Introduction

Bovine cysticercosis is a disease caused by the larval infection of *Taenia saginata* in cattle. The adult stage of *Taenia Saginata* occurs in the small intestine of humans who are the final host of this tapeworm. Humans get infected by eating raw or under cooked meat containing viable cysticerci (*Allepuz et al., 2009*). Cattle and buffaloes represent the main reservoirs for human infection with *Taenia Saginata* (*Basem et al., 2009*).

Taenia saginata known as beef tapeworm because beef is the main source of infection and it has a cosmopolitan distribution. The economic significance of *Cysticercus bovis* on the livestock industry may be considerable especially in developing countries (*Basem et al., 2009*).

Economic losses may be high due to the condemnation of heavily infected carcasses and the necessity to freeze or boil infected meat and losses may also occur from restriction of exports (*Bekele et al., 2010*). The annual losses in cattle feedlots in South Africa due to cysticercosis may reach to 3,300,000 US$ per year (*Megersa et al., 2009*).

Globally, there are 77 million human carriers of *Taenia saginata* out of which about 40 percent live in Africa. Cattle get measles from humans, so the occurrence of beef measles in cattle would be indicative of a human health problem (*Dzoma et al., 2011*).

Taeniasis, which is the infestation in humans, is a food-borne disease where the consumption of meat containing a viable cysticercus may result in the development of a tapeworm and patients are

frequently asymptomatic, however, they may present with mild symptoms of nausea, abdominal discomfort, flatulence, epigastric pain, diarrhoea, vitamin deficiency, excessive or loss of appetite, weakness and loss of weight, digestive disturbances , and intestinal blockage may occur. Variably adult tapeworms release motile distal segments containing eggs and their independent motility is the reason for various disorders such as appendicitis, biliary tract obstruction and anal pruritus (*Asaava et al., 2009*).

Animals infected with measles do not show any signs (*Dzoma et al., 2011*) , in those induced experimentally by 200,000 to 1,000,000 *Taenia Saginata* eggs, may show rise to fever , weakness , profuse salivation , anorexia , increase heart and respiratory rate and a dose of one million or more eggs may cause death between 14 to 16 days due to a degenerative myocarditis (*WUBIE., 2004*)**.**

Justification:

Bovine cysticercosis is a meatborne parasite that remains an important cause of illness and economic loss. *Taenia Saginata* / *Cysticercus bovis* is important from the stand point of the health of cattle because of consequences for the meat supply and more importantly, from the direct effects on the well-being of humans who almost universally, consume beef as a source of protein and other minerals. Bovine Cysticercosis has little effect on animal health, but it is economically important disease as it causes carcass condemnation arising from heavy infestation with the cysticerci of *Taenia Saginata* as well as the cost of inspecting meat, the necessity to freeze or

boil infected meat and losses may also occur from restriction of exports of live animals and animal products.

Therefore determination of the prevalence of the disease in North Kordofan is very important in order to explore the size of the problem which helps to control the disease in animals and prevent humans from infection.

Objectives:

This study aimed to:

1- Estimate the prevalence of *Cysticercus bovis* in North Kordofan.
2- Investigate the potential risk factors which could be associated with *Cysticercus bovis*.
3- Determine the distribution of cysts in organs and tissues within the infected animals.
4- Determine the viability of the cyst.

Chapter One

Literature Review

1.1 Classification :

Kingdom : Animalia

Phylum : Platyhelminths

Class : Cestoda

Order : Cyclophyllidea

Family : Taeniida*e*

Genus : Taenia

1.2 Etiology :

Bovine Cysticercosis is caused by the larval stage of the beef tapeworm *Taenia saginata*. Humans are the final hosts of the parasite. *Cysticercus bovis* is the larval stage of *Taenia Saginata* of the small intestine of humans as a larvae or cysts in cattle (*C. bovis*), man acquires infection only by eating poorly cooked or raw beef (*Rabi'u et al., 2010*).

1.3 Life cycle:

Bovine cysticercosis refers to the infection of cattle, while the adult tapeworms in the human small intestine cause taeniasis. The life cycle and transmission of the parasite occurs most commonly in environments characterized by poor sanitation, primitive livestock

husbandry practices, inadequate meat inspection management and control policies.

Humans are the obligate final host and they become infected by ingesting infected meat that has been inadequately cooked or frozen. Most incidents arise in cattle as a result of direct exposure to proglottids shed from humans, but there have been some reports of large scale outbreaks resulting from sewage-contaminated feed or forage (*Tesfaye et al., 2012*). The tapeworm occurs in the small intestine of humans, and although it is generally 4-8 meters long , it can reach 15 meters. Like all tapeworms , its scolex (head) attached to the bowel wall and it has up to 2000 body segments. Each segment contains up to 80,000 eggs. The end segments of the tape worm detach and are passed with faeces, They look like white fleshy capsules similar to a grain of rice (*NSW.,2012*).

If the eggs in the segments find their way onto pasture , cattle may ingest the eggs which then hatch in the small intestine. Small embryos develop and penetrate the bowel wall. They are carried through the blood stream to various muscles where they develop into cysts, the muscles most commonly affected by *Cysticercus bovis* cysts are the heart , tongue , diaphragm and muscles of the jaw. The cysts may remain infective for up to 2 years (*NSW., 2012*).

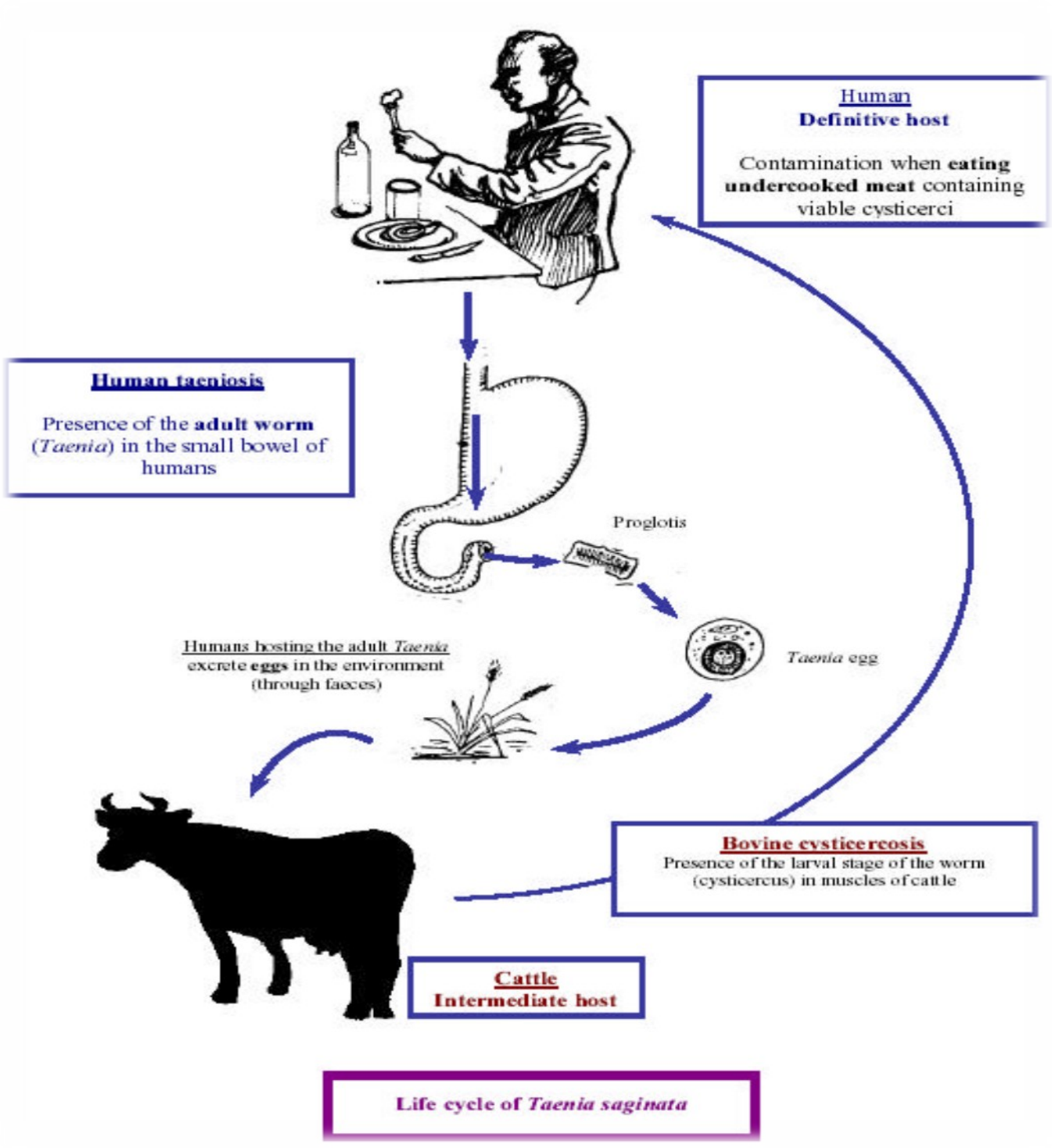

Figure 1: Life cycle of *Taenia Saginata*
(*European Commission., 2000****)***

1.4 Morphology of cyst:

The larval stages , or metacestodes also referred to as “beef measles” are found in all striated muscles of the intermediate host. *C.bovis* is a small (pea-sized) oval in shape, semi-translucent cyst filled with dense white fluid containing an invaginated scolex (*WUBIE., 2004*).

