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Metacestodes of Small Ruminants, their Economic Impacts and Public Health Importance with particular Emphasis to Ethiopia Situation

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Abstract

Metacestodes, the larval stages of canid cestode parasites, are among the causes of morbidity, mortality and financial losses in farm animals in Ethiopia as a result of organ and carcass condemnation at slaughter. Several studies have been conducted over the years; however, these studies often had limited scope and coverage. This systematic review was conducted to collate the information so far available in order to provide a pooled prevalence, indicate economic and public health importance. The distribution is associated with economic conditions, religious beliefs and the close proximity of humans to farm animals in utility function. It is important to note that eggs of zoonotic cestodes have been demonstrated to survive almost all stages of sewage treatment. In addition to this, the construction of well-equipped abattoirs and the enhancement of awareness of people about the economic and public health importance of the zoonotic cestodes are also crucial. Numerous findings indicate that CE imposes a significant economic burden on Ethiopia export abattoirs. Many researchers also emphasize the importance of maintaining or reinforcing current control measures to consolidate the progress achieved and to reduce human and animal infection rates. Better coverage and accuracy of the current surveillance systems are needed, as are improvements in the cooperation between the central and regional administrations, and the institutions responsible for collecting, providing and epidemiological relevance.

Keywords: Control; Metacestodes; Small ruminants; Zoonotic cestodes.

Introduction

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).

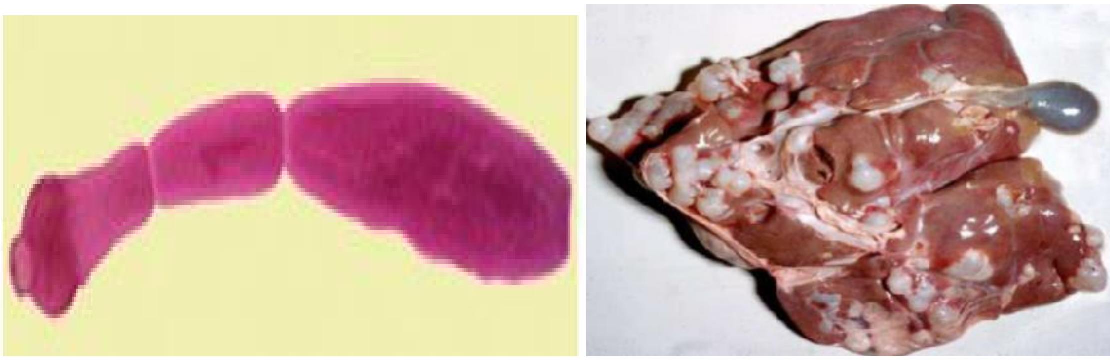
Morphology

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 *Taeniahydatigena*. 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).



A B

Figure 1: Morphology of adult worm of *E. granulosus* (A) and hydatid cysts in sheep liver (B) **Source:** Rahman (2015) and Kumsa and Mohammedzein (2016)

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).

