Thesis Ref. No._____

M AJOR METACESTODES OF SHEEP AND GOATS SLAUGHTERED AT THREE SELECTED EXPORT ABATTOIRS IN CENTRAL OROMIA: PREVALENCE, CYST CHARACTERIZATION, ASSESSMENT OF FINANCIAL LOSSES AND PUBLIC AWARENESS ABOUT METACESTODES AND THEIR RISK FACTORS

MVSC THESIS

BY

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JUNE 2019

BISOFTU, ETHIOPIA

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A Thesis Submitted to College of Veterinary Medicine and Agriculture of Addis Ababa University in Partial Fulfilment of the Requirements for the Degree of Master of Veterinary Science (MVSc) in Veterinary Parasitology

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As members of the Examining Board of the final MVSc open defence, we certify that we have read and evaluated the thesis prepared by: Geremew Haile Lemu entitled: "***Major Metacestodes of Sheep and Goats Slaughtered at Three Selected Export Abattoirs in Central Oromia: Prevalence, Cyst Characterization, Assessment of Financial Losses and Public Awareness About Metacestodes and their Risk Factors"*** and recommend that it be accepted as fulfilling the thesis requirement for the degree of Masters of Veterinary Science in Veterinary Parasitology.

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DEDICATION

I dedicate this thesis to my beloved mother Fekade Gudeta whom I lost for her continuous love, encouragement, moral, and financial support throughout my life. I never forget her until my death.

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 fulfilment of the requirements for an advanced (MVSc) 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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College of Veterinary Medicine and Agriculture, Bishoftu

Date of Submission: June, 2019

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ABBREVIATIONS AND ACRONOMIES

BCS	Body Condition Score
CACC	Central Agricultural Census Commission
CNS	Central Nervous System
CSA	Central Statistics Authority
CSF	Cerebro Spinal Fluid
CT	Computerized axial Tomography
CVMA	College of Veterinary Medicine and Agriculture
DNA	Deoxyribonucleic Acid
EITB	Enzyme-linked Immunoelectrotransfer Blot
ELISA	Enzyme-linked Immunosorbent Assay
ILRI	International Livestock Research Institute
MoARD	Ministry of Agriculture and Rural Development
NMSA	National Meteorology Service
OIE	Office Internationales des Epizooties
PCR	Polymerase Chain Reaction
RNA	Ribonucleic Acid
SNNP	Southern Nations, Nationalities and Peoples'

ABSTRACT

In small ruminants metacestodes are important as a main cause of organs and meat condemnation contributing to a significant financial loss and they cause human diseases, especially in poor and developing countries. A cross sectional study was conducted between November 2018 and March 2019 with the aim of determining the prevalence, organ distribution, fertility rate, cyst burden and assessing financial losses and public awareness of metacestodes in sheep and goats slaughtered at selected export abattoirs in central Oromia. Routine ante-mortem and post-mortem examination were conducted for the presence of metacestodes. Post-mortem examination was conducted through visual inspection, palpation and systemic incision of each visceral organ particularly the lungs, kidneys, liver, spleen, heart, omentum, mesentery, and striated muscles. In this study, *Cysticercus ovis, Cysticercus tenuicollis* and hydatid cyst in small ruminants slaughtered at Bishoftu Abyssinia, Elfora and Modjo Allana abattoirs were detected with the overall prevalence of 29.2 % (224/768). Of 384 goats examined, 8 (2.1%), 44 (11.5%) and 33 (8.6%) were found to be infected with *C. ovis*, *C. tenuicollis* and hydatid cysts, respectively with over all prevalence of 85 (22.1%). Similarly a total prevalence of 139 (36.2%), 22 (5.7%), 64 (16.7%) and 53 (13.8%) were detected in 384 sheep carcass examined with similar pattern of metacestodes species. Statistically significant variation of infection rate was seen between body condition and agro ecology of animals ($P<0.05$). In this study, cyst count shows 436 total cysts (34 *C. ovis*, 239 *C. tenuicollis* and 163 hydatid cysts) were counted in total infected small ruminants: in sheep 247 (56.7%) and goats 189 (43.3%). Organ distribution shows the infection with *C. ovis* was only found in the heart, while *C. tenuicollis* in slaughtered sheep and goats was found mainly in the omentum. Hydatid cysts had a tendency to be located more in the lungs than liver and kidneys. The difference between infections rate of organs was significantly different ($p<0.05$). Similarly cyst characterization shows, fertile and viable cysts were 87 (19.9%) and 44 (10.1%) in sheep and 58 (13.3%) and 23 (5.2%), in goats respectively. In both animals, high fertile and viable cysts of *C. tenuicollis* were found in omentum while that of hydatid cysts were found in lungs. Cyst size measurement on a total of none calcified *C. tenuicollis* in goats (105) and sheep (130) shows, 32 and 28 were small, 51 and 65 medium and 22 and 37 large in size in goats and sheep respectively. Similarly, out of none calcified hydatid cysts in goats (59) and sheep (85), 15 and 20 were small, 35 and 47 medium and 9 and 18 large in size, respectively. All 34 none calcified *C. ovis* cysts were small in both species. In this study; an overall annual financial losses due to organ condemnation from total infected

small ruminants was estimated to be: 1036505 ETB (37018USD): hydatid cysts 638265 (22795.2), *C. tenuicollis* 325345 (11619.4) and 72895 ETB (2603.4USD) *C. ovis*. Large dog population**,** dogs free all the time**,** widespread stray dogs**,** free access of dogs to offal, inappropriate disposal of offal, large number of free grazing goat and sheep, inadequate animal health services especially worm control are major predisposing factors which contribute to persisting of the diseases. Majority of the community in this study were at risk to contract the disease due to lack of knowledge on transmission, zoonosis, treatment and control of metacestodes. These results suggest that the occurrence of the metacestodes infection in goats and sheep is a great concern for both medical and veterinary authorities. Thus, the development of effective disease management and awareness creation are required to overcome these problems.

Keywords: *Central Oromia, Financial losses, Goat, Prevalence, Public awareness, Sheep*

1. INTRODUCTION

The livestock population of Ethiopia is currently estimated at 57.83 million cattle, 28.89 million sheep, 60.51 million poultry, 29.7 million goats, excluding nomadic areas (CSA, 2016). The subsector has an enormous contribution to Ethiopia's national economy and livelihoods of many Ethiopian farmers in the various farming system (Endashaw, 2007; Belete, 2009) and serves as a source of food, traction, manure, raw materials, cash income, foreign exchange earnings and has social and cultural values. The sub sector contributes about 30% of the national Gross Domestic Product (GDP) and 45% of the agricultural GDP (Roger *et al*., 2003). It also contributes 15% of the export earnings (Behnke, 2010).

Small ruminants are widely reared in a crop-livestock farming systems and are distributed across different agro-ecological zones of Ethiopian country (Abule, 2003; ILRI, 2011; CSA, 2015). They are important domestic animals in the animal production systems of the world (Getahun, 2008; Rosen *et al*., 2005). They are source of income for agricultural community and Ethiopia's economy because they provide a vast range of products such as meat, milk, wool, skin and manure (MoARD, 2005; Yohannes, 2007; Adane and Girma, 2008). Especially within the African society sheep and goat comprise a greater proportion of the total wealth of poor families because of low input requirements such as small initial capital, ability to produce milk and meat using marginal lands and due to they need only short periods to reconstitute flocks after disaster and respond quickly to the demand (Tsedeke, 2007; Belete, 2009; Urgessa *et al*., 2012; Dejene *et al*., 2013;). They are major source of foreign currencies and several functional export abattoirs, majority of which located in Central Oromia (Bishoftu and Modjo), are involved in exporting small ruminant chilled meat mainly to the Middle East and North and West African countries (Berhanu *et al*., 2006; EMDTI, 2010; ESGPIP, 2011).

Although they are contributing to the livelihood of Ethiopian society and the country's economy, sheep and goats are poorly productive due to various factors such as diseases (Assegid, 2000; CACC, 2003; Sisay, 2015). Diseases caused by parasites directly affect health and productivity of the animals, with consequences for food safety, trade and rural development, while also affect the health of human beings (Taylor *et al*., 2007; Gadahi *et al*., 2009; WHO, 2000; Torgerson *et al*., 2015). In Ethiopia, 5-7 million sheep and goats die

each year and the overall economic loss from meat industry due to parasitic diseases is estimated at 400 million Ethiopian birr (ETB) annually (Sileshi and Lidetu, 2013).

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). Small ruminants are usually kept in pasture, and therefore they have an increased risk of infection due to contamination of the environment (Brown *et al*., 2003; Radostitis *et al*., 2007). They are an important source of the infection and play a vital role in transmission of the disease ((Tenter *et al*., 2000; Samra *et al*., 2007). Infestation with the larval stage of *Taenia* represent a problem of medical, veterinary, and economic importance in endemic areas. In the intermediate hosts, they are known to cause mortality, morbidity, abortions, lower meat yield, and meat condemnation contributing to a significant economic problems (Achenef *et al.*, 1999; Anas *et al.*, 2011). They have both aesthetic and food safety implications to consumers of meat (Sisay *et al*., 2015). The economic losses incurred by metacestodes are of special significance in countries of low economic output where small ruminant production is of particular importance (Torgerson, 2001; Anteneh *et al*., 2011; Kumsa and Mohammedzein, 2012). They are also a source of human parasitic infection which arise from a variety of domestic and wild animals, including sheep and goats (Reza *et al*., 2018) and they cause coenurosis and hydatidosis in man especially in poor and developing countries (Christine and Christopher, 2000; Jenkins *et al*., 2013).

Metacestodes still cause great health and economic problems in market oriented livestock (Sissay *et al*., 2008; Anteneh *et al*., 2011; Adane *et al*., 2015; Ermias, 2017) and the disease is much more common where dogs and domestic animals live in a very close association (Fromsa and Jobre, 2011). Despite of these, there is limited information on the current status of metacestodes of small ruminants, their implications on financial concerns and public awareness in central Oromia. Study of these parasites together with associated risk factors and determination of the economic significance are very important in planning and implementation of control strategies, and to understand the risk of spreading of the disease both to domestic animals and humans.

Therefore, the objectives of this study were:

- To estimate the prevalence of metacestodes and assess the associated risk factors in small ruminants slaughtered at Abyssina, Allana and Elfora export abattoirs.
- To determine cyst burden, organ distribution, fertility and cyst size of metacestodes in small ruminants
- To assess the monetary losses from organ/carcass condemned due to the metacestodes
- To assess public awareness about metacestodes and potential risk factors at Bishoftu and Modjo towns.

2. LITRATURE REVIEW

2.1. Etiological Agents and Taxonomy

Cestode parasites are segmented, parasitic tapeworms, belong to the kingdom of Animalia, phylum of Platyhelminthes, order of Cyclophyllidea (Symth, 2004). 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 domestic carnivores, wild Canidae and man (Acha and Szyfres, 2003). Cysticercosis of sheep and goats, with the cysts occurring in several organs are caused by larval stages of *Taenia ovis* and *T. hydatigena*, while hydatidosis and coenurosis are caused by larval stage of *Echinoccocus granulosus* and *T. multiceps* respectively (Urquhart *et al*., 2003).

2.2. Morphology

Adult cestodes all have a tape-like segmented body and they consist of a head or scolex with attachment organs of suckers (which may bear hooks) and they may also have hooks on an anterior protrusible cone (rostellum). The body of an adult tapeworm is made up of hundreds to thousands of individual segments, termed proglottids. These segments progress in size and maturity as one travels down the tapeworm's body: ranging from very tiny (those proglottids nearest the scolex or 'head' of the tapeworm) right through to very large (easily seen with the naked eye) (Bowman *et al*., 2003). Each segment (or proglottid) contains reproductive organs that become packed with eggs as they mature. These are then shed from the final host as proglottids or may rupture to release eggs. The egg consists of an embryo with six hooks (oncosphere) covered in a thick shell (embryophore). The tegument of the adult parasite is highly absorptive and absorbs nutrients while in the gastrointestinal tract of its host (Taylor *et al*., 2007).

Tapeworms are hermaphrodites (bearing both male and female sex structures). Each proglottid segment has its own testicular-type organ structure/s and its own uterine organ structure/s (for creating and maturing eggs) and every single proglottid is, therefore, capable of producing and fertilising its own set of eggs, once mature. The small-sized proglottids nearest the anchoring 'head' of the *Taenia* tapeworm are the most under-developed and

immature of all the tapeworm's segments and are, consequently, incapable of creating fertile eggs because of their under-developed state. The large proglottids nearest the 'tail-end' of the *Taenia* tapeworm are the most mature of all the tapeworm's segments and are capable of having their eggs fertilized and matured into an embryo-bearing state (Urquhart *et al*., 1996).

Adult *Echinococcus granulosus* worms are small (2-6mm long) and have a scolex with only three attached segments (Figure 1). The scolex has four lateral suckers and the rostellum is non-retractable and armed with a double crown of 28-50 recurved hooks. The anterior segment is immature, the middle segment is mature with functional testes and ovaries, and the posterior segment is gravid with the uterus filled with eggs. The eggs are typical for most taeniid species and are small and round (30-43µm in diameter), thick-shelled and contain a hexacanth (6-hooked) embryo (oncosphere) (Bowman *et al*., 2003). The encysted larval (metacestode) stage is known as a bladder-worm or hydatid, and it produces multiple infective stages (protoscoleces, apparent as invaginated scolices already containing suckers and hooks) either directly from the germinal layer of the cyst wall, or by forming brood sacs (hydatid sand) by endogenous (internal) or exogenous (external) budding of the germinal layer. *E. granulosus* forms fluid-filled unilocular cysts with endogenous budding of brood capsules (Urquhart *et al*., 2003).