The metacestode is morphologically similar to the adult tapeworm. It measures about 10 mm in diameter and 6 mm in length. When incised, viable containing a thin fibrinous capsule, while the degenerate showing cream or green colored calcification. The cysticerci are formed over a period of 3 - 4 months after the egg is ingested.

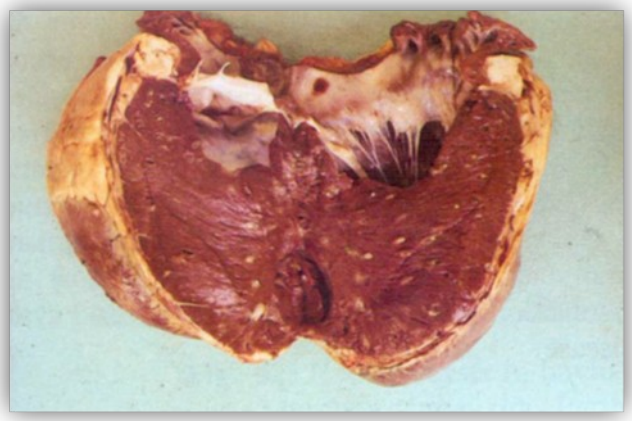

Figure 2: Caseous cysticercus. Numerous clear transparent cysts on the heart surface (*Herenda et al ., 2000***)**

The cyst may remain viable in the host for up to 9 months or even up to the entire life of the host. In the carcass *Cysticercus Bovis* can survive for about 15 days at -5^{o}c , 9 days at -10^{o}c or 6 days at -15^{o}c to -30^{o}c.

If a carcass is found to contain cysts, it is required to be frozen at -10°c for 10 days , or if the lesions are extensive, the entire carcass is condemned (*WUBIE., 2004*).

1.5 Modes of infection:

Cattle, intermediate host, become infected after eating *Taenia Saginata* eggs (proglottids) from infected humans (Final host). Once cattle are infected , cysticerci develop in the muscles and subsequently become infective to humans after approximately 10 weeks. A person infected with a single *Taenia Saginata* tapeworm is capable of contaminating the environment with up to half a million eggs per day over the course of Infection, which if left untreated, can persist for years.

Eggs contaminating the environment via defecation or spontaneous discharge of proglottids can be disseminated by water, wind, scavenging birds such as gulls feeding on raw sewage, oribatid mites, flies, earth worms, or fomites such as boots or farm machinery (*Kandil et al., 2012*). Infective taenia eggs can persist under a variety of environmental conditions as with most parasite environmental stages, cool and moist conditions favor long-term survival. They can also survive in sewage and in sludge for up to several months, and are resistant to most conventional chemical and disinfecting agents (*Kandil et al., 2012*).

Transmission to animals occurs by contamination of food or water by faeces of infected humans. The contaminated material can derive directly from human faeces or via sewage plants after flooding or sewage sediment distributed on pastures. Direct transmission of eggs , resulting from hand rising of suckling calves by tapeworm carriers has been reported , but appears

to be rare (*Allepuz et al., 2009*). Lack of awareness about raw meat consumption , existence of highest population density, poor hygiene and sanitary facilities are some of the factors that facilitate the transmission (*Belachew et al., 2012*).

1.6 Diagnosis:

Diagnosis in animals is usually based on the host and the location of the metacestode when identified at meat inspection or necropsy. Adults in definitive hosts are acquired by the ingestion of viable metacestodes in meat and offal that has not been adequately cooked or frozen to kill the parasite.

In live animals *Taenia Saginata* metacestodes might be palpable in the tongue but, both in the living animal and on post-mortem examination or meat inspection, tongue palpation is of a diagnostic value only in cattle heavily infected with metacestodes (*WUBIE., 2004*).

Predilection sites are heart, tongue, masseters and diaphragm, presumably because they receive the greatest circulation. Nonetheless, cysts may be found in any muscle of the body (*OIE., 2008*).

Cattle with cysticercosis are unlikely to exhibit clinical signs, and detection is made during post-mortem carcass examination. In most parts of the world where regulated post-mortem screening for these parasites occurs, examination of so-called “predilection sites” is conducted during routine meat inspection. However, such procedures are insensitive, particularly for lightly infected carcasses.

Despite its limitations, visual inspection of carcasses remains the most common method of diagnosing bovine cysticercosis.

The metacestodes are readily visible in the organs or musculature at autopsy and therefore diagnosis of *bovine cysticercosis* is usually made during postmortem examination in abattoirs and packing plants. The effectiveness of meat inspection in the detection of *C.bovis* depends on the procedure used (*WUBIE., 2004*).

The routine inspection of carcass is to be done as per the procedure stated below (*Kumar et al., 2011*):

- Visual inspection and palpation of the surfaces and a longitudinal ventral incision of the tongue from the tip of the root.
- One deep incision into the triceps muscles of both sides of the shoulder.
- Extensive deep incision into external and internal muscles of masseter parallel to the plane of the jaw.
- Visual inspection and longitudinal incision of the myocardium from the base to the apex. But more incision can be made when necessary.
- Visual inspection and 3 parallel incisions into long axes of the neck muscles on both sides.
- Two parallel incisions on the thigh muscles of both hind legs.
- Careful inspection, palpation and two parallel incisions into the diaphragmatic lobes of the lung through the lung substances.
- Visual examination of intercostals muscles and incisions when necessary.
- One extensive incision into the fleshy part of diaphragm, visual examination , palpation and Incision of kidneys, liver, oesophagus and associated lymph nodes.

However, minor infections are difficult to detect irrespective of the skill of the inspector. If a *Cysticercus* is found in any of

these sites and organs , thorough inspection of the whole carcass and offal should be done. The location , nature and number of cysts should be recorded (*Kumar et al., 2011*).

Serological test, e.g., Enzyme-linked Immunosorbent Assay (ELISA) was available for use on live animals. The immune response against taeniid parasites is reported to be antibody-mediated. A positive antibody ELISA indicates that the animals have been exposed to the infection, but may not necessarily have a current infection. However, it is a useful method for epidemiological studies to indicate the spread of the infection in outbreaks or high-infected areas (*Kandil et al., 2012).*

Several studies have shown that the true prevalence of *bovine cysticercosis* as detected by the classical meat inspection techniques (carried out properly) is underestimated by at least a factor of 3–10, diagnosis by serology in cattle has been done with varying successes. Studies have indicated that antigen detection by ELISA (Ag-ELISA) is 2–10 times more sensitive than routine meat inspection and that this technique may therefore be recommended for epidemiological surveys. The sensitivity of Ag-ELISA has been shown to vary with the live cyst burden, in addition due to its unexplained false positive and negative reactions it can at best be used as a screening test and not as a diagnostic test (*Asaava et al., 2009*).

1.7 Differential diagnosis :

In cattle *Cysticercus bovis* should be differentiated from:

- *Cysticecus dromedaries* (*C.cameli*) :

The larval form of *Taenia hyaenae*. The identification of *C.cameli* is by double row of hooks on the lateral invaginated scolex and its length being twice as large as *C.bovis* measuring 12-18 mm in length and pearly white in color (*WUBIE., 2004*).

- *Sarcocystis bovifelis* (*Sarcocystis hirusta*) :

Is a soft bradizoite cyst very large and visible to the naked eye whitish streaks running in the direction of the muscle fibers. The cyst ranges from 0.5 mm to 5mm in length, localized in the esophagus , heart , in different muscular tissue (*Minozzo et al., 2002*).

- *Onchocerca dukei* measurs :

The cyst ranges from 3mm to 6mm in diameter , forms intra-muscular and subcutaneous nodules that are firm to touch and reveals worms surrounded by pus when sectioned (*WUBIE., 2004*).

1.8 Treatment:

In animals, treatment with compounds such as *albendazole* (50mg per kg) , *praziquatel* (50mg per kg), *mebendazole* (50mg per kg) can be given but they are considered not to be fully effective.
Praziquantel is effective at 50mg / kg / day for four days but this treatment is impractical because of its high cost (*WUBIE., 2004*).

1.9 Control and prevention:

Lack of and improper use of latrine or open field defecation leads to contamination of grazing lands. The use of latrine reduces spread of *Taenia Saginata* eggs . Controlled grazing , avoiding use of sewage effluent to fertilize pasture, prevents infection in cattle (*Symth., 1994*).

Adequate meat inspection , abstinence from eating raw or inadequately cooked beef (thorough cooking of meat at a temperature of 56 – 60 ^{0}c) and freezing the infected carcass at -10^{0}c for 10 days prevent human infection. Chemotherapy in humans reduces the spread of eggs and infection in cattle (*Solusby., 1982*). In Africa, inadequate health education and scarcity of Taenicides are the major obstacles for the control of the disease (*Rabi'u et al., 2010*).

