

Thesis Ref. No. _____

**MAJOR METACESTODES OF CATTLE, SHEEP AND GOATS
SLAUGHTERED AT BISHOFTU ELFORA EXPORT ABATTOIR,
COMMUNITY PERCEPTION AND PUBLIC HEALTH SIGNIFICANCE OF
ZOOBOTIC CESTODES**



MSc Thesis

By

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Veterinary Parasitology**

JUNE 2017

BISHOFTU, ETHIOPIA

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**A Thesis submitted to College of Veterinary Medicine and Agriculture of Addis
Ababa University in partial fulfillment of the requirements for the degree of
Master of Science in Tropical Veterinary Parasitology**

By

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**JUNE, 2017
BISHOFTU, ETHIOPIA**

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DEDICATION

I dedicated this thesis manuscript to all my families and my wife Seble Kebede for their continuous love, appreciation, encouragement, moral, and financial support during my studies.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my own original work and has not been presented for a degree in any University and that all sources of materials used for this thesis have been correctly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an advanced (MSc) degree at the AA University and is deposited at the University Library to be made available to borrowers under rules of the Library.

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Above all, praised and glorified be the supreme God who is the Lord of lords, the Alpha and Omega, my salvation, redemption forecaster of everything and according his will lead me to the eternal truth. It would have been impossible to complete the work under such tiresome hardship without his support.

I would like to express my sincere gratitude and appreciation to my principal advisor Professor Yacob Hailu, for his earnest and constructive comments during the research work. He has worked hard to keep me on the right track and to accomplish my study. I am also thankful to my co-advisor Dr. Tariku Jibat, for his willingness to advise me, as well as his valuable guidance, preparation and correction of questionnaire format and support throughout my research work.

I would like to sincerely thank Addis Ababa University, College of Veterinary Medicine and agriculture department of pathology and parasitology for allowing using the laboratory. My special thanks to the staff of Edom and Medhinalem private clinics, Bishoftu referral hospital and Elfora Abattoir workers, owners of butcher shops and study participants for their collaboration, enthusiasm and willingness to share their experiences during this study.

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ABBREVIATIONS

Ab- ELISA	Antibody- enzyme linked immunosorbent assay
Ag-ELISA	Antigen-enzyme linked immunosorbent assay
CSA	Central Statistic Authority
EITB	Enzyme-Linked Immunoelctro Transfer Blot
FAO	Food and Agricultural Organization
IHAT	Indirect Haemagglutination Antibody Test
MOA	Minister of Agriculture
OIE	Office International des Epizootics
PCR	Polymerase Chain Reaction
RFLP	Restriction Fragment Length Polymorphism
WHO	World Health Organization

ABSTRACT

A cross-sectional study was carried out from November, 2015 to March, 2016 in the Elfora export Abattoir, in the Bishoftu city of Ethiopia with the objective of estimating the prevalence, organ distribution, viability of *Cysticercus bovis* and Hydatid cyst, identifying major risk factors and assessing the level of risk perception of community about zoonotic cestodes. A total of 1169 animals comprising 384 cattle, 385 sheep and 400 goats. Out of the total 785 small ruminants examined for the presence of hydatid cysts and *Coenurus cerebralis* an overall prevalence of 7.39% and 3.8% was recorded, respectively. Of the total 400 goats examined for hydatid cysts, 6.8 % and *Coenurus cerebralis* 5% were found positive. There was no significant difference in the prevalence of *Coenurus cerebralis* in sheep and at different age groups and in both species. However, young goats found significantly affected by Coenurosis. More Hydatid infected sheep were found in Negelle 17.6 % where as 11.7 % of goats with Hydatid cyst was found in Yabello zone. Organ distribution hydatid cyst revealed that lung and liver were found frequently infected. Out of 49 sheep with hydatid cysts, 57.1 % harbored hydatid cysts in lung, 36.7 % in liver, 2.04% in kidney and 4.08 % in muscle. In sheep, a total of 49 cysts were examined to identify cyst fertility or viability out of these 24%, 20%, 28% and 28% were identified as fertile, non viable, sterile and calcified, respectively. From a total of 27 lung cysts there was no fertile cyst detected in goats. Out of 384 randomly selected slaughtered cattle, 17 (4.4%) and 47 (12.2%) were infected with *Cysticercus bovis* and Hydatid cyst, respectively. Regarding organ distribution, tongue was the most frequently infected organ with *Cysticercus bovis*. The total 119 Hydatid cysts being collected from the infected cattle were distributed as in the lungs 63.03 %, liver 33.6 % and kidneys 3.36 %. Of a total of 74,684 patients admitted for stool examination in the two private clinics and one referral hospitals in Bishoftu, 495 (0.61%) Taeniosis cases were registered. Males are 2 times more prone to acquiring Taeniosis than female (OR=2.096,P=0.000). Education status created significant role in risk of exposure in which tertiary educated individuals has low risk than illiterates and other levels of education. From a total of 100 people 69% knew that tapeworm could spread from animals to humans. There was significant difference in high risk group where large number of Christians experienced consumption of raw meat (p = 0.001). These results

suggest that the high prevalence of metacestode infestations in this area is a great concern for both medical and veterinary authorities to design therapeutic and preventive programmes to overcome this problem.

Key words: *Cestodes, Coenurus cerebralis, Hydatid Cysts, Taeniosis, Cattle, Sheep, Goats*

1. INTRODUCTION

Ethiopia's estimated livestock population is often said to be the largest in Africa. In the country, there were approximately 57.8 million cattle, 28 million sheep, 28.6 million goats, 1.23 million camels and 60.5 million poultry (CSA, 2016). Ethiopia's great livestock potential is not properly exploited due to different factors such as traditional management system, limited genetic potential, lack of appropriate disease control policy and lack of appropriate veterinary services. Apart from this (Ayele *et al.*, 2003) foods of animal origin are often the preferred source of protein. However, if not properly prepared or handled, they can lead to food-borne infections (Karshima, 2012).

In a country confronted with challenges of an ever-rising human population and food shortage, such enormous losses caused by helminthes parasites, 'the silent predators', are intolerable (Biffa *et al.*, 2006). Moreover, these diseases are also known to cause public health problems as humans can be infected from accidental ingestion of parasite eggs/larvae passed into the environment with faeces from definitive hosts (Jenkinsa *et al.*, 2005; Ashrafi *et al.*, 2006).

Cestodes of the family Taeniidae infect dogs and humans as the definitive host and are transmitted to a wide range of intermediate host species where they cause Coenurosis, Hydatidosis, and Cysticercosis (Ahmadi and Badi, 2011).

Hydatid cyst is the metacestodes of the tapeworm *Echinococcus granulosus*. Adult worms have been reported to be found in small intestines of dogs and wild carnivores like the wolf and fox (Abidi *et al.*, 1989). Infested carnivores eliminate eggs with their faeces. Herbivores (intermediate host) become infested with the eggs on account of having fed on contaminated pastures (Craig *et al.*, 2007).

Man is infected incidentally up on ingestion of infective eggs in contaminated water, vegetables and other food or through direct contact with dog. Possible intermediate

hosts for *Coenures cerebralis* are sheep and goats, for *Cysticercus bovis* are cattle and buffalo, and for *Hydatid cysts*, domestic ungulates and man act as an intermediate host (Kumsa, 1994). Consumption of offal containing viable cyst results in infection of definitive host carnivores including dogs. The adult tapeworm in definitive host is harmless unlike the metacestodes in the intermediate host animals that is responsible for immense economic and medical importance in infected host (Azlaf and Dakkak, 2006; Bettelli, 2009; Ibrahim, 2010).

Coenurosis, the bladder worm stage of *Taenia multiceps* predominantly develops in the brain and spinal cord of many mammal species, including human (Tafti *et al.*, 1997; Ing *et al.*, 1998; Sharma and Chauhan, 2006; Oryan *et al.*, 2012). Coenuruses due to larval stage of *Taenia multiceps* can occur in both an acute and a chronic disease form. Occasionally the signs are more severe and the animal may develop encephalitis, convulse and die within 4-5 days (Oryan *et al.*, 2012).

The infection is acquired in cattle by grazing on pasture contaminated with faeces of humans. *Cysticercus bovis* infection in cattle may not show any clinical disease and therefore goes un-noticed except during abattoir meat inspection. These larvae remain embedded in the tissues of cattle posing serious public health threats. The observations were reinforced by a probabilistic model developed by Kyvsgaard *et al.* (1990) which showed that over 85% of infected animals may be missed during routine meat inspection.

Hydatidosis and taeniosis is of public health and economic importance not only in areas of endemicity but also in non endemic countries due to the migration of infected people and livestock exchange, their products, and potentially contaminated produce or other fomites which promotes emergence in previously free-disease areas (Mamuti *et al.*, 2002). They are frequently reported from different corners of the country (Adem, 2006; Biluts *et al.*, 2006; Kebede *et al.*, 2009a, b), and the disease is much more common in rural areas of Ethiopia where dogs and domestic animals live in a very close association (Fromsa and Jobre, 2011). Additionally, where home slaughtering of cattle, sheep, goats and camels is still predominant and uncooked offal and carcass wastes are normally given for dogs and cats, peoples to eat the ingestion

of raw or undercooked beef dishes such as “kurt” and “kitfo” (Teka, 1997; Tembo, 2001; Kumar and Tadesse, 2011).

However, there is lack of recent information on some major metacestodes in East Shoa Zone of Oromia Regional State particularly in and around Bishoftu town. This area is known for its commercial, domestic and export abattoirs growing in number currently. To establish appropriate strategy for prevention and controls, it is very important to know public perception about the risk of the diseases and up to date epidemiological information is needed on zoonotic parasites and their public health importances.

Therefore, the objectives of current study are:

- To determine the prevalence, organ distribution, viability of metacestodes.
- To identify major risk factors associated with metacestodes in cattle, sheep and goats slaughtered at Elfora export abattoir.
- To assess the level of risk perception by community about zoonotic cestodes.

2. LITERATURE REVIEW

2.1. Etiological agents and taxonomy

Echinococcus and *Taenia* spp. are segmented, parasitic tapeworms, belong to the the kingdom of Animalia, phylum of Platyhelminthes, class of Cestoda, order of Cyclophyllidea, Family of Taeniidae and Genus of *Echinococcus* and *Taenia* (Soulsby, 1982; Symth, 1994 and Urquhart *et al.*, 1996).

The adults are found in domestic carnivores and man. *Cysticercosis*, *Hydatidosis* and *coenurosis* of farmed and wild animals is caused by the larval stages (metacestodes) of cestodes of the family Taeniidae (tapeworms), the adult stages of which occur in the intestine of humans, dogs or wild Canidae. *Bovine cysticercosis* (primarily in muscle) is caused by the metacestodes (*cysticerci*) of the human cestodes *Taenia saginata*. (Soulsby, 1982; Jabbar *et al.*, 2010a) Cerebral coenurosis (gid or sturdy) is caused by *Coenurus cerebralis* cyst, which is a metacestode or larval stage of *Taenia multiceps* and particularly affects sheep and goats (Sharma and Chauhan, 2006; varcasia *et al.*, 2012; Miran, 2013).

At present, four species of the genus *Echinococcus* are recognized and regarded as taxonomically valid: *E. granulosus* (cystic hydatidosis), *E. multilocularis* (multivesicular hydatidosis), *E. vogeli* (polycystic hydatidosis) and *E. oligarthrus* (Soulsby, 1982). The definitive hosts of *E. granulosus* are domestic dogs and some wild canids. Intermediate hosts are sheep, bovines, swine, goats, equines, camelids (Asian and American), cervids, and man (FAO, 1982).

2.2. Morphology

2.2.1. *Taenia species*

The scolex has an armed rostellum with a concentric double row of hooks (the important exception is *Taenia saginata* whose scolex is unarmed). The gravid segments are longer than they are wide. The intermediate stage is a *cysticercus*, *coenurus* or *hydatid cyst* and these occur only in mammals (Wanzala et al., 2003).