Fully formed cysticerci attached to internal abdominal organs or the peritoneum are characteristic to *Taenia hydatigena*. If viable they consist of a long- necked single scolex in translucent cyst fluid. The cysts can measure from 1 cm up to 6/7 cm in diameter. Adults *T. ovis* in the intestine of dogs and wild canines reach 1–2 metres in length and have an armed rostellum. The metacestodes (*Cysticercus ovis*) that occur in the musculature (skeletal and cardiac) of sheep and less commonly goats reach 0.5–1.0 × 0.5 cm. Adults *T. multiceps*, up to a metre 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, goats and occasionally humans (OIE, 2014).

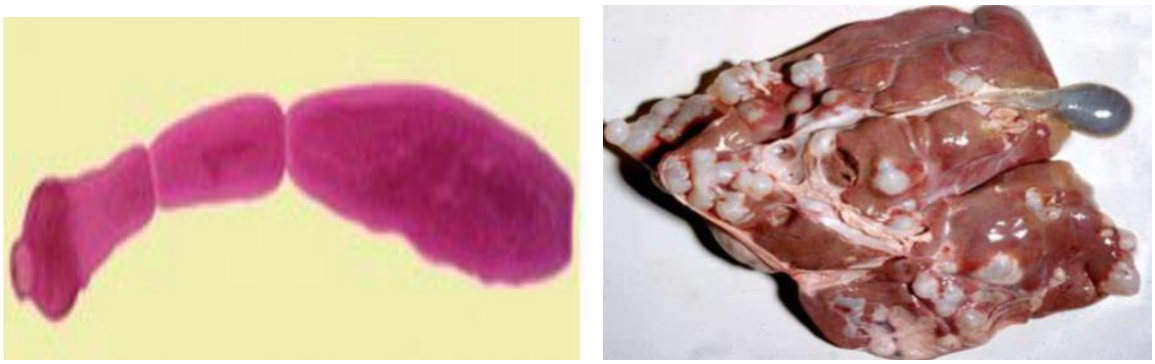


Figure 1: Morphology of adult worm of *E. granulosus* (A) and hydatid cysts in sheep liver (B)

Source: Rahman (2015) and Mohammed *et al*. (2016)

2.3. Life Cycles

Different species of tapeworms occur in different vertebrates and they cycle through three stages (eggs, larvae and adults). They all require definitive and intermediate hosts in order to complete their life cycle (Figure 2). Domestic livestock may, depending on the species of tapeworm, be involved as either the definitive hosts, or as the intermediate hosts (Radfar *et al*., 2005). As with other tapeworms, these parasites have an indirect life cycle, cycling between a definitive and an intermediate host. Adult *Taenia* tapeworms live and feed in the small intestines of such host animals as the dog, cat and human. These host animals are termed definitive hosts because they are the hosts that their parasitic tapeworm species reach adulthood and sexual maturity in (Murell, 2005).

When a proglottid enlarges and develops to a certain stage, becoming sexually mature, gametes from the male testicular components of the proglottid segment fertilize the eggs present within that or a nearby proglottid segment. The newly fertilized tapeworm eggs mature inside of the proglottid, developing embryos inside of them, and the proglottid continues to grow in size (Oryan *et al*., 2012). Once the fertilised tapeworm eggs are fully-matured (ready to enter the next stage of the tapeworm life cycle), the now-enlarged, fat proglottid segment bearing them breaks away from the main body of the tapeworm. This proglottid segment exits the definitive host animal's body intact via the anus. The segment either physically crawls from the anus of the host animal by contracting its muscles or it is voided in the animal's stools as the pet defecates. Sometimes a large section of the *Taenia*

tapeworm (several proglottids in length) breaks away and is voided in the feces (Brown *et al*., 2003). Once out in the environment, the shed proglottid segment continues to writhe, breaking apart and expelling its fertilized, matured tapeworm eggs into the environment as it does so. Taeniids lack a pore for the eggs to come out of and so the proglottid needs to physically split open to release them. The eggs are expelled from the proglottid segment as individuals. Each egg is infective the moment it exits the proglottid and generally contains an embryo (called a hexacanth) that has the potential to develop into an adult Taenia tapeworm (Urquhart *et al*., 2003).

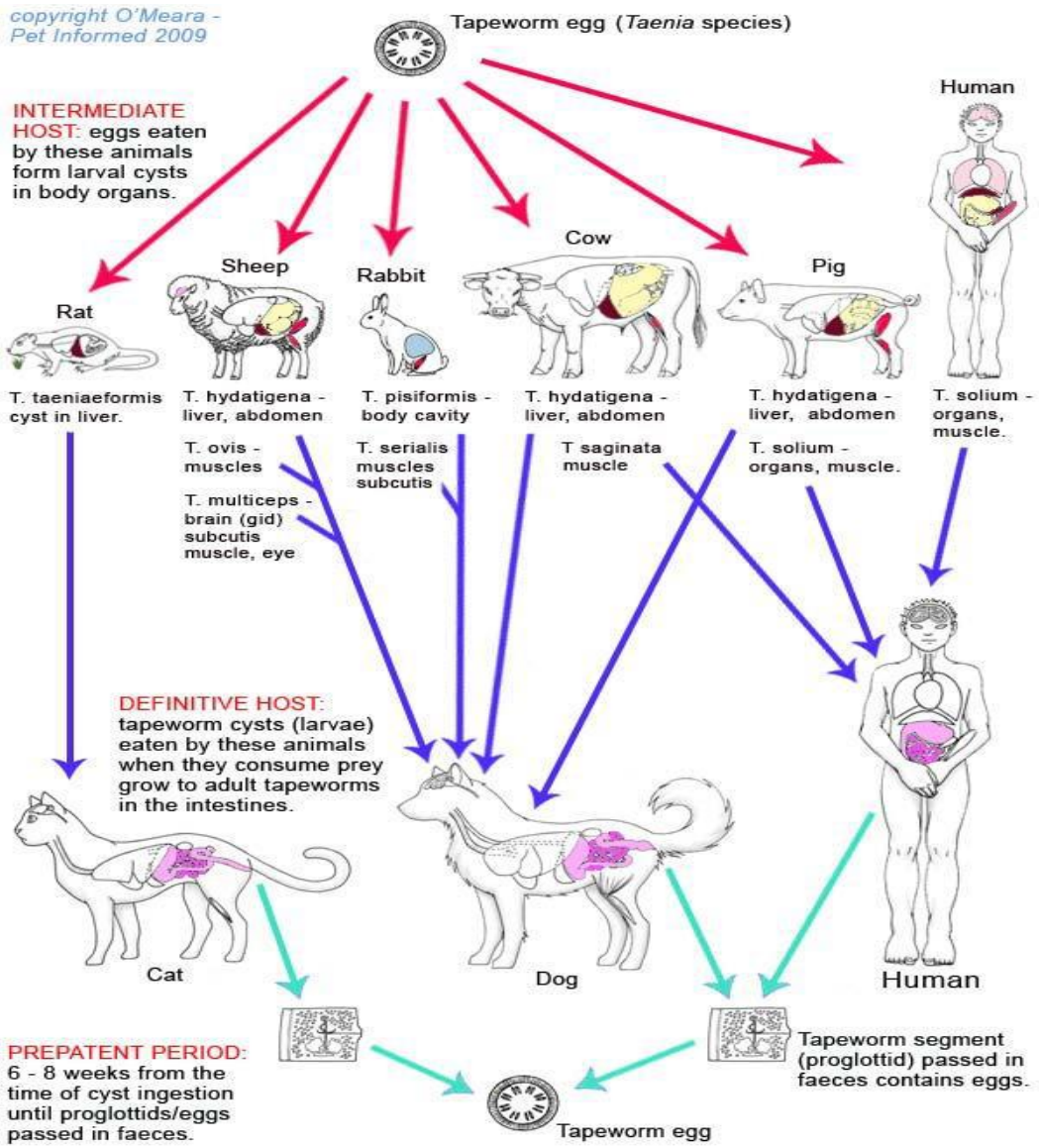


Figure 2: Life cycle of Taenia tapeworm

Source: http://www.pet-informed-veterinary-advice-online.com/Taenia.html

2.4. Major Metacestodes in Small Ruminants

2.4.1. Hydatid cyst

Hydatid cyst is a larval stages of *E. granulosus*. It causes hydatidosis, which is a serious problem for both livestock and public health in many part of the world. In livestock industry, it inflicts enormous economic losses due to condemnation of edible organs and lowering the quality and quantity of meat, milk and wool production ((Eckert *et al*., 2001; Craig *et al*., 2007; Bekele and Butako, 2011; Fromsa and Jobre, 2011). The infection in domestic animals is usually asymptomatic and detected only at post-mortem inspection at the slaughter houses (Torgerson and Budke, 2003; Ahmadi and Meshkehkar, 2011). The parasite spends most of its adult life in the intestine of the definitive host, particularly in dogs (McManus *et al*., 2003; Getaw *et al*., 2010).

Morphologically, the hydatid cyst is a fluid-filled, spherical, unilocular cyst that consists of an inner germinal layer of cells supported by a characteristic acidophilic-staining, acellular, laminated membrane of variable thickness. Each cyst is surrounded by a host-produced layer of granulomatous adventitial reaction. Small vesicles called brood capsules bud internally from the germinal layer and produce multiple protoscolices by asexual division. In humans, the slowly growing *cysts* can attain a volume of several litters and contain many thousands of protoscolices. With time, internal septations and daughter cysts can form, disrupting the unilocular pattern typical of the young echinococcal cysts (Urquhart *et al*., 1996; Shyamapada and Manisha, 2012).

The greatest prevalence of cystic Echinococcus in human and animal hosts is found in South America, the entire Mediterranean littoral, southern and central parts of the former Soviet Union, central Asia, China, Australia, and parts of Africa (Moro and Schantz, 2006; Yang *et al*., 2006). Geographically, distinct strains of *E. granulosus* exist with different host affinities. Molecular studies using mitochondrial DNA sequences have identified 10 distinct genetic types of the parasite. These include two sheep strains (G1 and G2), two bovid strains (G3 and G5), a horse strain (G4), a camelid strain (G6), a pig strain (G7), and a cervid strain (G8). A ninth genotype (G9) has been described in swine in Poland and a tenth strain (G10) in reindeer in Eurasia (Thompson and McManus, 2002).

The life cycle of *E. granulosus* (Figure 3), involves carnivores such as dogs as well as wild canids like wolves and foxes as definitive hosts in which the adult stage develops and resides in the small intestine. Herbivores mainly sheep (also goat, swine, cattle, horses and camels) serve as a suitable intermediate hosts where larval stages of echinococcal cysts develop (Moro and Schantz, 2006; Moro and Schantz, 2009). Human act as accidental intermediate host and become infected with food or water contaminated with feces of dog parasite eggs or with direct contact with dogs (Craig *et al*., 2007). Eggs hatch in small intestine of the canids and parasite larvae can reach to almost any organ, where they develop and form cysts. Liver and lungs are the most common sites for the cyst development, however it can be found in other organs, such as the spleen, kidneys, heart and central nervous system (Das *et al*., 2003; Taylor *et al*., 2007). In human, the cyst can reside and grow in liver, lung and other visceral organs. In symptomatic patients, infection may lead to symptoms of space occupying lesion due to cyst pressure on the surrounding tissues/organs or due to cyst rupture (Eckert and Deplazes, 2004). Rupture of hydatid cysts often leads to sudden death due to anaphylaxis, haemorrhage and metastasis (Getaw *et al*., 2010).

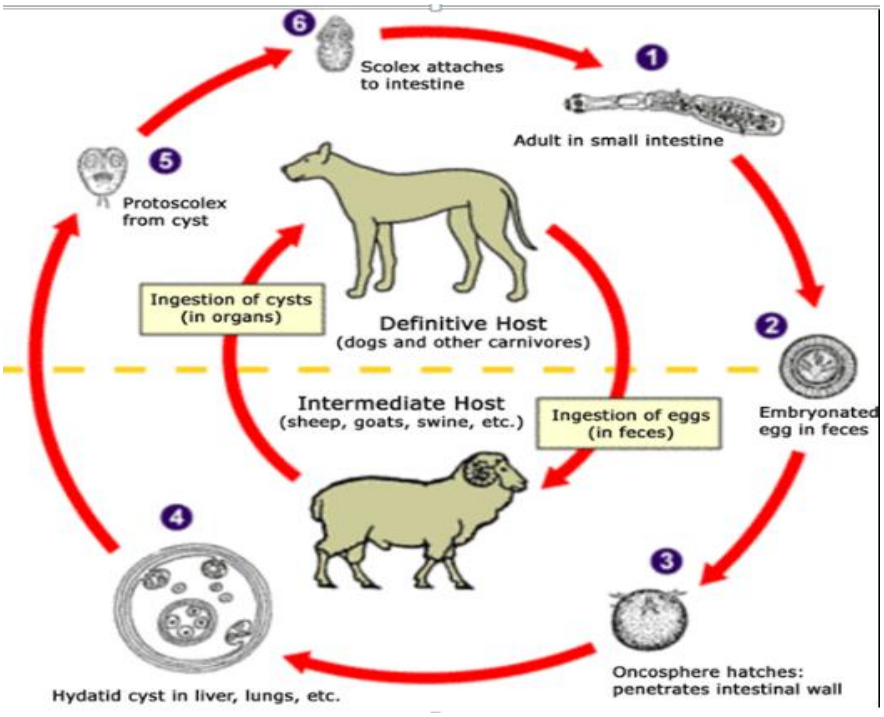


Figure 3: Life cycle of hydatid cysts *(E. granulosus)*

Source: Pedro and Peter (2008)

2.4.2. Coenurus cerebralis

Coenurus cerebralis cyst, a metacestode or larval stage of *Taenia multiceps* causes cerebral coenuruses (gid or sturdy), which particularly affects sheep and goats (Sharma and Chauhan, 2006; varcasia *et al*., 2012; Miran, 2013). Adult parasite, *T. multiceps*, inhabits the small intestine of dogs and other canids (foxes, wolves, and jackals), making these definitive hosts a widespread infection reservoir (Gauci *et al*., 2008). The coenurus (larva of *T. multiceps*) parasitizes the central nervous system (CNS) of sheep, occasionally goats, deer, antelopes, chamois, rabbits, hares and horses, and less commonly, cattle (Benifla *et al*., 2007; Varcasia *et al*., 2009). The onchosphere of *T. multiceps* has a specific affinity for CNS tissues (brain or spinal cord) due to the cerebro spinal fluid (CSF) is required for the differentiation, nourishment and growth of the metacestode and the scolices develop from the base of the invaginated outer surface of the metacestode wall (El-Din, 2010). Coenuruses frequently causes the death of infected animals, and can lead to huge economic losses of sheep/goats, predominantly in developing countries, such as those in Africa and Southeaster Asia. The parasite can also cause zoonotic infections in humans, leading to serious pathological conditions in humans (Mahadevan *et al*., 2011).

