ; Onyango-Abuje *et al*., 1996b; Jansen *et al*., 2017 ; Jansen *et al*., 2018) have relied on meat inspection which has been proven to underestimate by 50% prevalence rates (Wanzala et al., 2002). Meat inspection can only detect the heavily infected carcasses that have the cysts. Furthermore, meat inspectors only rely on predilection sites to detect cysts and can easily miss out on cysts in other areas that are not predilection sites (Kyvsgaard *et al*., 1990). It has been shown that ELISA is three times more sensitive than meat inspection and should be used for epidemiological studies (Wanzala *et al*., 2002).

This study was therefore undertaken to determine the seroprevalence of *C. bovis* in Kajiado County, the hospital reported cases of human taeniasis over a period of six years and risk factors associated with *Taenia saginata* cysticercosis and taeniasis in Kajiado County, Kenya. This was a mixed study model. The findings of this study would be used to provide epidemiological data for designing prevention and control strategies that are suitable for Kajiado County. Policy makers and researchers will benefit from data that has been generated from this study.

1.3 Objectives

1.3.1 Overall objective

To determine the seroprevalence of *Taenia saginata* cysts in cattle, human hospital cases of taeniasis and risk factors for human taeniasis in Kajiado County, Kenya.

1.3.2 Specific Objectives

1. To determine the seroprevalence of *Taenia saginata* cysts (*Cysticercus bovis)* in cattle presented for slaughter in selected slaughterhouses in Kajiado County, Kenya.
2. To determine the annual hospital reported cases of *Taenia saginata* in humans attending level 4 hospitals in Kajiado County, Kenya.
3. To assess the risk factors for *Taenia saginata* in humans in Kajiado County, Kenya.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Taenia saginata, popularly known as the beef tapeworm of man is an important zoonotic parasite. The tapeworm has the cattle as the primary intermediate host and the buffalo, giraffe and llama as alternative intermediate hosts (Pawlowski and Schultz, 1972), and the human as the definitive host. The adult tapeworm, *Taenia saginata* causes taeniasis in humans while the larval stages, *Taenia saginata* cysts (*Cysticercus bovis*) causes cysticercosis in the bovine. The disease has a global distribution in both developed and developing countries and is important since it affects the beef industry. Approximately 50,000 deaths occur annually in humans worldwide as a result of taeniasis (Kumar and Tadesse, 2011).

The humans get the infection when they ingest raw or undercooked beef that contain viable cysticerci. The cattle get infected when they ingest pasture or drink water that is contaminated with *Taenia saginata* egg (Symeonidou *et al*., 2018). The disease cycle is maintained when an infected human releases proglottids by defecating in the open, or by active migration of mobile proglottids from the anus to the environment, and when the cattle feed on contaminated pasture or fodder, or when infected persons handle cattle or contaminate their feeds (Jorga *et al*., 2020). A high prevalence of between 10% and 80%, has been recorded in Africa, and in particular Eastern and Southern African countries including Kenya, Ethiopia, Zambia, South Africa, Zimbabwe, Sudan and Botswana (Dermauw *et al*., 2018). This is due to breach of sanitary measures and because most small scale households keep bovine as a source of livelihood, source of food and source of manure (Dermauw *et al*., 2018).

The disease causes economic losses due to reduced productivity, trade restrictions, downgrading and condemnation of organs or the entire carcass in the abattoir depending on the number of

cysts. (Adem and Alemneh, 2016). These losses are usually quantified in terms of market price of cattle, cost of treatment of an infected carcass, cost of treatment of an infected person, disease prevalence and grading of the infected carcass (Adem and Alemneh, 2016). In humans, taeniasis causes fear and distress as a result of pruritus, nausea, abdominal discomfort, weight loss, mild diarrhoea (Dermauw *et al*., 2018). Serious gastrointestinal tract disorders like intestinal blockage and peritonitis have also been reported (Silva and Costa-cruz, 2010).

Bovine cysticercosis causes substantive losses in the meat sector, and in particular the beef industry. The Meat Control Act recommends that no carcasses with cysts should directly be passed on for human consumption. Carcasses with 1-5 cysts should be retained, frozen at −10°C for at least 10 days and released unconditionally, those with 6-20 cysts, should be treated in the same manner as above but released conditionally, and those with over 20 cysts should be totally condemned (Meat Control Act, 2012).

Diagnosis of *Taenia saginata* in cattle is usually done at meat inspection in the abattoir. This follows a standard as recommended by the Meat Control Act of Kenya, of visual inspection, palpation and incision of the predilection sites (Meat Control Act, 2012). Routine meat inspection has been reported to underestimate prevalence rates (by what percentage), according to previous studies (Dorny *et al*., 2000) and the most recent study in Belgium (Jansen *et al*., 2017 ; Jansen *et al*., 2018). Serological diagnostic tools that detect either antigens or antibodies have since been developed and used for detection of *T.saginata* cysts (Harrison *et al*., 1989 ; Onyango-Abuje *et al*., 1996b ; Ogunremi and Benjamin, 2010).

Detection of *Taenia saginata* in humans has relied on coprological methods, that have low sensitivity besides not being species specific. Copro PCR techniques have also been developed to aid in detection of human taeniasis (Gonzalez *et al*., 2004).

To control taeniasis in humans, it is recommended that beef from an infected cattle is cooked properly, at temperatures of between 56◦C to 65◦C to ensure all cysts are killed and the meat is safe (Lesh and Brady, 2019). Other control measures include use of drugs to treat human carriers that have presented with typical signs of taeniasis, that is ridding off the proglottids. The medication include praziquantel, tribendimidine, albendazole and niclosamide (Thomas, 2017). Other measures include community education on use of latrines, consumption of properly cooked beef and inspection of carcass before release for human consumption (World Health Organization, 2014).

2.2 Bovine Cysticercosis

Bovine cysticercosis (BCC) is the parasitic infection of cattle with the larval stages, *Cysticercus bovis,* of *Taenia saginata* (Laranjo-González *et al*., 2017). Cattle get infected when they consume pasture or drink water that is contaminated with tapeworm eggs or proglottids from feces of infected humans (Geysen *et al*., 2007). BCC is mostly prevalent in areas/communities that still have limited access to clean water, still practice uninspected home slaughter, and where open defecation takes place (Rossi *et al*., 2015). The disease causes appreciable economic losses in the beef industry due to condemnation of organs or entire carcass during meat inspection (Trevisan *et al*., 2018). The quality and value of the beef carcass also reduces when released post treatment (Trevisan *et al*., 2018).

2.2.1 Cysticercus bovis

Cysticercus bovis, popularly known as beef measles, is the larval stages of *Taenia saginata* that is found in cattle (El-Sayad *et al*., 2021). It is a small whitish cyst filled with fluid that contains immature stages of tapeworm (Figure 2.1) (Alemneh *et al*., 2017). The cysts are either of soft or hard consistency and are mostly found in muscles of the heart, masseter, triceps, tongue and diaphragm (Chengat *et al*., 2018). The size ranges between 5-8mm. The cyst can become calcified after death of the larva. The presence of *C.bovis* in the muscles can cause the carcass to be condemned partially or in entirety (Alemneh *et al*., 2017). Cattle get *Cysticercus bovis* when they ingest pasture contaminated with tapeworm eggs from human feces (Marshall *et al*., 2016).

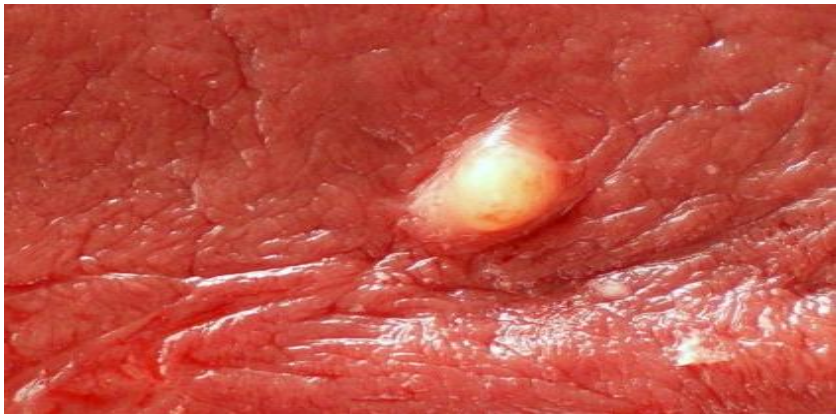

Figure 2.1: A picture of C.bovis in the triceps muscles

2.2.2 Distribution and Prevalence of Bovine cysticercosis

Bovine cysticercosis occurrence is worldwide especially in places where beef consumption is high, where open defecation is still practiced and in places where human sewerage is used as manure in farms (Chengat *et al*., 2018). Disease prevalence may vary from place to place depending on the standards of meat inspection. A high prevalence has been recorded in Africa due to breach of sanitary measures and because most small scale households keep bovine as a source of livelihood, source of food and source of manure (Dermauw *et al*., 2018).