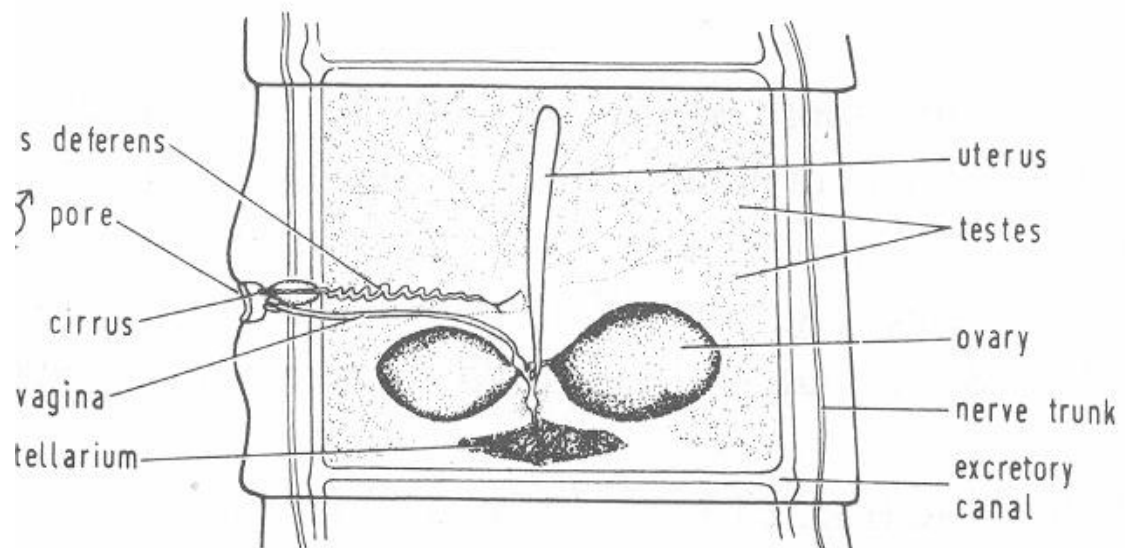


Figure .1. Morphology of proglottids

Source: Parija, 1996

➤ ***Taenia saginata* (the beef tapeworm)**

The adult is large, 4–8 meters long and can survive many years, usually singly, in the small intestine of humans. The scolex (or head) has no rostellum or hooks. Gravid segments have >14 uterine branches. They usually leave the host singly and many migrate spontaneously from the anus (Soulsby, 1982; Khalil *et al.*, 1994 and Loos-Frank, 2000).

The eggs are typical ‘taeniid’ eggs that cannot be differentiated morphologically from other *Taenia* or *Echinococcus* spp. eggs. *Taeniid* eggs measure about 25–45 µm in diameter; contain an oncosphere (or hexacanth embryo) bearing three pairs of hooks; have a thick, brown, radially striated embryophore or ‘shell’ composed of blocks; and there is an outer, oval, membranous coat, the true egg shell, that is lost from faecal eggs (Khalil *et al.*, 1994; Loos-Frank, 2000).

Metacestodes (*Cysticercus bovis*) of *T. saginata* usually occur in the striated muscles of cattle (beef measles), but also buffalo, and various *Cervidae*. Viable cysts are oval, fluid-filled, about 0.5–1 × 0.5 cm, translucent and contain a single white scolex that is morphologically similar to the scolex of the future adult tapeworm. They are contained in a thin, host-produced fibrous capsule. Cysts occasionally are found in the liver, lung, kidney, fat and elsewhere (Soulsby, 1982).

Taenia multiceps

Adults, up to a meter long in the intestine of canids, have an armed rostellum. The metacestodes (*Coenurus cerebralis*) are large, white fluid-filled cysts that may have up to several hundred scoleces invaginated on the wall in clusters. Coenuri grow to 5 cm or more in size in the brain of sheep, the brain and inter muscular tissues of goats, and also the brain of cattle, wild ruminants and occasionally humans. The cysts induce neurological signs that in sheep are called ‘gid’, ‘sturdy’, (Attindehou and Salifou, 2012).

2.2.2. Echinococcus granulosus

Morphologically adult *Echinococcus* is only a few millimeters long (rarely more than 10 mm) and usually has no more than six segments (Soulsby *et al.*, 1982). Anteriorly, an adult echinococcus possesses a specialized attachment organ. The scolex that has four muscular suckers and two rows of hooks, one large and one small; on the rostellum, the body or strobila is segmented and consists of reproductive units (proglotids), which may vary in number from two to six (Dorny *et al.*, 2000).

The gravid proglottid, containing several hundred eggs, detaches from the strobila, Each egg contains an embryo (oncosphere) with six hooks (hexacanth). Metacestode of *E. granulosus* is hydatid, it measures approximately 1 cm and it is apparent that its wall consists of two layers: an external, cuticular or laminar layer, formed by numerous thin nacreous lamina that resemble the cross-section of an onion, and another, internal layer, germinative or proligerous, which is a delicate cellular syncytium. The larval form of *E. granulosus* typically consists of a single cavity (is unilocular). The interior of the hydatid is filled with liquid (Alum *et al.*, 2010).

2.3. Epidemiology

2.3.1. Distribution

Taenia saginata, Taeniosis occurs throughout the world with variable degree of prevalence (Harrison and Sewell, 1991). In the world there are 77 million bovine Taeniosis patients of which 32 million are in Africa, 11 million in Asia and about 3 million in the new world. Its prevalence could be classified into three groups (Frolova, 1982; Dorny *et al.*, 2000; Minozzo, *et al.*, 2002).

Reports by Cabarat *et al.* (2002) indicate that global human taeniosis prevalence results from the last 25 years ranging from less than 0.01 to 10% in Europe and up to 36% in Dagestan. It is unclear whether the data available reflects only *T. saginata* or also includes *T. solium* infections, since *Taenia* eggs of all species are morphologically alike.

Highly endemic areas include Central and East African countries (Ethiopia, Kenya, and Zaire), Argentina and in the Mediterranean Region (Syria, Lebanon and Yugoslavia) (Florova, 1982). In some parts of Serbia and Montenegro, up to 65% of children have been reported to harbor *T. saginata* (Florova, 1982). Moderate prevalence is encountered in South East Asia (Thailand, India, Vietnam and Philippines), Japan as well as countries of Western Europe and South America while Canada, the USA, Australia and some countries of the Western Pacific have low prevalence (Harrison and Sewell, 1991).

Globally, *T. saginata* is the most widely distributed human *Taenia* tapeworm, with an estimated 60 million human infections worldwide (Craig *et al.*, 2007). In developing countries, cattle are reared on extensive scale, human sanitation is of comparatively lower standards and the inhabitants traditionally eat raw or inadequately cooked beef. The prevalence of Taeniosis is over 20% in certain areas of these countries. Based on routine carcass inspection the infection rate of bovine cysticercosis is often around 30-60% although, the real prevalence is considerably high (Tembo, 2001).

Taenia saginata infections also occur in developed countries, where standards of sanitation are high and meat is carefully inspected and generally thoroughly cooked. Taeniosis/cysticercosis spreads in developed areas of the world through tourists enjoying the consumption of lightly grilled meat, mass migration of labor and the export of meat unreliably passed by “eye or knife” inspection or from live animals imported from endemic areas (Mann, 1984).

Prevalence in these parts of the world is less than 1%. Occasionally, cysticercosis “storms” have been reported on particular farms. The cause of the storm has been attributed to the use of human sewage on pasture and the use of migrant labor (O.I.E., 2000). In developed countries, cattle of any age, are susceptible to infection since they generally possess no acquired immunity (Yoder *et al.*, 1994).

A high prevalence of *T. saginata* / *Cysticercus bovis* occurs in Africa where cattle are kept in community grazing lands. The parasites appear to be specific to cattle, while wild animals play no part as intermediate hosts (Symth, 1994). The prevalence, economic and public health impact of cystic hydatidosis is higher in rural communities of developing countries where there is close contact between dogs, intermediate host species, and man (Romig *et al.*, 1999; Ibrahim, 2010).

Infection by the larval stage of the tapeworm *T. multiceps* in small ruminants is common worldwide (Oryan *et al.*, 2012). It has been documented in scattered foci throughout the world, including the Americas and parts of Europe and is distributed worldwide (Abo-Shehada *et al.*, 2002; Sharma and Chauhan, 2006).

The disease (coenurosis) has been documented in Ethiopia, Ghana, Mozambique, Uganda, Egypt, Democratic Republic of Congo, Senegal, Sudan, Chad, Angola, Kenya and Southern Africa (Miran, 2013). It has been reported that 2.5 sheep and 3.9 goats in Ethiopia (Adane *et al.*, 2015), 2.9% sheep in Jordan (Abo-Shehada *et al.*, 2002), 18.65 % in Uramia abattoir, Iran (Tavassoli *et al.*, 2011), 14.8 % in Tete municipal abattoir, Mozambique (Afonso *et al.*, 2011), 44.4 % Ngorongoro district, Tanzania (Miran *et al.*, 2015), and 3.1–28.5% in Kars Province of Turkey (Gicik *et al.*, 2007; Uslu and Guclu, 2007) have been infected with the cerebral form of the *C. cerebralis*.

Human coenurosis is much less common than Teaniosis. Approximately 100 or more cases have been reported worldwide, mainly in Africa and South America. Only a few cases have been documented in the U.S. and Europe. *T. multiceps* infection (gid) can be a common and important livestock disease in some countries or regions, *Coenurosis* is endemic in Ethiopia, especially in the highlands where 75% of the sheep population occurs (Bekele *et al.*, 1988; Njau *et al.*, 1990).

E. granulosus is one of the world's most geographically wide spread zoonotic diseases (Azlaf and Dakkak, 2006; Christodoulouopoulos *et al.*, 2008). In Africa *E. granulosus* has been recognized from most countries including Ethiopia. Several reports had indicated that hydatidosis is widely prevalent in livestock population of various regions of Ethiopia. The highest prevalences were recorded in central Ethiopia with up to 52.7% of 632 cattle being infected with *Echinococcus* spp (26.9% of cysts were fertile) (Kebede *et al.*, 2009).

Human CE, which is the most common *Echinococcus* spp. infection, probably accounts for more than 95% of the estimated 3 million global cases, with human AE causing only 0.3–0.5 million cases (Thompson and MacManus, 2002). The annual incidence of CE can range from less than 1 to >200 per 100 000 inhabitants in various endemic areas (Pawlowski *et al.* , 2001; Dakkak, 2010). Due to the wide geographical distribution and extent greater than previously believed, CE is currently considered an emerging or re-emerging disease (Thompson and MacManus, 2002; Torgerson *et al.*, 2003 and Grosso *et al.*, 2012).

2.3.2. Host range

Cattle are the preferred intermediate hosts and humans are the only final hosts of *T. saginata*. Cattle of all ages are susceptible; however young age groups are more susceptible. Parasitism is sometimes observed in other ruminants (sheep, goats, antelops, gazelles, buffaloes) but *Cysticercus* development is unlikely. Man cannot spread taeniasis to his own species. Management of animals in their natural environment predisposes them to infection. Cattle grazing communally have a higher risk of picking up *T. saginata* eggs since they are frequently in contact with human feces compared to commercial herds, the risk of cattle coming into contact with *T. saginata* eggs is much higher when cattle are at pasture (Harrison and Sewell, 1991).

In developing countries cattle are reared on extensive scale, human sanitation is poorly developed which makes the incidence of *T. saginata* infection in humans very high. Calves are infected usually in early life, often within the first few days after birth from infected stockmen whose hands are contaminated with *Taenia* eggs (Maedia *et al.*, 1996).

For the case of *Coenurus*, domestic and wild canids such as dog, fox, wolf and jackals constitute the definitive hosts; while dog is the most common definitive host for this parasite due to more exposure to the brain of sheep and goat. Wide range of herbivores including sheep, goats, cattle, buffaloes, camels, yak and equines are the intermediate hosts. *Coenurus* is quite common in sheep and goat compared to the other animals. Human can get infected with this parasite if accidentally ingest the egg of the parasite (Sharma and Chauhan, 2006; Lescano and Zunt, 2013; Oryan *et al.*, 2015).

Echinococcosis is a zoonotic disease caused by *Echinococcus* spp. tapeworms. The definitive hosts, which include dogs, other canids, hyenas and cats, carry the adult tapeworms sub-clinically. Dogs are particularly important in zoonotic transmission due to their close relationships with humans. Intermediate hosts are initially asymptomatic; however, the growth of the larvae, which form cysts in vital organs such as the liver and lungs, can lead to illness and death. Echinococcosis is a major public health problem in some countries, and it may be emerging or re-emerging in

some areas. Approximately 2-3 million human cases are thought to occur worldwide (CDC, 2011).

2.3.3. Source of Infection and Mode of Transmission

Tapeworms of the family Taeniidae are transmitted from the definitive hosts such as carnivores to the intermediated hosts including herbivores or omnivores and human beings via oral-fecal cycle (Oryan *et al.*, 2012). This family includes two major genera namely *Taenia* and *Echinococcus*. In many endemic areas the diseases caused by the genus *Taenia* in humans are often categorized as neglected tropical diseases (Jia *et al.*, 2010). In general, the larval stages or metacestodes belonging to these tapeworms include hydatid cysts, *cysticerci* and *coenuri* (Oryan *et al.*, 2012).

All *Taenia* species except for *T. hydatigena* (*C. tenuicollis*), *T. ovis* (*Cysticercus ovis*) and *T. pisiformis* (*C. pisiformis*), cause zoonotic parasitic diseases and thereby are of public health importance (Van *et al.*, 2014). Humans acquire infection by inadvertent consumption of ova or larval stages (metacestode) present in undercooked meat (Jia *et al.*, 2010). *Cysticercus bovis*, the metacestode of *T. saginata*, occurs only in beef and humans are only the definitive hosts and receive the infection by ingestion of the raw meat containing the *cysticerci* (Oryan *et al.*, 2012; Nunes *et al.*, 2013).

The transmission cycle of infection by *T. multiceps* takes place between dogs and domestic herbivores. Man is an accidental host and does not play any role in the epidemiology of the disease. The main factor in maintaining the parasitosis in nature is access by dogs to the brains of dead or slaughtered domestic herbivores that were infected with *coenuri* (Jia *et al.*, 2010).