The cysts are morphologically large, white, round or oval, have translucent structures and numerous protoscoleces attached to the wall and scolex has a double ring of rostellar hooks (Desouky *et al.,* 2011; Miran, 2013). The average number of scoleces in the metacestode is 85 with a range of 40-550 scoleces per coenuri (Rostami *et al.,* 2013). Cysts are approximately 0.8-6.5cm in diameter and are filled with large amount of fluid (Figure 4). In addition, they contain numerous macroscopic invaginated scolices. Microscopically the scolices shows the C-shaped suckers and a rostellum armed with typical taenia hooks arranged in double rows (Neni, 2012; Oge *et al.,* 2012).

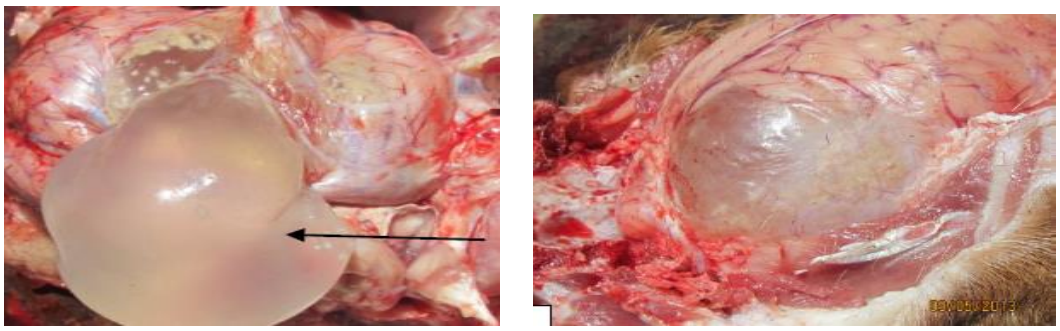


Figure 4: Large *Coenurus cerebralis* cyst occupying brain of goat.

Source: Miran (2013)

The life cycle is indirect with sheep and goats acting as an intermediate host (Figure 5). Coenuruses results from ingestion of contaminated pasture with eggs. The gravid proglottids of *T. multiceps* are discharged from infected dogs and are ingested by intermediate hosts including humans, especially in rural grazing areas where people raise small ruminants or other ungulates, and keep guard dogs in close proximity through contaminated food or water (Craige *et al*., 2007). The proglottids then release oncospheres in the intestine and penetrate the intestinal mucosa and blood vessels. After reaching the brain through the bloodstream, they will take 2–3 months to grow into a coenurus causing increased intracranial pressure. This will lead to the onset of clinical signs, such as ataxia, hypermetria, blindness, head deviation, stumbling and paralysis (Abo-Shehada *et al*., 2002). Once the tissue of infected has been ingested by a definitive host, the lifecycle is completed, and the parasites develop into adult tapeworms in the small intestine of the host (Varcasia *et al*., 2009).

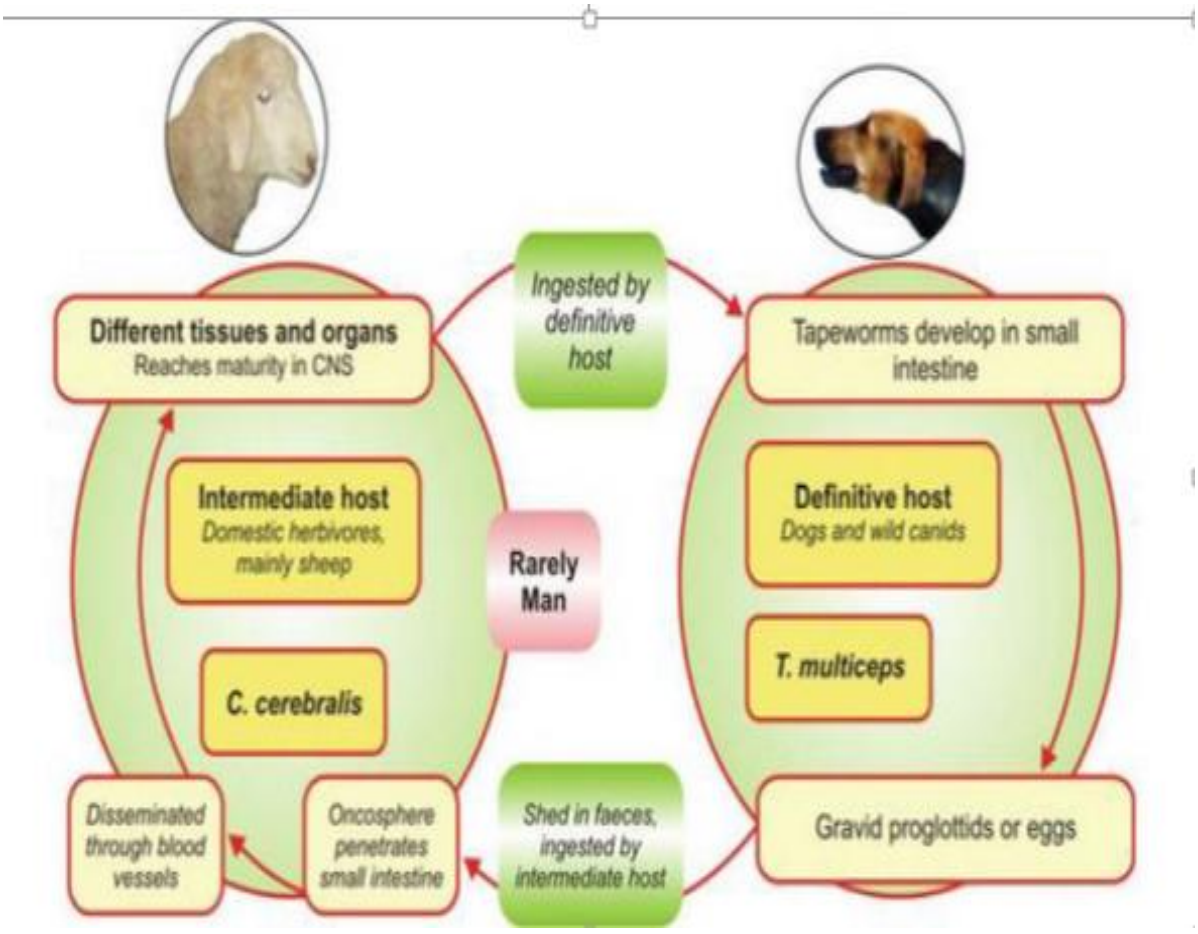


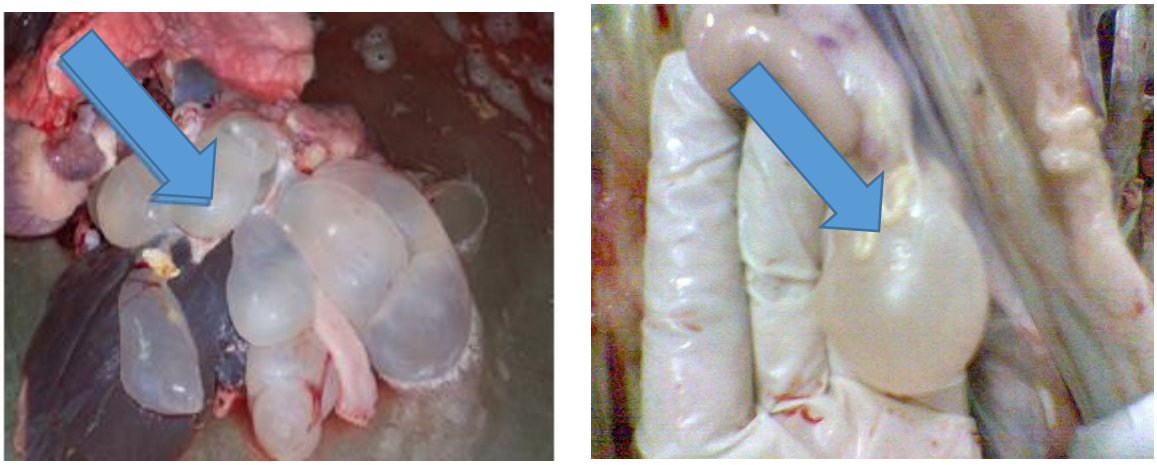
Figure 5: life cycle of *C. cerebralis* involving intermediate and definite host

Source: Dhaliwal and Julal (2013).

2.4.3. Cysticercus tenuicollis

Cysticercus tenuicollis is a metacestode of *Taenia hydatigena*, for which the definitive hosts are dogs and wild canids. Its intermediate hosts are mainly goats, sheep, pigs, cattle, horses and deer (Kassai, 1999). Adult *T. hydatigena* tapeworm is found in the intestine of carnivores. The eggs hatch in the small intestine of the intermediate hosts and the released oncospheres enter liver through blood circulation. The metacestode migrate through the hepatic parenchyma to the peritoneal cavity (Nourani *et al*., 2010). It matures over a period of five to eight weeks and it is then found attached as a bladder worm called *C. tenuicollis* to the mesentery, serosal surface of the abdominal organs, and omentum (Smith and Sherman, 2009). Detection of such cyst is performed commonly at meat inspection in which the cyst is loosely filled with transparent fluid found in the abdominal viscera attaching to their cavities and livers of infected animals (Figure 6) (Kaufman, 1996).

In slaughter animals, tenuicollosis has an important economic loss due to condemnation of offal's containing these larvae. Apart from direct tissue damage, infection with *C. tenuicollis* favours infection and growth of pathogenic microorganisms that can cause necrotic hepatitis, black disease and/or peritonitis which gives rise to economic losses associated with reduced productivity among the affected animals and condemnation of damaged organs (George, 2008; Oryan *et al*., 2012; Popova and Kanchev, 2013).



A B

Figure 6: *Taenia hydatigena* cysts attached to the visceral surface of a sheep (A= liver, B= ovary).

Sources: Anteneh *et al*. (2011).

2.4.4. Cysticercus Ovis

Cysticercus ovis is the larval stage of canid tapeworm, *Taenia ovis*. It is one of the most common metacestodes which found in infected slaughtered sheep lead to a disease in infected sheep called "sheep measles" (Paula, 2009). Sheep are infected by grazing pasture contaminated with the infective eggs that have been shed in dog faeces. Definitive host such as wild and domestic canids, are infected by the ingestion of viable cysts in ovine muscle. Over time, the cysts in the muscle will degenerate and then calcify and form a small nodule with a 'gritty' texture, which known as sheep measles (DeWolf *et al*., 2012). The adult stage of the parasite (*T. ovis*) found in the intestines of dogs while the larval stage is found in the muscles of sheep (Sissay *et al*., 2008). They occur in the musculature (skeletal and cardiac) of sheep and less commonly goats Within skeletal and cardiac muscles, *C. ovis* appears as a thin-walled, fluid-filled, cyst-like structure (Figure 7), approximately which can be 0.5–1.0 × 0.5 cm in size, but can be larger from 1 cm up to 6–7 cm, and the scolex has a long neck (Payan *et al*., 2008).

Although *C. ovis* is not zoonotic issue, it does impact food quality. The calcified and viable cysts are unpleasant to eat and can result in carcasses being downgraded or even condemned at the abattoir (Mohammad *et al*., 2016). As a result, carcasses are condemned at slaughter using guidelines provided by the Food and Agricultural Organization of the United Nations (FAO). The FAO guidelines recommend that a carcass be condemned due to *C. ovis* infection if lesions are found in two of the usual inspection sites (masseter muscle, tongue, oesophagus, heart, diaphragm or exposed musculature) and in two sites during incision into the shoulder and the rounds (Food and Agriculture Organization 2000). Thus, *C. ovis* infection is a major concern for sheep industries in the endemic areas and cause economic loss in these countries (Sisay *et al*., 2007; Ahmed *et al*., 2017).