Prevalence has been estimated using meat inspection records, at ante-mortem using serological techniques and at post mortem during meat inspection. Most of the prevalence data are estimates of data collected at the slaughterhouse during meat inspection. However, the meat inspection reports have been proven to underestimate the prevalence and have a low sensitivity for detection of the cysts in the muscles (Dorny *et al*., 2000). Furthermore, the lesions caused by *C.bovis* can be confused with those of *Sarcocystis spp* and *Actinobacillus spp* (Ogunremi *et al*., 2004).

Studies show that antigen ELISA is 2 to 10 times more sensitive than meat inspection and is recommended for epidemiological studies (Dorny *et al*., 2000). Meat inspection has been very

useful in detecting carcasses that are heavily infected. However, carcasses that are lightly infected and do not show lesions have been missed and passed for human consumption (Walther *and* Koske, 1980). Serology (Ag-ELISA) has been proven to be twice as much effective than meat inspection in the determination of prevalence rates (Onyango-Abuje *et al*., 1996a). A survey by Cheruiyot (1981) noted a prevalence range of 0.74% and 18% in Coast and Kisii, respectively. In Ngong district of former Rift Valley Province, and now part of Kajiado County, a prevalence of 10.3% was recorded. This study mainly relied on meat inspection records from abattoirs in all provinces in Kenya and Kenya Meat Commission abbatoir. The records were obtained from the Director of Veterinary Services Office in Kabete (Cheruiyot, 1981). A seroepidemiological survey of *Taenia saginata* noted a high prevalence in Eastern and Rift Valley Provinces. Narok district recorded the highest prevalence of 31.47% (Onyango-Abuje *et al*., 1996a). This study combined serology and meat inspection records. It noted that Ag ELISA was more sensitive and detected more cases as compared to Ab-ELISA (Onyango-Abuje *et al*., 1996a). The study also concluded that serology was two times more sensitive than meat inspection (Onyango-Abuje *et al*., 1996a). A study by Kangethe (1995) noted that the national prevalence had drastically reduced from 8.8% in 1974 to 1.1% in 1991. This was attributed to meat inspection (Kang'ethe, 1995). In 2009, a study conducted in Northern Turkana estimated a prevalence of cysticercosis at 16.7% (Asaava *et al*., 2009). This combined both serology and meat inspection. A study conducted in 2016 in Kajiado County noted a prevalence of 2.56% for bovine cysticercosis, using meat inspection (Kimari *et al*., 2017).

2.2.3 Life cycle of Taenia saginata

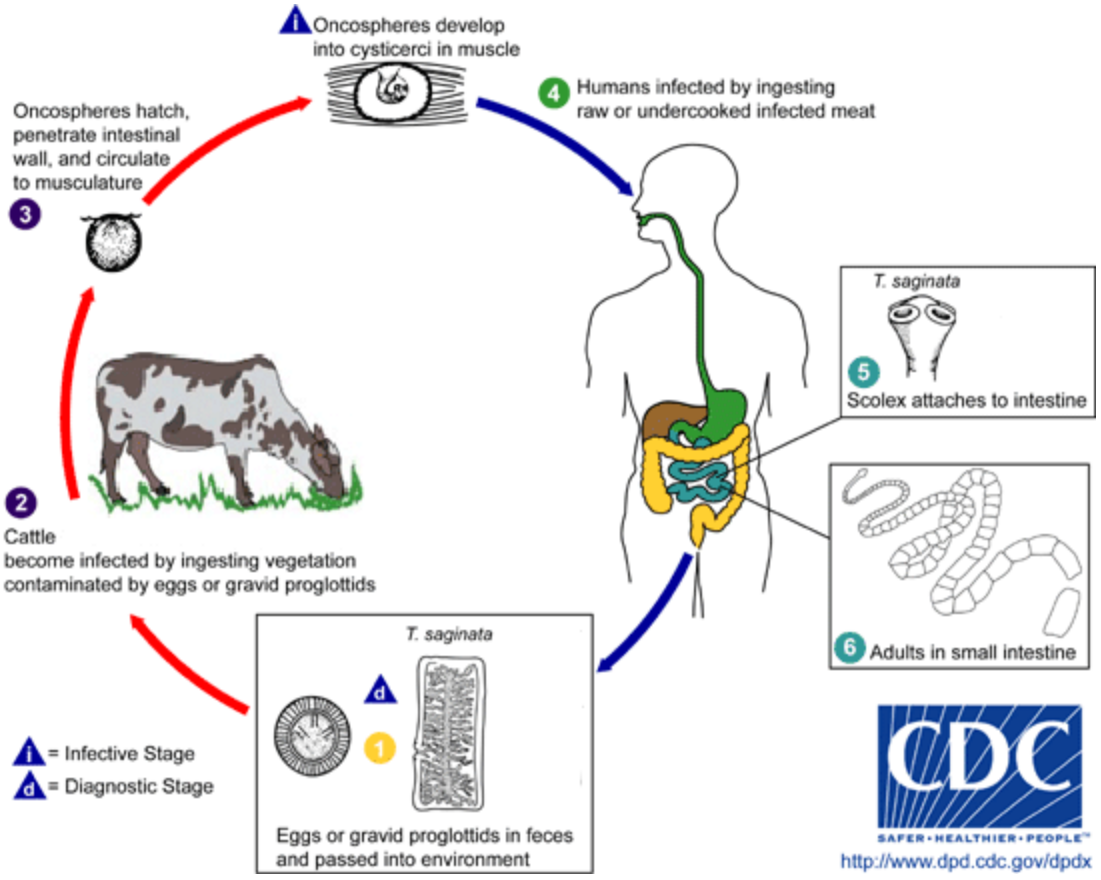

Figure 2.2: Life Cycle of Taenia saginata

Source: Centre for Disease Control *and* Prevention, National Centre for Infectious Diseases, Division of Parasitic Diseases.

The adult parasite is found in the small intestine of humans (Figure 2.2). The humans get the infection through ingestion of raw or undercooked beef with viable cysticerci (Jorga *et al*., 2020). Gravid proglottids of *T. saginata* contain embryonated eggs that are motile and migrate from the anus independently of defecation or get expelled in stool during defecation (Dorny and Praet, 2007). The eggs can remain viable for several weeks or months in the environment, water

and in sewerage. The environment gets contaminated by feces from the definitive hosts (humans). Cattle become infected through grazing on contaminated pastures, or ingesting contaminated fodder or water (Jorga *et al*., 2020). After the eggs hatch, they change into oncospheres which penetrate the intestinal wall to reach the blood circulation, they are distributed throughout the body where they develop into cysticerci (Chengat *et al*., 2018). Common predilection sites for *T. saginata* cysticerci include the triceps, tongue, heart, lungs and masseter muscles (Chengat *et al*., 2018).

2.2.4 Clinical signs of Bovine Cysticercosis in cattle

Cattle affected with *C. bovis* are mostly asymptomatic, however, myocarditis and heart failure may result in case of heavy infestation (Kumar and Tadesse, 2011). Heavy infestation can also result into muscle stiffness and nervous signs (Rabi and Jegede, 2010).

2.2.5 Diagnosis of Bovine Cysticercosis in Cattle

2.2.5.1. Meat Inspection in cattle

Meat inspection has been used routinely to diagnose carcasses that are heavily infected by *Taenia saginata* cysts. According to the Kenya Meat Control Act cap 356, diagnosis of *C.bovis* should be done by visual inspection, palpation and incision of the predilection site for the presence of cysticerci (Meat Control Act, 2012). The predilection sites include heart, tongue, *Triceps brachii* and masseter muscle (Chengat *et al*., 2018). However, studies have shown that the cysticerci could be found in other areas, and not necessarily the predilection site. This is because of variation in distribution of cysticerci to preferred sites (Kyvsgaard *et al*., 1990). A study recommended an increase in number of predilection sites to be inspected during meat inspection (Wanzala *et al*., 2003). The same study also recommended development of a sero-

diagnostic test to aid in diagnosis of *C.bovis* in live animals. This would avert the unnecessary mutilation of carcass and improve on meat inspection (Wanzala *et al*., 2003).