The inspection of meat, which is the most important public health control measure, identifies only a minor fraction of heavily infected animals, and also only when it is too late to avoid losses.
Ante-mortem diagnostic test that reflects the number of live cysticerci would be desirable because as it could assist in identifying infected animals before slaughter. A reliable ante -mortem diagnostic test has yet to be defined. However, there have been endeavor to develop an enzyme-linked immunosorbent assay (ELISA) that can be used for the diagnosis of *Taenia Saginata* cysticercosis infection under natural and controlled conditions. Results from antibody-ELISA were found to be unreliable and insensitive due to failure of the test to distinguish between animals harboring live and dead cysticerci (*Wanzalaa et al., 2002*).

During meat inspection heavily infected carcass, all meat, offal and blood must be condemned. The description of a heavy infection varies, but generally it is the detection of cysts at two of the predilection sites plus two sites in the legs. In the case of a lesser infection, the infected parts and surrounding tissues are removed and condemned. Even a single dead cyst requires that the carcass and edible viscera must then be treated and this is justifiable as about 10% of lightly infected carcasses were found on dissection to have both dead and viable parasites within them (*OIE 2008*).

Treatment varies with country and facilities available and includes (*OIE 2008*):

i) Freezing at lower than ⁻10°C for 10 or 14 days, or lower than ⁻7°C for 21 days.
ii) Boxes of boned meat are frozen at less than ⁻10°C for 20 days.
iii) Heated to above 60°C throughout.
iv) Steamed at moderate pressure (0.49 kg/cm2), heated at 95–100°C for 30 minutes.
v) Pickled in salt solution for 21 days at 8–12°C.

1.10 Vaccines against bovine cysticercosis:

Vaccination , when available , is undoubtedly the most cost effective means of preventing and controlling , and even eradicating , infectious diseases. A vaccine against sheep cysticercosis has been developed experimentally and may lead to the development of similar vaccines to control *bovine cysticercosis* and thus *Taenia Saginata* infestation in humans.

Rickard and Adolph., (*1976*) vaccinated calves with antigens collected during cultivation of the larval stages of *Taenia Saginata*

in-vitro, and challenged 4 weeks later with 4,000 *Taenia Saginata* eggs. Calves vaccinated with *Taenia Saginata* antigen were highly resistant to the challenge infection.

Sheiba and ZeinEldin., (*1987*) vaccinated four Zebu calves subcutaneously with hatched ova of *Taenia Saginata*. The immunity elicited protected the animals from subsequent oral infections with this cestode as manifested by the early degeneration of the metacestodes and failure to attain maturity in three of four animals.

Lightowlers et al., (*1996*) used the recombinant antigens in vaccine trials in cattle. Vaccination with a combination of two antigens, designated TSA-9 and TSA-18, induced up to 99.8% protection against experimental challenge infection with *Taenia Saginata* eggs (*Kumar and Tadesse 2011*).

1.11 Economic loss :

While ill-health caused by the adult worms in humans give rise to high medical costs , the economic losses due to bovine cysticercosis are mainly due to condemnation, refrigeration and downgrading of infected carcasses. Economic losses from cysticercosis are determined by disease prevalence, grade of animals infested, potential markets, prices of cattle and treatment costs for detained carcasses. For the African continent, an annual loss was reported to be US$ 1.8 billion under an overall infestation rate of 7% (*Kumar and Tadesse., 2011*).

Khaniki et al., 2010 reported that The economic losses of infected carcasses were calculated from the treatment of carcasses and the carcasses

condemnations. The costs of carcasses treatment included the expenses of freeze storage and the weight loss during freezing.

Bovine Cysticercosis has little effect on animal health, but it is economically important disease as it causes carcass condemnation arising from heavy infestation with the cysticerci of *Taenia Saginata* as well as the cost of inspecting meat, the necessity to freeze or boil infected meat and losses may also occur from restriction of exports of live animals and animal products (*Belachew and Ibrahim., 2012*).

In the meat industry, economic losses are closely associated with the status of infection. In a heavy infestation or generalized cysticercosis carcass, must be totally condemned. Light infection or localized cysticercosis leads to condemnation of the infected parts, furthermore, the carcass must be kept in cold storage at a temperature not exceeding -7°C for up to 3 weeks to inactivate the parasites (*Abuseir et al., 2006*).

In England, the costs of refrigeration , handling and transport are estimated at £100 per carcass, or £4.0 million annually. Africa suffers great losses due to bovine cysticercosis estimated to be $1.8 billion annually (*Abuseir et al., 2006*). The annual losses in cattle feed lots in South Africa due to cysticercosis may reach to 3,300,000 US$ per year . In Assiut Governorate , the economic losses in cattle and buffaloes feed lots during 1989-1992 due to *Cysticercus bovis* were 112000 L.E (Livre egyptienne - Egyptian pound) (*Basem et al., 2009*).

1.12 Epidemiology:

Taenia saginata of humans causes *bovine cysticercosis* , which occurs virtually world-wide, but particularly in Africa, Latin America, South/ Central Asian and eastern Mediterranean countries and the infection occurs in many countries in Europe (*OIE 2008*).

Globally, there are 77 million human carriers of *Taenia saginata* out of which about 40% live in Africa. In developed countries, even if the disease has a very low prevalence, the problem with the removal and treatment facilities in their sewage system plays a role in the distribution of eggs, since it was recorded that the egg can survive in sewage (*Megersa et al., 2010*).

The disease has been reported in 15 Latin American countries , and it is estimated that 400 thousand people are infected in South America. However, the prevalence of this disease in humans is highly variable within a country and between countries, and can be directly related to the differences of hygienic conditions, quality of meat inspection, and culinary habits (*Dutra et al, .2012*).

According to meat inspection data, the prevalence of *bovine cysticercosis* varies between 0.01 and 6.8% in various European countries, but the actual prevalence is expected to be between three and ten times higher (*Abuseir et al., 2006*).

In Sudan, Sid-Ahmed reported a prevalence of 0.3% in Atbara *(Sid-Ahmed., 1995)*, also Elkhawad reported a prevalence of 9.4% in Juba and 18% in Malakal *(Elkhawad et al., 1976)*. In Ethiopia, Florava reported a prevalence of 100% which is the highest in Africa and also in the word, due to habit of eating raw or under cocked beef dishes (Kowt and kitto). In other East Africa countries, prevalence rate about (30-80%) has been reported (*Ibrahim and zerihun., 2012*). In many developing countries this disease

constitutes a serious but less recognized public health problem (*Ibrahim and zerihun., 2012*).

Habit of eating raw beef dishes, low level of toilet used by human population, backyard slaughter, low availability of taenicides, free access of cattle to surface water, and proximity of waste water are important causes for transmission of *bovine cysticercosis* to a herd of cattle and *taeniasis* in human population (*Kumar and Tadesse., 2011).*

Cysticecosis was significantly more prevalent in feedlots and in traditional farming systems than in dairy farms. It is suggested that the continuous contact between man and animal and the use of causal workers in feedlots may be factors that are conducive to *Taenia saginata* transmission (*Ibrahim and Zerihun., 2012*).

Most incidents arise in cattle as a result of direct exposure to proglottids shed from humans, but there have been some report of large scale out breaks resulting from sewage contaminated feed or forage. In developed countries , even if the disease has a very low prevalence, the problem with removal and treatment facilities in their sewage system plays a role in the distribution of eggs, since it was recorded that the egg can survive in sewage (*Tesfaye et al.,2012*).

A cross sectional study on *Taenia saginata* cysticercosis was carried out in slaughtered cattle in Iran in order to determine the infection rate during a three-years period , from 2005 to 2007. A total of 4,534,105 cattle were examined by routine meat inspection. The results showed that 11,410 cattle (0.25%) were infected with *Cysticercus bovis*, among those 1,041 carcasses (0.02%) were condemned. In such carcasses the metacestodes caused extensive damage in the vicinity of

cysts in infected cattle. The rejected carcasses had an average of 410 thousands USD loss annually (*Khaniki et al.,2010*).

Another cross sectional study on the prevalence of bovine cysticercosis in Hawassa municipal abattoir was conducted from October 2011 to March 2012 with the objectives of determining the prevalence of *cysticercus bovis*, cyst viability and cyst distribution in different organs/tissues and public health implication of *Taenia Saginata* cysticercosis. Questionnaire survey and inventory of pharmaceutical drug shops were also used to determine human taeniasis and associated financial losses. Ante and post mortem examination of 384 cattle at the abattoir showed a prevalence of 22.9% for cysticercosis. Of the total cysticerci collected, 55 (62.5%) were found to be viable while 33 (37.5%) were non-viable. The percentage of *Cysticercus bovis* cysts in different organs was observed as 67.74% in tongue, 52% in shoulder, 60% in heart and 75% in masseter muscle, respectively. Result indicated that only age groups are highly significant effect ($p<0.003$), But sex, body condition, origin and breed of animals didn't have significant effect ($p>0.05$) on prevalence of cysticercosis. The prevalence of taeniasis among interviewed respondents of Hawassa town was 44%. Result indicated that the sex , occupation , educational level, eating habit and martial status showed highly significant effect ($p<0.05$). But age groups and religion didn't have significant effect ($p>0.05$) on prevalence of the disease. however, statistically significant difference was observed in the disease prevalence between raw and cooked meat eaters. For the years 2008 and 2009, a total worth of 184,406 ETB was estimated from a sale of 92,203 adult taenicidal drugs. The result of this study revealed that

taeniasis was a widespread public health problem In the study area which needs attention to safeguard the public (*Belachew and Ibrahim., 2012*).