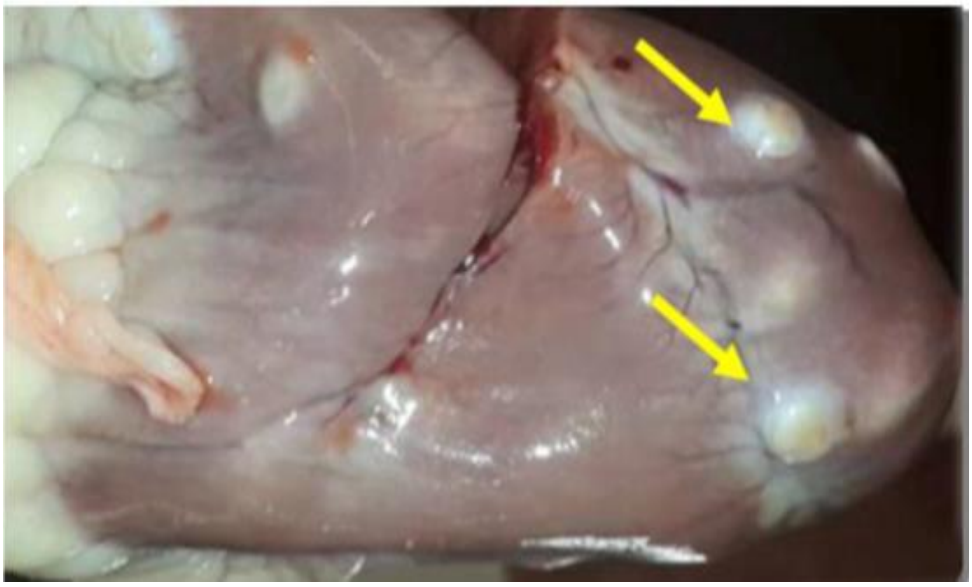


Figure 7: Heart of sheep showing *C. ovis* (arrow)

Source: Ahmed *et al*. (2017)

2.5. Transmissions

The infested definitive host animal defecates onto the pasture or in the forest in which they shed infective tapeworm eggs into this environment. An intermediate host animal that is specifically suited to the particular species of *Taenia* tapeworm consumes the eggs that have been shed into the in a pasture (Urquhart *et al*., 1996). On some occasions, an intermediate host animal may even consume an entire, freshly-shed, gravid proglottid through the ingestion of fresh definitive host feces resulting in the uptake of hundreds of eggs all at once by that intermediate host (Bowman *et al*., 2003). Aside from pasture contamination, tapeworm eggs (oncospheres) can also find their way into intermediate host animals via the contamination of waterways with tapeworm-infected feces in which the animal drinks the contaminated water and ingests the tapeworm eggs. Crops, vegetables and fruits fertilised with untreated sewage or effluent can also become diffusely contaminated with tape worm eggs, which can then make their way into intermediate host through the consumption of these crops (Taylor *et al*., 2007).

Man can be infected incidentally up on ingestion of infective eggs in contaminated water, vegetables, by the ingestion of viable metacestodes in meat and offal that has not been adequately cooked frozen to kill the parasite or through direct contact with dog (Kumsa and

Mohammedzin, 2012). Consumption of offal containing viable cyst results in infection of definitive host carnivores including dogs (Azlaf and Dakkak, 2006; Bettelli, 2009). The remarkable biotic potential of metazoan parasites is known by the fact that a heavily infested dog may carry as many as 40,000 tapeworms, shedding approximately 1,000 eggs per 2 weeks (Schantz *et al*., 2006).

2.6. Diagnosis

Timely and accurate diagnosis of cestode parasites is essential in the control and prevention of the diseases caused by the parasites. Such diagnosis could be both in the final and intermediate hosts. Different methods have been widely used in the diagnosis of the disease including imaging techniques in humans, immunodiagnostics in livestock, final hosts and humans (Sisay *et al*., 2015). In the final hosts, the segments or eggs of the adult parasite could be identified in live patients whereas in the intermediate host where the cysts are embedded in tissues, diagnosis is based on identification of the metacestode at meat inspection or necropsy (Craige, 1997). When recovered from the abattoir, a suspect lesion requires laboratory confirmation particularly if it contains a dead cyst (Ogunremil *et al*., 2004). Fluid aspirated from a cyst may show the presence of protoscoleces. The presence of protoscoleces is diagnostic in which its presence indicates activity of the cyst. However, if they are absent, they are an indication for growth of cyst or degeneration (Craige *et al*., 1995).

The access to critical clinical and epidemiological information remains important for diagnosis of the parasites. The location of several cysts in the abdominal viscera is usually associated with gross abdominal distension and a palpable mass. However, the ante mortem diagnosis based on clinical signs is usually not possible because clinical symptoms are not well defined in animals. This results in continued transmission and maintenance of the infections and failure to control or prevent the problem (OIE, 2004). As some of them are commonly hidden in soft tissues, post-mortem examination often misses majority of the infections although the level of detection depends on the skill of the inspector (DeWolf *et al*., 2012). Such limitations of the meat inspection procedures pose significant challenges for regulators and diagnosticians tasked with preventing zoonotic transmission of the parasite (Ogunremi and Benjamin, 2010). The most important diagnostic tools for the diagnosis are radiography, especially CT, ultrasonography, Magnetic Resonance Imaging (MRI) and

immunodiagnosis (Sayek and Onat, 2001). The radiological findings are important for recognition of the cysts, the size of the lesion, the presence and thickness of a wall, calcifications and internal nodules (Mortele and Ros, 2001). The differential diagnosis of cystic lesions suspected should also consider pseudocysts, fungal or pyogenic abscesses, granulomas, hematomas, neoplasms (Shah *et al*., 2002) and lesion due to other parasites (trematodes and nematodes). Therefore diagnostic techniques should be thoroughly analysed with respect to their anatomical-pathological structures. Immunodiagnosis and (Wellinghausen and Kern, 2001) and molecular techniques (Siles-Lucas and Gottstein, 2001) may help in dubious cases to identify the lesion with respect to its etiology.

Serologic tests used include enzyme-linked immunoelectrotransfer blot (EITB), ELISAs, complement fixation and hemagglutination. Antibodies may be found in serum or CSF. Cross-reactions occur with other parasites. The application of a monoclonal antibody which is specific for an oncosphere antigen of *Taenia* has been described for the species-specific identification of the parasite eggs. Eggs are either treated with artificial gastric and intestinal fluids in order to hatch and activate the oncospheres, or treated with sodium hypochlorite and sodium deoxycholate. *Taenia* oncospheres can then be identified by incubation with the monoclonal antibody and examination using fluorescence microscopy (Kara *et al*., 2003).

Molecular techniques have evolved rapidly, resulting in technical innovations with potential applications to diagnostic parasitology. The identification of parasite species nucleic acid sequences has resulted in the development of DNA probes useful for hybridization to DNA from diagnostic samples (Sisay *et al*., 2015). Molecular diagnosis based on Polymerase Chain Reaction (PCR) test assumed significance due to its high specificity and sensitivity and can be used as simple presence / absence assay to detect *Taeniid species* cysticerci. DNA approaches are now being used routinely for accurate identification of *Taenia species*, subspecies and strains. The complete sequences of the mitochondrial genomes of *Taenia species* and the availability of DNA sequences for a number of their genotypes, has provided additional genetic information that can be used for more in depth phylogenetic and taxonomic studies of these parasites (Jia *et al*., 2010).

Polymerase Chain Reaction (PCR) based techniques are being employed to study genetic variability, for species-specific identification of *Taeniid species cysticerci* and to validate meat inspection results, which is an appropriate post-mortem test that could be applied on

meat samples in suspected cases. PCR shows the best features, providing rapid amplification of parasite-specific DNA (or RNA) sequences and there by greatly increasing the sensitivity of the assay. However, the use of PCR for routine diagnostic or large-scale epidemiological studies is limited by its high cost and complexity. In addition, this methodology requires highly purified nucleic acids to avoid the inhibitory effect of uncharacterized substances. Thus, PCR is generally used for confirmation of positive or suspected positive results obtained with other diagnostic tests. In the final host, copro-diagnosis by PCR has been used for the diagnosis of infection in dogs and wild canids in which the test allows the detection of parasite genetic matterial in faeces with high specificity (nearly 100%) and sensitivity (at least 89%) (Dinkel *et al*., 2000; Gottstein, 2002; McManus, 2006).

2.7. Treatment and Control

Adult tapeworms in the intestines can be killed with anthelmintics such as praziquantel, niclosamide, buclosamide or mebendazole. In some cases, cysticercosis may be treated with anthelmintic drugs such as albendazole and praziquantel. Surgery may be used for cysticerci in locations such as the eye, cerebral ventricles, and spinal cord, as anthelmintic drugs can exacerbate the symptoms when the parasite dies. Asymptomatic infections and calcified cysticerci may not require treatment. Treatment of coenurosis and hydatid disease is mainly surgical, although anthelmintics may also be used (Taylor *et al*., 2007).

Control of metacestodes in livestock relies on regular anthelmintic treatment, by using an effective taenicide, and correct disposal of infected sheep and goat offal after slaughtering or death of animals to prevent scavenging by dogs ((Varcasia *et al*., 2009). Effective control measures can also be taken by methods such as prohibition of backyard slaughtering and public awareness of the epidemiology of the parasites (Gicik *et al*., 2007). Communities and governments can make sure their water supply remains sanitary and free of dog feces can control number of stray dog populations. Individuals should wash all fruits and vegetables thoroughly before eating and make sure their dogs are not infected with tapeworm (Bechelli, 2005).

Preventing dogs from becoming infected involves eliminating offal and other potentially infected material from their diets, curbing their hunting behaviour, properly disposing of carcases in the field, and culling wild and feral dogs. Recently, a recombinant vaccine has

been developed to prevent hydatid formation in domestic herbivores, and is undergoing further evaluation. For man, individual prevention from metacesstodes consists of avoiding the ingestion of raw meat or water that may be contaminated with dog feces (Acha and Szyfres, 2003). Traditional methods of control such as burning out the infected organ can disrupt the lifecycle of the parasite (Scala *et al*., 2007, EIOn *et al*., 2008).

2.8. Public Health Impact

Foodborne parasitic infections have been recently identified as an important public health problem. Poor sanitation and traditional methods of food preparation accelerated the spread of foodborne parasite infections (Macpherson *et al*., 2000; Carabin *et al*., 2005). The dog tapeworm *E. granulosus* is one of a group of medically important parasitic helminths that infect million people globally (Moro *et al*., 1999; Gracia *et al*., 2005). The larval (metacestode) stage causes hydatidosis (cystic hydatid disease; cystic echinococcosis), a chronic cyst-forming disease in the human host. In some areas, 10% of the population has detectable hydatid cysts by abdominal ultrasound and chest X-ray (Li *et al*., 2011). The most frequent strain associated with human hydatidosis appears to be the common sheep strain (G1) (Torgerson and Budke, 2003; Wani *et al*., 2007). Recent molecular characterization of human and animal *E. granulosus* isolates demonstrated that the camel strain (G6) is also equally important source of infection to humans (Magambo, 2006).

Coenuruses is a relatively rare zoonotic disease, and the disease in human being is 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. 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 in which a CT scan showed fluid filled lumps in her brain (Bechelli, 2005). The cysts have been responsible for epilepsy, hemiplegia, monoplegia and cerebral ataxia. When the spinal cord is affected there may be spastic paraplesia, lymphadenopathy, fever and malaise can occur, raising the suspicion of lymphoma (Adane *et al*., 2015).

2.9. Economic Importance

Metacestodes causes considerable economic impacts in terms of morbidity, loss of productivity and health care costs. They causes economic loss through condemnation of infected meat and offal. Infection with the parasites favours infection and growth of pathogenic microorganisms that can cause inflammation in affected organs, which gives rise to economic losses due to condemnation of damaged organs. They also produces cystic lesions in the skeletal and cardiac muscle of infected animals which, if numerous, will result in the condemnation of an entire carcass (Popova and Kanchev, 2013). Significant economic losses resulted from zoonotic metacestodes have been estimated for some regions. For example, in Mexico, cysticercosis caused a loss of more than US$ 17 million annually in hospitalization and treatment costs for humans with neurocysticercosis. In addition in Latin America and Africa, cysticercosis accounts for an economic loss of US$164 million and 2 billion, respectively (Pal *et al*., 2018). In the North African countries, the cost to human health treatment and animal losses was estimated at US$ 60 million per year (Budke *et al.*, 2005; Moro and Schantz, 2006). In Jordan alone, an estimate was reported at an equivalent of 21 million US$ dollars (Conteh *et al.*, 2010).

In Ethiopia, abattoir survey indicated the economic importance of metacestode in small ruminants. Study by Abiyot *et al*. (2011), calculated the annual financial of loss of 69,139.77 ETB due to small ruminants hydatidosis at Modjo export abattoir. Similarly the annual loss due to small ruminant's hydatidosis at Gindebirit was estimate as 58,755.1ETB (Muhammadhussien, 2017). According to Deressa *et al*., (2012) total annual financial loss due to brain/animal condemnation was estimated at 8330 Ethiopian Birr (490 US$). Main causes of brain condemned is due to brain with a higher *C. cerebralis cyst*. Current study at Elfora export abattoir indicated the total annual financial loss of 18,127.2 USD (335,353.2 ETB) from brain condemnation due to *C. coenurus* (Shimelis *et al*., 2017). Though brain is not a common dish for Ethiopians, there is a higher demand in the Middle East countries (Jibat *et al*., 2008). Similarly study by Anteneh *et al*. (2011) the annual local market monitory loss of 1,044317.79 ETB per year was calculated due to rejection of organs and tissue by *C. tennuicollis* alone.

2.10. Status of Small ruminants Metacestode in Ethiopia

Different abattoir survey indicated that metazoan parasites are endemic disease of small ruminants in Ethiopia, especially in the highland where 75% of the sheep population is found (Fromsa and Jobre, 2011; Getachew *et al*., 2012). The presence of freely roaming dogs in grazing land greatly contributes to the existence of the disease. Dogs are routinely fed on sheep and goat's offal such as lungs, liver and head thus maintaining the parasite cycle (Adane *et al*., 2015). Their distribution is higher in developing countries especially in rural communities where there is close contact between dogs (definitive host) and various domestic animals intermediate hosts (Eckert and Deplazes, 2004). Certain deeply rooted traditional activities could be commonly described as factors substantiating the spread and high prevalence rates of the disease. These include the wide spread back yard animals slaughter practice, the absence of rigorous meat inspection procedure and the long standing habit of most Ethiopian people to feed their dogs with condemned offal which in effect facilitate the maintenance of the life cycle of the parasites (Kebede *et al*., 2009).

According to study by Anteneh *et al*. (2011), Out of the 576 goats and 576 sheep inspected for visceral organs, *C. tenuicollis* was found in 63.9% of goats (n=368) and 56.8% of sheep (n=327), respectively with the annual economic loss of 65,269.89 USD or 1,044,317.79 ETB. Current study by Ermias 2017 in Elfora export abattoir indicated that small ruminant's metacestodes were prevalent in Ethiopia. Accordingly 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.