2.2.5.2. Immunodiagnosis of Bovine Cysticercosis in cattle

Immunological methods have been used to diagnose *C.bovis* with various degrees of sensitivity and specificity. These include; Enzyme Linked Immunosorbent Assay (ELISA) (Onyango-Abuje *et al*., 1996b ; Wanzala *et al*., 2007 ; Wanzala *et al*., 2002 ; Ferrer *et al*., 2003) and Indirect-Haemagglutination Test (IHAT) (Walther and Grossklaus, 1972). ELISA has been widely used and recommended for epidemiological studies to detect circulating antigens and antibodies in experimental and naturally infected cattle (Onyango-Abuje *et al*., 1996b ; Dorny *et al*., 2002). This has been done on individual cattle and in herds. These diagnostic tools have been developed for use in detection of *T.saginata* cysts (Harrison *et al*., 1989 ; Onyango-Abuje *et al*., 1996b ; Ogunremi and Benjamin, 2010). Antibody tests have been used to detect exposure to the parasite while antigen tests have been used to detect presence of a viable cysticerci causing an active infection (Kumar and Tadesse, 2011).

Onyango –Abuje *et al*, (1996) used monoclonal antibody produced against secretory-excretory products of the cysticerci to detect antigen using ELISA (Onyango-Abuje *et al*., 1996a). The method has been widely used and confirmed to be twice as effective as meat inspection (Onyango-Abuje *et al*., 1996b). This method needs to be complemented by meat inspection since it's not able to pick dead cysts and light infections (Onyango-Abuje., 1996a).

Kebede (2004) in his study, did an evaluation of various immunological techniques to diagnose *Cysticercus bovis*, using live *C.bovis* cysts to prepare antigen. The tests included ELISA, indirect hemagglutination test (IHAT), indirect Enzyme-Linked-Immuno-Sorbent Assay (ELISA) and

fecal examination. The findings revealed that Indirect Haemagglutination Test (IHAT) had a sensitivity of 100% and a specificity of 91%, and performed better than ELISA (Kebede, 2004)

Abuseir *et al*., (2007) in their study, used peptide Ts45S-10 and HP6-2 as antigens to detect antibodies against *C.bovis* in serum and meat juice samples. This study indicated that use of HP6-2 as an antigen for detecting antibodies in serum had a sensitivity of 100% and a specificity of 98% (Abuseir *et al*., 2007).

Ogunremi and Benjamin (2010) used ELISA to detect animals that had *T.saginata* cysts. This was done using the excretory-secretory (ES) antigens of *C.bovis* to detect IgG1 activity in bovine sera (Ogunremi and Benjamin, 2010). Their technique had a sensitivity of 92.9% and a specificity of 90.6% and was recommended for diagnosis of *C.bovis* in a field outbreak.

2.2.5.3. Molecular methods for detection of Bovine Cysticercosis in cattle

The World Organization for Animal Health (WOAH) recommends use of Polymerase Chain Reaction (PCR) in differentiation of *Taenia* species, and especially to identify the metacestodes (OIE, 2008). Both multiplex and Real Time Polymerase Chain Reaction (PCR) have been used in detection of *Cysticercus bovis* and *Taenia saginata*. PCR has be used to differentiate the taeniid cestodes (Mayta *et al*., 2000).

Hiroshi (2004) used multiplex PCR to conduct a differential diagnosis of cysticercosis and taeniasis (Hiroshi *et al*., 2004). Abuseir *et al*, (2006) used PCR to validate the results of meat inspection (Abuseir *et al*., 2006). PCR for detecting *Taenia saginata* DNA in muscles has also been developed (Geysen *et al*., 2007).

2.2.6 Treatment of Bovine Cysticercosis in Cattle

Cattle with *Taenia saginata* cysts are usually asymptomatic, therefore treatment against *C.bovis* is normally done as a prophylactic therapy when deworming cattle against other worms. In areas that have reported high prevalence of *C.bovis*, treatment has been done successfully and reported to be economical (Blazek *et al*., 1981).

Niclosamide is the drug of choice and most preferred, according to a study that indicated it was the highest sold taenicide in Ethiopia (Abunna et al., 2007). Mebendazole, albendazole and praziquantel have also been used to treat cattle diagnosed with *C.bovis* (Abunna et al., 2007). Other drug molecules that have been used effectively to manage *C.bovis* include Oxfendazole, fenbendazole, flubendazole, and nitazoxanide (Winskill *et al*., 2017).

2.3 Human taeniasis

Human taeniasis is a food borne infection caused by consumption of raw or undercooked beef that contains viable cysticerci (Symeonidou *et al*., 2018). The disease mostly presents with asymptomatic signs but occasionally, may cause fear and distress as a result of pruritus, nausea, abdominal discomfort, weight loss, and mild diarrhoea. Serious gastrointestinal tract disorders like intestinal blockage and peritonitis have also been reported (Silva and Costa-cruz, 2010). This food borne parasitic disease commonly occurs in areas where there is uninspected home slaughter, consumption of raw or improperly cooked beef and where there are insufficient or no latrines therefore humans defecate in open fields where cattle graze on (Komba *et al*., 2012 ; Trevisan *et al*., 2018).

2.3.1 Taenia saginata

Taenia saginata, a zoonotic tapeworm, commonly found in small intestine of man, causes human taeniasis (Mwasunda *et al*., 2022). The adult worm is made up of segments, known as proglottids, that contain both the male and female reproductive organs, thereby able to reproduce by self-fertilization (Alemneh, 2017).

Infected humans can either release embryonated eggs or proglottids in feces, which are infective.

The tapeworm is the largest species in the genus *Taenia*. Other members include *Taenia solium, Taenia hydatigena* and *Taenia asiatica*. The tapworm measures between 4 – 10 meters in length (Figure 2.3). The body is flattened dorsoventrally, is white in colour and divided into three sections; the scolex which contains four suckers and no hooks, the neck, and the strobilla (Alemneh and Adem, 2017).

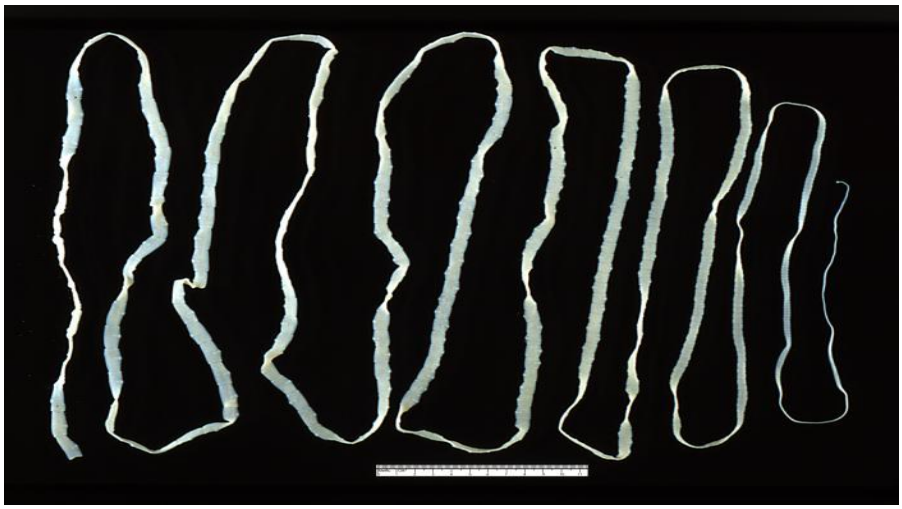

Figure 2.3: A picture of Taenia saginata

Source: https://commons.wikimedia.org/w/index.php?curid=776561

2.3.2 Distribution and Prevalence of Taenia saginata

Taenia saginata has a global distribution in both developed and developing countries but more important in some Mediterranean countries, Africa, Latin America and Asia (Kandil *et al*., 2015). A high prevalence has been recorded in Africa, and in particular Eastern and Southern African countries including Kenya, Ethiopia, Zambia, South Africa, Zimbabwe, Sudan and Botswana (Dermauw *et al*., 2018). This is due to breach of sanitary measures and because most small scale households keep bovine as a source of livelihood, source of food and source of manure (Dermauw *et al*., 2018). In 2009, a study conducted in Northern Turkana estimated a prevalence of human taeniasis at 2.5% (Asaava *et al*., 2009).

2.3.3 Risk factors for Human Taeniasis and Bovine Cysticercosis

Bovine cysticercosis mostly occurs in areas where there is uninspected home slaughter (Kimari *et al*., 2017). Poor sanitation and lack of latrines also plays a role in spread of parasite eggs and/or proglottids that are subsequently consumed by cattle in pasture (Kimari *et al*., 2017). The risk factors for *Taenia saginata* include poor sanitation and consumption of raw, undercooked or sundried beef (Gebrie and Engdaw, 2015), lack of or inadequate meat inspection practices that lead to beef with cysticerci getting to the butcheries, lack of latrines hence deposition of feces along highways and rail lines and in farms (Flütsch *et al*., 2008), poor hand hygiene and lack of sanitary education. The farm workers may also serve to disseminate the parasite egg when they handle animal feeds (Mwita, 2013). Another risk factor is lack of, and/ or ineffective fly and bird control methods around cattle grazing and feeding yards (Jansen *et al*., 2021).