Taenia eggs expelled in the feces of infected dogs or other canids are the source of infection for man and for the other intermediate hosts. In general, the eggs are eliminated by the definitive host in the proglottids. Since these dry out rapidly and are destroyed outside the host, the eggs are released and dispersed by the wind, rain, irrigation, and waterways (Nunes *et al.*, 2013).

The dog-sheep-dog cycle is the most important cycle for maintenance of the parasitism in the endemic areas of the southern part of South America and many other areas of the world. Sheep are the most important intermediate hosts of unilocular hydatidosis caused by *E. granulosus* for several reasons: the infection rate is generally high among these animals, 90% or more of their cysts are fertile, they live in close association with dogs, and, since they are often sacrificed for household consumption on ranches, the viscera are customarily fed to dogs (Jia *et al.*, 2010).

Sheep and other intermediate hosts contract hydatidosis by grazing on pastures contaminated with dog feces containing eggs of the cestode. Those eggs are deposited directly on the grazing land or are carried by rain or wind. The dogs in turn are infected by eating viscera that contain fertile cysts (with viable protoscolices). Man is an intermediate host and plays no role in the transmission of the parasite, unless he is eaten by a carnivore. Nevertheless, his sanitary habits make him the main agent responsible for perpetuating the infection by feeding dogs viscera that contain hydatid cysts (Oryan *et al.*, 1998).

The adult cestode of *E. granulosus* can live in a dog's intestine for about a year, but it remains fertile for just 6 to 10 months. Therefore, theoretically the infection would die out if man ceased re infecting dogs by feeding them raw viscera. Domestic animals that serve as secondary hosts could still become infected for a time, since the eggs of *Echinococcus* are resistant to environmental factors, but the infection cycle would be halted if dogs were prevented access to the infected viscera (Oryan *et al.*, 2012).

A gravid proglottid of *E. granulosus* contains a very small number of eggs (from 200 to 800) compared with those of other tapeworms, which contain many thousands. It is estimated that only one segment of *E. granulosus* is eliminated every two weeks (Lawson and Gemmell, 1983). This low biotic potential of *E. granulosus* is compensated for by the high rate and intensity of infection in the definitive host and by the asexual multiplication of the larva in the intermediate host (Fakhar and Sadjjadi, 2007).

The survival time and dispersion of the eggs are of great epidemiological interest. The eggs have little resistance to desiccation and extreme temperatures. In the laboratory,

the eggs of *E.granulosus* can survive in water or damp sand for three weeks at 30°C, 225 days at 6°C, and 32 days at 10–21°C (Lawson and Gemmell, 1983). After 10 days, radial dispersion up to 80 m from the place the feces were deposited has been confirmed for eggs of other taeniids; they may be able to disperse even greater distances with the aid of mechanical vectors such as carrion birds and arthropods. The physical composition of the soil, its porosity, and the kind of vegetation cover also help determine the length of time that the eggs survive (Lawson and Gemmell, 1983).

As we have said, man is an accidental host, and his direct contact with dogs is important. The gravid proglottids are found primarily on the surface of fecal matter, and they can accumulate in the perianal region, where they disintegrate and release the eggs. The dog carries the eggs on its tongue and snout to different parts of its body, and a person's hands can become contaminated by touching the animal. Close contact with dogs and deficient personal hygiene practices, such as failure to wash the hands before eating, are important factors in the transmission of the infection from dogs to humans. Another important source of human infection can be vegetables and water contaminated with infected dog feces. Coprophagic flies may also serve as mechanical vectors of the eggs (Van *et al.*, 2014).

2.4. Life cycle

All species of *Taenia* have similar life cycles. The adult tapeworm lives in the definitive host's small intestine. Proglottids, which contain eggs, break off the posterior end of the tapeworm, and these proglottids are either passed intact in the host's feces or they dissolve in the host's intestine and eggs are passed in the feces. When a suitable intermediate host ingests the eggs, the oncosphere larva is released and, with the aid of the embryonic hooks, penetrates the intestinal wall and enters the bloodstream. Upon reaching the liver the oncosphere begins to develop into a *cysticercus*. Bladder worms break out of the liver and attach to the mesenteries throughout the abdominal cavity. The definitive host is infected when it eats an intermediate host infected with *cysticerci*. Upon ingestion the scolex evaginates, attaches to the intestinal lining, the bladder disintegrates, and the strobila is formed by the budding of the neck region (Van *et al.*, 2014).

As adults in the definitive host's small intestine, tapeworms rarely cause problems; in exceptional cases the tapeworms might physically block the intestinal tract, due to their large size, or proglottids might become lodged in the appendix and result in appendicitis. The proglottids of *Taenia* are large and muscular. Occasionally single proglottids or long chains of proglottids might crawl out of the anus of an infected human (Oryan *et al.*, 1998).

Echinococcus species have an indirect life cycle and must develop in both an intermediate and the definitive host. In many cases, the parasite cycles through the specific predators, scavengers, and its preys. The dog-sheep cycle is most likely to result in human infections. Other cycles include dog-camel, dog-horse, wolf-deer and coyote-deer. The intermediate hosts which include cattle and humans are infected by ingestion of eggs within the faeces of the definitive host. Parasites can develop in a variety of organs in the intermediate host but are often found in the liver and lungs. Larval/hydatid cyst stage from the embryo released from an egg develops a hydatid cyst, which grows to about 5–10 cm within the first year and is able to survive within organs for years (Palmer, 2011).

2.5 Clinical manifestations

The clinical manifestations in humans Teaniosis include abdominal pain, nausea, debility, weight loss, flatulence and diarrhea or constipation. A patient may have one or several of these symptoms and a high percentage of patients experience gastric hyposecretion. Individual reactions to the infection differ and may be influenced by psychogenic factors, since patients often notice symptoms only after they see proglottids (Symth, 1994). Signs like those of epigastric discomfort, hunger sensations and irritability were also observed in infested individuals (Harrison and Sewell, 1991).

Light or moderate cysticercosis in cattle is not usually associated with any defined clinical picture. Heavy infections, those induced experimentally by 200,000 to

1,000,000 *T. saginata* eggs, may give 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 (Oryan *et al.*, 1998).

Clinical syndrome is based on location and size of the Coenurus cyst in the brain or spinal cord (Avcioglu *et al.*, 2012). The time taken for the larvae to hatch, migrate and grow large enough to present nervous dysfunction varies from 2 to 6 months (Giadinis *et al.*, 2012). The disease is known as gid or sturdy which disease primarily localizes in the central nervous system of sheep and goats mostly, but can also be seen in camels, deer, pigs, horses, however rarely in cattle and humans (Yoshino and Momotani, 1988). While *C. cerebralis* initially causes purulent meningoencephalitis, later as the cyst grows, it leads to central nervous system symptoms resulting in death (Christodoulouopoulos, 2007).

Infected animals showed severe nervous manifestations including circling towards the side of the cyst location, blindness, convulsions, cerebral atrophy, thinning and morphologic changes in the cranium (Yoshino and Momotani, 1988). Various reported human cases were infected with *C. cerebralis* in the central nervous system (Benifla *et al.*, 2007) and the intraocular cavities resulting in endophthalmitis and retinal detachment (Inechukwu and Onwukeme, 1991).

The adult echinococcus is considered to be rather harmless to the definitive host, except when it occurs in large numbers, which may cause severe enteritis. The effect of the hydatid cyst on the intermediate host depends on the size and location of the cyst. There are few available data on the clinical effects of the cystic hydatid disease in animals since the cyst is slow in growing and animals are often slaughtered before it manages to create sufficient pressure on the tissue or organs. The hydatid cyst is normally well tolerated in humans until its development results in pressure on adjacent tissue or organs. The cyst may also burst into the peritoneal or thoracic cavity, which can cause anaphylactic shock or give rise to many new cysts (Yoshino and Momotani, 1988).

2.6. Diagnosis

The metacestodes are readily visible in the organs or musculature at autopsy and therefore; diagnosis of *C. bovis*, hydatidcyst and *C.cerebralis* is usually made during postmortem examination in abattoirs and packing plants (Gracey, 1999). Individual countries have different regulations regarding the inspection of carcasses, which usually attempts to reconcile the interests of owners and those of the consumers (Eom and Rim, 1999).

Taenia saginata, *T.multiceps* and *Echinococcus* spp. also infect humans and, as taeniid eggs in dogs cannot be differentiated to species or genus level, in areas where these are endemic, the same safety precautions apply. While six other cestode genera are recorded occasionally in humans. These are described by Lloyd (2011) and all can be differentiated from *Taenia* spp. by egg/proglottid morphology.

In canids, *Echinococcus* spp. eggs cannot be distinguished from *Taenia* spp. eggs, but the presence of the former can be determined by tapeworm size and *Echinococcus* - specific antigen-capture enzyme linked immunosorbent assay (Ag-ELISA) (Allan *et al.*, 1992).

Adult cestodes can be expelled from humans using an anthelmintic followed by a saline purgative and are identified on the basis of scolex and proglottid morphology. A self-detection tool was used in Mexico (Flisser *et al.*, 2011); medical staff in health centers is supplied with preserved tapeworm segments in a bottle and a manual of questions to ask patients to try to identify carriers (Flisser *et al.*, 2011).

In animals, arecoline purgation has been useful; again, the recovered tapeworms are identified morphologically. Arecoline is no longer available as an anthelmintic, but can be obtained from chemical supply companies. As it has side-effects, old, infirm and pregnant animals should be excluded from treatment. A dose of 4 mg/kg should result in purgation in less than 30 minutes, provided food has been withheld for several hours (Allan *et al.*, 1992). Walking and abdominal massage of recalcitrant cases or enema for constipated dogs may avoid the use of a second dose (2 mg/kg), which should be given only sparingly. Fortunately, arecoline purgation is being

replaced rapidly by the coproantigen ELISA for *Echinococcus* spp. and perhaps in the future this will also be the case for *Taenia* spp. Tapeworms can be recovered after anthelmintic treatment, and require appropriate disposal (Flisser *et al.*, 2011).

Loos-Frank (2000) has given descriptions of parasitic diagnosis of all the *Taenia* spp. of humans and animals, their hosts and geographical distributions. Keys for identification are given by Khalil *et al.* (1994). Loos-Frank (2000) gives methods for mounting, embedding, sectioning and staining the proglottids. Flotation can be carried out in commercially marketed qualitative or quantitative flotation chambers or by centrifugal flotation that includes a modified Wisconsin technique (faeces, diluted in water, are sieved and centrifuged, the pellet is resuspended in sugar or Sheather's solution and centrifuged at 300 *g* for 4 minutes). Eggs adhering to the cover-slip can then be detected (Yoshino and Momotani, 1988).

Faecal egg examination will be less sensitive for *T. solium* than the other species. Species cannot be determined by egg morphology. (Cheesbrough, 2005; 2006) reports that *T. saginata* eggs can be differentiated from *T. solium* on staining with Ziehl-Neelsen as used for acid-fast bacilli: the striated embryophore of *T. saginata* is acid fast (stains red), that of *T. solium* is not acid fast.

DNA probes, the polymerase chain reaction (PCR) and PCR restriction fragment length polymorphism (RFLP), have proved useful for differentiation though largely used experimentally to differentiate faecal eggs of *T. solium*, *T. saginata* and *T. asiatica* (Gasser and Chilton, 1995; Gonzalez *et al.*, 2004). While equally applicable to differentiation in dogs, the same examinations have not been done for *Taenia* spp. An Ag-ELISA to detect *Taenia* coproantigen is available from Cestode Diagnostics, University of Salford and can be developed independently if laboratory facilities are available (Allan *et al.*, 1992).

This Ag-ELISA was developed experimentally by Allan *et al.* (1992) to detect coproantigen in dogs, and so, with appropriate controls, could be used to detect *Taenia* infection in this species. The technique, however, is only *Taenia*-genus specific. The test is a solid-phase, microwell assay with wells coated with polyclonal, rabbit anti-*Taenia*-specific antibody (TSA).

Sensitivity of serological tests for animals has not reached the stage where commercialization for individual diagnosis or large scale detection of infected carcasses in slaughter houses is possible. All assays tested – Ag-ELISA, antibody ELISA, enzyme-linked immunoelectro transfer blot (EITB) and tongue inspection – show low sensitivity in rural pigs infected naturally with low levels of *T. solium* (Dorny *et al.*, 2005; Abusier *et al.*, 2006). This finding is also true for *T. saginata* infections in cattle (Eichenberger *et al.*, 2013).

Diagnosis of human hydatidosis is suspected based on the clinical symptoms and epidemiological circumstances. Imaging methods such as radiography, computerized tomography, ultrasonography, and scintigraphy are used. While they do not confirm the diagnosis, they are very helpful to the specialist. Ultrasonography is the first choice because it is economical, noninvasive, simple, and accurate and reveals developing cysts that generally cannot be found with Xrays (Suwan, 1995).

Numerous immunobiologic tests have been used in the diagnosis of human hydatidosis by *E. granulosus*, among them Casoni's intradermal test, complement fixation, indirect hemagglutination, latex agglutination, immuno electrophoresis, electrosyneresis, and double diffusion to detect antibodies against the arc 5 antigen. Practically all have been displaced by ELISA and the immunoelectrotransfer or Western blot test. Casoni's intradermal test is not very sensitive and isnonspecific for the diagnosis (Navarrete *et al.*, 1995).