In another study, data from slaughtered cattle was used to generate a *bovine cysticercosis* database for all states and municipalities of Brazil, in order to analyze and create epidemiological maps using the GIS software. During the period analyzed, 75.983.590 cattle were slaughtered and the prevalence of bovine cysticercosis in Brazil was 1.05%, with the Southeast region presenting the majority of cases. The highest amount of bovine cysticercosis cases occurred in the state of São Paulo (400,834) followed by Mato Grosso do Sul (151,735), and Paraná (94,046), while there was no observation of occurrence in nine states (*Dutra et al., 2012*).

From March 2005 to December 2007, 284 animals from 67 cattle farms (24 dairy and 43 beef) affected by *bovine cysticercosis* were detected in the region of Catalonia (North- Eastern Spain), (*Allepuz et al., 2009*). Dairy farms were almost twice more likely to be affected than beef farms (OR = 1.79, 95% CI = 1.08–2.96, $p < 0.05$), and infected premises have a statistically significant ($p < 0.05$) larger number of animals when compared to uninfected farms in Catalonia. The geographical distribution of the infected farms was evaluated and two statistically significant clusters were identified. The most likely cluster was located in the western part of the study region, with 8 out of 10 farms infected. Epidemiological investigations revealed that the 8 farms belonged to the same company. The second cluster was located in Eastern Catalonia with 12 infected farms out of 167 cattle farms. No epidemiological links were found among the 12 infected premises. A

questionnaire, based on the *EFSA* risk assessment, was used to assess the most likely route of introduction into each affected farm. Water supply for animals was the route with the highest score in 41.8% of the cases (*Allepuz et al., 2009*).

In another study aimed to determine the occurrence of cysticercosis in cattle and buffaloes in Assiut Governorate, Upper Egypt. the occurrence of cysticercosis among examined cattle and buffaloes was 1.6 % and 0.8 % respectively. Female cattle and buffaloes were more susceptible to *bovine cysticercosis* (2.7% and 1.3%) than males (1.4% and 0.5%), respectively. There was a positive relationship between the age of the examined animals and the occurrence of bovine cysticercosis. The higher occurrence was recorded among cattle and buffaloes above 2 years (2.7% and 0.9%) than those below 2 years (1.1% and 0.6%), respectively. Detailed meat inspection showed to be sensitive (1.6%) than routine meat inspection (1.4%) (*Basem et al., 2009*).

Another cross sectional study was conducted during October 2010 to march 2011 to estimate the prevalence of *bovine cysticercosis* in cattle slaughtered at Addis Ababa municipal abattoir with the objectives of determining the prevalence of *Taenia saginata* cysticercosis, cyst viability and cyst distribution in different body tissues. The abattoir survey was carried out by routine inspection of carcasses and viability test methods. Post -mortem examination of 535 slaughtered cattle were examined from randomly selected animals of which 19 (3.6%) were infected with *Taenia Saginata* metacestodes (*Ibrahim and zerihun., 2012*). Of the total of 24 *Cysticercus bovis* collected during the inspection, 11 (46%) were found to be alive while others (54.0%) were degenerative cysts. The tongue, masseter muscles, heart

muscles, triceps muscles, diaphragm and liver were the main predilection sites of the cysts. Anatomical distribution of the cyst showed that highest proportions of *Cysticercus bovis* cyst were observed in triceps muscle 10 (1.9%), followed by tongue 5 (0.95%), masseter muscle 4 (0.7%), heart 2 (0.4%), diaphragm 2 (0.4%) and liver 1 (0.2%). Out of 477 male cattle, examined, 14 (2.9%) had cysts of bovine cysticercosis while 5 (8.6%) of the 58 investigated female animals were infected. The prevalence varied significantly between sex ($P<0.05$), but not varied between age groups and breed of the animals. The proportion of viable cysts in the inspection sites was triceps muscles (70%), masseter (50%), diaphragm (0%), heart (50%), tongue (20%) and liver (0%). The current study suggests that high prevalence of *Taenia Saginata* metacestodes throughout the edible organs, and therefore sufficient emphasis should be given to this problem so as to improve health, quality and quantity of beef that may satisfy the domestic requirements of the counry (*Ibrahim and zerihun., 2012*).

Another cross sectional study was conducted during November 2008 to March 2009 to estimate the prevalence of Cysticercosis in animals, Taeniasis in human and estimate the worth of taeniasis treatment in Jimma town, Ethiopia (*Megersa et al., 2010*). Active abattoir survey, questionnaire survey and inventory of pharmaceutical shops were performed to accomplish the study. Of the total of 500 inspected animals, 22 animals had varying number of *Cysticercus bovis* giving an overall prevalence of 4.4% (22/500). Anatomical distribution of the cyst showed that highest proportions of *Cysticercus bovis* cyst were observed in shoulder muscle , followed by tongue, heart and masseter

muscle. Of the total of 114 *Cysticercus bovis* collected during the inspection, 49 (42.9%) were found to be a live while others (57.1%) were degenerative cyst. Of the total 60 interviewed respondents, 56.7% (34/60) had contracted *Taenia Saginata* infection , of which , 95% and (5%) cases reported using modern drugs and traditional drugs, respectively. The majority of the respondents had an experience of raw meat consumption as a result of traditional and cultural practice. Human Taeniasis prevalence showed significant difference ($p<0.05$) with age groups, meat consumption, sex and use of spice. Accordingly adult individual (OR=47.4), frequent raw meat consumers (OR=18.4), spice users (OR=7.0) and male (OR=5.0) had higher odds acquiring Taeniasis than children, occasional meat consumer, non-spice users and females, respectively. In this analysis there was no significance difference between religion, education status, occupational risks and marital status ($p>0.05$), (*Megersa et al., 2010*). An inventory of pharmaceutical shops (pharmacies, drug stores and rural drug vendors) revealed a total of 103, 596 adult taeniacidal drug doses worthing a total of 222,706 Eth. Birr (22,270.6 USD) during two years of 2007 and 2008. *Vermox* and *Niclosamide* were the most frequently sold drug for the treatment of taeniasis, while *Praziquantel* was least sold drug. The findings of this study including prevalence of *C.bovis*, questionnaire survey of taeniasis prevalence and the pharmaceutical shops inventory indicated the importance of Cysticercosis and Taneniasis both in public health and economical aspects (*Megersa et al., 2010*).

A cross-sectional study to determine the prevalence of *bovine cysticercosis* was conducted from October 2007 to March 2008 in cattle

slaughtered at the Jimma municipal abattoir. Cyst distribution and viability of bovine cysticercosis were determined. A total of 512 carcasses were inspected of which 15 (2.93%) were infected with *Taenia Saginata* metacestodes. From a total of 109 cysticerci collected from infected carcasses, 47 (43.12 %) were viable. The anatomical distribution of the cysticerci was, shoulder muscle (39.5 %), heart (33.9 %), neck muscle (13.8 %), tongue (10.1 %), masseter muscles (1.8 %) and diaphragm (0.9 %) (*Tolosa et al., 2009*).

Also a combination of retrospective and cross-sectional study was employed to estimate the economic and public health significance of *Taenia Saginata*. A total of 540 carcasses were examined during the study period. Of which, 14 (2.59%) were infected with *Taenia Saginata* cysticerci. Prevalence of *Cysticercus bovis* based on the various anatomical locations was: 2.22% in tongue, 1.66% in masseter muscle, 1.11% in heart, 0.92% In shoulder muscle and 0.32% in the diaphragm. *Taenia Saginata* was found to be a widespread public health problem in the study area with an overall prevalence of 62.5%. *Taenia Saginata* infection rate among the respondents showed significant difference ($p<0.05$) with age groups and different levels of raw meat consumers. Adult individuals had higher odds of acquiring taeniasis (OR=31.8) than young age groups. However, there was no significant difference ($p>0.05$) in the infection rate of the parasite between sex, religion and educational status groups. *Albendazole* and *menbendazole* were the most frequently sold drugs for the treatment of taeniasis. The finding indicates the importance of cysticercosis and taeniasis both in economic and public health aspects (*Tesfaye et al., 2012*).

The examination of various organs of 500 cattle in Meshkinshahr Abattoir in Iran showed that 15(3%) were infected with *Taenia Saginata* cysticercosis. The tongue, masseter muscles, cardiac muscles, triceps muscles and thigh muscles were the main predilection sites of the cysts. The cysts of bovine cysticercosis were also identified on the spleen, intercostal muscles, diaphragm and liver. Out of 460 male cattle, examined, 14 (3%) had cysts of bovine cysticercosis while 1 (2.5%) of the 40 female animals investigated were infected. The animals slaughtered were all adults. No significant difference in prevalence rates was recorded between the sexes. The prevalence of bovine cysticercosis was higher in local sarabi cattle breeds than Holstein-Frisian cattle (*Garedaghi et al., 2011*).