2.3.4 Symptoms of Human taniasis

The disease is mostly asymptomatic but heavy infection presents with symptoms like nausea, diarrhoea, lethargy, weight loss, epigastric pain, flatulence, abdominal discomfort and intestinal blockage (Dermauw *et al*., 2018).

2.3.5 Diagnosis of Human taniasis

2.3.5.1 Examination of stool

Diagnosis of *Taenia saginata* has been based on history, symptoms and examination of stool for tapeworm eggs or proglottids (Alemneh and Adem, 2017). Examination of stool has either been macroscopic or microscopic. Diagnosis has also been done by peri-anal swabbing using an adhesive tape, which has been proven to be more sensitive than fecal examination (Alemneh and Adem, 2017).

2.3.5.2 In- person interview of respondents

Diagnosis can be made through in-person interviews of respondents to determine whether or not the respondents have experienced passing of proglottids at any point (Silva and Costa-cruz, 2010).

2.3.5.3 Immunological tests

A copro-antigen detection using ELISA has been used to detect cases of *Taenia saginata* (Silva and Costa-cruz, 2010). This method, besides having a high sensitivity, is unable to differentiate between the Taenia species (Allan *et al*., 1990).

2.3.5.4 Molecular techniques

Molecular techniques have been used to distinguish between the different taenia species. In diagnosing an adult tapeworm, it's been difficult to distinguish between the taenia species based on their morphology. Molecular techniques have therefore come in handy to ensure the adult tapeworms are correctly identified (Somers *et al*., 2007). The molecular techniques, have provided solutions with tapeworm identification, that would enable diagnosis, treatment and control of taeniasis amongst the affected humans (Somers *et al*., 2007). Identification of *Taenia saginata* has been done successfully using multiplex PCR and RFLP protocols (Gonzalez *et al*., 2004). Identification of the tapeworm specimen using Cytochrome C Oxidase subunit I (COI) gene sequence, has been used as a common marker to deduce phylogenetic relationships among the cestodes (Chang *et al*., 2021). The other molecular markers that could be used to follow phylogenetic relationships amongst cestodes include 28s, 18s and ITS (Anantaphruti *et al*., 2013).

2.3.6 Treatment of Human Taeniasis

The treatment of choice is by use of Praziquantel, as a single dose of 10mg/kg body weight, and in some cases Niclosamide. Treatment is considered successful when no taenia egg is detected in stool, three months after drug administration (CDC, 2021).

2.3.7 Prevention and control of Human Taeniasis and Bovine Cysticercosis

World health Organization recommends that for successful prevention and control, elimination and eradication, there are 5 strategies that need to be considered. These include preventive chemotherapy, intensified disease management, intermediate host and vector control, veterinary public health at the human animal interface, hygiene and sanitation and safe water provision (WHO, 2012) The areas of interventions should be done at different levels to ensure effective

control of the disease. A one health approach should be adopted to ensure control at the level of definitive host (human), intermediate host (cattle) and the environment. The measures include proper meat inspection to prevent transmission of cysts to humans, human sanitation to prevent transmission of the eggs and proglottids to cattle, surveillance, chemotherapy using albendazole and praziquantel to interfere with the transmission cycle, cooking meat properly, freezing meat at -10°C for 10 days before releasing either conditionally or unconditionally, pickling meat in 25% salt solution for 5 days, screening of workers and prompt treatment of any positive cases and educating the farmers and consumers on hygiene practices and on the importance of proper cooking of beef. A study conducted by Wanzala (2003) noted that meat inspection is a proper way of controlling *Cysticercus bovis* transmission to human. However, its limitation is that cysts can still be found in areas that are not considered to be predilection sites on routine meat inspection (Wanzala *et al*., 2003).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Area

The study area selected was Kajiado County, in Kenya. The study area was purposively selected because the main economic activity is livestock rearing (Kajiado County Integrated Development Plan, 2018-2022), and cases of *T.saginata* have been reported from previous studies (Cheruiyot, 1981 ; Kimari *et al*., 2017)

Kajiado County has an area of 21,292.7km^2.It is situated between Longitudes 360.5' and 370.5' East and between Latitudes10 0' and 30 0' South. It is located in the Southern part of Kenya (Kajiado County Integrated Development Plan, 2018-2022). Kajiado County is subdivided into 5 Sub-counties namely; Kajiado North, Kajiado South, Kajiado East, Kajiado West and Kajiado Central (Figure 3.1).

Kajiado County experiences both long and short rains. The pattern of the rainfall is not uniform across the County. Rainfall ranges from between 300mm to 1250mm.

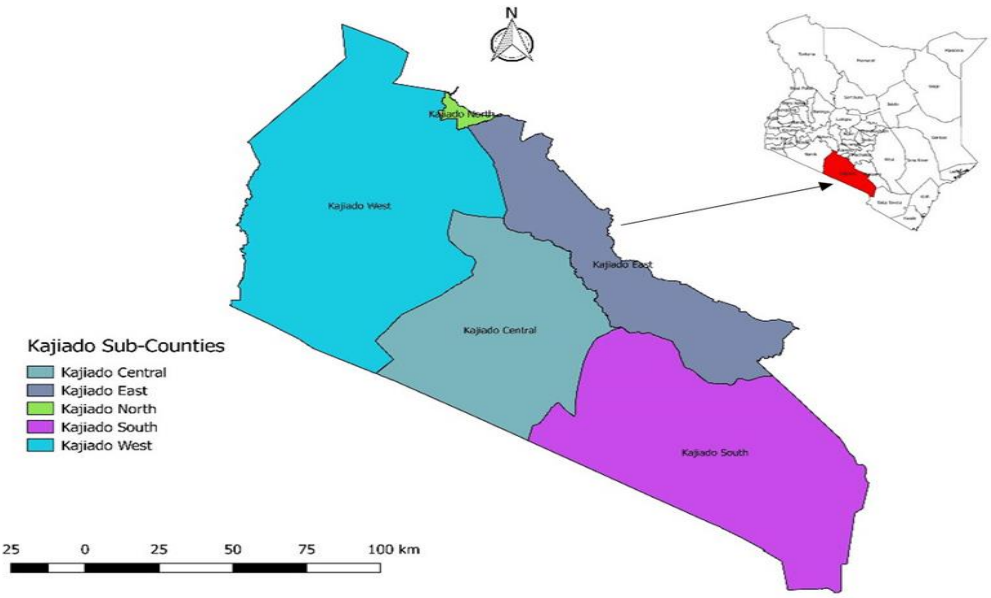

Figure 3.1:Map of Kenya showing administrative regions in Kajiado County.

3.2 Determination of the seroprevalence of Taenia saginata cysts (Cysticercus bovis) in cattle presented for slaughter in selected slaughterhouses in Kajiado County, Kenya.

3.2.1 Study design

A cross sectional study design was used to collect data from selected slaughterhouses in Kajiado County.

3.2.2 Study sites

Kitengela, Kiserian and Keekonyokie slaughterhouses were the study sites selected because they receive animals from the entire county and are category B slaughterhouses (have a high daily throughput). They are also located in different Sub-counties; Kitengela slaughterhouse is in Kajiado East sub county while Kiserian and Keekonyokie are in Kajiado West sub counties.

3.2.3 Sample size determination

Sample size was determined according to the method described in (Dohoo *et al*., 2003).

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

Where, n=required sample size,

Zα =the normal deviate that provides 95% confidence intervals (1.96)

p = A priori estimate of the prevalence of the disease.

An estimation of 2.56% was adopted in Kajiado County (Kimari *et al*., 2017)

q=1-p

L =the allowable error of the estimate

Therefore,

$n = (1.96)^2 \times 0.0256 (1-0.0256)/ (0.05)^{2.}$

The total sample size of cattle is 38.

The sample size was adjusted to 150 using design effect to cater for possible clustering (aspect of different sub counties) effects.

3.2.4 Sampling Strategy

Each of the selected slaughterhouse was visited daily for twenty days. The animals to be sampled were selected based on the movement permits presented to the meat inspectors. Only animals that originated from Kajiado County were sampled.

3.2.5 Blood collection

The cattle to be slaughtered were restrained, and stunned, and their jugular slit before being bled as recommended by the Meat Control Act of Kenya (Meat Control Act, 2012). Sampling was done after the jugular was slit whereby approximately 10ml of blood was collected from each animal. The sample collection bottles were labelled and placed in cool box that contained icepacks. The blood samples were transported to the Department of Public Health Pharmacology and Toxicology laboratory in a cool box, within two hours of blood collection.

To ensure biosafety and biosecurity, the researcher and assistant were donned in white labcoats, gumboots, gloves and masks at all times during sample collection.