Study also indicated the presence of human taeniosis in Ethiopia. During 1995 and 2005, 234 patients were operated for hydatid disease at Tikur Anbessa Hospital in Addis Ababa (Minas *et al*., 2007). In addition, a retrospective survey conducted between 2002 and 2006 revealed the registration of 24 hydatidosis cases out of the total of 36,402 patients, giving a mean annual incidence of 2.3 human hydatid cases per 100,000 people per year in North-western Ethiopia (Kebede *et al*., 2010). According to the current study by Ermias (2017), of a total of 74,684 patients admitted in private clinics and referral hospitals in Bishoftu town, 495 (0.61%) human taeniosis cases were registered between September 2005–August 2007 E.C.

3. MATERIALS AND METHODS

3.1. Study Area

The study was conducted from November 2018 to March 2019 at three selected export abattoirs namely, Allana, Abysinia and Elfora, which are located in East Shoa Zone of Oromia Regional State (Figure 8). Allana is found in Modjo town, which is located 70 km Southeast of Addis Ababa, 8°35′N and 39°10′E at an altitude of 1,777 m above sea level. The town has an average temperature of 23°C/73.4°F and the monthly mean maximum and minimum temperature ranges from 25.6°C-30.8°C and 8.5°C to 13.5°C, respectively (NMSA, 2009/2010). Elfora and Abyssinai abattoirs are found in the Bishoftu town, which is located at 9 N0 and 400 E with altitude of 1880 meter above sea level in the central highland of Ethiopia at 47 km South East of Addis Ababa. It has annual rainfall of 1151.6mm of which 84% fall down during the long rainy season that extends from March to May. The mean annual minimum and maximum temperature are 8.50C and 30.70C respectively, and the mean annual minimum and maximum humidity is 61.3 % (NMSA, 2003).The selected Export Slaughterhouse are a family owned private limited company established which supplies fresh chilled meat, mainly goat and sheep meat, to the Middle East and African countries. The major motive to establish the export Slaughterhouses is due to the rich animal resources available in the country (http://www.lunafarmexport.com/index.html).

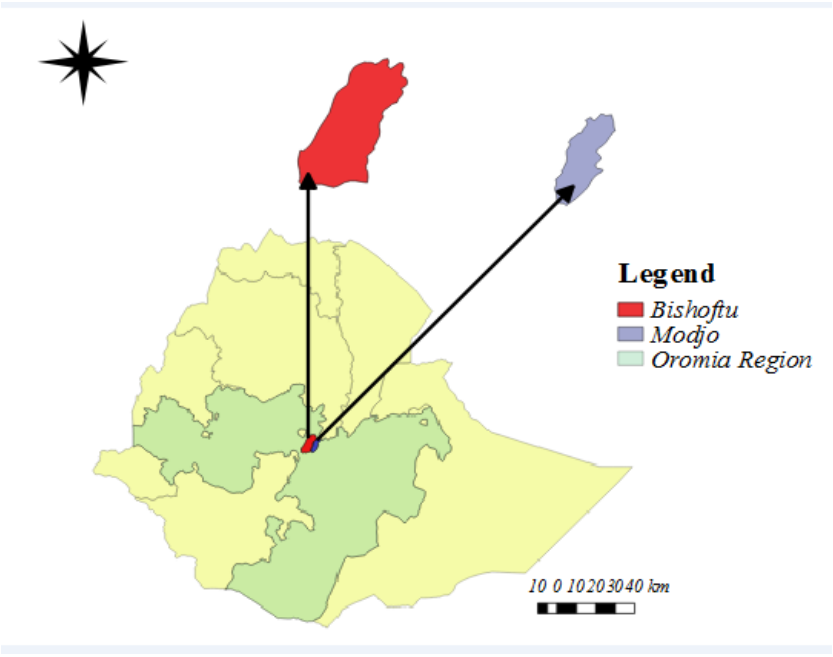


Figure 8: Map of the study area

3.2. Study Animals

The study was conducted on sheep and goats of local breeds slaughtered at Allana, Abyssinia and Elfora export abattoirs that originated from neighbouring localities and different regions of Ethiopia. In the areas of their origin, the animals were owned by smallholder farmers under traditional management system.

3.3. Study Design

A cross- sectional abattoir survey was carried out from November 2018 to March 2019 with the aim of study of metacestode parasites and to assess the direct financial losses on sheep and goats slaughtered at selected export abattoirs.

Questionnaire survey: Questionnaire survey aiming to assess public awareness about metacestodes of small ruminants and the risk factors for their occurrence was carried out at Bishoftu and Modjo towns during the study period. The detail format is found on Annex 9.

3.4. Sample Size Determination and Sampling Technique

The number of animals required for the study was determined using the formula given by Thrusfield (2007), by using 95% level of confidence, 50% expected prevalence and 0.05 desired absolute precision.

$$n = \frac{1.96^2 \, Pexp \, (1-Pexp)}{d^2}$$

Where: n = required sample size, P exp= expected prevalence and d = desired absolute precision

Accordingly, the required sample size for this study was 384; but in order to increase precision, it was multiplied by two thus 768 animals (384 sheep and 384 goats) were used for study which were 256 from each abattoirs. The study animals were selected by systematic sampling technique. A questionnaire survey was based on the formula recommended by Arsham (2002).

$$N = 0.25/SE^2$$

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%. Accordingly, 100 volunteer individuals were selected and interviewed considering different age, sex and working conditions.

3.5. Ante Mortem and Post Mortem Examination

Routine ante mortem and post mortem examination was carried out according to (FAO, 2000), and each study animal was given an identification number and grouped in to different categories of species, age, body condition score and agro ecology. All selected animals were grouped into 2 age groups (adult and young) based on dentation (Gatenby, 1991; Steele, 1996; Alemu and Merkel). The body condition was scored following the guidelines set by Abebe (2007) and the animals was categorized in to two agro ecologies based on information from abattoirs personnel. Sex was not considered as risk factor because only male animals were slaughtered throughout the study period (Annex 2). Post-mortem examination was conducted thorough visual inspection, palpation and systemic incision of each visceral organ particularly the lungs, kidneys, liver, spleen, heart, omentum, mesentery, and striated muscles for the presence of hydatid cyst, *C. tenuicollis* and *C. ovis* (Getaw *et al*., 2010; Ahmed *et al*., 2017). Cysts were identified based on their morphological basis and predilection sites. Inspection of the skulls and brains was not permitted due to the slaughter houses formalities; therefore it was not possible to assess the status of *C. cerebralis*.

3.6. Cyst Characterization

3.6.1. Fertility and viability tests

The individual cysts from each of the infected organs of sheep and goats were grossly examined for degeneration, then cysts were selected, carefully incised (Annex 4), and examined for protoscoleces. The content of the fluid was aspirated using 18 gauge needle and 20ml syringe into sterile cylinder container to reduce pressure and risk of entering the eye. After the pressure was reduced, the whole cyst content was transferred into beaker. Then a drop of cyst fluid was placed on the microscope slide, covers with cover slip and examined under a microscope (40X) for the presence of protoscolices in the cyst. The cysts which contain protoscolices were classified as fertile cysts (Daryani *et al*., 2007). Fertile cysts were further subjected to viability test to observed amoeboid like peristaltic movement. For clear vision, a drop of 0.1% aqueous eosin solution was added to cyst fluid on microscope slide

with the principle that viable protoscolices should completely or partially exclude the dye while the dead ones take it up (Dalimi *et al*., 2002).

3.6.2. Cyst Burden and size measurement

The total number of cysts were counted and recorded. The size of the diameter of non-calcified cyst of each metacestodes was measured and classified as large (diameter >10cm), medium (5 - 10cm) and small (diameter < 5cm) (Oostburg *et al*., 2000).

3.7. Financial Losses Assessment

The direct financial losses incurred organ/carcass condemnation due to metacestodes in slaughtered sheep and goats was estimated by using the formula indicated by Orgunriade and Orgunriade (1980). To calculate the direct financial loss the following data were considered; the annual slaughtered rate of the abattoirs, the percentage of each organ/carcass condemned and the average of market price of an organ,

$$\mathrm{EL} = \sum SRX * CoY * RoZ * PM$$

Where EL is the annual economic loss estimated due to organ/carcass condemnation, ∑SRX is the annual sheep and goats slaughter rate of the abattoir, Coy is the average cost of each sheep and goat organ/carcass, Roz is the percentage of organ condemned.

3.8. Data Analysis

Microsoft excel 2013 data base system was used for entry, coding and simple calculation of recorded data. Statistical data analysis was done by using STATA Stastical software Version 13. Burden of the cyst was calculated by using Microsoft excel. The association between metacestode infection and risk factors were determined by multiple logistic regression. A statistically significant difference between variables exists when $p<0.05$ at 95% confidence level (CI).

4. RESULTS

4.1. Prevalence and Associated Risk Factors

In the present study, *C. ovis*, *C. tenuicollis* and hydatid cyst in small ruminants slaughtered at Bishoftu Abyssinia, Elfora and Modjo Allana abattoirs were detected with the overall prevalence of 29.2 % (224/768). Out of the 384 goats, 85 (22.1%) metacestodes involving 8 (2.1%) *C. ovis*, 44 (11.5%) C. *tenuicollis* and 33 (8.6%) hydatid cysts were detected at the three selected export abattoirs. Similarly a total prevalence of 139 (36.2%) metacestodes, 22 (5.7%) *C. ovis*, 64 (16.7%) C. *tenuicollis* and 53 (13.8%) were detected in total 384 sheep slaughtered. Abattoir based prevalence show that 73 (28.5%), 70 (27.3%) and 81 (31.6%) of metacestodes was recorded in small ruminants slaughtered at Abyssinia, Allana and Elfora, respectively. Statistical analysis showed sheep was significantly infected with *C. ovis* than goats (P<0.05), however, there was no significance difference with infection of *C. tenuicollis* and hydatid cyst in the study animals (P>0.05) (Table 1).

Table 1: Logistic regression analysis of metacestodes in goats and sheep at each abattoirs

Abattoirs	**Total examined**	**Identified metacestodes**			**Total prevalence**
		C. ovis	***C. tenuicollis***	**Hydatid cyst**	
Abyssinia					
Goats	130	1 (0.8)	15 (11.5)	10 (7.7)	26 (20)
Sheep	126	8 (6.4)	23 (18.3)	16 (12.7)	47 (37.3)
Total	256	9 (3.5)	38 (14.8)	26 (10.2)	73 (28.5)
OR (P-value)		1.26 (0.03)	1.06 (0.8)	1.07 (0.6)	2.3 (0.23)
Allana					
Goats	157	2 (1.3)	13 (8.3)	12 (7.6)	27 (17.2)
Sheep	99	6 (6.1)	17 (17.2)	20 (20.2)	43 (43.4)
Total	256	8 (3.1)	30 (11.7)	32 (12.5)	70 (27.3)
OR (P-value)		1.19 (0.04)	0.99 (0.06)	1.09 (0.9)	0.97 (0.08)
Elfora					
Goats	97	5 (5.2)	16 (16.5)	11 (11.3)	32 (33)
Sheep	159	8 (5.1)	24 (15.1)	17 (10.7)	49 (30.8)
Total	256	13 (5.1)	40 (15.6)	28 (10.9)	81 (31.6)
OR (P-value)		1.6 (0.2)	1.8 (0.07)	1.07 (0.8)	6.3 (0.09)
Over all total	**768**	**30 (3.9)**	**108 (14.1)**	**86 (11.2)**	**224 (29.2)**

Statistically significant variation between metacestode infection and body condition and agro ecology was seen in both goats and sheep, however, it is not statistically significant with the age of both animals as indicated in Table 2 in goats and Table 3 in sheep.

Table 2: Logistic regression analysis of metacestodes identified in goats by age, body condition and agro ecology at the three selected export abattoirs.

Risk factors	**No. examined**	**Prevalence (%)**			**Total**
		C. ovis	***C. tenuicollis***	**Hydatid cyst**	
Age					
Adult	250	6 (2.4)	29 (11.6)	24 (9.6)	59(23.6)
Young	134	2 (1.5)	15 (11.2)	9 (6.7)	26 (19.4)
OR (P-value)		1.01 (0.7)	0.99 (0.1)	1.09 (0.9)	1.1 (0.8)
BCS					
Good	92	1 (1.1)	9 (9.8)	6 (6.5)	16 (17.4)
Medium	198	3 (1.5)	16 (8.1)	10 (5.1)	29 (14.6)
Poor	94	4 (4.2)	19 (20.2)	17 (18.1)	40 (42.6)
OR (P-value)		1.02 (0.01)	1.08 (0.008)	1.11(0.001)	1.4 (0.03)
Agro ecology					
Highland	179	6 (3.4)	28 (15.6)	24 (13.4)	58 (32.4)
Lowland	205	2 (0.98)	16 (7.8)	9 (4.4)	27 (13.2)
OR (P-value)		0.91 (0.1)	0.93 (0.01)	0.92 (0.002)	0.90 (0.004)
Total	**384**	**8 (2.1)**	**44 (11.5)**	**33 (8.6)**	**85 (22.1)**

Table 3: Logistic regression analysis of metacestodes identified in sheep by different risk factors at three selected export abattoirs.

Risk factors	**No. examined**	**Prevalence (%)**			**Total**
		C. ovis	***C. tenuicollis***	**Hydatid cyst**	
Age					
Adult	220	14 (6.4)	38 (17.3)	32 (14.5)	84 (38.2)
Young	164	8 (4.9)	26 (15.9)	21 (12.8)	55 (33.5)
OR (P-value)		1.3 (0.56)	1.05 (0.57)	1.04 (0.7)	1.1 (0.6)
BCS					
Good	107	4 (3.7)	16 (14.9)	13 (12.1)	33 (30.8)
Medium	187	6 (3.2)	20 (10.7)	18 (9.6)	44 (23.5)
Poor	90	12 (13.3)	28 (31.1)	22 (24.4)	62 (68.9)
OR (P-value)		1.2 (0.00)	1.27 (0.01)	1.3 (0.003)	1.4 (0.002)
Agro ecology					
Highland	235	17 (7.2)	48 (20.4)	41 (17.4)	106 (45.1)
Lowland	149	5 (3.4)	16 (10.7)	12 (8.1)	33 (22.1)
OR (P-value)		0.97 (0.04)	0.92 (0.013)	0.91 (0.009)	0.94 (0.01)
Total	**384**	**22 (5.7)**	**64 (16.7)**	**53 (13.8)**	**139 (36.2)**

4.2. Burden of Cyst and Organ Distribution

A total of 436 cysts comprising 34 *C. ovis*, 239 *C. tenuicollis* and 163 hydatid cysts were counted in the total small ruminants harbouring metacestodes. 189 total cysts were counted in total infected goats while 247 cysts in total infected sheep.