Another survey was carried out in Northern Turkana District, Kenya to estimate the prevalence through both serology and meat inspection, to determine the prevalence of the adult tapeworm in the human definitive host, and to determine risk factors for cattle seropositivity. The seroprevalence of cysticercosis in cattle was estimated at 16.7% (95% CI 13–20.9%) using a secretory–excretory antigen detection ELISA. There was a poor agreement between meat inspection and serology ($k = 0.025$; $p = 0.2797$). The prevalence of taeniosis was estimated as 2.5% (95% CI 0.8–5.6%) by microscopy. A backwards elimination logistic regression analysis indicated that the grazing unit (Adakaar), the deworming history of household members and the distance (>2 km) of grazing fields from the homestead were significant explanatory variables for cattle being found to be positive on serology. An intra-cluster correlation coefficient (ICC) of

0.07 (0.02–0.12), $p < 0.0001$ was calculated for bovine cysticercosis in this area (*Asaava et al., 2009*).

A prevalence study was conducted to investigate *Cysticercus bovis* at Jos abattoir during post mortem examination conducted on 14,372 slaughtered cattle over a period of two years (January 1997 – Dec.1999). Out of 14,372 carcasses examined 1924 (13.4 %) tested positive for *C. bovis*. The sites of the location of the larvae varied from one organ to another with the heart having the highest 48 (30.0 %) and the least affected were the visceral organs livers, lungs and esophagi. There is a positive correlation between the number of *Cysticercus bovis* cyst and the percentage frequency of the organ affected ($P<0.05$) (*Qadeer., 2008*).

A retrospective study covering the period 2000-2010 was conducted using post mortem meat inspection records of the Provincial Veterinary Department to determine the prevalence , seasonal and sex related variations in the occurrence of *Cysticercus bovis* infections. Monthly and annual records from three randomly selected abattoirs in the Northwest province were examined with regards to total cattle slaughtered and post mortem inspection results. Between 2000 and 2010, a total of 393858 cattle were slaughtered at the 3 abattoirs. The overall prevalence of *Cysticerus bovis* was 0.2%. 52% of the positive animals were female although the difference was not significant ($p>0.05$). The prevalence was significantly ($p<0.05$) higher (0.3%) at low throughput abattoirs (>20 adult cattle/day) than at high throughput abattoirs (<20 adult cattle/day), (0.2%). The prevalence decreased slightly from 0.2% to 0.1% after 2005 although the decrease was not significant. The dry season also had a non-significantly higher prevalence of 0.2%

than the 0.1% over the wet seasons. Only abattoir type had influence on prevalence, with the low throughput (>20 adult cattle/day) abattoirs recording a significantly higher rate (*Dzoma et al., 2011*).

The records of meat inspection carried out for 24 consecutive days at the Awka main abattoir in Anambra State, South-Eastern Nigeria , was used to estimate the direct economic loss in carcass condemnation due to *bovine cysticercosis*. Among the 614 cattle slaughtered 306 (49.8 %) were examined, out of which cystcerci were detected in 61.1 % , 61.1 % , 46.2 % , 45.2 % and 50.7 % of the masseter , tongue , inter-costal, diaphragmatic and pectoral muscles from 221 (72.2 %) of infected cattle. This amounted to an estimated loss of ₦186892.38 in terms of condemnation of cysticerci-infected carcasses. Condemnation due to generalized infection of the specified organs amounted to ₦109467.50 (58.6 %) , while moderately and locally infected organs contributed ₦28435.08 (15.2 %) and ₦48989.8 (26.2 %) to the total loss, respectively. This loss was equivalent to 4 heads of cattle in 24 days at ₦50000 per head , which translated to an annual loss of ₦2842321.61 or 57 heads of cattle at the Awka main abattoir alone. Since 10000 to 20000 trucks of beef cattle are reported to be daily transported to abattoirs in different parts of Nigeria, the direct economic loss of revenue in the beef industry on account of cysticercosis would run into billions of naira (*Ikpeze et al., 2008*).

The incidence of *Cysticercus bovis* infection in Kano abattoir located in Fagge local government area (LGA) of Kano state, Nigeria was studied. Out of the 11,804 cattle which were examined , 315 (2.67%) were found to be infected. The highest rate of infestation

was found in tongue (76%), heart muscle (66%) and masseter (63%). There was no significant difference ($p>0.05$) in the distribution of the cysticerci in the organs of cattle slaughtered at the abattoir. The results also show 205 (0.37%) and 304 (0.55%) head and heart condemnations respectively. This information is considered useful for government authorities to direct control strategies as well as for farmers to take measures tailored to local situations (*Rabi'u and Jegede., 2010*).

In another study, post-mortem examination of 3711 cattle done at three municipal abattoirs at Mekelle, Wukro and Adigret in Tigray region, Ethiopia for detecting infection of *Cysticercus bovis* revealed 308 (8.29%) cattle positive for this infection. The cysts were observed either at one or more than one sites in the carcass with variable numbers. The sites showing cysts included tongue 0.61%, masseter muscles 0.59%, shoulder muscles 0.26%, heart 0.26% and liver 7.45%. The economic loss calculated for six months period of this study on account of condemnation of carcass/organs was about 31952 Birrs. The presence of cysts of *Cysticercus bovis* in beef may be a public health problem as the practice of eating raw or undercooked meat is not uncommon in the area of this study (*Kumar and Berhe., 2008*).

An ante mortem antigen-ELISA-based diagnosis of *Taenia Saginata* cysticercosis was studied in artificially ($n = 24$) and naturally ($n = 25$) infected cattle with the objective of further validating the assay as a field diagnostic test. Based on total dissection as the definitive method of validity, the assay minimally detected 14 live cysticerci in

artificially infected calves and 2 in naturally infected steers. In natural infections , the minimum number of live cysticerci consistently detected by Ag-ELISA was 5 while in artificial infections it was above 14. However , other animals with 12 and 17 live cysticerci in artificially infected calves, and 1 and 2 live cysticerci in naturally infected steers , escaped detection for unknown reasons. Animals harboring dead cysticerci gave negative reactions in the assay as was the case in non-infected experimental control calves. There was a statistically significant positive linear correlation between Ag-ELISA optical density values and burdens of live cysticerci as obtained by total dissection of both artificially infected calves ($r = 0.798$, $n = 24$; $P < 0.05$) and naturally infected steers ($r=0.631$, $n = 25$; $P < 0.05$). These results clearly show the potential effectiveness of ante-mortem monoclonal antibody-based antigen detection ELISA in the diagnosis of bovine cysticercosis in cattle. Its value lies in the diagnosis of infection in cattle as a screening test in a herd, rather than as a diagnostic test at the individual level, due to false positive and negative reactions. In a herd of heavily infected cattle, the assay may, however, provide for individual diagnosis (*Wanzalaa et al., 2002*).

In another study a total of 267 cysts were collected from March to December 2004 from two main abattoirs in northern Germany. The cysts were classified by the usual organoleptic methods during meat inspection as *Cysticercus bovis*. The reported prevalence of cysticercosis in the 2 abattoirs was 0.48 and 1.08%. The cysts were examined macroscopically for description of their morphology and constituents and classified as viable or degenerating (dead). The DNA was extracted from these cysts and subjected to polymerase chain

reaction (PCR) for evaluation of the detection methods used and to make certain that the cysts did indeed belong to *Cysticercus bovis* , as indicated at the slaughterhouses. Two sets of primers were used with different sensitivity levels. The first , HDP1, was able to detect 200 fg of *Taenia saginata* DNA and 100 pg of *Cysticercus bovis* DNA. The other primer set, HDP2, was able to detect 1 pg of *Taenia Saginata* DNA and 1 ng of *Cysticercus bovis* DNA. No more than 52.4% of the samples tested positive for *Cysticercus bovis* in the PCR using both primers , while 20% of the viable cysts and 49.2% of the degenerating cysts tested negative with both primers (*Abuseir et al., 2006*).

Chapter Two

Materials and Methods

2.1 Study area:

The study was conducted at Elobied abattoir in North Kordofan. North Kordofan lies in arid and semi-arid zones between Latitude 11.15-16.45 N

and longitude 27-32.15 E. It also has desert climate zone on the far northern parts and more humid climate to the south. The northern parts of North Kordofan State lie in the desert and semi-desert. May and June are the hottest months, July to October are the rainy months while December to February are the coldest months. In general two air movements affect the climate of the area. Avery-dry air movements from the north reaching its southern limit in mid-winter and a major air flow of maritime origin that carries moisture, enters from the south and brings rains.

The state covers an area of 58.7 million feddans (25 million hectars) out of which 14.5 million hectar are rangeland. The livestock population, mainly cattle, sheep, goats and camels are about 6894425 head (*Goma., 2008*). Generally the state can be divided into four ecological zones extending from North to South as follows:-

- The desert zones with rainfall ranging between 0-75 mm per annum.
- The semi-arid zone with annual rainfall ranging between 75- 300 mm per annum.
- The arid zones with poor savannah in sandy soil (central zone) with rainfall between 300 - 400mm per annum.
- The low rainfall savannah in clay soil zone with rainfall ranging between 400-500 mm per annum.