3.2.6 Serum preparation

The blood samples were kept overnight at room temperature and centrifuged at 3000g for 30 minutes. Serum was then extracted into cryovials and labelled. The resultant serum in labelled cryovials were stored at -20°C until used for serology.

3.2.7 Serology

Serum samples from slaughtered cattle were screened for circulating cysticercus antibodies using the procedure adopted from the manufacturer, Shenzhen Lvshiyuan Biotechnology Co.,Lt, as described below;

1) Add Sample diluent: Add 2 drops sample diluent to each well.
2) Add Sample: For sample wells, only add 10ul sample per well; set 2 wells of negative control, only add 10ul negative control per well; set 2 wells of positive control, only add 10ul positive control per well. Cover with adhesive foil and **incubate at 37^0 in dark for 30min**.

3) Washing plate: Discard the liquid of the well, add 1 drop washing solution into each well, then full each well with distilled water immediately, be static for 30s and discard; then directly use distilled water to wash for 4 times, be static for 30s each time; at last time flap to dry with the absorbent paper.

4) Adding Enzyme conjugate: Add 2 drops of Enzyme Conjugate into all wells, Cover with adhesive foil and **incubate at 37^0 in dark for 30 minutes.** Discard the liquids of the wells and wash as described in step 3, flap to dry.

5) Adding substrates. Add one drop of substrate A and one drop of substrate B, mix evenly, and incubate at 37℃ in dark for 10 minutes.

6) Add 1 drop of Stop solution into all wells to stop reaction. Read the OD value at ELISA reader 450nm (630nm as a reference).

3.2.7.1 Reference

1) Cut-off Value (COV) = Average OD Value of Negative control X 2.1 (calculate as 0.05 when the OD Value of Negative control < 0.05).

2) Validation judge

OD value of Negative control well ≤ 0.15 (Test is invalid when > 0.15);

OD value of Positive control well ≥ 0.30 (Test is invalid when < 0.30)

3.2.7.2 Results interpretation

When Sample OD value ≥ COV, it is POSITIVE;

when Sample OD value < COV, it is NEGATIVE.

3.3 Determination of the annual hospital reported cases of *Taenia saginata* in humans attending level 4 hospitals in Kajiado County, Kenya.

A retrospective study was conducted in all level 4 government hospitals in Kajiado County. The hospitals are shown in table 3.1 below;

Table 3.1 Hospitals where records were obtained

S/No	Sub County	Hospital
1	Kajiado Central	Kajiado County Referral Hospital
2	Kajiado East	Kitengela Sub-county Hospital
3	Kajiado North	Ongata Rongai Sub-county Hospital
4	Kajiado North	Ngong Sub-county Hospital
5	Kajiado South	Loitoktok Sub-county Hospital

The study utilized retrospective data of patients that visited all level 4 hospitals between 2015 and 2021. Those that were diagnosed with *Taenia saginata* were noted and recorded. The data was obtained from all level 4 hospitals in Kajiado County. In Loitoktok Sub-county Hospital and Kajiado County Referral Hospital, the data was obtained by perusing available records. In Kitengela Sub-county Hospital, Ongata Rongai Sub-county Hospital and Ngong Sub-county Hospital, the data was obtained from the District Health Information Software (DHIS-2) system.

3.4 Assessment of the risk factors for *Taenia saginata* in humans in Kajiado County, Kenya.

3.4.1 Study population

Livestock keeping households in Kajiado County consisting of both male and female livestock keepers formed the study population. The households to be interviewed were randomly selected based on the inclusion criteria as indicated below:

1. Permanent resident of Kajiado County.
2. A pastoralist household
3. Household that keep cattle.

3.4.2 Sampling

Multistage sampling was used to sample respondents whereby from Kajiado County, all Sub-counties were selected and from each Sub-county, one ward was selected using simple random sampling using random number generator. The selected ward served as the site for conducting interviews. A sample size of 140 was used based on the method by (Dworkin, 2012). The study involved conducting interviews to at least 25 households from each ward, until sample saturation was obtained.

3.4.3 Data collection

Interviews were used to collect quantitative and qualitative data using structured questionnaires. Two sets of interviews were conducted; to the livestock keepers and to the meat inspectors. Digitized questionnaires using the Open Data Kit (ODK) application, were administered to livestock keepers, and used to collect data on meat inspection and preparation, animal husbandry practices, availability and access to anthelmintic and management practices for taeniasis.

Informed consents were sought before conducting the interviews amongst livestock keepers. The local leaders were informed on the purpose and scope of the study for community support.

Meat inspectors were interviewed using questionnaires to collect data on number of positive cases of *Taenia saginata* cysts that were observed between June and July 2021.

3.4.4 Preparation for data collection

In preparation for the field-based data collection, research assistant was recruited and trained on good data collection and management and ethical requirements. To facilitate quality data collection, research assistant was recruited based on competence and trained through practical sessions as well as involved in piloting the study in a purposively selected location. The local leaders were sensitized before the start of the study for community support.

3.4.5 Pretesting the questionnaire

This was done in Keekonyokie ward of Kajiado West Sub-county. 10% of the sample size was used for the pretest, which is equivalent to 13 respondents.

3.4.6 Conducting the Interviews

The interviews were conducted in selected wards in each Sub-county as shown in table 3.2 below;

Table 3.2: Selected wards where interviews were conducted

Sub-county	Selected Ward
Kajiado Central	Ildamat
Kajiado East	Kitengela
Kajiado West	Magadi
Kajiado North	Ngong
Kajiado South	Kimana

3.5 Data management and Analysis

Data on number of serum samples that tested positive and negative for circulating antibodies were recorded in Microsoft Excel and prevalence calculated as the number positive for circulating antibodies divided by the total number of serum samples that were analyzed, multiplied by 100.

Proportion of seropositive (Prevalence) = $\frac{count\ of\ seropositve\ n}{total\ number\ of\ animals\ N}$ x 100

Test for proportions was used to assess for differences between/among the stratified prevalence (by slaughter house).

Data from hospital records on number of patients diagnosed with taeniasis between 2015 and 2021, and the total number of patients that visited the facility between 2015 and 2021 were recorded in Microsoft Excel and yearly proportion of hospital records of taeniasis calculated as the number of patients that were diagnosed with taeniasis divided by the total number of patients that visited the facility, divided by 100. Test for proportions was used to assess for differences between/among the stratified proportions (by sub county and by year). Further comparison of the

proportions was conducted using pairwise test for proportions to detect if the differences were statistically significant.

Responses from the questionnaires on risk factors for human taeniasis were exported to excel for data validation and cleaning. Data analysis was done using STATA version 17 to determine the frequency distribution for the different risk factors. The results were presented in tables.

Data analysis was performed using R software version 4.2.1 to assess difference between /among the stratified proportion of reported hospital taeniasis cases (by year and by sub county).

3.6 Ethical Consideration

The study was reviewed and ethical approval granted by Faculty Biosafety Animal Use and Ethics Committee (Appendix IV), a research permit from NACOSTI was granted (Appendix V). Authorizations to conduct the study in Kajiado County were obtained from County Director of Health (Appendix VI).

All interview respondents were provided with written consents (Appendix I) and all the respondents that consented to be part of the study filled in the questionnaire for livestock keepers (Appendix II) and questionnaire for meat inspectors (Appendix III).

CHAPTER FOUR: RESULTS

4.1 Seroprevalence of Taenia saginata cysts (Cysticercus bovis) in cattle presented for slaughter in selected slaughterhouses in Kajiado County, Kenya.

From 150 serum samples that were analyzed, 4 tested positive for presence of *Taenia saginata* cysts (*C.bovis*) antibodies. This translates to an overall prevalence of 2.67% at 95% Confidence Interval (0.89%,7.1%; p-value <0.0001) in the selected slaughterhouses. The highest prevalence, 4% at 95% Confidence Interval (0.69%,14.86%) was encountered at Kitengela slaughterhouse, followed by Keekonyokie slaughterhouse, 3.33%, at 95% Confidence Interval (0.58%,12.55%). No positive sample was recorded from Kiserian slaughterhouse (Table 4.1).

The difference in seroprevalence between Keekonyokie (3.33%) and Kitengela (4%) slaughterhouses was not statistically significant at 95% Confidence Interval (-0.07,0.08; p-value – 1)

Table 4.1: Prevalence of Taenia saginata cysts (Cysticercus bovis) in selected slaughterhouses

Sub-County	Slaughterhouse	Total Sampled	Total positive	Prevalence in %	95% CI	p-value
Kajiado West	Kiserian	40	0	0	(0,0)	-
Kajiado West	Keekonyokie	60	2	3.33%	(0.58%,12.55%)	<0.0001
Kajiado East	Kitengela	50	2	4%	(0.69%,14.86%)	<0.0001
	OVERALL	150	4	2.67%	(0.89%,7.1%)	<0.0001

4.2 Annual hospital reported cases of *Taenia saginata* in humans attending level 4 hospitals in Kajiado County, Kenya.

4.2.1 Proportion of human taeniasis recorded in level 4 hospitals in Kajiado County between 2015 and 2021

Data from hospital records showed that a total of 1,487,687 patients visited different facilities between 2015 and 2021. Subsequently, 29 patients were diagnosed with human taeniasis between 2015 and 2021. The highest proportion (0.006%) was encountered in 2015 and the least proportion (0.004%) in 2020 (Table 4.2).