In the definitive host, a post-mortem examination is the most reliable method of diagnosis. Examination of the faeces after using arecoline as a purgative is less reliable, although proglottides in the faeces are conclusive. Egg counts are not specific because of the similarity of eggs from other tapeworms of the Taenia family (FAO, 1982).

Serological screening has recently proved to be a powerful tool in detecting infected dogs (Gasser *et al.*, 1990) and is superior to the arecoline testing. In the intermediate host, diagnosing hydatidosis is possible through scanning, radiology, serology and postmortem examination. The post-mortem examination of sheep is usually an

important component in monitoring the efficiency of control programs (Eichenberger *et al.*, 2013).

Diagnosis of cerebral coenurosis in the intermediate hosts can be made by recovery and examination of the cyst (Acha & Szyfres, 2003). The disease can be diagnosed on the basis of history, clinical signs and on the basis of the postmortem examinations in the animals died due to this disease (Uphadhayas, 2005). Diagnosis of the cerebral coenurosis is dependent on the clinical manifestations, neurological examination, ultrasound examination and post-mortem examination (Godara *et al.*, 2011; Biswas, 2013).

Animal cerebral coenurosis is usually diagnosed based on a clinical examination protocol and seldom includes imaging methods like radiology, ultrasonography and CT-scan which are mainly used in experimental situations. Immunodiagnosis tests such as skin test for immediate hypersensitivity, indirect haemagglutination antibody test, immuno-electrophoresis, gelldouble diffusion, ELISA tests have been used experimentally. Despite the availability of these tests which have their own practical challenges, post mortem findings of a thin walled cyst filled with transparent fluid and with numerous scoleces in the wall remain the definitive diagnosis (Afonso *et al.*, 2011).

The presumptive diagnosis in man is generally made by establishing the existence of a lesion that occupies space; however, since coenurosis is much less common than hydatidosis, coenurosis is rarely considered before the parasite is recovered (Pierre *et al.*, 1998). Because of the relative infrequency of human coenurosis, there has been no incentive to develop immunological diagnostic techniques.

2.7. Treatment

For human there are a number of taenicidal drugs available in the market. However the drug of choice in treating Taeniosis is niclosamide (Niclocide, Yomesan). Adult dose rate of 2000 mg is effective in damaging the worm to such an extent that a purge following therapy often produces the scolex. Praziquantel (Biltricide) at a dose rate

of 5 to 10 mg per kg also has been reported highly effective (Doyle *et al.*, 1997) but the scolex is partially digested and often not recovered (Symth, 1994). Other drugs used in the treatment of *T. saginata* are mebendazole (Soulsby, 1982; Doyle *et al.*, 1997) followed by purgative, for example magnesium sulphate (MSO₄) to expel the dead worms in to (Soulsby, 1982; Symth, 1994).

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(Soulsby, 1982; Symth, 1994). Praziquantel is effective at 50mg/kg/day for four days but this treatment is impractical because of its high cost (Reniecke, 1983). A number of anthelmintic drugs have proved to be effective against adult stages of *E. granulosus* in the final host. The best drug currently available is exterminates all juvenile and adult echinococci from dogs (Schantz, 1982; WHO 1983)

Unfortunately, surgery is the treatment of choice at present, but several of the benzimidazole compounds have been shown to have efficacy against the hydatid cyst in the intermediate host. Long-term treatment with albendazole has a particularly marked effect on the cysts. While long-term treatment with praziquantel only has a limited effect with few changes in the germinal layer of the cyst (McManus and Smyth, 1986; Morris *et al.*, 1990).

Recombinant vaccines have been developed using non-living antigens of the parasite, host protective responses can be induced readily in the intermediate hosts, may be used to control in cattle (Lightowlers *et al.*, 1996).

Treatment based on surgical removal of the coenurus cyst after general anaesthesia of the animal, achieves a very good success rate, especially after accurate anatomic localization of the lesion within the brain (Scott, 2012). Surgery of the skulls and brains of Sheep with cerebral coenurosis would be effective up to 90%, if the brain and skull are first tested by magnetic resource imaging or ultrasonography (Manunta *et al.*, 2012).

According to Ghazaei (2007) combination of fenbendazole together with praziquantel and albendazole is effective against the *cerebral coenurosis*. He has shown that praziquantel administration with dosage rates of 50 to 500 mg/kg resulted in successful treatment of this metacestode. Chemotherapy could be applied only immigration stages of the parasite. The efficacy of the antiparasitic drugs such as albendazole, fenbendazole, and praziquantel against cerebral coenurosis was supported by other studies too; for instance, one study was done by Afonso et al.(2014).

The commonly used medical herbs in decreasing order of preference based on toxicity, higher potency and shorter worm expulsion time are: *Cucurbito pepo*, *Thymusserrulatus*, *Maesa lanceolata*, *Cynodon dactylon*,, *Glinus lotoides*, (Desta,1995; Tembo, 2001).

Table 1: Commonly used traditional anticestodal medicinal plants

Local name	Scientific name	Part of plant
Bisana	<i>Croton macrostchys</i>	Seeds
Kosso	<i>Hagenia abyssinica</i>	Flower
Enkoko	<i>Embelia schimperi</i>	Fruit
Mettere	Amkint <i>Glinus lotoides</i>	Seed
Duba fre	<i>Cucurbitapepo;the pumpkin</i>	Seed
Gortteb	<i>Plantago lanceolata</i>	Dn
Wogert	<i>Silen macrosclen</i>	Root
Dendero	<i>Echinopis gigantean</i>	Dn
Serdo	<i>Cynodon dactylon</i>	Dn
Kkeleum	<i>Maesa lanceolata</i>	Dn
Tossigne	<i>Thymus serrulatus</i>	Dn
kechemo	<i>Myrsine africana</i>	Dn

Dn# = Do not kno,

Source: (Desta, 1995)

2.8. Prevention and Control

Lack of and improper use of latrine or open field defecation leads to contamination of grazing lands. The use of latrine reduces spread of *T. 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 - 600c) and freezing the infected carcass at -100 c for 10 days prevent human infection. Chemotherapy in humans reduces the spread of eggs and infection in cattle (Solusby, 1982).

Control of coenurosis in livestock relies on the same measures as those used to prevent other metacestodoses (Varcasia *et al.*, 2009). Cerebral coenurosis can be controlled by regular anthelmintic treatment of dogs at 6–8 week intervals, by using an effective taenicide, and correct disposal of sheep and goat brain after slaughtering or death of animals to prevent scavenging by dogs belonging to the general public, which may not receive regular anthelmintic treatment (Scott, 2012).

Echinococcosis can be controlled through preventive measures that break the cycle between the definitive and the intermediate host. These measures include dosing dogs, inspecting meat and educating the public on the risk to humans and on avoiding feeding offal to dogs, as well as introducing legislation. None of these measures will work in isolation (Van *et al.*, 2014). However, the disease can be controlled successfully through health education and appropriate legislation only when people understand the life cycle of the parasite. It is of the utmost importance that the government be involved, through the Ministries of Health, Agriculture and the Interior, for example. So far, the only successful control programs have been those where the Ministry of Agriculture has been the responsible control authority (Van *et al.*, 2014).

Therefore, dogs should be considered as the main source of infection and the major risk factor. The big problem for control of these diseases is reducing the risk factors including access of the stray dogs and other wild carnivores to the infected carcass wastes, consumption of raw meat and unwashed vegetables, poor sanitation, use of

human feces as fertilizer, and inadequate meat inspection (Oryan *et al.*, 2012; Van *et al.*, 2014).

Regular deworming of carnivorous pets and repeated treatment of dogs (the major final host in most cases) with anti-parasitic agents, public awareness of different ways of parasite transmission, accuracy in carcass inspection, health education for dog owners, proper condemnation of the infected carcass to reduce the stray dog population, all can be useful in reducing the prevalence and incidence of these zoonotic parasitic diseases (Oryan *et al.*, 2012; Van *et al.*, 2014).

2.9. Zoonotic importance and risk factors

Man is the only final host where the adult *Taenia saginata* resides in the small intestine. The size reached by the adult worm is related to the number of worms present (Maeda *et al.*, 1996). In a single worm infection, a worm can develop longer and produce large number of proglottids (Symth, 1994). Multiple infections up to 20 tapeworms in one host have often been reported in developing countries. The effect on human health is generally slight and symptoms may be vague or absent. However, taeniosis has a debilitating effect on people who live on protein deficient diets and those who suffer from iron deficiency and infected by hookworm (Mann, 1984).

Taeniosis causes various symptoms, which probably depend very much on the psychological and physical characteristics of the host. Some patients lose their appetite and thus lose weight while others tolerate the infection. Sometimes the gravid proglottids of *T. saginata* migrate to different organs appendix, pancreatic duct, nasopharyngeal pathways and bile ducts producing obstruction and inflammation of the affected organs (Florova, 1982).

Tapeworms can also cause intestinal obstruction (Doyle *et al.*, 1997). *T. saginata* in the small intestine of man absorbs digested food. From the day the Cysticercus is ingested it may take 2-3 months for the parasite to produce ripe segments. As long as the scolices are attached to the intestinal mucosa of the victim new segments will

continually grow to replace those, which are being detached from the worm (Teka, 1997).

The prevalence of Taeniosis associated with different risk factors. The potential risk factors of Taeniosis are: habit of raw meat consumption, age, sex, religion, educational level and presence and usage of sanitary facilities especially toilets. Different scholars have controversies regarding to disease prevalence in association with such risk factors. Most researchers underline that there is higher prevalence of Taeniosis in those who consume raw meat than those having cooked meat dishes, in Ethiopia (Dawit, 2004 ; Hailu, 2005; Endris and Negussie, 2011 and Tesfaye *et al.*, 2012).

Cystic echinococcosis is a public health problem in different geographical areas of the world, particularly in Asia, South America, Central America and Africa (McManus and Smyth *et al.*, 1986). Spain and other Mediterranean countries are considered as hyper endemic areas (McManus and Thompson *et al.*, 2003). *E. granulosus* of carnivores and its metacestode in herbivores and man have been recognized as the most important helminth zoonosis and of great economic and public-health significance in developing countries (Eckert *et al.*, 2000).

Echinococcosis due to *E. granulosus* which occurs at high prevalence in both dogs and livestock and also accounts for the highest number of condemned lungs in slaughterhouses is of major public health concern in Zambia (Pandey and Sharma, 1987). Dogs are the most successful canids adapted to human habitation world-wide (Robertson *et al.*, 2006; Ugbomoiko *et al.*, 2008; Dohoo *et al.*, 2009).

They have contributed to physical, social and emotional well-being of their owners, particularly children who are often at greatest risk of exposure. However, despite the beneficial effects, close bonds of dogs and humans (in combination with inappropriate human practices and behavior) remain a major threat to public health, with dogs harboring a bewildering number of infective stages of parasites (including *Echinococcus*) transmissible to man and other domestic animals (Molyneux, 2004; Ugbomoiko *et al.*, 2008).

Certain deep-rooted traditional activities have been described as factors associated with the spread and high prevalence of the disease in some areas. These factors include; the wide spread backyard slaughter of animals, the corresponding absence of rigorous meat inspection procedures, the long standing habit of feeding domesticated dogs with condemned offal and the subsequent contamination of pasture and grazing fields (Getaw *et al.*, 2010). This can facilitate the maintenance of the life cycle of *Echinococcus granulosus* which is the causative agent of cystic hydatidosis and consequently the high rate of infection of susceptible hosts (Biffa *et al.*, 2006).

Risk factors for human hydatidosis include: a pastoral occupation, a history of dog ownership, poor education background, eating habits, age, sex and drinking water source (McManus *et al.*, 2003).

Coenurus cerebralis in human beings diagnosed for the first time in 1913 in Paris, when a man presented symptoms of CNS nerve degeneration. He had convulsions and trouble speaking/ understanding speech. During his autopsy, two coenuri were found in his brain. Recently (within the last 25 years), human cases have been recorded in Uganda, Kenya, Ghana, South Africa, Rwanda, Nigeria, Italy, Israel, Mexico, Canada and the United States, and animal cases have been found in many other countries as well. In 1983, a 4-year-old girl in the USA was admitted to the hospital with progressive, generalized muscle weakness, inability to walk, rash, abdominal pain and deteriorating neurological ability (McManus *et al.*, 2003).

The presence of shepherd (dog used as sheep keeper) dogs on grazing land as well as in paddocks, greatly contributes to the existence of the disease. Dogs are frequently fed on viscera, trimmings, and heads of butchered animals, and they are not treated for parasitic diseases, thus maintaining *C. cerebralis* –*T. multiceps* life cycle. Introduction of dog or sheep with *taenia multiceps* or *coenurus cerebralis* in to an area where the disease is less prevalent, could pose a considerable risk for the introduction of coenuruses into the new area (Gicik *et al.*, 2007; Jibat *et al.*, 2008).