Figure 3: North Kordofan map (*MARF., 2011***)**

The population of the state is 3.75 million, according to National Census (1993) of which 64% are rural, 24% nomads and 13% urban. Animal population estimated at 5 to 6 million animal unit (*Goma., 2008*).

Water availability, social service and land for agriculture are the main determining factors for population settlements. The main people activity is agriculture, the major crops that are produced in the study area are millet, sorghum and ground nuts. The major cash crops are sesame, karkade, watermelon, groundnut, Gum Arabic and vegetables. Major tribes are Bederia, Shiweihat, Kababish, Kawahla, Hamar, Dar Hamid, Jawama and Maganeen (*Goma., 2008*).

The animals examined in this study came from three regions, These regions are Kordofan, White Nile, and South Sudan.

2.2 Criteria for selecting the area:

- Animals come from different States.
- Large numbers of animals.
- Easily accessible.
- There was no prveious epidemiological studies to estimate the prevelance and investigate the risk factors of *cycticercos boivis* in the area.

2.3 Elobied Slaughterhouse :

Elobied slaughterhouse is located near a residential area . Thus, constitutes nuisance and endangers the health of the community in the immediate surrounding environment. It is a small low-walled open-air slaughterhouse with an impermeable sloped killing floor. Carcasses are cut into parts and hanged on fixed hooks for inspection. Sewege disposal is by collection into pits and then carried away in tanks to be disposed in remote areas of town on open places where, because of the water problem in the town , water supply is insufficient specially during summer for cleaning.

2.4 Study Population:

The study population consists of cattle at different ages, sex, origins and breeds categories in the study area.

2.5 Sampling:

2.5.1 Sampling Method:

The animals in the slaughterhouse were selected by random sampling method. Animals were selected randomly during ante-mortem and each selected animal was given an ear tag (number).

2.5.2 Sample Size:

The expected prevalence of bovine cysticercosis for calculation of sample size was taken from the study in Ethiobia (Public Health and Economic Significance of Bovine Cysticercosis in Wolaita Soddo, Southern Ethiopia) in which the prevalence of cysticercosis in cattle was 2.59% (*Tesfaye et al., 2012*). Sample size was calculated according to the following formula by Martin et al., (1987).

$$n = \frac{4\,\hat{P}\hat{Q}}{L^2}$$

Where:

n ≡ Required Sample Size $\hat{P}$ ≡ Expected Prevalence

$\hat{Q}$ ≡ 1- $\hat{P}$ L ≡ Allowable Error (0.05)

$\hat{P}$ = 2.59% (0.0259) $\hat{Q}$ = 0.9741

$$n = \frac{4 \times 0.0259 \times 0.9741}{0.0025} = \mathbf{40}$$

The small sample size calculated (40) was multiplied by 5 to increase precision of the results (*Thursfield., 2007*).

2.6 Study Design:

The study design was a cross sectional study which provides snapshot information on occurance of a disease (Martin *et al* , 1987). A Cross-sectional study was conducted at Elobied slaughterhouse on three randomly selected days, the animals in these days selected by systematic random sampling method, From each five animals, one was selected for examination.

2.6.1 Ante-mortem examination:

Regular visits were made by the investigator to Elobied slaughterhouse in Sunday, Tuesday and Thursday to conduct ante-mortem examination of slaughter animals. A total of 200 cattle were examined in the Elobied slaughterhouse during the survey period which extended from April to June 2013.

During the ante mortem inspection, the age, sex, breed, origin, body condition and type of grazing of each animals were determined . The age of animals was determined by Incisors of animals teeth, body condition of each individual animal was assessed and recorded depending on their body condition score, were ranked as poor or good , animal origin was also recorded as the state, from which the animal came.

2.6.2 Post-mortem examination:

The study was based on routine meat inspection for randomly selected cattle slaughtered at the slaughterhouse. Visual

inspection of all exposed surfaces was done to shoulder muscles, hearts, masseters (cheek muscle), diaphragms, tongues and livers. This is followed by incision of masseters (cheek muscle) , tongues , hearts , and livers to be examined for *Cysticercus bovis* cysts. The incision procedure for each organ was for the masseter muscle, two deep linear incisions were done parallel to the mandible from its upper muscular insertion , the tongue was incised longitudinally from the apex to the root on the lower surface (also was examined by palpation), the heart was split from the base to the apex and further incisions were carried out into the muscle, the other organs were also examined based on the standard methods of the meat inspection and the findings were recorded. Carcasses which had one cyst or more in any of these organs was introduced to detailed meat inspection (including shoulder muscle). An animal was considered heavily infected if lesions were discovered in two of the usual inspection sites. Generalized infection according to FAO regulations means 2 or 3 cysts found on each cut into the muscles of mastication, heart, diaphragm and its pillars, and also in muscles exposed during dressing procedures (*Herenda et al. 2000*). In parallel, the following data were recorded: Serial number, infection and infected organs. Tissue organs containing cysts were collected in plastic containers and taken to Elobied veterinary hospital laboratory to conduct cyst count and cyst viability.

2.6.3 Examination of the cysts:

Infected tissue organs containing cysts were transported to the laboratory of Elobied hospital and further analysis to determine the state of the cysts was performed .

2.7 Statistical analysis:

Results of the study were analyzed using statistical package of social science (SPSS) version 22. At first, descriptive statistical analysis was displayed in frequency distribution and cross tabulation tables . Then, univariate analysis using the Chi-square for qualitative data was carried out. P-value of 0.25 was considered as significant association and the risk factor was then selected to enter the multivariate analysis . Logistic regression was used to analyze the data and to investigate association between a potential risk factors and the occurrence of cysticercosis. A p-value of 0.05 indicated significant association between cysticercosis and the risk factor.

Chapter Three

Results

Descriptive statistical analysis frequency tables, cross tabulation and association tables between the disease and risk factors:

Out of 200 cattle inspected, only 2 (1%) animals were positive, and the rest were negative for cysticercus bovis (table 3.1).

Table 3.1: Frequency table for distribution of *cysticercus bovis* infection among 200 cattle examined in Elobied abattoir:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-ve	198	99.0	99.0	99.0
	+ve	2	1.0	1.0	100.0
	Total	**200**	**100.0**	**100.0**	

Age of animals:

Two hundred cattle of various ages were examined in this study. The presence of *cysticercus bovis* in various organs was investigated. The result showed the age distribution of cattle, 135 of the cattle were less than 4 years (young) and 65 of cattle were more than or equal to 4 years (old), (table 3.1.2). Among young animals 2 animals were found infected. Rate of infection within young animals was 1.48% (2/135). However among adults no animal was found infected. Rate of infection within adults was 0% (table 3.1.3).

The Chi- square test showed no significant association between *cysticercus bovis* infection and age of animal (p-value = 0.32),(table 3.1.4).

Sex of animals:

The results of this study showed the distribution of 200 cattle examined for *cysticercus bovis* according to sex. Total number of male examined was 156 animals, while the total number of female examined was 44 (table 3.1.2). Among males, 2 animals were found infected. Rate of infection within males was 1.2% (2/156). While among females, no animal was found infected. The rate of infection within females was 0% (table 3.1.3).

The Chi-square test showed no significant association between *cysticercus bovis* infection and sex of animal (p-value = 0.45), (table 3.1.4).

Breed:

The results of study showed distribution of *Cysticercus bovis* infection in Elobied slaughterhouse according to breed. Total number of local breed was 190 animal. Among these 190 animals, 2 were found infected. The rate of infection was 1.05% (2/190). Total number of cross breed examined was 8. Among these, there was no infection. Total number of foreign breed examined was 2. Among these, there was no infection (table 3.1.3).

The chi- square test showed no significant association between the infection and breed (p-value = 0.95), (table 3.1.4).

Body condition:

The body condition of animals and the presence of infection were investigated. One hundredr eighty five of cattle were found to be in good condition, while 15 of cattle were found to be in poor condition (table 3.1.2). Among good animals, 2 were found infected. The rate of infection within good condition animals was 2.6% (2/185). However no animal was found infected among poor animals. The rate of infection within poor animals was 0.0% (table 3.1.3).

The chi- square test showed no significant association between the infection and body condition (p-value = 0.69),(table 3.1.4).

Source of animals:

Of the total 200 cattle inspected, 184 animals were from Kordofa, 10 animals were from South Sudan and only 6 animals were from White Nile (table 3.1.2). All infected animals found in this study (2 animals) were from Kordofan. The rate of infection in Kordofan was 1.08% (2/184). On the other hand there was no infection found in White Nile and South Sudan (table 3.1.3).

The chi- square test showed no significant association between the infection and source of animal (p-value = 0.92), (table 3.1.4).