Table 4.2: Proportion of human taeniasis recorded in level 4 hospitals in Kajiado County between 2015 and 2021

Year	Number that attended hospitals	Number Positive	Proportion (%)	95% CI
2015	178,839	10	0.006%	(0.003%,0.04%)
2016	202,086	2	0.0009%	(0.0002%,0.004%)
2017	137,890	4	0.003%	(0.0009%,0.008%)
2018	240,844	5	0.002%	(0.0008%,0.005%)
2019	292,810	3	0.001%	(0.0003%,0.003%)
2020	211,211	1	0.0004%	(0.00002%,0.003%)
2021	224,007	4	0.0018%	(0.00057%,0.0049%)

There was an overall statistically significant difference in the proportion of recorded cases of *T.saginata* in level 4 hospitals (p-value 0.004) across the different years. Pairwise comparison

further revealed a significantly higher proportion in 2015 compared to 2016 (p-value 0.025), 2015 compared to 2019 (p-value 0.009) and 2015 compared to 2020 (p-value 0.007)

The proportion as encountered in the different facilities where cases of *T. saginata* were reported are shown in Table 4.3;

Table 4.3: Proportion of human taeniasis in the different hospitals that reported cases of T.saginata in Kajiado County

Hospital	Cases reported	Number attending hospital	proportion	Lower CI	Upper CI	p-value
Loitoktok Sub-county Hospital	1	145599	0.00069%	0.00004%	0.00450%	<0.0001
Ongata Rongai Sub-county Hospital	20	379895	0.00526%	0.00330%	0.00830%	<0.0001
Kitengela Sub-county Hospital	5	392820	0.00127%	0.00047%	0.00320%	<0.0001
Ngong Sub-county Hospital	3	319221	0.00094%	0.00024%	0.00299%	<0.0001

Ongata Rongai Sub-county hospital recorded the highest proportion of 0.00526%, followed by Kitengela Sub-county hospital with a proportion of 0.00127%. Loitoktok Sub-county hospital had the least proportion of 0.00069%. There was an overall statistical significance when testing

for differences in the proportion of the different facilities (p-value <0.0002). Pairwise comparison indicated a significant difference between the following facilities; Loitokitok vs Ongata Rongai (p-value 0.0352), Ongata Rongai vs Kitengela (p-value 0.0039) and Ongata Rongai vs Ngong (p-value 0.0034)

Hospitals in Kajiado North Sub-county (Rongai and Ngong Sub-county hospitals) recorded the highest proportions of hospital recorded cases of human taeniasis in all years except 2020 and 2021. All the other hospitals except Kajiado County Referral Hospital only recorded cases at certain points in time (Table 4.4).

Table 4.4: Proportion of hospital recorded human cases of T.saginata in different sub-counties within Kajiado County.

Sub-county(Hospital)	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Loitokitok Sub-county Hospital	0	0	0	0	0	0.004%	0
Kajiado North (Rongai+Ngong Sub-county Hospitals)	0.01%	0.002%	0.005%	0.005%	0.001%	0	0
Kajiado East (Kitengela Sub-county Hospital)	0	0	0	0	0.001%	0	0.006%
Kajiado County Referral Hospital	0	0	0	0	0	0	0

4.3 Risk factors for Taenia saginata in Kajiado County, Kenya.

4.3.1 Demographic characteristics of the respondents

Out of the 140 respondents participated in the questionnaire survey. Majority of the respondents were male 94(67%) while 46 (33%) were female. On the age group segregation, the majority, 67(48%) were between 31-60 years, followed by the youth, 18-30years, 65(46%) and the elderly (>60 years) were the minority 8(6%). A majority of respondents were from Kajiado West Sub-county 39(28%), while Kajiado East had the least number of respondents 22(16%) (Table 4.5).

Table 4.5: Demographic characteristics of respondents

Socio-demographics	*Category*	*Number*	*Percentage*
Gender	Male	94	67%
	Female	46	33%
Age Group	18-30 years	65	46%
	31-60 years	67	48%
	>60 years	8	6%
Sub-county	Kajiado North	26	18.5%
	Kajiado South	26	18.5%
	Kajiado West	39	28%
	Kajiado East	22	16%
	Kajiado Central	27	19%

4.3.2: Risk factors for human taeniasis

Risk factors considered for this study included; home slaughter and meat inspection, preparation and consumption of beef, presence and use of latrines, reported presence of tapeworm infection and treatment as shown in table 4.6. Majority of the respondents 105/140 (75%), indicated that they still carry out home slaughter, especially during ceremonies. Of the respondents that carry out home slaughter, 90% indicated that the carcass is not inspected by a veterinary meat inspector.

All respondents (100%) indicated that they still consume some parts of the cattle carcass without cooking. Omental fats (39%) was the most consumed part, followed by Kidney (35%), then Blood (1%).

Out of the 140 respondents, 74(53%) indicated that when roasting meat(beef) they consume it when it is well done while 66(47%) indicated that they still consume improperly cooked/ roasted beef.

With regards to presence and use of latrines, 124 (89%) respondents highlighted that they have and use latrines in their homesteads/manyattas while 16(11%) indicated lack of latrines.

On the reported presence of infection with *Taenia saginata* within the community, a majority of the respondents, 111 (79%) indicated that they hadn't seen an infected person, for the past two years. The minority, 29 respondents (21%) indicated that they had seen an infected person within the community.

When the people in the community are affected with *Taenia saginata*, majority of respondents 124(89%) indicated that the people take drugs to enable them rid off the tapeworm eggs.

58(41%)of the respondents highlighted that the drugs used for managing taeniasis are sourced from Chemist, while 12(8%) from hospitals, 8(6%) from traditional healers and 7(5%)source the drugs from local shops. The remaining 55 (39%) indicated that the drugs can be obtained from multiple sources as listed above.

Table 4.6: Risk factors for human taeniasis.

Variable	**Yes n(%)**	**No n(%)**	**p-value**
Home slaughter	105 (75%)	35 (25%)	<0.0001
Consumption of beef raw(some parts)	140 (100%)	0 (0%)	<0.0001
Preparation (properly cooked)	74 (53%)	66 (47%)	0.5329
Presence and use of a latrine	124 (89%)	16 (11%)	<0.0001
Reported presence of *T. saginata* infection	29 (21%)	111 (79%)	<0.0001
Treatment	124 (89%)	16 (11%)	<0.0001

Home slaughter, consumption of parts of beef raw, presence and use of latrines and treatment were statistically significant variables for taeniasis as indicated in the table 4.6 above.

Home slaughter was significantly high in all Sub-counties except in Kajiado North Sub-county where only a minority did slaughter at home. In all the Sub-counties, all respondents indicated that they still consume some parts of beef raw. In terms of meat preparation, more than half of the respondents indicated they consume improperly cooked beef in Kajiado West and Kajiado South. In the other Sub-counties, a majority indicated that they consume beef that has been properly cooked/ roasted. Presence and use of latrines was significantly high across all the Sub-counties. All Sub-counties except Kajiado South indicated low presence of taeniasis in the past

two years. All Sub-counties reported that when people get infected with taeniasis, they seek treatment (Table 4.7)

Table 4.7: Risk factors for human taeniasis by Sub-county

Sub county Variable	East N=22	West N=39	North N=26	South N=26	Central N=27	Total= 140	p-value
Home slaughter	17(77%)	32(82%)	9(35%)	25(96%)	22(81%)	105	<0.0001
Consumption of raw beef (some parts)	22(100%)	39(100%)	26(100%)	26(100%)	27(100%)	140	-
Preparation (improperly cooked)	8(36%)	24(62%)	1(4%)	24(92%)	9(33%)	66	<0.0001
Presence of latrine	22(100%)	35(90%)	25(96%)	16(62%)	26(96%)	124	<0.0001
Presence T. saginata	5(23%)	4(10%)	1(4%)	16(62%)	3(11%)	29	<0.0001
Treatment	21(95%)	34(87%)	26(100%)	21(81%)	22(81%)	124	0.1179

4.3.3: Presence of Cysticercus bovis in Cattle

The meat inspectors did not record any cases of *C.bovis* between June and July 2021 in the selected slaughterhouses.