Farmer or the owner often facilitate the contamination of the environment by opening the skull of infected sheep leaving the *Coenurus* cyst free to be eaten by dogs or, feeding them directly with the definitive host (Scala and Varcasia, 2006). The higher

percentages of ecological variables (rainfall, relative humidity and air temperature) are considered to be the influencing factors for coenurosis. In rainy season, rain causes spread of feces of dog, fox (Final host) over the grasses and these contaminates are responsible for the increased occurrence of gid during rainy season (Hashim *et al.*, 2000). According to Gicik *et al.*(2007) selling of sick animals to abattoirs or market by owners as soon as they noticed the coenurosis without informing the local authorities leads to the high prevalence of *Coenurus cerebralis* in the area.

2.10. Economic importance

Attempts to reduce the prevalence of *T. saginata* in humans and their *cysticerci* in cattle may have a considerable impact on the economics of meat production industries. Cysticercosis in domestic animals is a significant food safety problem and causes economic loss in food production. This will be particularly important where export industries are involved, since most importing countries have stringent regulation designed to prevent the importation of infected meat (Harrison and Sewell, 1991).

The cost implication can be broken down into those involved in treating human taeniosis and cattle carcasses (costs of freezing, boiling) or condemned, as well as the costs involved in the inspection procedures that amounts to millions of dollars (Mann, 1984). An annual loss due to treatment in USA was USD 100, 000 (Robert, 1985).

Similarly, different reports have shown that losses due to treatment of human taeniosis are significant, Megersa *et al.* (2009), reported 4,913,346 adult taeniocidal drugs doses worthing 72,190,21 Eth, Birr (820,343 USD) in Jimma. Carcasses shall be considered excessively infested and totally condemned if incision in various parts of the musculature exposes on most of the cut surfaces (Budke *et al.*, 2005). In this regard, findings so far reported in Ethiopia have demonstrated losses due to partial condemnation of carcasses and edible internal organs. Examples are: - liver, kidney, heart.

Echinococcosis in humans and animals is both an economic and public health problem in many parts of the world (Budke *et al.*, 2005; Moro and Schantz *et al.*, 2006). For example, in the North African countries, the cost to human health treatment and animal losses was estimated at US\$ 60 million per year (Budke *et al.*, 2005; Moro and Schantz, 2006). In Jordan alone, a more recent estimate was reported at an equivalent of twenty one million US\$ dollars (Conteh *et al.*, 2010).

Hydatidosis in animals is equally an economic problem and results in growth delays; the qualitative and quantitative production loss of meat, milk, wool; the fall in fertility as well as the seizures of viscera (offal) during meat inspection (Torgerson *et al.*, 2002; Torgerson and Budke, 2003).

Cerebral coenurosis is an economically important disease as it causes serious problems especially in the sheep industry and breeding (Scala and Varcasia, 2006; Varcasia, 2009; Kheirandish *et al.*, 2012). The disease has 100% mortality rate which cause severe economic losses in small ruminants (Upadhayay, 2005). Gicik *et al.*(2007) reported that as coenurosis is one of the major contributors to sheep mortality, especially in young sheep of the region in Kars province in Turkey.

Miran (2013) show that Coenurosis ranked amongst the most important sheep and goats diseases in Tanzania, where 58.8% and 47.9% of respondents ranked it as the disease of most concern in sheep and goats respectively in terms of mortality and all have felt the effects of the disease. Among the direct losses arising from cerebral coenurosis are emergency sales or slaughter of affected animals once the clinical disease became apparent and sometimes death occur.

In Ethiopia, according to Deressa *et al.*(2012) total annual financial loss due to brain/animal condemnation estimated at 8330 Ethiopian Birr (490 US\$). Main causes of brain condemned is due to brain with a higher *coenures cerebralis* cyst. Though brain is not a common dish for Ethiopians, there is a higher demand in the Middle East countries (Jibat *et al.*, 2008).

3. MATERIALS AND METHODS

3.1. Study area

The present study was conducted from November, 2015 to March, 2016 in the Elfora export Abattoir, in the Bishoftu city of Ethiopia. Elfora export abattoir is found in Bishoftu town which is located at 90 N and 40 E. Its altitude is about 1880 m above sea level at 47 km South East of Addis Ababa (CSA, 2016).

3.2. Study animals

All local breeds of sheep and goats that originated from neighboring localities and/or regions for slaughter in Elfora export abattoir were included in the study population. All male sheep & goats were subjected for the study and age of the animals were grouped based on dentition, for those which have not erupted permanent incisor teeth, are classified as young, while those with pair or more permanent incisor teeth erupted were classified as adult (Alemu and Merkel, 2008). All cattle inspected were adult males and from similar agro-ecological sites and husbandry systems.

3.3. Study design and sample size

A cross-sectional study type was carried out from November, 2015 to March, 2016. The total number of animals required for the study was calculating based on the formula given by (Thrusfield, 2005). A simple random sampling procedure was employed to carry out this study. By rule of thumb where there is no information for an area it is possible to take 50% of expected prevalence. Using 5% degree of absolute precision, 384 animals need to be sampled. For this study, the required sample size was 384, but in order to increase precision, it was maximized to a sample size (1169) of 384 for cattle, 385 for sheep and 400 for goats. Whereas, a questionnaire type of study were based on the formula recommended by Arsham (2002) $N = \frac{0.25}{SE^2}$, $SE = 5\%$, $N = 100$, Where $N =$ sample size, $SE =$ standard error assuming the standard error of 5% at a precision level of 0.05 and the confidence interval of 95%. the sample size for the questionnaire survey was expected to be 100.

3.4. Data collection and examination

3.4.1. Active Abattoir Survey

Active abattoir survey was conducted during routine meat inspection on randomly selected cattle, sheep and goats. During ante-mortem examination of each study animal was given an identification number and its age and origin was recorded. After slaughtering the cattle, sheep and goats, post-mortem examination was carried out using standard procedures recommended by FAO/UNEP/WHO (FAO/UNEP/WHO, 1994; Swai and Schoonman, 2012). During post-mortem examination, carcasses and their respective organs was carefully examined for the presence of metacestodes. Visual inspection and palpations followed by multiple incisions in livers, kidneys, lungs, hearts, spleens and other organs were made to detect metacestodes.

3.4.2. Cyst fertility and viability test

All the positive samples were transported to Addis Ababa University, College of Veterinary Medicine and Agriculture, Veterinary Parasitology Laboratory for confirmation of cyst viability. The viability of the cysts (*C. bovis*) was examined by using 30% ox bile solution diluted in normal saline and incubated at 37 °C for 1 to 2 h. A cyst was regarded as viable if the scolece vaginated according to Gracey (1999).

For the case of hydatid cysts, individual cysts were grossly examined for degeneration, then according to the size (not too small) hydatid cysts in cattle, sheep and goats were selected for fertility study. To reduce intracystic pressure, the cyst wall was penetrated, using needle and it was cut with scalpel and scissors. The contents were then with out any protoscoices), calcified, non viable (cysts with dead protoscoices) and viable or fertile (cysts with live protoscoices). To determine viability of the protoscolices, a drop of cyst fluid was placed on a microscopic glass slide and cover slip was applied and observed for the motility of flame cells activity like peristaltic movement. When it becomes doubtful for motility, a drop of 0.1% aqueous eosin solution was added and examined under a light Microscope for taking

the dye. Live protoscolices did not take the dye whereas, the dead ones did according to Daryani et al.(2006).

3.4.3. Retrospective data collection

The data was collected from randomly selected health centers and referral hospitals in Bishoftu town, case book retrospective data of three years (2013-2015 E.C) were collected and analyzed to assess the prevalence of human taeniosis. Sex was recorded.

3.4.4. Questionnaire survey

To determine the infection rate and associated risk factors of human taeniosis, 100 volunteer respondents from different sex, age, level of education, occupation and religion were selected using random sampling based on willingness to participate in the questionnaire survey.

3.5. Data Management and Analysis

The data collected from abattoir and questionnaire was stored into Microsoft excel. The collected data was analyzed using SPSS.ver.20 (USA) statistical software. The degree of risk factors association with the disease occurrence was further analyzed using odd ratios. Chi-square (X^2) test was used to determine the variation in infection, prevalence between species, ages and origins. Questionnaire survey data was summarized using descriptive analysis and important factors were tested with logistic regression for their contribution for the occurrence of taeniosis in human. For the questionnaire survey we were used Health belief model (HBM) to assess the risk perception level.

4. RESULTS

4.1. Prevalence of metacestodes

In the current study, a total of 1169 animals comprising 384 cattle, 385 sheep and 400 goats slaughtered in Elfora abattoir were examined for the presence of metacestodes. Out of the total 785 small ruminants examined for the presence of hydatid cysts and *C.cerebralis* an overall prevalence of 7.39% and 3.8% was recorded, respectively. Of the total 400 goats examined for hydatid cysts, 27 (6.8 %) and *C.cerebralis*, 20 (5%) were found positive. Likewise, of the 385 sheep examined, 31 (8.1%) and 10 (2.6%) were found positive for hydatid cysts and *Coenurus cerebralis*, respectively. Statistical analysis showed that there was no significant difference among the species ($P>0.005$) (Table 2).

Table 2: Prevalence of hydatid cysts and *C.cerebralis* in sheep and goats

Species	No of examined	Hydatid positive	Prevalence (%)	<i>C.cerebralis</i> Positive	Prevalence (%)
Sheep	385	31	8.1	10	2.6
Goat	400	27	6.8	20	5
Total	785	58	7.39	30	3.8

The risk of exposure to *C.cerebralis* based on different origin and age groups of both species were examined. Higher prevalence *C.cerebralis* was found in young of both sheep and goats compared adult groups. There was no significant difference in the prevalence of *Coenurus cerebralis* in sheep at different age groups and in both species due to geographical origin. However, young goats found significantly affected by *Coenurosis*.

Table 3: Risk factors associated with the occurrence of *C. cerebralis* in carcass inspected at Elfora abattoir

Risk factor	Total number	Positive	Prevalence (%)	X ²	P-value	CI	OR
Sheep							
Age							
Young	147	4	2.7	0.14	0.905	(0.257-0.333)	0.925
Adult	238	6	2.5				
Origin							
Negelle	86	2	2.3	0.375	0.829	(0.104-0.085)	0.951
Yabello	120	4	3.3				
Konso	179	4	2.2				
Goats							
Age							
Young	163	9	5.5	0.005	0.944	(1.413-2.587)	1.033
Adult	237	11	4.6				
Origin							
Negelle	130	7	5.4	0.341	0.952	(0.016-0.144)	0.397
Yabello	128	7	5.5				
Konso	142	6	4.2				

Prevalence of *Hydatid* cysts revealed significant variation in the origin of both species of small ruminants. There was statistically significant difference in origin and age of

the goats ($p < 0.05$). where old goats by far had higher opportunities of obtaining hydatid cyst than young ones. More Hydatid infected sheep were found in Negelle(17.6%) where as 11.7 % of goats with Hydatid cyst was found in Yabello zone. In General, the prevalence of HC in sheep were higher compared with goats but not significance difference($P > 0.05$) (Table 4).

Table 4: Risk factors associated with the occurrence of Hydatid cysts in carcass inspected at Elfora abattoir.

Risk factor	Total Number(N)	Number of positive	Prevalence (%)	X ²	P-value	CI	Crude OR
Sheep							
Age							
Young	147	9	6.1	1.196	0.274	(0.699-3.491)	1.562
Adult	238	22	9.2				
Origin							
Negelle	91	16	17.6	14.782	0.001		
Yabello	116	5	4.3				
Konso	178	10	5.6				
Goats							
Age							
Young	163	6	3.7	4.117	0.042	(1.003-6.450)	2.544
Adult	237	21	8.9				
Origin							
Negelle	130	8	6.2	8.584	0.014		
Yabello	128	15	11.7				
Konso	142	4	2.8				

Organ distribution hydatid cyst revealed that lung and liver were found frequently infected. Out of 49 sheep with hydatid cysts, 28 (57.1 %) harbored hydatid cysts in lung, 18 (36.7 %) in liver, 1 (2.04%) in kidney and 2 (4.08 %) in muscle. Similarly in

goats, out of 42 with hydatid cysts, lungs accounted for 30 (71.4 %), liver 10 (23.8 %), kidney 1 (2.38 %) and 1 (2.38 %) harbored hydatid cysts in muscle (Table 5).

Table 5: Distribution of hydatid cysts in different organs of infected sheep and goats

Animals	N ₀ .Examined	Lung	Liver	Kidney	Muscle
Sheep	385	28(57.1%)	18(36.7%)	1(2.04%)	2(4.08%)
Goats	400	30(71.4%)	10(23.8%)	1(2.4%)	1(2.4%)

In sheep, a total of 49 cysts were examined to identify cyst fertility or viability. From those 12 (24%), 10(20%), 14 (28%) and 13 (26%) were identified as fertile, non viable, sterile and calcified, respectively. Fertile cysts were mostly detected in lung which were 8 (66.7 %) of the whole fertile cysts. However, most of cysts in the liver 8 (66.7%) were found calcified (Table 6). Viable cysts were higher in lungs compared to liver although not statistically significant. In goats, a total of 42 cysts were examined to identify cyst fertility. From those 6 (14.29 %), 11 (26.19 %), 8 (19.05 %) and 17 (40.48 %) were identified as fertile, non viable, sterile and calcified, respectively. From a total of 10 liver cysts there was no sterile cyst detected in goats. Rather calcified cysts in goats were found mostly in lungs which were 11(36.67 %) of the whole cysts (Table 6).