Grazing type:

The grazing type of animals and the presence of *Cysticercus bovis* infection were investigated. One hundred ninety seven of cattle were found to be in open grazing type, while 3 of cattle were found to be in close

grazing type (table 3.1.2). Among open grazing type animals, 2 were found infected. The rate of infection within open grazing type animals was 1.02% (2/197). However no animal was found infected among close grazing type animals (table 3.1.3).

The chi- square test showed no significant association between the infection and grazing type (p-value = 0.86),(table 3.1.4).

Location of cysts:

The location of cysts in different organs was investigated. Our results showed that liver was the only infected organ with *Cysticercus bovis* where 2 cases (1%) were found infected. No infection was found on tongue, masseter muscle, heart, diaphragm and shoulder (table 3.8.1).

Viability of cysts:

Viability of the cyst was determined by cyst translucence, cysts which contain translucent fluid with visible white scolex were classified as viable and those which contain bluish-green caseous masses or necrotic patches were classified as dead or calcified (*Qadeer., 2008*). Macroscopic examination of the cysts revealed a total of 18 cysts, 9 cysts present in two cases were viable (50%) and 9 cysts were calcified (50%), (table 3.8.1).

Table 3.2: Summary of frequency tables for potential risk factors of *Cysticercus bovis* in 200 cattle examined at Elobied slaughterhouse

Risk Factors	Frequency	Relative Frequency %	Cumulative Frequency %
Age			
Old (≥4)	65	32.5	32.5
Young (<4)	135	67.5	**100**
Sex			
Male	156	78	78
Female	44	22	**100**
Breed			
Local	190	95	95
Cross	8	4	99
Foreign	2	1	**100**
Body condition			
Good	185	92.5	92.5
Poor	15	7.5	**100**
Source			
Kordofan	184	92	92
White Nile	6	3	95
South Sudan	10	5	**100**
Grazing type			
Open	197	98.5	98.5
Close	3	1.5	**100**

Table 3.3: Summary of cross tabulation for potential risk factors of *Cysticercus bovis* in 200 cattle examined at Elobied slaughterhouse

Risk factors	No. inspected	No. affected (%)
Sex:		
Male	156	2 (1.28)
Female	44	0 (0)
Age:		
Young (<4)	135	2 (1.48)
Old (≥4)	65	0 (0)
Body condition:		
Poor	15	0 (0)
Good	185	2 (1.08)
Breed:		
Local	190	2 (1.05)
Cross	8	0 (0)
Foreign	2	0 (0)
Source:		
Kordofan	184	2 (1.08)
White Nile	6	0 (0)
South Sudan	10	0 (0)
Grazing Type:		
Open	197	2 (1.02)
Close	3	0 (0)

Table 3.4: Summary of univariate analysis for potential risk factors of *Cysticercus bovis* in 200 cattle examined at Elobied slaughterhouse using the Chi- square test

Risk factors	No. inspected	No. affected (%)	d.f	Chi-square value	p- value
Sex:			**1**	**0.57**	**0.45**
Male	156	2 (1.28)			
Female	44	0 (0)			
Age:			**1**	**0.973**	**0.32**
Young (<4)	135	2 (1.48)			
Old (≥4)	65	0 (0)			
Body condition:			**1**	**0.164**	**0.69**
Poor	15	0 (0)			
Good	185	2 (1.08)			
Breed:			**2**	**0.106**	**0.95**
Local	190	2 (1.05)			
Cross	8	0 (0)			
Foreign	2	0 (0)			
Source:			**2**	**0.176**	**0.92**
Kordofan	184	2 (1.08)			
White Nile	6	0 (0)			
South Sudan	10	0 (0)			
Grazing Type:			**1**	**0.031**	**0.86**
Open	197	2 (1.02)			
Close	3	0 (0)			

Table 3.5: Multivariate analysis of *Cysticercus bovis* and potential risk factors in 200 cattle examined at Elobied slaughterhouse

Risk factors	No. inspected	No. affected (%)	Exp(B)	P-value
Sex:				
Male	156	2 (1.28)	827.9	**0.941**
Female	44	0 (0)	Ref	
Age:				
Young (<4)	135	2 (1.48)	0.00	**0.922**
Old (≥4)	65	0 (0)	Ref	
Body condition:				
Poor	15	0 (0)	Ref	
Good	185	2 (1.08)	346.1	**0.968**
Breed:				
Local	190	2 (1.05)	0.001	**0.974**
Cross	8	0 (0)	0.00	**.0986**
Foreign	2	0 (0)	Ref	

Table 3.6: Anatomical distribution and viability of cysts among inspected organs

Organ	No. tested	No. positive (%)	No. of cysts	No. of viable cysts (%)	No. of dead cysts (%)
Tongue	200	0	0	0	0
Masseter	200	0	0	0	0
Heart	200	0	0	0	0
Liver	200	2 (1)	18	9 (50)	9 (50)
Diaphram	200	0	0	0	0
Shoulder	200	0	0	0	0
Total	1200	2 (0.17)	18	9 (50)	9 (50)

Chapter Four

Discussion

Results of the present study have increased knowledge on the epidemiology of *Cysticercus bovis* in cattle slaughtered in North Kordofan

state of the Sudan. Meat inspection conducted on slaughtered cattle showed that the prevalence rate of *Cysticercus bovis* was considerably low in the study area. While there is a lack in the studies conducted on *Cysticercus bovis* in the Sudan, therefore, this study was conducted to estimate the prevalence rate of *Cysticercus bovis* in cattle slaughtered in Elobied slaughterhouse, North Kordofan and to investigate potential risk factors associated with the infection.

In the present study the prevalence of *Cysticercus bovis* in cattle slaughtered in Elobied slaughterhouse, North Kordofan state, Sudan was 1%. This result is in agreement with the findings of Dutra *et al.*, (2012), who reported a prevalence of 1.05% in Brazil, Basem *et al.*, (2009) who reported a prevalence of 1.6% in Egypt and Abuseir *et al.*, (2006) who reported a prevalence of 1.08% in Germany. However the result of the present study was higher than the prevalence reported by Dzoma *et al.*, (2011) who reported a prevalence of 0.2% in South Africa and Khaniki *et al.*, (2010), who reported a prevalence of 0.25% in Iran. While the prevalence of the present study was lower than the prevalence reported in Nigeria of 2.67% by Rabi'u and Jegede., (2010), Ethiopia of 2.93% by Tolosa *et al.*, (2009), Iran of 3% by Garedaghi *et al.*, (2011), Ethiopia of 3.6% by Ibrahim and zerihun., (2012), Ethiopia of 4.4% by Megersa et al., (2010), Ethiopia of 8.29% by Kumar and Berhe., (2008), Nigeria of 13.4% by Qadeer., (2008), Ethiopia of 22.9% by Belachew and Ibrahim., (2012), and Nigeria of 72.2% by Ikpeze *et al.*, (2008). This variation of prevalence may be due to personal and environmental hygiene, variation in the method and quality of meat inspection, management of animals, experience and diligence of inspector and other factors may have contributed for the change of prevalence of *Taenia saginata* cysticercosis.

The prevalence of *Cysticercus bovis* infection according to sex of investigated animals has been estimated in this study. This study showed that male cattle have higher rate of infection than female cattle. The rate of infection in male animals was 1.28% (2/156), while there was no infection found among female animals. There was no significant association between *Cysticercus bovis* infection and sex of animals (p-value = 0.45). This result is in agreement with report of Belachew and Ibrahim., (2012) in Ethiopia, Garedaghi *et al.*, (2011) in Iran and Dzoma *et al.*, (2011) in Nigeria. But this finding disagree with study carried out in Ethiopia where the p-value was 0.027 *(Ibrahim and Zerihun., 2012*), and a p-value of <0.05 reported in Nigeria (*Qadeer., 2008*) . Logically, females have a high rate of infection than males, because the female remain longer for reproductive purposes so the cysts have a chance to develop.

With regards to rate of infection of *Cysticercus bovis* in different age groups of cattle, the rate of infection among animals with more than 4 years of age was 1.48% (2/135), while there was no infection among animals less or equal 4 years. There was no significant association observed between *Cysticercus bovis* infection and age of animals (p-value = 0.32). This result is in accordance with report of Ibrahim and Zerihun., (2012) in Ethiopia. But this result is in contrary with finding of study carried out in Ethiopia where the p-value was 0.003 (*Belachew and Ibrahim., 2012*). This significant variation in prevalence of *Cysticercus bovis* might be due to age dependent immunity.

The results of this study showed that the prevalence of *Cysticercus bovis* infection within 2 parameters of body condition of the animals was: 1.08% (2/85) in good body condition and 0.0% in poor body condition.

However, there was no significant association between *Cysticercus bovis* infection and body condition of animals (p-value = 0.69). This could be attributed to the fact that, *Cysticercus bovis* infection is a mild disease which may not affect the general health of the affected animals. Also lack of variability in relation to body condition might be due to the little tendency of excluding emaciated animals from being slaughtered. This finding is in line with finding of Belachew and Ibrahim., (2012) in Ethiopia.