Cysticercus ovis was detected only in the heart of both goats and sheep. The result showed *C. tenuicollis* had more tendency to be located in omentum followed by mesentry, liver, lungs and peritoneum of both goats and sheep while the lungs showed the highest rate of infestation for hydatid cyst followed by liver and kidney (Table 4).

Table 4: Organ distribution of *C. tenuicollis* and hydatid cysts in slaughtered goats and sheep

Organ	***C. tenuicollis***		**Hydatid cyst**	
	Goats	**Sheep**	**Goats**	**Sheep**
Liver	6 (1.6)	9 (2.4)	11(2.9)	19 (4.9)
Liver and lungs	1 (0.3)	2 (0.5)	2 (0.5)	3 (0.8)
Liver and omentum		2 (0.5)		-
Lungs	3 (0.8)	4 (1.1)	18 (4.7)	26 (6.8)
Kidney	-	-	2 (0.5)	5 (1.3)
Mesentry	9 (2.3)	10 (2.6)	-	-
Mesentry and omentum	2 (0.5)	4 (1.1)	-	-
Omentum	20 (5.2)	27 (7.1)	-	-
Peritoneum	3 (0.7)	6 ((1.6)	-	-
Total	**44 (11.5)**	**64 (16.7)**	**33 (8.6)**	**53 (13.8)**
P-value	**000**	**000**	**000**	**000**

4.3.Cyst Characterization

Fertility and Viability Tests: Out of the total 436 cysts, 145 (33.3%) were fertile and contained protoscolices whereas the remaining 268 (61.5%) and 23 (5.3%) were sterile and calcified cysts, respectively. Of the fertile cysts (145), 67 (46.2%) were viable while 78 (53.8%) were non-viable. Cyst fertile and viable results in goats and sheep were presented in Table 5.

Table 5: Cyst fertility and viability in sheep and goats

Fertility and viability %		*C. ovis*	*C. tenuicolis*	Hydatid cyst	Total
Fertile	Goats	3 (0.7)	30 (6.9)	25 (5.7)	58 (13.3)
	Sheep	10 (2.3)	45 (10.3)	32 (7.3)	87 (19.9)
Sterile	Goats	6 (1.4)	75 (17.2)	34 (7.8)	115 (26.3)
	Sheep	15 (3.4)	85 (19.7)	53 (12.1)	153 (35.2)
Calcified	Goats	0	2 (0.5)	14 (3.2)	16 (3.7)
	Sheep	0	2 (1.2)	5 (1.2)	7 (1.4)
Viable	Goats	1 (0.23)	16 (3.7)	6 (1.4)	23 (5.2)
	Sheep	2 (0.5)	25 (5.7)	17 (3.9)	44 (10.1)
Total No. of cysts		**34**	**239**	**163**	**436**

Fertility and viability tests of *C. tenuicollis* in different organs of goats and sheep were indicated in Table 6. In both goats and sheep, more fertile and viable cysts were observed in omentum. Likewise more fertile and viable hydatid cysts were detected in lungs in both animals (Table 7)

Table 6: Fertility and viability of *C. tenuicollis* in different organs of goat and sheep

Fertility and viability tests	**Organ**					**Total**
	Liver	Lungs	Messentry	Omentum	Peritoneum	
Goats						
Fertile	2 (0.5)	6 (1.4)	8 (1.8)	12 (2.8)	2 (0.5)	30 (6.9)
Sterile	6 (1.4)	2 (0.5)	22 (5.1)	39 (8.9)	6 (1.4)	75 (17.2)
Calcified	2 (0.5)	-	-	-	-	2 (0.5)
Viable	1(0.23)	4 (0.9)	4 (0.9)	7 (1.6)	-	16 (3.6)
Sheep						
Fertile	2 (0.5)	8 (1.8)	7 (1.6)	25 (5.7)	3 (0.7)	45 (10.3)
Sterile	5 (1.2)	3 (0.7)	25 (5.7)	42 (9.6)	11 (2.5)	85 (19.5)
Calcified	1 (0.23)	1 (0.23)	-	-	-	2 (0.5)
Viable	-	3 (0.7)	2 (0.5)	19 (4.4)	1 (0.23)	25 (5.7)

Table 7: Fertility and viability of hydatid cyst in different organs of goat and sheep

Fertility and viability tests	**Organ**			**Total**
Goat	**Liver**	**Lung**	**Kidney**	
Fertile	6 (1.4)	18 (4.1)	1 (0.23)	25 (5.7)
Sterile	4 (0.9)	28 (6.4)	2 (0.5)	34 (7.8)
Calcified	10 (2.3)	3 (0.7)	1 (0.23)	14 (3.2)
Viable	1 (0.23)	5 (1.2)	-	6 (1.4)
Sheep				
Fertile	10 (2.3)	20 (4.6)	2 (0.5)	32 (7.3)
Sterile	15 (3.4)	34 (7.8)	4 (0.9)	53 (12.1)
Calcified	4 (0.9)	1 (0.23)	-	5 (1.2)
Viable	3 (0.7)	14 (3.2)	-	17 (3.9)

Cyst size measurement: Out of the total 436 counted metacestodes cysts, 23 were calcified cysts which reduce the total number of cysts to be assessed for size to 413. Accordingly, Out of a total none calcified *C. tenuicollis* in goats (105) and sheep (130), 32 and 28 were small, 51 and 65 medium and 22 and 37 large in size in goats and sheep respectively. Similarly, out of none calcified 59 and 85 hydatid cysts in goats and sheep, 15 and 20 were small, 35 and 47 medium and 9 and 18 large in size, respectively. All 34 none calcified *C. ovis* cysts were small in both goats and sheep (Table 8).

Table 8: Size of non-calcified cysts in sheep and goats

Size of cyst		***C. ovis***	***C. tenuicolis***	**Hydatid cyst**	**Total**
Small	Goats	9 (2.2)	32 (7.7)	15 (3.6)	56 (13.3)
	Sheep	25 (6.1)	28 (6.7)	20 (4.8)	73 (20.8)
Medium	Goats	0	51 (12.3)	35 (8.5)	86 (23.2)
	Sheep	0	65 (15.7)	47 (11.4)	112 (27.1)
Large	Goats	0	22 (5.3)	9 (2.2)	30 (5.3)
	Sheep	0	37 (8.95)	18 (4.4)	56 (7.7)
Total non-calcified cysts		**34**	**235**	**144**	**413**

Cyst size in organ of goats and sheep indicated, most of medium and large *C. tenuicollis* were found in omentum than other organs in both goats and sheep while small cysts were high in liver (Table 9). Likewise, most of medium and large hydatid cysts were found in lungs than liver and kidney in both animals (Table 10).

Table 9: Size of non-calcified *C. tenuicollis* in different organs of goats and sheep.

Organ	**Total non calcified cysts**	**Cyst size**		
		Small	**Medium**	**Large**
Goats				
Liver	8	6	2	-
Lungs	8	4	3	1
Mesentry	30	7	18	5
Omentum	51	13	23	15
Peritoneum	8	2	5	1
Total	**105**	**32**	**51**	**22**
Sheep				
Liver	7	3	4	-
Lungs	11	2	5	4
Mesentry	32	8	15	9
Omentum	67	12	34	21
Peritoneum	14	3	7	4
Total	**131**	**28**	**65**	**38**

Table 10: Size of non-calcified hydatid cysts in different organs of goats and sheep

Organ	**Number of non calcified cysts**	**Cyst size**		
		Small	**Medium**	**Large**
Goats				
Liver	11	7	2	2
Lungs	45	5	33	7
Kidney	3	3	-	-
Total	**59**	**15**	**35**	**9**
Sheep				
Liver	25	6	15	4
Lungs	54	12	28	14
Kidney	6	2	4	-
Total	**85**	**20**	**47**	**18**

4.4. Assessment of Direct Financial Losses

For direct financial analysis, both partially and totally condemned organs due to *C. ovis*, *C. tenuicollis* and hydatid cysts were taken into account. Based on information gathered from hotels and restaurants in Modjo and Bishoftu, mean unit price of heart, liver, lungs and kidney for local market were 5, 10, 3 and 2 ETB respectively. The mean annual small ruminants slaughter rate of the three selected export abattoirs was estimate based on observation during study period together with the judgment of meat inspector which were 25000 at Abyssinia, 120000 at Allana and 20000 at Elfora. Based on the formula given by Orgunriade and Orgunriade (1980), the total annual monitory losses due to rejection of organs at each abattoirs was estimated to be 1036505 ETB (Table 11).

Table 11: Direct financial losses associated with metacestodes of small ruminants at the selected abattoirs

	Annual financial losses (ETB)			
Abattoir	***C. ovis***	***C. tenuicollis***	**Hydatid cyst**	**TAL**
Abyssinia	10375	45925	86825	**143125**
Allana	58020	247080	480480	**785580**
Elfora	4500	32340	70960	**107800**
TAL	**72895**	**325345**	**638265**	**1036505**

Where TAL = Total annual losses; ETB = Ethiopian birr

4.5. Community Awareness and Knowledge on Goat and sheep Metacestodes

4.5.1. Assessment on risk factors

In this study, out of the total 100 interviewed respondents of Modjo and Bishoftu towns, 85% (85/100) had dogs that shared their house with them, and the potential predisposing factors associated with the metacestodes infection are; dogs fed raw offal 65 (76.5%), scavenging dogs 15 (29.4), dogs left free all-time 70 (82.4), lack of worm control in sheep, goats and dogs (98). In this study 98% and 15% of the total respondents also confirmed that stray and wild dogs are also predisposing factors. Similarly 75% of the respondents had sheep and goat, and the risk factors related to this animals are: free grazing animals 68 (90.6%), offal thrown into environment 20 (26.7%) and offal thrown raw to dog(s) 55 (73.3%) after slaughtering or when the animal died (Table 12).

Table 12: Risk factors of metacestodes based on questionnaire survey

Predisposing factors	**Number of respondents**	**Positive respondents (%)**
Dog fed raw offal	85	65 (76.5)
Dog scavenging	85	15 (29.4)
Dogs with full time tied	85	5 (5.9)
Dogs tied at day/night only	85	10 (11.8)
dogs free all time	85	70 (82.4)
Lack of worm control in sheep, goats and dogs	85	80 (94.1)
Stray dog in locality	100	98 (98)
Wild dogs in the grazing ground	100	15 (15)
Free grazing goat and sheep	75	68 (90.6)
Raw offal thrown to dogs after slaughtering	75	55 (73.3)
Raw offal thrown to the environment	75	19 (26.7)

4.5.2. Assessment on zoonosis, transmission mechanism, treatments and control

Out of the total 100 respondents, those community at risk for zoonotic metacestodes are: 72% who had no information about sheep and goats zoonotic metacestodes, 65% who do not know as hydatid cyst can be share between humans and dogs, 67% who do not know as the disease can be shared between dogs and small ruminants, 61% who do not know as dogs can be affected by eating raw uncooked offal, and those who do not know as human can be infected by eating raw/partially cooked vegetables/fruits (55%) and contaminated soil (70%). This study also shows us 53 and 55% of the respondents had no information regarding treatment and control measures for the metacestode infection, respectively. Similarly 71 and 32% of the respondents had no information on the importance of feeding dogs with cooked offal (71%) and deworming animals (32%) in reducing risk of the infection (Table 13).

Table 13: Knowledge on zoonosis, transmission, treatment and control of metacestodes

Total number of respondents = 100	**Yes**	**No**
Knowledge on possibility of human to be infected by metacestodes	28	72
Knowledge on transmission between human and dogs	35	65
Knowledge on transmission between dogs and small ruminants	33	67
Knowledge on transmission to Dogs via eating uncooked offal	39	61
Raw/partially cooked vegetables/fruits as source of human infection	45	55
Knowledge on transmission when contacting contaminated soil	30	70
Knowledge about existence and efficacy of treatments	47	53
Knowledge about possible control measures	45	55
Knowledge on importance of feeding dogs with cooked offal	29	71
Knowledge on importance of deworming sheep, goats and dogs in the control of metacestodes	68	32

5. DISCUSSION

Ethiopia is one of the endemic areas of *Taenia species* in dogs and wild carnivores as final hosts, and livestock and wild herbivores as intermediate hosts. Metacestode infections, cysticercosis and hydatidosis in small ruminants are important because they are main cause of meat condemnation contributing to a significant economic problems and they cause human infectious disease, especially in poor and developing countries (Sisay *et al*., 2015; Reza *et al*., 2018; Christine and Christopher, 2000; Jenkins *et al*., 2013). In the present study, *C. ovis, C. tenuicollis* and hydatid cyst in small ruminants slaughtered at Bishoftu Abyssinia, Elfora and Modjo Allana abattoirs were detected. The 2.1% *C. ovis* in goat is agrees with the report of Abebe *et al*. (2014) (1.9), however it is lower than the study by Sissay *et al.* (2008) who reported 22% *C. ovis* infection in goats in Ethiopia and higher than the study by Ahmed *et al*. (2017) in Egypt who did not record the infection in goats. Similarly, the 5.7% prevalence of *C. ovis* in sheep is agreement with study by Abdel-Maogood *et al.* (2005) (5.66%) in Cairo, in Egypt. However, this result is relatively higher than the study by Hashemnia *et al.* (2016) (1.27%), and Oryan *et al.* (2012) (0.09%) in Iran and Ali (2013) (0.35%) in Qena, Egypt and lower than that of Sissay *et al.* (2008) (26%) and Abebe *et al*. (2014) (9.02%) in Ethiopia.