Table 6: Classification of hydatid cysts collected from sheep and goats slaughtered in Elfora abbator based on viability of cysts.

Organs	Viable		Non Viable		Sterile		Calcified		Total	
	sheep	goat	sheep	goat	sheep	goat	sheep	goat	sheep%	goat%
Lung	8	3	6	8	9	8	5	11	28(57.1)	30(71.4)
Liver	2	1	4	3	4	0	8	6	18(36.7)	10(23.81)
Kidney	0	1	0	0	1	0	0	0	1(2.04)	1(2.38)
Muscle	2	1	0	0	0	0	0	0	2(4.08)	1(2.38)

All 384 cattle inspected were adult males and from similar agro-ecological sites and husbandry systems. Of those, 17 (4.4 %) and 47 (12.2%) were infected with *Cysticercus bovis* and hydatid cysts, respectively. A total of 47 cysticerci were collected and occurred in decreasing order, in the tongue 29.79% (14), triceps muscle 23.4% (11), masseter muscle 19.15% (9), shoulder muscle 17.02% (8) and heart 10.64% (5) (Table 7).

Table 7: Distribution of hydatid cysts and *Cysticercus bovis* in different organs of cattle slaughtered in Elfora abbator

Cysticercus bovis			Hydatid cyst		
Organs inspected	No positive	Proportion (%)	Organs inspected	No positive	Proportion (%)
Tongue	14	29.8	Lung	75	63
Triceps muscle	11	23.4	Liver	40	33.6
Masseter muscle	9	19.1	Kidney	4	3.36
Shoulder muscle	8	17			
Heart	5	10.6			
Total	47	100		119	100

Out of 47 cysticerci, 21 (44.68 %) were viable and 26 (55.32 %) were non viable. Viable cysticerci were observed in the triceps (7), tongue(6), masseter (4) shoulder (3) and heart (1) muscles, in descending order. Non viable cysts were recovered from tongue (8), masseter(5), shoulder (5), triceps (4) and heart (4) muscles, in decreasing order (Table 8).

Table 8:Fertility of *Cysticercus bovis* in different organs of cattle slaughtered in Elfora abbator

Organ	Viable	Non Viable	Total
Tongue	6	8	14(29.8%)
Triceps	7	4	11(23.4%)
Masseter	4	5	9(19.1%)
Shoulder	3	5	8(17.0%)
Heart	1	4	5(10.6%)
Total	21(44.7%)	26(55.3%)	47 (100%)

Out of a total of 384 cattle carcasses, 47 (12.2 %) were infected with hydatid cysts, a total of 119 hydatid cysts being collected from the infected animals. Of these cysts, 25 (21.01 %) were viable,15(12.61%) non viable, 19 (16 %) sterile and 60 (50.4 %) calcified. Cysts were found in the lungs75 (63.03 %), liver 40 (33.6 %) and kidneys 4 (3.36 %) (Table 9).

Table 9: Viability of hydatid cyst different organs of infected cattle slaughtered in Elfora abbator.

Organ	Viable	Non Viable	Sterile	Calcified	Total
Liver	5	1	0	34	40(33.6%)
Lung	20	14	15	26	75(63%)
Kidney	0	0	4	0	4(3.36%)
Total	25 (21%)	15 (12.6%)	19 (16%)	60 (50.4%)	119(100%)

4.2. Retrospective Hospital and Clinical Case-Book Survey

The significance impact of cyst of taeniosis on public health was investigated through retrospective data from Bishoftu referral hospital,Amanuel and Edom private clinic of admitted cases during the period of 2005 to 2007 E.C as revealed in the table below.

Table 10: Total number of patients admitted for stool examination and registered cyst of taeniosis cases in Bishoftu referral hospital and two private clinics in Bishoftu town, Sept. 2005–Aug 2007 E.C.

Hospital/clinic and patient type	Number of patients				
	2005	2006	2007	Total	%
Bishoftu referral hospital					
<i>Admitted</i>	12,165	9,676	13,104	34,94	46.8
<i>Cases</i>	26	28	26	80	17.4
Edom private clinic					
<i>Admitted</i>	8676	8964	10,620	28,260	37.8
<i>Cases</i>	16	12	263	291	63.4
Amanuel private clinic					
<i>Admitted</i>	3,880	3,683	3,916	11479	15.4
<i>Cases</i>	21	20	47	88	19.2
Total					
<i>Admitted</i>	24,721	22,323	27,640	74,684	100
<i>Cases</i>	63	60	336	459	100
Prevalence	0.26	0.27	1.2	0.61	0.61

In the study area, the number of patients admitted and the number of human Taeniosis cases were unexpectedly high at Edom private clinic. This may be related to the preference of patients for that clinic due to the relatively superior disease diagnosis. Of a total of 74,684 patients admitted for stool examination in the two private clinics and one referral hospitals in Bishoftu town, 495 (0.61%) Taeniosis cases were registered between September 2005–August 2007 E.C. Of these, 291 (63.4%) were from Edom clinic, 88(19.2%) were from Amanuel clinic and 80 (17.4%) from Bishoftu referral hospital (Table 10). sex groups of the human Taeniosis cases are shown in Table 11.

Table 11: Sex distribution of human Taeniosis cases in referral and private health institutions in Bishoftu, September 2005 to August 2007 E.C

Sex	TotalNo. examined	Infected		Odds ratio	95% CI	P-value
		No.	%			
Male	31,173	275	0.88	2.096	1.738-2.527	
Female	43,511	184	0.42	0.477	0.396-0.575	.000
Total	74,684	459	0.61			

Odds ratio of gender (male/female) is 2.096, indicates that males are 2 times more prone to acquiring Taeniosis than female. Higher prevalence of taeniosis among male individuals could be due to economic reasons and cultural practices in that male do not prepare their dish at home, rather consume at restaurants and butcheries.

4.3. Questionnaire Survey on Human Teaniosis

From a total 100 people responded to the questionnaires. In this study 41% of them, referred to as ‘the high risk group’ which means that this individuals have been practiced eating raw or undercooked meats denoted that they are engaging in a high risk behavior, whereas 59% of those who confirmed that they do not eat raw or undercooked meats are in turn referred to as ‘the low risk group’.

The demographic table indicated that there was a significant variation among all risk factors. In the evidence that the groups people differed in their behavioral experience of eating raw or undercooked meat except for any immediate family member work in the human or veterinary health care field (IFMWHV). Based on the gender almost half of the men experienced eating raw or undercooked meat but, only 6 out of 29 interviewed women were found to be in high risk behavior ($p = 0.007$) (Table 12). Education status created significant role in risk of exposure in which tertiary educated

individuals has low risk than illiterates and other levels of education. Although in terms of religion varied, there was significant difference in high risk group where large number of Christians experienced consumption of raw meat ($p = 0.001$).

Table 12: Results of questionnaire survey based on risk factor assessment

		Do you eat raw meats			P- value
		Total no	No	Yes	
Age	21-30	37	34	3	0.000
	31-40	49	23	26	
	41-50	13	2	11	
	51-60	1	0	1	
Gender	Male	71	36	35	0.007
	Female	29	23	6	
Religion	Christian	69	33	36	0.001
	Muslim	31	26	5	
Education	None	7	3	4	0.009
	Primary	16	5	11	
	Secondary	21	10	11	
	Tertiary	56	41	15	
Income	None	13	13	0	0.000
	<1USD	3	3	0	
	>11 USD	13	3	10	
	1-5 USD	35	27	8	
	6-10 USD	36	13	23	
IFMWHV	No	62	37	25	0.86
	Yes	38	22	16	

From a total of 100 people 69 (0.69%) knew that tapeworm could spread from animals to humans. More than (0.5%) was aware that even healthy looking meat could be contaminated by parasite. In this study less number of people 39(0.39%) knew about fatality of tapeworm, however, majority of these people were recognized for the presence of its treatment, prevention and well-endowed about its high cost treatment. Although there was statistically significant difference in the knowledge of people about the parasite; lower risk group still demonstrated better knowledge compared to the high risk group(Table 13).

Table 13: Questionnaire results on the Knowledge of respondents about meat borne parasites by risk category (n=100)

	Total No	Do you eat raw or undercooked meats		P-value
		Yes	%	
Tapeworm is caused by parasite?				
No	37(0.37%)	28	0.76	0.000
Yes	63(0.63%)	13	0.21	
How can I be caught by Tapeworm?				
Don't know	4(0.04%)	3	0.75	0.152
Eating raw/undercooked meat	96(0.96%)	38	0.4	
Who can transmit tapeworm?				
Exclude cattle	31(0.31)	13	0.42	0.89
Cattle	69(0.69)	28	0.41	
Tapeworm prevented by cooking meat				
No	46(0.46%)	38	0.81	0.000
Yes	54(0.54%)	3	0.06	
Animal has tapeworm show a symptom				
No	43(0.43%)	22	0.5	0.073
Yes	57(0.57%)	19	0.33	
Eats cooked meat, to prevent tapeworm				
No	52(0.52%)	39	0.75	0.000
Yes	48(0.48%)	2	0.04	
Tapeworm can be fatal disease				
No	61(0.61%)	25	0.41	0.478
Yes	39(0.39%)	16	0.4	
Rx start developing tapeworm symptom				
No	10(0.1%)	3	0.3	0.000
Yes	90(0.9%)	38	0.42	
Family/neighbor/friend suffered from tapeworm				
No	45(0.45%)	15	0.33	0.2106
Yes	55(0.55%)	26	0.47	
I know the disease has costly treatment				
No	31(0.31%)	10	0.32	0.206
Yes	69(0.69%)	31	0.45	

The evidence for the respondents' perception on susceptibility had a clear-cut in terms of for their knowledge with the question regarding if they eat raw or undercooked meats showing a significant difference compared with others with low level of perception ($P \leq 0.05$). In this case, the difference was in the expected direction, with

the low risk group more likely to agree that eating raw or undercooked meat keeps them at greater risk ($p = 0.00$). A related question about being at greater risk when used to eat eating raw or undercooked meat showed an effect in the same direction and was statistically significant ($p = 0.00$). Interestingly, high risk groups were also more likely to agree that the absence of access to cooking facilities, inspected meat or abattoir slaughtered meat increase their chances for the consumption of raw meat there by tends to attain the parasite. There was a significant difference between the two risk groups ($p = 0.00$) in terms of whether or not they think that contracting tape worm infection from eating raw meat.

There were statically significant differences ($p = 0.00$) in the self-action to prevention of tape worm infection. In this case, the low risk group was more likely to agree that they know where to buy safe meat and protect themselves, their family and neighbors. Two of the three items making up the self-efficacy construct were not statistically significant ($p \geq 0.00$). The two groups only differed in terms of whether they were able to differentiate infected carcasses, with the low risk group more likely to agree that they were able to do that ($p=0.02$).The vast majority of respondents agreed or strongly agreed that educational programmes and free maintaining of protective behavior would help ensure themselves not to prone to tapeworm infection.In addition, large number of respondents felt that they would give information about their deworming status and more intentioned not to eat raw/undercooked meat.

5. DISCUSSION

The present study revealed that the overall prevalence of cysticercosis in cattle slaughtered at Bishoftu Elfora abattoir was 4.4 %, which is comparable to the prevalence of 4.4% reported from Jimma (Megersa *et al.*,2010) 7.5% from Addis Abeba (Kebede *etal.*,2009), 8.2% fromTigray region (Kumar and Gebretsadik,2008), 6.7% from Kombolcha Abattoir (Endris and Negussie,2011). However, it was higher than the reported prevalence of 3% in Zeway (Bedu *et al.*, 2011), 3.11% in central Ethiopia (Tembo, 2001), 3.6% in Addis Abeba (Ibrahim and Zerihun, 2012), 2.98% in Nekemte (Abunna *et al.*,2011) and 2.93% in Jimma abattoir (Tolosa *et al.*,2009).

The prevalence of *cysticercus bovis* in this study was relatively lower as compared with previous reports from different abattoirs of Ethiopia, such as 11.3% from Wolaita Soddo (Regassa *et al.*, 2009), 22.9% from Hawassa municipal abattoir (Belachew and Ibrahim, 2012), 26.25% from Southern Ethiopia (Abunna*et al.*,2008 and from other countries 16% from Upper Egypt (Basem *et al.*, 2009), 72.2% from Nigeria (Ikpeze*et al.*, 2008)and other endemic areas in Africa and Asia by other authors (Opara *et al.*, 2006; Muneyeme *et al.*, 2010; Garedaghi *et al.*, 2011).The variation of prevalence in different study sites may be due to variations in personal and environmental hygiene, religion, culture and feeding habits of the population and their production systems (Megersa *et al.*, 2010). The difference in prevalence rate could also attribute due to the limitation of conventional method of meat inspection which is less sensitive to pick all animals that are infected with *T. saginata* metacestodes. Experimental studies showed a 5-50 times higher prevalence rates by complete slicing of the predilection sites (Minnozo *et al.*, 2002). Observations indicated that except for dead and degenerated cysts which form white and fibrotic lesions viable cysts pass to human consumption without being detected due to carless meat inspection as described by Dorny *et al.* (2000) and Garedaghi *et al.*(2012). The majority of the findings in Ethiopia were based on surveys carried out on carcasses subjected to routine meat inspection procedures.