The prevalence of *Cysticercus bovis* infection related to breed of investigated animals was: 1.05% (2/190) in local breeds, while there was no infection found among cross and foreign breeds. However, there was no significant association between *Cysticercus bovis* infection and body breed of animals (p-value = 0.95). This result is in agreement with report of Belachew and Ibrahim., (2012) in Ethiopia, and another observations reported in Ethiopia *(Ibrahim and zerihun., 2012*).

The prevalence of *Cysticercus bovis* infection according to source of investigated animals was estimated in this study . The rate of infection in Kordofan was 1.08% (2/184), and there was no infection found in White Nile and South Sudan. There was no significant association between the *Cysticercus bovis* infection and source of the animals (p-value = 0.92). This result is comparable to the finding of Belachew and Ibrahim., (2012) in Ethiopia, and Tesfaye *et al.,* (2012) in Ethiopia.

According to the current study, the cysts were found only at one site (liver), while there was no infection found at shoulder muscle, heart, masseter (cheek muscle), diaphragm and tongues. This could be attributed to that infection might be in the early stage, and cysts did not reach the other

organs yet. This result is in line with the finding of Kumar and Berhe., (2008) in Ethiopia, who reported a highest infection in the liver. But this result is in contrary with finding of Belachew and Ibrahim., (2012) in Ethiopia, Ibrahim and zerihun., (2012) in Ethiopia, Megersa *et al.,* (2010) in Ethiopia, Tolosa *et al.*, (2009) in Ethiopia, Tesfaye *et al.*, (2012) in Ethiopia, Garedaghi *et al.*, (2011) in Iran, Rabi'u and Jegede., (2010) in Nigeria and Qadeer., (2008).

Of the total cysts collected, 50% (9/18) were viable while the rest 50% (9/18) were calcified, which is in agreement with the report of Ibrahim and zerihun., (2012) in Ethiopia, Megersa *et al.*, (2010) in Ethiopia and Tolosa *et al.,* (2009) in Ethiopia. But this result dis agree with finding of study carried out in Ethiopia where the viable cysts were 62.5%, while calcified one were 37.5% *(Belachew and Ibrahim., 2012*).

Conclusions

- The output of this study indicates that the overall prevalence of *Cysticercus bovis* was: 1%.

- The distribution of prevalence of *Cysticercus bovis* infection by age showed that the prevalence in young animals was 1.48%, while there is no infection found among old animals.
- For body condition the prevalence was higher in good body condition animals (1.08%), while there is no infection found among poor body condition animals.
- The prevalence of *Cysticercus bovis* infection according to the geographical areas of cattle was higher in Kordofan (1.08%), while there is no infection found among animals brought from Darfur and White Nile State.
- Distribution of *Cysticercus bovis* infection by sex was 1.28% in male, while there was no infection among female.
- The prevalence of *Cysticercus bovis* infection according to the Breeds of cattle was higher in Local breed (1.05%), while there was no infection among Cross and Foreign breeds.
- The prevalence of *Cysticercus bovis* infection according to the Grazing type of cattle was higher in open Grazing type animals (1.02%), while there was no infection found among close Grazing type animals.
- There was no significant association observed between *Cysticercus bovis* infection and any of the risk factors.
- For the location of *Cysticercus bovis* cyst in organs, the liver was found to be the only affected organ, with the prevalence of 1% .

- Macroscopic examination of *Cysticercus bovis* cyst, showed that 50% of the cysts were viable while 50% of the cysts were calcified.

Recommendations

- More elaborate studies on *Cysticercus bovis* to reveal the prevalence in other states .
- Economic importance of the disease.
- Study from development of cyst to calcification.
- Improve diagnosis in Sudan.

- Enhancement of awareness of people about the economic and public health importance of the disease.

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Appendix I

Frequency tables for distribution of infection among 200 cattle examined at Elobied abattoir according to potential risk factors:

Appendix I, table 1: Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Female	44	22	22	22
	Male	156	78	78	**100**
	Total	**200**	**100**	**100**	

Appendix I, table 2: Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Young	135	67.5	67.5	67.5
	Old	65	32.5	32.5	**100**
	Total	**200**	**100**	**100**	

Appendix I, table 3: Body condition

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Poor	15	7.5	7.5	7.5
	Good	185	92.5	92.5	**100**
	Total	**200**	**100**	**100**	

Appendix I, table 4: Breed

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Local	190	95	95	95
	Cross	8	4	4	99
	Foreign	2	1	1	**100**
	Total	**200**	**100**	**100**	

Appendix I, table 5: Source of Animal

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Kordofan	184	92	92	92
	White Nile	6	3	3	95
	South Sudan	10	5	5	**100**
	Total	**200**	**100**	**100**	

Appendix I, table 6: Grazing Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Close	3	1.5	1.5	1.5
	Open	197	98.5	98.5	**100**
	Total	**200**	**100**	**100**	

Appendix II

Cross-tabulation of the prevalence of *cysticercus bovis* in 200 cattle examined at Elobied slaughterhouse according to potential risk factors:

Appendix II, table 1: Sex

	Sex of animal		Total
	Female	**Male**	
Results **-ve**	44 44/44x100 **100%**	154 154/156x100 **98.7%**	198 198/200x100 **99%**
+ ve	0 0/44x100 **0%**	2 2/156x100 **1.3%**	2 2/200x100 **1%**
Total	**44** **100%**	**156** **100%**	**200** **100%**

Appendix II, table 2: Age

	Age of animal		Total
	Young	**Old**	
Results **-ve**	133 133/135x100 **98.5%**	65 65/65x100 **100%**	198 198/200x100 **99%**
+ ve	2 2/135x100	0 0/65x100	2 2/200x100

	1.5%	**0%**	**1%**
Total	**135** **100%**	**65** **100%**	**200** **100%**

Appendix II, table 3: Body Condition

	Body condition		**Total**
	Poor	**Good**	
Results **-ve**	15 15/15x100 **100%**	183 183/185x100 **98.9%**	198 198/200x100 **99%**
+ ve	0 0/15x100 **0%**	2 2/185x100 **1.1%**	2 2/200x100 **1%**
Total	**15** **100%**	**185** **100%**	**200** **100%**

Appendix II, table 4: Breed

	Breed			**Total**
	Local	**Cross**	**Foreign**	
Results **-ve**	188 188/190x100 **98.9%**	8 8/8x100 **100%**	2 2/2x100 **100%**	198 198/200x100 **99%**
+ ve	2 2/190x100 **1.1%**	0 0/8x100 **0%**	0 0/2x100 **0%**	2 2/200x100 **1%**

	190	**8**	**2**	**200**
Total	**100 %**	**100%**	**100%**	**100%**

Appendix II, table 5: Source of Animal

	Animal source			**Total**
	Kordofan	**White Nile**	**South Sudan**	
Results	182	6	10	198
-ve	182/184x100	6/6x100	10/10x100	198/200x100
	98.9%	**100%**	**100%**	**99%**
	2	0	0	2
+ ve	2/184x100	0/6x100	0/10x100	2/200x100
	1.1%	**0%**	**0%**	**1%**
	184	**6**	**10**	**200**
Total	**100 %**	**100%**	**100%**	**100%**

Appendix II, table 6: Grazing Type

	Grazing type		**Total**
	Close	**Open**	
Results	3	195	198
-ve	3/3x100	195/197x100	198/200x100
	100%	**99%**	**99%**
	0	2	2
+ve	0/3x100	2/197x100	2/200x100
	0%	**1%**	**1%**
	3	**197**	**200**
Total	**100%**	**100%**	**100%**

Appendix III

Association between *cysticercus bovis* infection and potential risk factors using the Chi- square test:

Appendix III, table 1: Sex

	Value	**Df**	**Asymp.sig** (2-sided)
Pearson chi- square	0.570	1	0.45
Likelihood Ratio	1.58	1	0.21
Linear by Linear Association	0.97	1	0.33

N of Valid Cases	200		

Appendix III, table 2: Age

	Value	**Df**	**Asymp.sig** (2-sided)
Pearson chi- square	0.973	1	0.324
Likelihood Ratio	0.158	1	0.21
Linear by Linear Association	0.97	1	0.32
N of Valid Cases	200		

Appendix III, table 3: Body Condition

	Value	**Df**	**Asymp.sig** (2-sided)
Pearson chi- square	0.164	1	0.686
Likelihood Ratio	0.31	1	0.56
Linear by Linear Association	0.16	1	0686
N of Valid Cases	200		

Appendix III, table 4: Breed

	Value	**Df**	**Asymp.sig** (2-sided)

Pearson chi- square	0.106	2	0.948
Likelihood Ratio	0.21	2	0.90
Linear by Linear Association	0.10	1	0.76
N of Valid Cases	200		

Appendix III, table 5: Source of Animal

	Value	**Df**	**Asymp.sig** (2-sided)
Pearson chi- square	0.176	2	0.916
Likelihood Ratio	0.34	2	0.85
Linear by Linear Association	0.16	1	0.69
N of Valid Cases	200		

Appendix III, table 6: Grazing Type

	Value	**Df**	**Asymp.sig** (2-sided)
Pearson chi- square	0.031	1	0.861
Likelihood Ratio	0.06	1	0.81
Linear by Linear Association	0.03	1	0.87
N of Valid Cases	200		