The prevalence of *C. tenuicoolis* in goats (11.5%) in this study is smaller than the reports by Tadesse *et al*. (2012) (36.2%), Anteneh *et al*. (2011) (56.8%), Mohammed *et al*., 2005 (18.04%), Sissay *et al*., (2007) at Haramaya (38%), Harar (30%), Dirre Dawa (32%) and Jigjigga (35%) abattoirs. The 16.7% prevalence of *C. tenuicollis* in sheep is agree with the report by Sisay *et al*. (2007), who has recorded prevalence of 17, 14, and 15% in sheep at Haramaya, Harar, and Jijiga abattoirs, respectively. However it is lower than the report of Tadesse *et al*. (2012) (39.5%) and and Anteneh *et al*. (2011) (63.9%).

Considering hydatidosis of goats and sheep, the 8.6% prevalence of Hydatid cyst in goats is consistent with the study of Assefa *et al*. (2015) (6.80); Daniel *et al*. (2012) (6.13); Saeed *et al*. (2000) (6.2%), Dalimi *et al*. (2002) (6.3%), Yeshiwork, 2009 (6.8%) and Getaw *et al*. (2010) (6.7%). However it is not agreement with the prevalence 16%, 4.5% and 3.4% reported by Kebebe *et al*. (2010), Haridy *et al*. (2000) and Njoroge *et al*. (2002). In sheep, the 13.6% prevalence of hydatid cyst in this study is slightly higher than the previous studies by Asseffa *et al*. (2015), Daniel *et al*. (2012), Getachew *et al*. (2012), Azlaf and Dakkak

(2006) and Elmahdi *et al.* (2004), who reported (8.02), (7.7), (8.05), (10.58%) and (10.3%) prevalence in sheep. This result is also much higher than the report of Haridy *et al*., 2000 and Njoroge *et al*., 2002 who reported lower (0.33%) and (3.6%) hydatid cyst infection in sheep respectively. However, this result is lower than the 68% infection rate in sheep reported by Sissay *et al*. (2008) in eastern Ethiopia, 34.7% prevalence rate recorded in Tanzania by Ernest *et al*. (2008) and the 19% hydatidosis in sheep reported by Kebebe *et al*. (2010).

In all above, the variation of metacestodes in both goats and sheep between this study and the previous study could be attributed to differences in agro ecology, breed, and management of studied animals. Difference in population of stray dogs, community culture, host age factors, and stocking rate of livestock are other contributing factors as has been suggested by Ibrahim (2009).

Considering the species of small ruminants, the prevalence with the three metacestodes in goats was lower than in sheep with significant difference in the prevalence of *C. ovis*, in goats (2.1%) and in sheep (5.7%) ($P<0.05$). However there is no significant variation in the prevalence of *C. tenuicollis* and hydatid Cyst between the two animals; in goats (11.5% and 8.6%) and sheep (16.7% and 13.8%), ($P>0.05$), respectively. The lower infection rate of the metacestodes in goats than sheep in this study agrees with the several studies; Daryani *et al*., 2007; Fakhar and Sadjjadi, 2007; Ernest *et al*., 2008 reported lower hydatid cyst infection in goats as compared to infection in sheep. Similarly, Yalelet *et al*., 2019, Endale *et al*., 2013, Dayana *et al*., 2017 reported lower infection of *C. tenuicollis* in goats than in sheep at Bishoftu Elfora, Dire Dawa municipal abattoir and in Brazil respectively and Sissay *et al*., 2008 reported lower infection of *C. ovis* in goat than sheep.

The higher prevalence of this findings 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 behaviour of sheep on pastures contaminated with taenia eggs (Fakahr and Sadjjadi 2007; Kebede *et al*., 2010). This finding suggests the importance of sheep as the main reservoir of infection in maintaining and perpetuation of the life cycle of *C. ovis, C. tenuicollis* and hydatid cysts in the region (Kebede *et al*., 2009).

In contrast, Anteneh *et al*., 2011 reported higher prevalence of *C. tenuicollis* in sheep than goats which were (56.8%) in sheep and (63.9%) goats. This could be probably due to under condition of high infestation with *C. tenuicollis*, most sheep develop protective immunity early in life, whereas goats develop protective immunity more slowly (Torgerson *et al*., 2008). This considerable degree of immunity against *C. tenuicollis* in sheep may be the reason for low prevalence of the parasite in sheep.

Multiple logistic regression analysis of the different risk factors (age/, body condition score, and agro ecology) considered during the study show higher infection of *C. ovis*, *C. tenuicollis* and hydatid cyst in adult with over all prevalence 23.6% in goats (2.4% *C. ovis*, 11.6% *C. tenuicollis* and 9.6% hydatid cysts) and 38.2% in sheep (6.4, 17.3 and 14.5% *C. ovis*, *C. tenuicollis* and hydatid cysts, respectively) than in the young goats (19.4%) (1.5, 11.2 and 6.7%) and sheep (33.5%) (4.9, 15.9 and 12.8%) with similar pattern of metacestodes. However, the association between the occurrence of metacestodes was not vary significantly with age ($P>0.05$). The higher infection in adult than young ones can be attributed to three 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 adult animals due to their bigger size. In younger animals, either the cysts are not developed into detectable size, which can be easily missed during post-mortem examination. Thirdly, the small sample size of young goats and sheep as compared with greater number of adult one slaughtered in the Abattoirs might be contributed to the higher prevalence in adult. Indeed, the present study as well many other studies elsewhere (Baswaid, 2007; Anteneh *et al*., 2011; Getachew *et al*., 2012; Muqbil *et al*., 2012; Ermias, 2017), have shown higher infestation rates of metacesstodes in adult animals.

Regarding body condition, high infection rate of *C. ovis, C. tenuicollis and* hydatid cyst were seen in goats and sheep with poor body condition than animals with medium and good body condition, which vary significantly ($P<0.05$). This finding is in line with the report of Samuel and zewde, 2010, Wondimu *et al*., 2011 and Endale *et al*., 2013, who reported higher infection of *C. tenuicollis* in poor body goats and sheep. Similarly Muhammadhussien, 2017 reported highest infection of hydatid cysts in poor body condition goats and sheep than medium and good body conditions one in Gindibret, Ethiopia. The highest infection in animals with poor body condition can be explained that in moderate to severe infection, the

parasite may cause retarded performance and growth, reduced quality and yield of meat as well as live weight loss (Urquhart *et al*., 2003; Taylor *et al*., 2007).

Similarly, the prevalence of metacestodes by agro ecology of slaughtered goats and sheep was statistically significant difference (P< 0.05) was found: goats (32.4 and 13.2%) and sheep (45.1 and 22.1%) from highland and lowland areas respectively, which indicate agro ecology play an important role in distribution of the cysts. This result is consistent with previous studies; Anteneh *et al*., (2011) and Kebebe *et al*. (2010) reported higher prevalence of tenuicollis and hydatidosis, respectively in goats and sheep from highland areas. The lower prevalence in both sheep and goats in this study from lowland areas can be attributed to environmental conditions such as high temperature and low humidity (adverse conditions for the survival of the eggs of *T. ovis, T. hydatigena* and *E. granulosus*). This could be also due to the difference in the socio-economic status and animal husbandry practices of community in all areas from where animals were brought for slaughter and frequent contact of animals with infected definite host.

In this study, cyst number were counted and their organ distribution observed. Accordingly 436 total cysts (34 *C. ovis*, 239 *C. tenuicollis* and 163 hydatid cysts). The burden was 247 (56.7%) total cysts in 139 infected sheep (25 *C. ovis*, 132 *C. tenuicollis* and 90 hydatid cysts) while in goats 189 (43.3%) total cysts in 85 positive goats for the metacestodes, (9 *C. ovis*, 107 *C. tenuicollis* and 73 hydatid cysts). This contributes to high organ condemnation with the consequence of huge financial losses. It also shows the risk of environmental contamination and continuous infection of final hosts if the offal are not disposed with great caution.

Regarding organ distribution, in both goats and sheep heart was the only organ infected with *C. ovis* which is supported by study of Oryan *et al*., 2012, who reported 0.09% *C. ovis* in heart of sheep. Infestation rate of *C. tenuicollis* in different organs of goats and sheep indicates the cysts had an affinity to be located in the omentum than any other organs which was 5.2 and 7.1% in goats and sheep, respectively, which is followed by the mesentery, 2.3 and 2.6%, liver 1.6 and 2.4%, and lowest was found in the lung 0.8 and 1.1% and peritoneum 0.7 and 1.6%, of goats and sheep respectively. Multiple organ distribution were also recorded in both goats and sheep; mesentery and omentum 0.5 and 1.1%, liver and lungs 0.3 and 0.5% respectively, and 0.5% was recorded in liver and omentum of sheep. This difference between

infections rate of visceral organs with the cyst was significantly associated ($p<0.05$). The organ distribution of *C. tenuicollis* in this study is consistent with previous study by Anteneh *et al*. (2011); Tadesse *et al*. (2012); Samuel and Zewde (2010); Senlik (2008), and Yalelet *et al*. (2019). The high tendency of *C. tenuicollis* in omentum in this study is due to the fact that the omentum covers a larger surface area in the peritoneal cavity. Normally, migration out of the lung, mesentery and other visceral organs is unusual; however, aberrant migrants, similar to those of the present study, sometimes occur with cysticerci found in the lungs, liver or other organs (Smith and Sherman, 2009).

Likewise, lungs (4.7 and 6.8%) and liver (2.9 and 4.9%) were the most preferred predilection site for hydatid cyst while kidney is the least infected (0.5 and 1.3%) in goats and sheep respectively. Multiple organ distribution in liver and lungs was recorded; 0.5 and 0.8% in goats and sheep, respectively. The observation in this study that the lungs and liver in both sheep and goats were found to be more commonly infested with hydatid cysts is in agreement with previous findings of Ermias (2017); Marshet *et al*. (2011) and Oryan *et al*. (2012). This is due to in fact that the lungs and liver are considered of having the first large capillary fields encountered by the blood-borne oncospheres, and location of the cyst in animal is controlled by filtering action of these capillaries. Lungs were more infected than liver, probably due to the presence of greater capillary beds in the lungs than liver. In addition to this, soft consistency of the lung might also allow easy growth of cysts. The development of the cyst in kidney is due to cyst occurs occasionally in other organs and tissues when oncosphere escapes into the general systemic circulation (Urquhart *et al*., 2003; Kebede *et al*., 2009).

Cyst characterization on a total of 436 cysts (in goats 189 and sheep 247 cysts) was done to identify cyst fertility or viability, which were, 34, 239 and 163 *C. ovis, C. tenuicollis* and hydatid cysts, respectively according to the identified metacestodes. Based on species of animals, fertile, sterile and viable cysts were in goats, 58 (13.3%), 115(26.3%), and 23 (5.2%) and in sheep, 87 (19.9%), 153 (35.2%), 44 (10.1%), respectively. Calcified cysts in goats 16 (3.7%) and in sheep 7 (1.4%) were detected. The relative lower number of fertile and viable cysts and higher number of calcified cysts in goats than sheep might be due to immunological response of the goat that might result in degeneration of the cysts.

With regard to fertility of cysts in different organs of goats and sheep, high fertile cysts of *C. tenuicollis* were found in omentum than the other organs which where 2.8 and 5.7% in goats and sheep respectively. Similarly higher viable cysts were recorded in omentum in both species. Conversely, high fertile cysts of hydatid cyst were found in lungs (4.1 and 4.6%) followed by liver (1.4 and 2.3%) and kidneys (0.23 and 0.5%) in goats and sheep, respectively. In both animals, most of the calcified cysts were found in the liver which were 10 (2.3%) and 4 (0.9%) in goats and sheep respectively. Likewise, viable cysts of *C. tenuicollis* were higher in omentum while that of hydatid cysts was in lungs when compared to other visceral organ of goats and sheep. The higher fertility and viability rates of cysts in lung due to hydatid cysts in the current study is in agreement with those of Muhammadhussien, (2017); Daniel *et al*. (2012) and Getachew *et al*. (2012). This might be due to softer consistency of tissues that allows the easier development of cyst and the viability. The occurrence of higher calcified cysts in liver than other organs of goats and sheep was agrees with earlier report by Muluneh *et al*. (2019) at Elfora export abattoir. This can be explained as the liver is firm in consistency and lack suitable matrix for long term cyst survival and hence the cyst degenerates. This could also be attributed to relatively higher reticuloendothelial cells and abundant connective tissue reaction of the organ (Kebede *et al*., 2009).

Cyst size measurement in this study shows, out of the total 236 non-calcified *C. tenuicollis*, 32 and 28 small, 51 and 65 medium and 22 and 37 large size cysts were recorded in goats and sheep, respectively. Similarly, out of 143 non-calcified hydatid cysts, 15 and 20, 35 and 47, and 9 and 18 were small, medium and large size cysts in goats and sheep, respectively. Higher numbers of medium and large sized cysts were found in omentum which were medium 21.9 and 32.4% and large 14.3 and 20% in goat and sheep, respectively. This could be due to the fact that the omentum has large surface area than other organs which allow easier development of the cyst.

In contrast, large number of medium (23.1 and 19.6%) and large (4.9 and 9.8%) size hydatid cysts were found in lungs than in the liver and kidney of both study animals, while the liver harboured higher number of small sized (4.9 and 4.2%) in goats and sheep respectively. The reason for higher percentage of medium and large sized cysts in lungs might be related to spongy consistency of the lung and allow easier development of the cyst (Kebede *et al*., 2009). The relatively higher proportion of small cysts in liver may be due to immunological

response of the host that might preclude expansion of cyst size (Islam *et al*., 2003). In addition to that, it might be due to the case in which the infected goat and sheep are slaughtered before the cysts become larger in size (Alemu and Merkel, 2008).