Hence, the same limitations with which meat inspection shares globally were reflected in the results of the present study. For instance, Onyango-Abuje *et al.* (1996) in low

and high risk areas of Kenya reported 0 and 31.47% of prevalence by meat inspection and 13.33% and 80.42% prevalence by serology respectively.

During inspection, *C.bovis* was found in different organs with higher number of cysts encountered in the tongue (14;29.79%), followed by triceps muscle (11;23.4%), masseter muscle (9;19.15%), shoulder (8; 17.02%) and heart (5; 10.64% . Other studies carried out else where showed that tongue; heart and masseter appear were the most frequent locations for cysticerci (Garedaghi *et al.*, 2012). Further, Abunna (2006) and Getachew (1990) reported triceps as being frequently affected by the cyst. However, the current study showed that the most frequently affected organ with the highest number of cysts was the tongue which is in agreement with the report of Bedu *et al.* (2011) and Garedaghi *et al.* (2012). It is evident from the result that other organs such as triceps, masseter muscle and heart were also frequently affected predilection sites for *C.bovis* which is similar to earlier reports in various endemic areas (Hailu, 2005; Dawit *et al.*, 2012).

The results of viability tests showing highest proportion of viable cysts in triceps muscles was comparable to the works of Tembo (2001), Shimeles (2004) and Emiru *et al.* (2015). Hydatidosis is known to be livestock and public health important disease and for establishment of a control strategy, detailed information on local epidemiology and significance of the disease must be known. The present study showed that the prevalence of hydatid cyst in sheep, goats and cattle were 8.1%, 6.8% and 12.2%, respectively.

The prevalence of hydatidosis in cattle recorded in this study 12.2% agreed with the findings of Belina *et al.* (1987) 9.4% in Harar, Regassa *et al.* (2009) 15.5% in Woliata and Kebede *et al.* (2009a) 16% in Wolita sodo. In contrast, the present study disagrees with the reports of Alemayehu (1990) 54.8% in Assela, Kebede *et al.* (2009b) 48.9% in Debre Markos, Tigist, (2009) 36.58 % in Jimma and Wubet (1988) 62.96% in Bale Robe. The prevalence of cystic echinococcosis in cattle in other countries has been reported to be lower than that in the cattle at Elfora Abattoir; for example, studies have quoted prevalence of 8.56% in Tunisia, Lahmar *et al.* (2012) 8.28% in Saudi Arabia, Ibrahim (2010) 7.4% in Turkey Sariozkan and Yalcin (2009) 6% in Sudan Omer *et al.* (2010) and 4.2% in Arusha Tanzania, Nonga and Karimuribo (2009).

This variation in prevalence of *cystic echinococcosis* among cattle of different areas in Ethiopia and in the countries could be attributed mainly to the strain difference of *Echinococcus granulosus* that exist in different geographical location (McManus,2006) and other factors like differences in agroecology, the times at which studies took place, stocking rates and movements of animals, animal husbandry systems, awareness, culture and religion of the society, and attitude to dogs in different regions of the country (Regassa *et al.*,2009; Ibrahim, 2010; Kebede *et al.*,2010).

Regarding organ distribution, the current study showed that lungs (63.03%) were the most preferred predilection site for hydatid cysts followed by liver (33.6%) which is in agreement with other study in cattle in Ethiopia such as Tolossa *et al.* (2009) and Getaw *et al.* (2010). This might be due to the fact that cattle are slaughtered at older age, during which period the liver capillaries are dilated and most oncospheres pass directly to the lung. It is also possible for the hexacanth embryo to enter the lymphatic circulation and be carried via the thoracic duct to the heart and then trapped in the lungs (Arene, 1985). Furthermore, the lungs and liver possess the first great capillaries encountered by the migrating echinococcosis oncosphere (hexacanth embryo) which adopt the portal vein route and primarily negotiate hepatic and pulmonary filtering system sequentially before any other peripheral organ is involved (Eckert and Deplazes, 2004).

Our overall finding that 50.4 % of hydatid cysts were calcified, 21.01% fertile (viable), 12.61% sterile and 15.97% non-viable implies that most hydatid cysts from cattle are not infective to the final hosts. This finding supports previous arguments by several investigators in Ethiopia that assume sheep to have a greater role than cattle as an intermediate host of cystic echinococcosis (Regassa *et al.*, 2009; Dawit *et al.*,2012).

The fertility rate among different organs also showed varied proportion. Accordingly, cysts in the lungs took the higher proportion of fertility rate is in agreement with earlier reports (Gebremeskel and Kalayo, 2009; Getaw *et al.*,2010). It has been stated that the relatively softer consistency of the lung tissue allows the easier development of the cyst and this may be aggravated due to reduced immunological compatibility of animals at their older age of infection. However, our finding is in contrast with a report

from Tunisia of the higher fertility of hepatic compared with pulmonary cysts in cattle (Budke *et al.*, 2006) this is most probably because different strains of hydatid cyst occur in the two countries (Ibrahim, 2010; Rominget *et al.*, 2011). The high prevalence and fertility of pulmonary cysts in the present study suggests that the lung is the most important organ as a source of infection to dogs of the area.

Unlike the case in lungs, relatively higher number of calcified cyst encountered in the liver (24%). The liver is firm in consistency and lack suitable matrix for long term cyst survival and hence the cyst degenerate earlier than the once found in lungs. The higher number of calcified cysts in the liver could also be attributed to relatively higher reticuloendothelial cells and abundant connective tissue reaction of the organ (Regassa *et al.*, 2009). The variation between tissue resistances of the infected organs may also influence the fertility rate of the hydatid cysts (Kebede *et al.*, 2009b).

An overall prevalence of 58(7.4%) hydatid cysts was recorded in examined small ruminants in the prevalence of CE in sheep (8.1%) and goats (6.8%). In sheep 8.52% prevalence was recorded and this value is in agreement with Assefa and Tesfay (2013);Getachew (2012); Abunna *et al.* (2011); Azlaf and Dakkak (2006) and Elmahdi *et al.* (2004), who reported (8.02), (8.52),(8.05), (10.58%) and (10.3%) prevalence in sheep. However, Haridy *et al.* (2000) and Njoroge *et al.* (2002) observed lower hydatid cyst infection in sheep; (0.33%) and (3.6%) respectively.

On the other hand the prevalence in goats in the present study was 6.8% which is agreement with the study of Saeed *et al.* (2000) 6.2%, Dalimi *et al.* (2002) 6.3%, Yeshiwork (2009) 6.8% and Getaw *et al.* (2010) 6.7% was is not in agreement with the study of Haridy *et al.* (2000) and Njoroge *et al.* (2002), who reported 4.5% and 3.4% respectively. This variation probably due to the reason explained in the discussion part of bovine hydatidosis.

The higher prevalence of cystic echinococcosis in sheep than goats in the present study was most probably due to the fact that goats feed mainly by browsing than grazing unlike in sheep and due to the close grazing to the rot of grasses behavior of sheep on pastures contaminated with oncospheres of *E. granulosus* on the pasture (Kebede *et al.*, 2010; Dawit *et al.*,2012). This finding suggests the importance of

sheep as the main reservoir of infection in maintaining and perpetuation of the domestic life cycle of *E. granulosus* in the region (Kebede *et al.*, 2009a).

On the other hand, categorical analysis of age in this study demonstrated higher infection rate of *cystic echinococcosis* in adult sheep and adult goats as compared to their young ones. This can be attributed to two factors: firstly, higher age reflects a much longer period of exposure to infective egg stage in the pasture, and secondly, the chances detecting cysts at meat examination are higher in aged animals due to their bigger size. In younger animals, either hydatid cysts are not developed into detectable size, which can be easily missed during post-mortem examination. Indeed, the present study as well many other studies elsewhere (Baswaid, 2007; Muqbil *et al.*, 2012) have shown higher infestation rates of hydatid cysts in older animals.

In this study, livers and lungs were the most frequently infected visceral organs to hydatid cysts in both host species examined. This is explained by the fact that livers and lungs possess the first great capillary sites encountered by the migrating *Echinococcus* oncosphere (hexacanth embryo) which adopt the portal vein route and primarily negotiate the hepatic and pulmonary filtering system sequentially before any other peripheral organs are involved (Kumsa 1994; Kebede *et al.*, 2010). The location of cysts and cyst morphology are influenced not only by host factors but also by parasite factors such as the strain of *E. granulosus* involved (Eckert and Deplazes, 2004).

The observation in this study that the lungs in both sheep and goats were found to be more commonly infested with hydatid cysts than the liver is in agreement with previous findings of Marshet *et al.* (2011) and Oryan *et al.* (2012). The lungs are considered of having the first large capillary fields encountered by the blood-borne oncospheres. In addition to this, the presence of greater capillary beds in the lungs than in other organs and soft consistency of the lung might also allow easy growth of cysts. The development of hydatid cyst occurs occasionally in other organs and tissues when oncosphere escapes into the general systemic circulation in both heart and spleen, no cysts were observed from both sheep and goats (Urquhart *et al.* 1996).

The higher viability rates of pulmonary cysts than hepatic cysts in both sheep and goats in the current study are in agreement with those of Kebede et al. (2009b) and Getachew et al. (2012). This might be due to softer consistency of tissues that allows the easier development of cyst and the viability.

Among other zoonotic cestodes, coenuruses is endemic in Ethiopia, especially in the highland sheep where 75% of the population is found (Bekele *et al.*, 1992 and Acheneff *et al.*, 1999). The presence of freely roaming dogs on grazing land greatly contributes to the existence of the disease. Dogs are routinely fed on offal, including sheep and goats head are not dewormed. Thus maintaining the *C. cerebralis* -*Taenia multiceps* cycle (Sharma and Chauhan 2006).

The findings of the present study revealed that up to 3.78% of sheep and goats slaughtered at Hashim export abattoir in Bishoftu town were found to be infected with *Coenuruses cerebralis* with prevalences of 3.9% in goats and 2.5% in sheep. The result of the current study in sheep is consistent with the report of Abo-Shehada et al. (2002) in Jordan (3% in sheep), Varma and Malviya (1989) in India (2.88% in sheep). But is slightly lower than Sharma and Chauhan (2006) in Ethiopia (5% in sheep) and Oryan et al (1994) in Iran (9.8% in sheep). The most probable reason for the variation of the results in different countries is supposed due to variations in climatic, geographical management of the study animals and the final dog hosts and social conditions.

Higher prevalence of coenuruses was recorded in young 6.8% animals than adult 1.9% small ruminants. Comparative results were reported by Morris (1988), 5% in sheep, Adem (2006) and Hayelome (2008) 4% in goats and 5.3% in sheep in different parts of Ethiopia. Previous studies show that clinical coenurosis in sheep is common in young animal (Abo-Shehada *et al.*, 2002; Scala *et al.*, 2007). This higher prevalence in young sheep and goats is most probably attributed to under developed immunity in young animals thus higher infection rate in these animals where as the adults have acquired immunity (Gemmell *et al.*, 1987).

The prevalence of human taeniosis was recorded based on the questionnaire survey and indicated an overall infection rate of 41% which demonstrates the importance of

taeniosis in Bishoftu town, surrounding kebeles and in the areas of animal origins. The high prevalence of taeniosis recorded in Hawassa 64.2% (Abunna *et al.*, 2008), Ziway 56.7% (Bedu *et al.*, 2011) and Jimma 56.7% (Megersa *et al.*, 2010). The prevalence of *T. saginata* varies from country to country and even differs within the same country from area to area depending on factors, such as variation in the habit of raw meat consumption, meat inspection procedures practiced, awareness of patients about the clinical pictures and transmission of the disease, variation in personal and environmental hygiene, and other factors related to the variation in the prevalence of taeniosis among countries. Moreover, some individuals in a society may become shy to tell openly about taeniosis infection and that may undermine the true infection rate of the disease.

The researchers recognize the consumption of raw or undercooked beef in Ethiopia. Previous reports from Ethiopia indicated that consumption of raw or inadequately cooked beef was strongly associated with *T. saginata* infection (Abunna *et al.*, 2008 ; Megersa *et al.*, 2010; Bedu *et al.*, 2011; Endris and Negussie, 2011). Reports have indicated that the prevalence of *T. saginata* taeniosis may also vary in relation to age, sex, religion, educational status and income of individual (Abunna *et al.*, 2008 ; Megersa *et al.*, 2010; Bedu *et al.*, 2011; Endris & Negussie, 2011).

The present study showed that there was strong association between age of the respondents and the prevalence of *T. saginata* infection, which is in agreement with previous reports by Hailu (2005) and Abunna *et al.* (2008). Taeniosis was more reported from respondents above 20 years of age /adults than from younger respondents. This may imply that the habit of raw meat consumption increases with age. Younger people, mostly students cannot afford to buy beef for raw consumption as most raw meats are consumed at the butcher's house and are more expensive (of high quality) than the one that is taken away for preparation at home. The current result was also supported by Cabaret *et al.* (2002) where he reported a high prevalence of *T. saginata*/cysticercosis in sub-Saharan Africa especially East Africa.