CHAPTER FIVE: DISCUSSION

Taenia saginata presents both public health and economic importance in developed and developing countries. The occurrence of the larval stage of this parasite, *Cysticercus bovis*, may vary from place to place depending on the standards of meat inspection, cattle husbandry practices, level of hygiene, and method of sewage management. From the slaughterhouse survey in this study, the seroprevalence of *Taenia saginata* cysts (*C.bovis*) in cattle in Kajiado County between June and July 2021 was 2.67% among 150 cattle that were sampled. The ELISA method adopted for this study was testing for the presence of circulating *Taenia* antibodies. It therefore can be rightly inferred that all the cattle that had positive ELISA test results had previous exposure to eggs of *Taenia saginata.*

The seroprevalence results observed in this study seem to be in agreement with the questionnaire survey results that indicated that 21% of Kajiado locals reported to have seen people releasing proglottids. In addition, a run through the hospital records also showed that cases of human taeniasis are being reported in level 4 hospitals in Kajiado County. It is therefore quite evident that active transmission of *Taenia saginata* could be occuring in Kajiado County.

However, during the study period, the meat inspectors in all the sampling abattoirs, did not find any case of *C. bovis*. This apparent contradictory results, as compared to the ELISA test and the outcome of the community administered questionnaire, may be due to the fact that the sensitivity of visual meat inspection, however well it may be undertaken, could be as low as 40% (Wanzala et al., 2002), while the sensitivity of ELISA test is as high as 80% (Wanzala et al., 2002). Although a positive antibody ELISA test is not a confirmation of a *C. bovis* infection in the tested animals, the results are still epidemiologically significant as they indicate exposure of the

cattle to *T. saginata* eggs and by extension, the existence of transmission risk factors of the foodborne parasite infection.

The findings of meat inspection results as reported by meat inspectors confirm that the sensitivity of meat inspection in detecting *Taenia saginata* cysts (*Cysticercus bovis)* is much lower than that of ELISA (Harrison *et al*., 1989 ; Kyvsgaard *et al*., 1990 ; Onyango-Abuje *et al*., 1996b ; Dorny *et al*., 2000 ; Dorny *et al*., 2002 ; Wanzala *et al*., 2002 ; Asaava *et al*., 2009). The findings of this study show that antibody ELISA test for *C. bovis* inspection was three times more sensitive than visual meat inspection. As pointed out by Wanzala *et al*., 2002, the high sensitivity of ELISA test for *C. bovis* compared to visual meat inspection, makes it a tool of choice for *T. saginata* epidemiological studies (Wanzala *et al*., 2002).

Antibody ELISA tests have been used to detect exposure to parasite's eggs that may or may not have resulted in an infection while antigen ELISA tests have been used to detect presence of a viable cysticerci confirming an active infection (Kumar *and* Tadesse, 2011). However, the antibody detection test has a downside of not being able to distinguish between an animal harbouring cysts and those that have only been exposed.

Prevalence of *C.bovis* using meat inspection has previously been reported in Kajiado County. In 1981, a retrospective study utilizing national data base on abattoir records, noted a prevalence of 10.3% in Ngong district of Rift Valley Province (currently part of Kajiado County). The records were obtained from the Director of Veterinary Services Office in Kabete (Cheruiyot, 1981). In 2016, a study conducted in slaughterhouses in Kajiado County noted a prevalence of 2.56% for bovine cysticercosis, using meat inspection (Kimari *et al*., 2017). In the current study, the meat inspectors from all the study slaughterhouses reported no case of *C. bovis* during the study period, translating to a prevalence of 0%. These three studies looked at together, seem to indicate

a progressive reduction in the prevalence of *C. bovis* over forty-year period. This is also in agreement with anecdotal reports from meat inspectors and University of Nairobi lecturers that have been taking students to slaughterhouses for meat inspection practicals, and have indicated that there has been a drastic reduction in *C.bovis* between 1980(s) and currently.

In addition, reported cases of human taeniasis from all the level four hospitals in Kajiado County, revealed that the proportion of cases of *Taenia saginata* also seemed to have declined between 2015 and 2021. A total of 29 patients were diagnosed with human taeniasis between 2015 and 2021 out of 1,487,687 patients that visited the different facilities. The highest annual average proportion (0.006%) was encountered in 2015 and the least proportion (0.004%) in 2020 The highest proportions were recorded from the only two hospitals located in the more urbanized areas of Rongai and Ngong. This may be explained by the fact that urban hospitals have better diagnosis and improved facilities and people in the urban areas consume more beef than the rural people who depend on milk and meat from sheep and goats. In addition, the two Sub-counties are residence to people from diverse regional backgrounds, that will tend to seek for treatment in the health facilities whenever they fall ill.

The likely factors that may have led to the apparent reduction in cases of *Cysticercus bovis* and *Taenia saginata* over the years are varied, and it may be difficult to identify which of them has had the greatest impact in reducing the risk of infection. These factors could include the increasing general level of education, increased use of anthelmintics and increased availability and use of latrines.

Increased general level of education can be alluded to construction of more schools and introduction of adult education over time. The current literacy levels of locals in Kajiado County stands at 70% (Kenya Population and Housing Census, 2019), from very low levels amongst

eligible children as shown by different studies (Gorham, 1980; Holland, 1992; Coast, 2002), meaning more locals are able to read and write. The introduction of WASH programme in 2013 also ensured that women and school going children don't walk long distances in search for water and in turn led to an increase in enrollment of children in schools. With enhanced general education comes enhanced hygiene awareness that would include knowledge of taeniasis and cysticercosis and the affected humans would easily take medication whenever they release proglottids.

Over time, anthelmintics have become available and easily accessible even at the local shops. This was confirmed by the current study that noted that 89% of respondents take drugs(anthelmintics) to rid off *Taenia saginata* eggs and proglottids. The anthelmintics are sourced from hospitals, chemists, local shops and even from traditional medicine men. In some instances, the dewormers are distributed to school going children by Ministry of Health to help in prevention and control of the tapeworms.

Control measures have also been effected. These include construction and use of latrines. The current study noted that a majority of households had and used latrines. The WASH programme that was introduced in 2013 also promoted reduction in open defecation through advocating for construction of latrines (Okumu et al., 2022).

However, despite the noted reduction in the prevalence *T. saginata* in Kajiado County, it has also been shown that transmission of this disease continues howbeit at a reduced level. This situation is not surprising as this study has shown that at least three risk factors still persist at some significant level within the community. The questionnaire respondents indicated that uninspected home slaughter, eating of raw/improperly cooked meat and open defecation by the herders still pose a risk to humans getting taeniasis and subsequently cattle getting cysticercosis.

Home slaughter is still being practiced in Kajiado County. 90% of those who slaughter at home indicated that the meat is not inspected by a veterinary meat inspector. This is in line with the findings of (Kimari *et al*., 2017) (Komba *et al*., 2012) (Trevisan *et al*., 2018) that established that *Taenia saginata* has been reported where the community practice uninspected home slaughter. 100% of the respondents indicated that they consume some parts of beef raw, while 47% indicated that they consume improperly cooked beef. This is significant in spread of taeniasis to humans, since the cysts can lodge anywhere and not necessarily in the predilection sites, due to variation in distribution of cysticerci to preferred site (Kyvsgaard *et al*., 1990). Most homes would slaughter sheep and goat regularly and occasionally slaughter cattle during major functions. This therefore means that majority of the beef/ parts of beef consumed raw or improperly cooked are sourced from slaughterhouses and butcheries which are mainly concentrated in the peri-urban areas. This would explain why more cases of human taeniasis were reported in Kajiado North Sub-county that have the level 4 facilities based in peri-urban areas.

Use of latrines aids in proper disposal of fecal matter thus significantly reducing contamination of the farms, grasses and pastures with taenia eggs. This breaks the cycle of transmission of the taenia eggs and proglottids from humans to the cattle. This study indicates that education and the WASH project have helped in creating knowledge and therefore increasing construction and use of latrines. A study that was conducted in 2017 in Kajiado County noted a significant lack of latrines, that played a role in spread of parasite egg (Kimari *et al*., 2017) . A study by (Mbogo *et al*., 2018) indicated that 59.2% of households in Kajiado East, West, South and Central Sub Counties do not have access to toilets and 98.4% of that population practice open defecation. In as much as a higher percentage have and use latrines, there are herders who move with livestock

from place to place and do not use latrines. They practice open defecation and therefore distribute the taenia eggs and proglottids, posing a challenge in control and prevention of human taeniasis.