In the current study; overall annual financial losses due to organ condemnation from goats and sheep infested by *C. ovis*, *C. tenuicollis* and hydatid cyst in three selected abattoirs was estimated to be: 1036505 ETB (37018USD): 143125 (5111.7), 785580 (28056.4) and 107800 ETB (3850 USD) in Abyssinia, Allana and Elfora export abattoirs, respectively. The annual losses due to hydatid cysts alone was estimated to be 638265 (22795.2) while 325345 (11619.4) and 72895 ETB (2603.4USD) losses were due to *C. tenuicollis* and *C. ovis* respectively. The huge economic loss in the abattoirs in this study was due to in the fact that the large number of small ruminants slaughter rate of the abattoirs and also due to their high standard in which any organ with single cyst or calcified cyst was disposed from market. Such loses are important in Ethiopia, which has low economic output where sheep and goat production are the major livestock industries.

Knowledge about the metacestode and risk factors is very important in the control of the disease caused by metacestodes. In this study the questionnaire survey show us the potential predisposing factors associated with the metacestodes infection in small ruminants are; dogs fed raw offal, scavenging dogs, dogs left free all-time, lack of worm control in animals, presence of stray and wild dogs. It is also important to note that, majority of the small ruminants are kept under free range, and during home animal slaughters, offal which are not fit for human consumption are simply thrown away into the environment or thrown raw to dogs. This study also indicated lack of knowledge in the community about metacestodes regarding their zoonosis, transmission and control.

Due to in the fact that the life cycle of metacestodes is maintained by close contact between small ruminants (sheep and goats), dogs and human**,** these habits were seen as an important factors which contribute to encourage the disease problems by dissemination of infected material and increasing the risk of sheep/goat-dogs-human infection. Dogs frequently fed on viscera, and not treated for parasitic diseases are important in maintaining metacestodes life cycle which pose a considerable risk for the occurrence of disease in the study area. Thus the problem due to metacestodes in susceptible hosts including human will exacerbate in the near future as more hosts are continuously being infected and re-infected on day to day basis.

6. CONCLUSION AND RECOMENDATIONS

The present finding indicated the occurrence of *C. ovis, C. tennuicolis* and hydatid cyst in small ruminants originated from different locations and slaughtered at the three selected export abattoirs in central Oromia. Besides their animal and public health risks, these metacestodes attributed meaningful financial losses from organ condemnation. The questionnaire survey in this study showed that the major predisposing factors which contribute to persisting of the diseases in the study area were free access of dogs to offal, inappropriate disposal of offal, widespread stray dogs**,** free grazing goat and sheep and inadequate animal health services. Lack of community knowledge on transmission, zoonosis, treatment and control of metacestodes were potential factors for public health risk.

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

- Effective control strategies against metacestodes should be designed and implemented.
- Focused awareness creation program is required to avoid the improper disposal of condemned offal's, denying access of dogs into raw offal, stray dogs and appropriate animal management.
- Adequate animal health services especially worm control should be implemented.
- Further detail epidemiological studies involving different species of livestock, dogs, wildlife, and humans in different zones of Ethiopia is required to establish a clear information system for launching a control programme.

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8. ANNEXES

Annex 1: Sheep and goats in the lairage and selection of study animals at the abattoirs

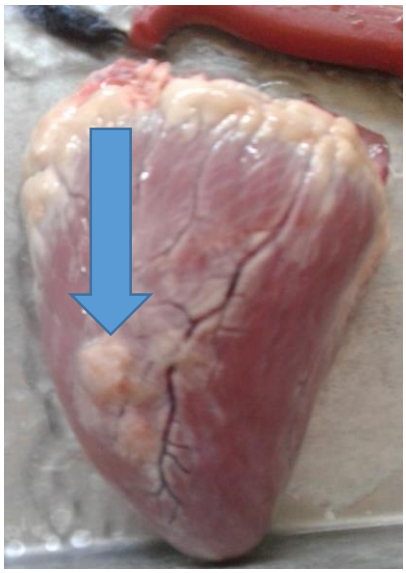


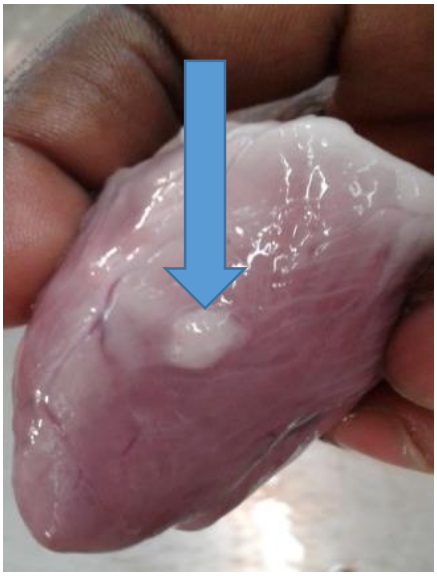

Annex 2: Antemortem inspection and data recording at lairage

Annex 3: Post-mortem inspection

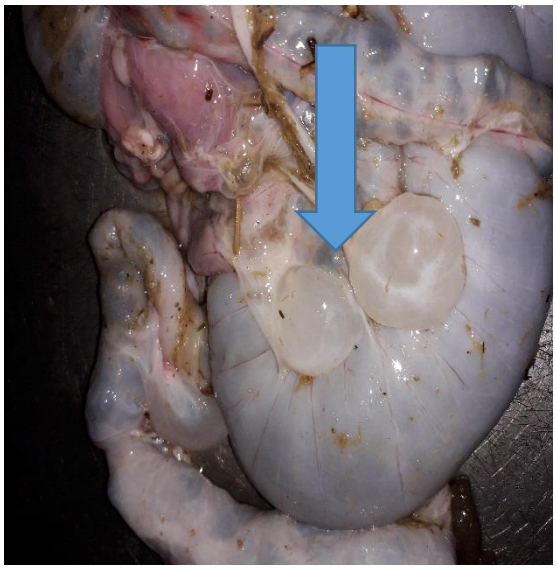
Annex 4: Collection of cysts for cyst characterization

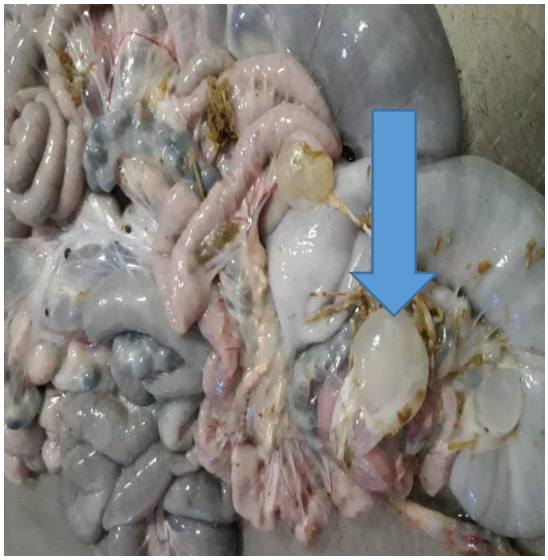
Annex 5: Heart of Goat (left) and Sheep (right) infected with *C. ovis*



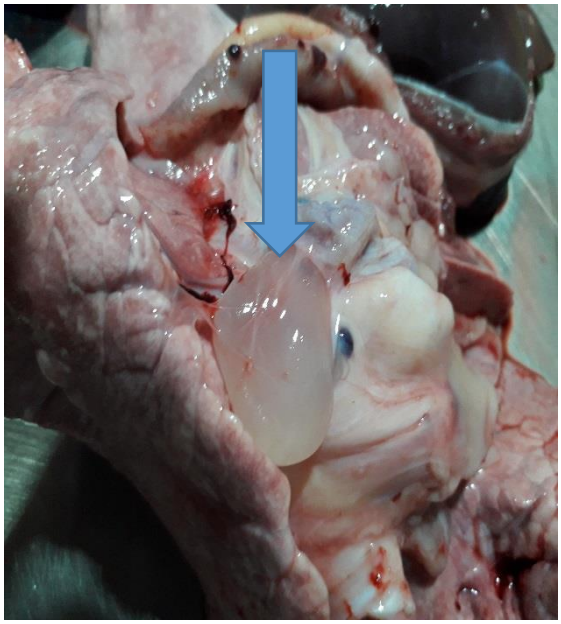


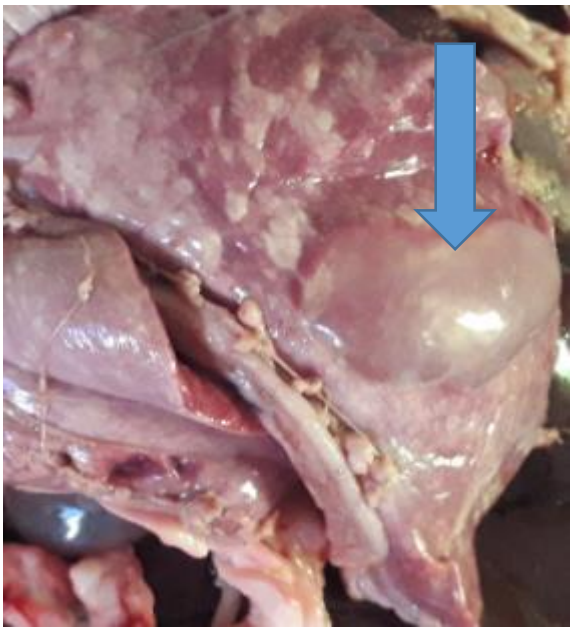
Annex 6: *C. tenuicollis* on mesentry of goat (left) and sheep (right)



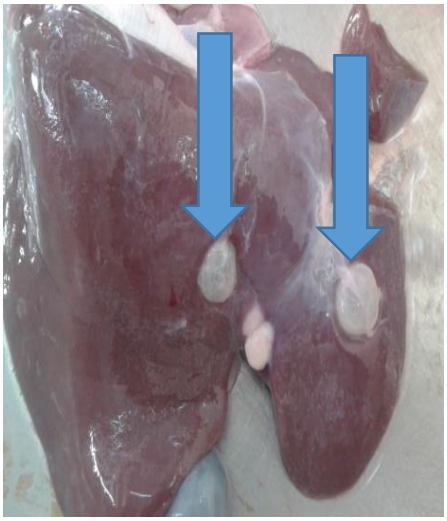


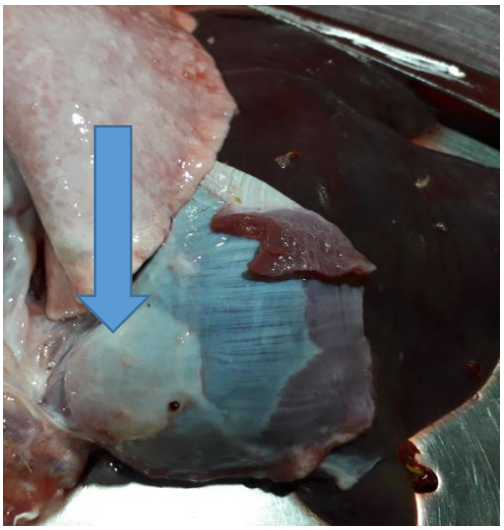
Annex 7: *C. tenuicollis* (left) and Hydatid cyst (right) on lung of sheep





Annex 8: Liver of goat (left) and sheep (right) infected with Hydatid cysts





Annex 9: Questionnaire format

Awareness and Knowledge Assessments about Small ruminant Metacestodes and their Risk factors in Bishoftu and Modjo Towns

Q. No_____

I. Demographic information

Zone_____, Woreda _____, PA/Keble _____, Age_____, Sex: _____ Level of education: Illiterate/Elementary/Some High School/High School Graduate /diploma/ degree/ Graduate degree, where do you work? Human health centre/veterinary health care/other sector _____

II. Risk factors assessments

1. Final hosts related factors

a. Do you have dogs that share your house with you? Yes/No
b. What is the source of food for your dog(s)?
   i. Raw offal ii. Leftovers iii. Scavenge
c. Which one is best indicate your dog(s)?

i. Full time tied ii. Tie at night only iii. Tie during the day iv. Free all time

d. Had you ever dewormed your dogs? Yes/No

e. How frequently do you see stray dogs in your locality?

i. Often ii. Occasionally iii. Never

f. How frequently do you see wild dogs in the grazing ground in your area?

i. Often ii. Occasionally iii. Never

2. Sheep and goats related factors

a. Do you have sheep and goats? Yes/no

b. If the answer to question (b) is yes,

i. How do you feed them? a) Free grazing b) they graze sometimes c) zero grazing

ii. What do you do with sheep and/or goat?

a) Sale at the livestock market or butcher

b) Slaughter at home

iii. When sheep/goat is slaughtered or die at home, what do you do with the offal such as lung and liver?

a. Thrown raw to dog
b. Given to dogs after cooking
c. Thrown into the environment
d. Buried/Burned
e. We trim and eat

II. Awareness assessments on zoonosis and transmission mechanisms

1. Do you have any information about zoonotic parasites from sheep and goats? Yes/no
2. Do you know that human being can be affected by hydatid cyst? Yes/no
3. Hydatidosis can be shared between humans and dogs. Yes/No
4. I can get hydatidosis by eating raw/partially cooked vegetables/fruits or drinking contaminated water. Yes/no
5. I can get hydatidosis when handling soil contaminated with dog faeces. Yes/no
6. I know that metacestodes can be shared between dogs and small ruminants Yes/No

7. I know that dogs can be affected by eating raw uncooked offal from small ruminants Yes/no

III. Knowledge on treatments and control of metacestodes

i. There is effective treatment for a person/animal infected by the parasites, Yes/no
ii. Is there any control measures against the metacestodes both in human and animals? Yes/no
iii. If all dogs are not fed uncooked offal, I agree that metacestodes would not be there. Agree/disagree
iv. If I deworm small ruminants and dogs regularly, I agree the risk of metacestode infection will decrease, Agree/disagree.