This study has also clearly demonstrated the impact of religion on raw meat consumption. The proportion of taeniosis infection was higher in the Christian respondents than in Muslim respondents. Tibo (2001) and Abunna *et al.* (2008) have

also reported similar observations in different parts of Ethiopia suggesting that the tradition of raw beef consumption is more important in the Christian community.

High prevalence of metacestodes infestation in the present study could be due to high population of carnivores particularly stray dogs in the grazing area of domestic ruminants and lack of proper efforts in segregating domestic and wild carnivores from livestock or their grazing areas. Feeding offal of ruminants to dogs also enhance completion of the life cycle. The results of the present study indicate the importance of metacestodes infestation in this area. Their significance is not only because they have great economic importance resulting in losses due to condemnation of the infected organs and downgraded carcasses but it is also because of the zoonotic aspects of some of these infestations such as cysticercosis, hydatidosis and coenurosis. In addition, substantial economic loss due to treatment of human taeniosis remains to be evaluated.

In other countries, the prevalences of 0.5-3% human infestations with *T. saginata* have recently been reported from different parts of Iran (Kia *et al.*, 2005; Solaymani *et al.*, 2011). In another study Daryani *et al.* (2008) reported that 14% of vegetables imported to and 16% of those cultivated in Ardabil, north-western Iran were contaminated with *T. saginata* eggs. Human cases of hydatidosis are regularly reported from different regions of Iran and it is one of the most important zoonotic diseases prevalent in different parts of this country (Mamishi *et al.*, 2007; Rafiei *et al.*, 2007; Ahmadi and Hamidi, 2008; Sarkari *et al.*, 2010; Ahmadi and Badi, 2011). Population studies on human hydatidosis, using serological and ultrasonographical methodologies, have shown 3.5-5.9% infestation in different areas of Iran (Sadjjadi, 2006; Sarkari *et al.*, 2010). Although there are reports of human coenurosis in the world (Antonios and Mina, 2000).

6. CONCLUSION AND RECOMMENDATIONS

Zoonotic metacestodes are a public health risk and causes considerable economic loss via decreasing livestock production and condemnation of offals in slaughter houses. The current abattoir survey proved that zoonotic metacestodes like hydatid cyst, *Cysticercus bovis* and *coenurus cerebralis* are the most and highly prevalent in slaughtered ruminants. The retrospective and the question-naire survey showed that taeniosis is a widespread problem with higher prevalence among the resident of Bishoftu town. religion, open air defecation, habit of raw meat consumption, age, and sex were identified to be the most important risk factors for the disease occurrence in the study area.

Based on the above conclusive remarks, the following recommendations are forwarded:

- Public education is required to avoid the consumption of raw and under cooked meat, keep their self-hygiene, prohibition of backyard slaughter, proper disposal of condemned offals.
- Sustainable community based control strategies against zoonotic metacestodes should be designed and implemented.
- Impact of zoonotic cestodes on meat export market should be further studied in export abattoirs including different species of slaughtered animals
- Further studies on the prevalence and economic importance of metacestodes in different zones of region involving different hosts (including wildlife) as well as on existing status in human would be mandatory to establish a clear information system for launching a control programme.

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8. APPENDICES

Appendix 1: Questionnaire format

Part A. Household information: Primary determinants of knowledge of Teaniosis

Region _____, Zone _____, Woreda _____, PA/Keble _____,
Village _____, Date _____, Age _____, Sex: Male ___ Female _____

Occupation: _____

1. Religion : Christian _____ Muslim _____ Other _____

2. Income if the family: <1 USD (20 birr/day) _____ 1-5 USD (20-100birr/day) _____
6-10 USD (101-200/day) _____ >11 USD (>200birr/day) _____

3. What is the highest level of education you have completed? *Check one:*

Illiterate/Elementary/Some High School/High School Graduate /diploma/ degree/
Graduate degree

4. Do you or any immediate family member work in the human or veterinary health care field?

Yes/no

5. How many people in your household? 1 ___ 2 ___ 3 ___ 4 ___ 5 ___ or more _____

6. How many individuals in the household are under the age of 18?

7. How many pets share your house with you? Dogs _____, Cats _____, Other (*please describe*) _____

8. How many animals do you have living on your property outside of the house?

Cattle _____ goats _____ sheep _____ Other (*please describe*) _____

Below are questions asking about your awareness of diseases that can affect animals and humans. Please select only one response for each question. Thank you for your time.

Outcome

1. Have you ever suffered from Teaniosis in the past one year? Yes/no
2. Do you eat raw/uncooked meat in the past one year? Yes/no
3. Do you eat raw uninspected meat in the past one year? Yes/no

4. Do you have latrine (Toilet) facility at home? Yes/No

1. Knowledge about meat borne parasites- representing causes, consequences and identification

1.1. Three items for knowledge on cause of Tapeworm

i. I know tapeworm is caused by parasite? Yes/no

ii. How can I be caught by Tapeworm?

1. = through eating raw/undercooked meat 2. = through a scratch, 3.= don't know,

iii. Who can transmit tapeworm? Dog/cat/cattle/donkey/others

iv. I know that tapeworm can be prevented by cooking meat. Yes/no

v. If an animal has tapeworm it will show a symptoms. Yes/no

vi. If everyone eats cooked meat, tapeworm would not be around. Yes/no

1.2. Items assessed knowledge of potential consequences

i. Tapeworm can be fatal disease, Yes/no

ii. Is there any treatment for a person who started developing tapeworm symptom?

Yes/no

iii. Do you have family/neighbour/friend suffered from tapeworm that helped me to realize potential consequences. Yes/no

iv. I know the disease has costly treatment. Yes/no

2. Protective behaviour - Items assessing the likelihood protective intention.

2.1. I intend not to eat raw or undercooked meat in the next 12 months.

Definitely not Not I don't know yes Definitely yes

2.2. I plan not to eat uninspected meat next year (I know where to buy inspected meat)?

Definitely not Not I don't know yes Definitely yes

2.3. How strong is your intention not to eat raw/undercooked meat?

Very weak Weak I don't know Strong Very Strong

2.4. I always eat well cooked meat.

Strongly Disagree Disagree I don't know Agree Strongly Agree

3. *Perceived Benefits*

3.1. If I eat cooked meat all the time, I will decrease the chance of having tapeworm.

Strongly Disagree Disagree I don't know Agree Strongly Agree

3.2. If I take deworming regularly, I will feel peace of mind for the health of myself/family and neighbours.

Strongly Disagree Disagree I don't know Agree Strongly Agree

3.3. If I don't consume uninspected meat, I will set a good example for others.

Strongly Disagree Disagree I don't know Agree Strongly Agree

3.4. By talking with a veterinarian about the risk of zoonotic disease I am doing something to care for myself and my animals.

Strongly disagree Disagree I don't know Agree Strongly agree

4. *Perceived Barriers*

4.1. If I want to eat meat, I don't have cooking facilities and increase the chance for me to eat raw meat.

Strongly Disagree Disagree I don't know Agree Strongly Agree

4.2. If I want to eat meat, access to inspected meat during holiday is limited.

Strongly Disagree Disagree I don't know Agree Strongly Agree

4.3. If I want to eat inspected meat, my families/neighbours will force me.

Strongly Disagree Disagree I don't know Agree Strongly Agree

4.4. If I want to take regular deworming, the efficacy and protective level of the drug is not trustable.

Strongly Disagree Disagree I don't know Agree Strongly Agree

5. *Perceived threat* (perceived *Susceptibility* (Q 5.1, 5.3,) and Perceived severity (Q 5.2, 5.4,).

5.1. Consuming raw meat, what do you think the likelihood is that you will have tapeworm in the future?.

Unlikely 1 2 Neutral 4 5 Likely

5.2. How serious would it be for you to become infected with tapeworm?

Strongly Disagree Disagree I don't know Agree Strongly Agree

5.3. I can get tapeworm from uninspected meat or eating raw meat

Unlikely 1 2 Neutral 4 5 Likely

5.4.If I get tapeworm, I will get sick and the illness would be very bad that could hurt my family and friends.

Strongly Disagree Disagree I don't know Agree Strongly Agree

6. Cue/Signs/readiness to action

6.1. I look for information about tapeworm in general and I am likely to stop, read and think about it when I encounter information about tapeworm.

Strongly Disagree Disagree I don't know Agree Strongly Agree

6.2.I talk with vets about the risks of diseases shared between humans and animals.

Strongly Disagree Disagree I don't know Agree Strongly Agree

6.3. I regularly take tablet/deworm myself.

Strongly Disagree Disagree I don't know Agree Strongly Agree

6.4. I am always cooperative to give information about my deworming status.

Strongly Disagree Disagree I don't know Agree Strongly Agree

7. Self-efficacy

7.1.If I want to buy inspected meat, I know where to buy.

Strongly Disagree Disagree I don't know Agree Strongly Agree

7.2.If I want to get dewormed, I believe I can protect myself, my family and neighbours.

Strongly Disagree Disagree I don't know Agree Strongly Agree

7.3.If I want to eat meat, I can cook enough without problem.

Strongly Disagree Disagree I don't know Agree Strongly Agree

7.4.I am confident that I can understand health instructions from veterinarian about zoonotic disease risk prevention for my family.

Strongly disagree Disagree I don't know Agree Strongly agree

Appendix 2: Diagnosis of metacestodes

Meat inspection the main diagnostic procedure: In general, meat inspection procedures consist of:

i) Visual inspection of the carcass, its cut surfaces and the organs within it. This may reveal *T. saginata*, *T. solium* and *T. ovis* in the muscles, *T. hydatigena* on the liver, mesenteries or omentum, or *T. multiceps* in the brain.

ii) The external and internal masseters and the pterygoid muscles are each examined and one or two incisions made into each, the cuts being parallel to the bone and right through the muscle.

iii) The freed tongue is examined visually and palpated, particularly for *T. solium*.

iv) The pericardium and heart are examined visually. The heart usually is incised once lengthwise through the left ventricle and inter ventricular septum so exposing the interior and cut surfaces for examination. Incisions may go from the base to the apex and regulations also may require additional, perhaps four, deep incisions into the left ventricle.

Alternately, the heart may be examined externally and then internally after cutting through the inter ventricular septum and eversion.

v) The muscles of the diaphragm, after removal of the peritoneum, are examined visually and may be incised.

vi) The oesophagus is examined visually.

vii) In some countries, the triceps brachii muscle of cattle is incised deeply some 5 cm above the elbow. Additional cuts into it may be made. The gracilis muscle also may be incised parallel to the pubic symphysis. These cuts are usually undertaken for *T. solium* in pigs.

Such incisions into the legs are made, particularly in African countries as it is suspected that more parasites lodge in these muscles in working or range animals walking long distances because of the exercise and consequent increased blood flow to these muscles. Other countries may also require such incisions into the legs.

However, as this devalues the meat, such incisions are made most commonly once one or more cysts have been found at the predilection sites so as to determine the extent of the infection. Overall, the initial incision into any tissue is the most important, but additional incisions may be required either by the regulations or if cysts are found on the initial incision(s). Eichenberger *et al.* (2013) reported an increase in sensitivity by multiple incisions. Details on meat inspection are supplied by Herenda (2000).

Additional or fewer procedures may be required for specific parasites and the judgments on the carcass, viscera, offal and blood will vary dependent on *Taenia* spp. and regulations within a country. Judgement on infected carcasses will fall into three main categories:

- i) Approve for human consumption;
- ii) Partially condemn and pass the remainder of the carcass, but in the case of the zoonoses, *T. saginata* and *T. solium*, the carcass, meat and viscera must be treated; and
- iii) Totally condemn heavily infected carcasses or emaciated diseased ones.

Appendix 3: Useful features for identification of scolices and segments of taenia spp.

Parasite species	No.hooks	Length of hooks		No. testes	Length of testes	Cirrus sac extends to longitudinal vessels	No. uterine branches	
		Large hooks	Small hooks					
<i>T. hydatigena</i>	28–36 (26–44)	191– 218 (170– 235)	118– 143 (110– 168)	600– 700	1	yes	6–10	Lobes of ovary that re-divide unequal in size. No vaginal sphincter. Testes extend to vitellarium, but not confluent behind.
<i>T. ovis</i>	30–34 (24–38)	170– 191 (131– 202)	111– 127 (89– 157)	350– 750	1	No	11–20	Lobes of ovary that re-divide unequal in size. Well developed vaginal Sphincter. Testes extend to posterior edge of ovary.
<i>T. multiceps</i>	22–30 (20–34)	157– 177 (120– 190)	98–136 (73– 160)	284– 388	2	yes	14–20	Lobes of ovary that re-divide equal in size. Pad of muscle on anterior wall of vagina. Testes
<i>T. saginata</i>	without rostellum	-	-	765– 1200	1	No	14–32	Lobes of ovary that re-divide unequal in size with small Well developed Vaginal sphincter. Testes extend to vitellarium, .

Source: OIE Terrestrial Manual 2014