This study also reported that 21% of residents have seen people infected with *Taenia saginata* in the past two years. This is an indication that there exists active presence of infection in the community, even though at low levels as indicated by records from level four hospitals. The meat inspectors did not record any positive cases of *Taenia saginata* cysts (*C. bovis*) during the study period, as per their response from the questionnaires. Absence of *Cysticercus bovis* at meat inspection could indicate that the risk of infection to humans is low. The respondents indicated that taenicides are available and easily accessible, and whenever a person is infected, they can easily obtain the drugs. The drugs are majorly sourced from chemists. They are also available in hospitals and in local shops. Most respondents self- medicate, and therefore do not visit the hospitals unless they have a serious disease. This could explain why the prevalence of taeniasis from hospital records was low.

From the seroprevalence of *C. bovis* levels reported, proportion of humans that were diagnosed with taeniasis in level four hospitals and risk factors assessed, it is apparent that *Taenia saginata* is still present in Kajiado County, though at low levels and uninspected home slaughter, consumption of raw/improperly cooked beef and open defecation by herders still pose a risk to humans getting infected by *Taenia saginata.* However, presence and use of latrines and availability, accessibility and use of taenicides have significantly contributed to reduction of *T. saginata*. Considering the cultural practices of the local community (carrying out home slaughter and consumption of raw meat and transhumant nature of moving with livestock in search for water and pasture by herders), and since humans are the only definitive hosts of *Taenia saginata*,

control of the infection should be centered towards continuous focused education coupled with regular deworming of human carriers, and especially the herders and school going children. This will gradually result in behavior and culture change that will ultimately reduce the prevalence and lead to elimination of the disease.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn from the current study;

1. *Taenia saginata* and *Cysticercus bovis* are still present in Kajiado County but at comparatively much lower prevalence than previously reported.
2. The study confirms that serology (ELISA) is three times as sensitive as meat inspection.
3. The risk of humans getting infected with *Taenia saginata* is significantly reduced by decreased bovine cysticercosis, increased use of latrines and availability of drugs for treating taeniasis.
4. Uninspected home slaughter and consumption of raw/improperly cooked beef still pose a risk of humans getting infected with taeniasis in Kajiado County.

Based on the above conclusions, the following recommendation was made:

1. Need for more sustained community health education on up scaled one health approach in managing cysticercosis and taeniasis to reduce impact in both cattle and humans. This can be done through improved and focused awareness creation on the zoonotic importance of *Taenia saginata* and need to break transmission cycle in cattle and humans.

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APPENDICES

1. Participant consent form

Greetings, my name is Margaret R. Anyango, taking a master's degree in Veterinary Public Health at the University of Nairobi. I am conducting an investigation on Tapeworms "Enchuka" in Kajiado County.

Your participation in this exercise is voluntary. You may withdraw from the interview at any point during the discussion. Information gathered will be confidential, will not contain any name and will not be used for any other purpose apart from this research.

Any further questions and/ or concerns regarding this survey can be directed to the undersigned.

Do you fully understand and consent to proceed with this interview?

YES: …… NO: …..... Date: ……

Questionnaire number……

Margaret R. Anyango: Investigator (0702422540)

Dr. Timothy Wachira: Supervisor (0723333591)

2. Sample questionnaire for livestock keepers

Questionnaire No: ……Enumerator: ……

Date of Interview: _____ Sub-county: _____

Location:_____ GPS coordinates:_____

A. DEMOGRAPHIC INFORMATION

1. Sex: Male ☐ Female ☐

2. Age:

18-30 years ☐ 31-60 years ☐ >60 years ☐

B. RISK FACTORS

1. Home slaughter

Do you slaughter cattle at home?

Yes ☐ No ☐

If yes, who inspects the meat?

Myself/Family member ☐ Veterinary Meat Inspector ☐

2.Consumption of Beef (Cattle meat)

Which parts of the cattle do you consume without cooking or roasting?

Kidney ☐ Heart ☐ Blood ☐ Other parts (Specify) ☐

When roasting meat, do you eat it when it is?

Still oozing blood ☐ Well done ☐

3. Presence and use of latrines

Do you have a latrine in your homestead/manyatta?

Yes ☐ No ☐

If Yes, do all the members of the homestead use the latrine?

Yes ☐ No ☐

4. Presence of tapeworm Infections

a. Have you seen humans with tapeworm "Enchuka" in your community?

Yes ☐ No ☐

b. When is the last time you saw tapeworm "Enchuka" in humans?

This year ☐ 2 years Ago ☐ More than 2 years ago ☐

5. Treatment

b. Do the people take drugs for Tapeworms "Enchuka" when they are infected?

Yes ☐ No ☐

c. If yes, where do they get the drugs from?

Chemists ☐ Hospitals ☐ Traditional Healers ☐ Others(Specify) ☐

3. Sample questionnaire for meat inspectors

Questionnaire No: …… Enumerator: ……

Date of Interview: _____ Slaughterhouse:_____

A. RISK FACTORS

1. Presence of *Cysticercus bovis* infection

Did you encounter any carcass with *Cysticercus bovis* between June and July 2021?

Yes ☐ No ☐

If yes, how many? _____

4. Faculty of Veterinary Medicine Biosafety, Animal Care and Use Committee University of Nairobi ethical approval

UNIVERSITY OF NAIROBI
FACULTY OF VETERINARY MEDICINE
DEPARTMENT OF VETERINARY ANATOMY AND PHYSIOLOGY

P.O. Box 30197,
00100 Nairobi,
Kenya.

Tel: 4449004/4442014/ 6
Ext. 2300
Direct Line. 4448648

REF: FVM BAUEC/2021/309

Dr. Ruphline Margaret Anyango.
PHP & Toxicology
University of Nairobi
13/08/2021

Dear Dr Anyango,

RE: Approval of proposal by Faculty Biosafety, Animal use and Ethics committee

Seroprevalence of Taenia saginata in cattle and Risk factors for human Taeniosis in Kajiado County, Kenya.

Ruphline Anyango J56/36035/2019

We refer to your MSc. proposal submitted to our committee for review and your application letter dated 5th August 2021.We have reviewed your application for ethical clearance for the study.

In handling objective (1 &2) in determining the seroprevalence of *Taenia saginata* cysts in cattle and humans, the blood sampling, serology protocol and utilization of retrospective data meets the minimum standards of the Faculty of Veterinary medicine ethical regulation guidelines.

We also note that registered Veterinary surgeons will supervise the study.

We hereby give approval for you to proceed with the project as outlined in the submitted proposal.

Yours sincerely,

Kaluwa

Dr. Catherine Kaluwa, Ph.D
Chairperson, Biosafety, Animal Use and Ethics Committee,
Faculty of Veterinary Medicine,
University of Nairobi

5. Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **986816**

Date of Issue: **06/September/2021**

RESEARCH LICENSE

This is to Certify that Dr.. Ruphline Margaret Anyango of University of Nairobi, has been licensed to conduct research in Kajiado on the topic: Seroprevalence of Taenia saginata in cattle and risk factors for human taeniosis in Kajiado County, Kenya for the period ending : 06/September/2022.

License No: **NACOSTI/P/21/12719**

986816

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

6. Permission letter from County Director of Health Services

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COUNTY GOVERNMENT OF KAJIADO

DEPARTMENT OF HEALTH SERVICES
OFFICE OF THE COUNTY DIRECTOR OF MEDICAL SERVICES
P. O. BOX 31, KAJIADO

REF: CGK/MEDICAL SERVICES/01/VOL.11/144 27th October, 2021

Received
SHA
HRIO T.A
27/10/2021

DR. RUPHLINE MARGARET ANYANGO
UNIVERSITY OF NAIROBI
P. O. BOX 29053
NAIROBI

RE: RESEARCH AUTHORIZATION

Reference is made on communication to you dated 6th September 2021 from the National Commission for Science, Technology and innovation license number: NACOSTI/P/21/12719 on the above subject for the period ending 6th September 2022, authorization from the County Commissioner, Kajiado County dated 27th October 2021 and authorization from the County Director of Education Kajiado County dated 27th October 2021.

The Department has no objection in you carrying out research on '***Seroprevalence of Taenia Saginata in Cattle and risk factors for human taeniosis in Kajiado County***'. You are however required to share findings of your research with this office.

Thank you.

COUNTY DIRECTOR OF HEALTH
KAJIADO COUNTY
27 OCT 2021
P.O. Box 31 - 01100

DR. EZEKIEL KAPKONI
COUNTY DIRECTOR OF HEALTH SERVICES

CC:

CHIEF OFFICER FOR MEDICAL SERVICES

CHIEF OFFICER FOR PUBLIC HEALTH & SANITATION SERVICES

THE RESPECTIVE MEDICAL SUPERITENDENTS,
KAJIADO COUNTY REFERRAL HOSPITAL, KITENGELA SCH
NGONG SCH, ONGATA RONGAI SCH & LOITOKITOK SUBCOUNTY HOSPITAL