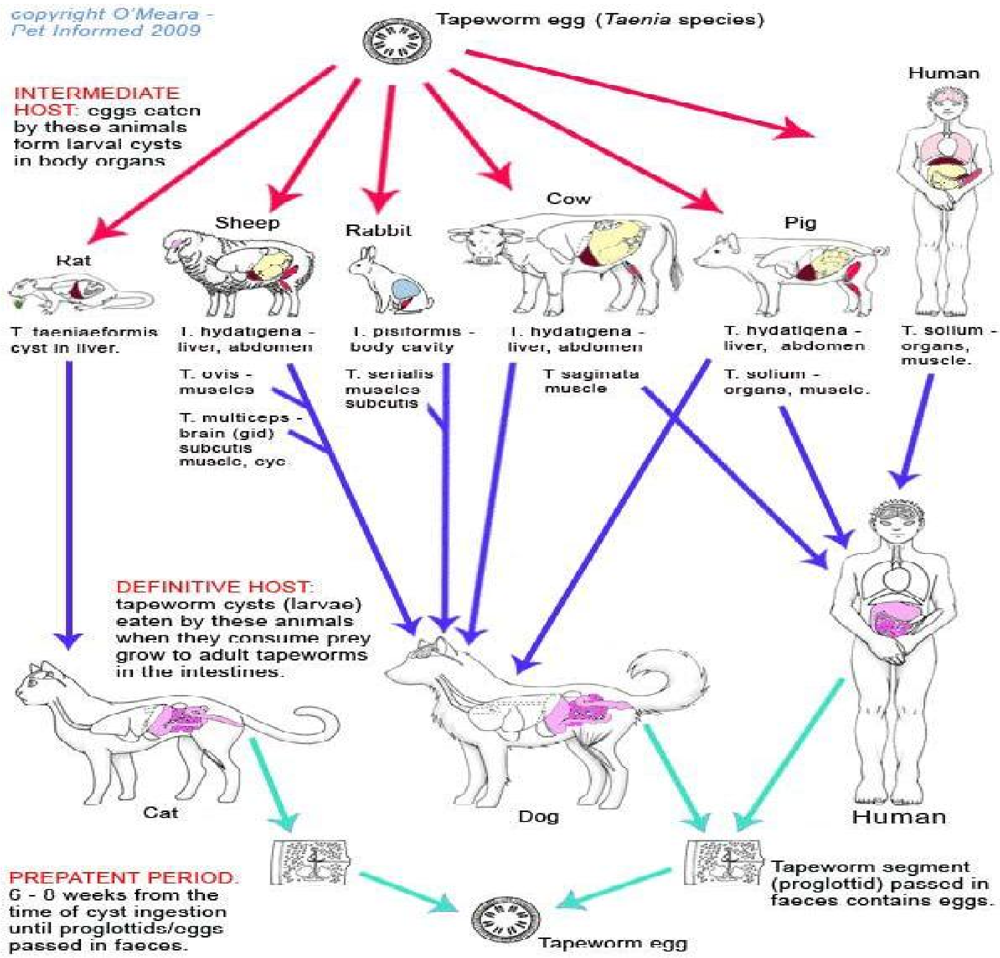


Figure 2: Life cycle of Taenia tapeworm
Source: http://www.pet-informed-veterinary-advice-online.com/Taenia.html

Major Metacestodes in Small Ruminants

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).

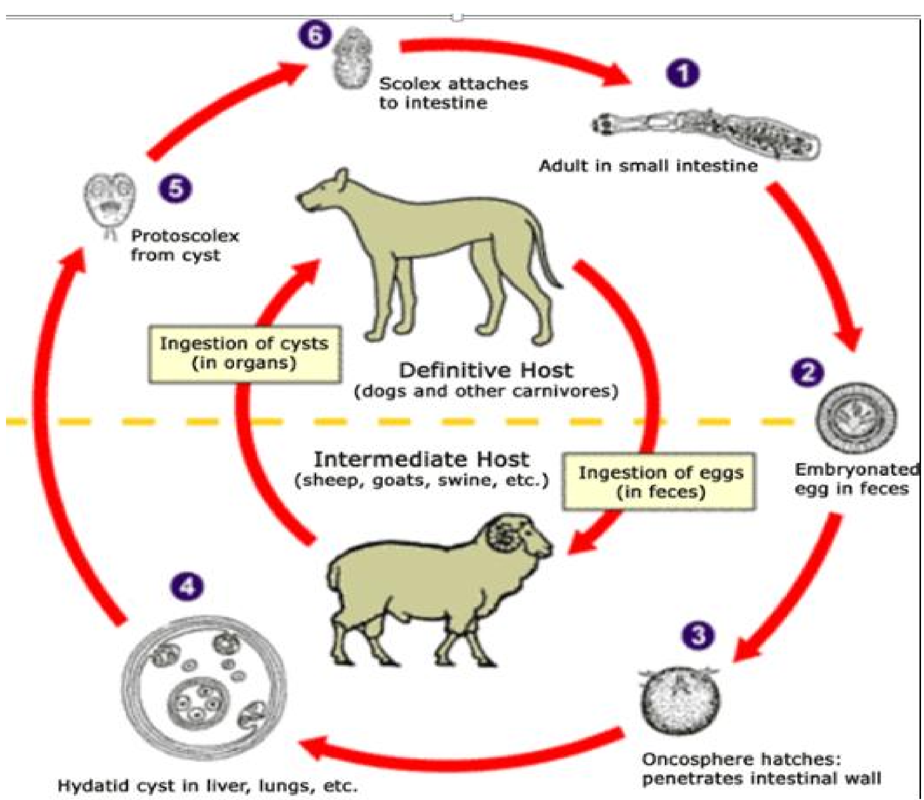


Figure 3: Life cycle of hydatid cysts *(E. granulosus)*
Source: Pedro and Peter (2008)

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). 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). 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 (Oge *et al.*, 2012).

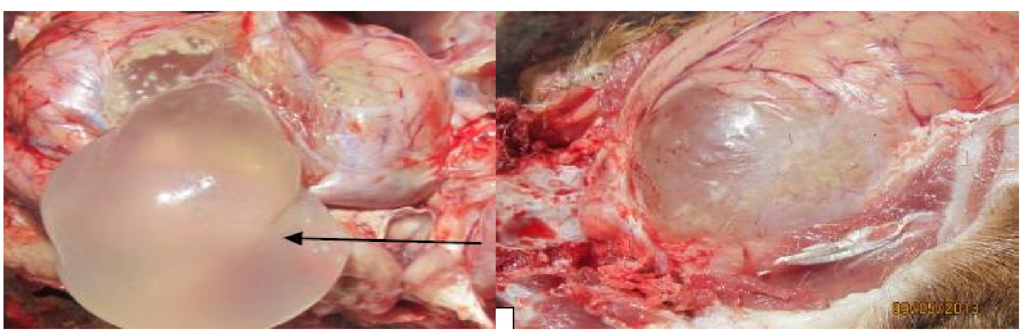


Figure 4: Large *Coenurus cerebralis* cyst occupying brain of goat
Source: Rostami (2013)

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).

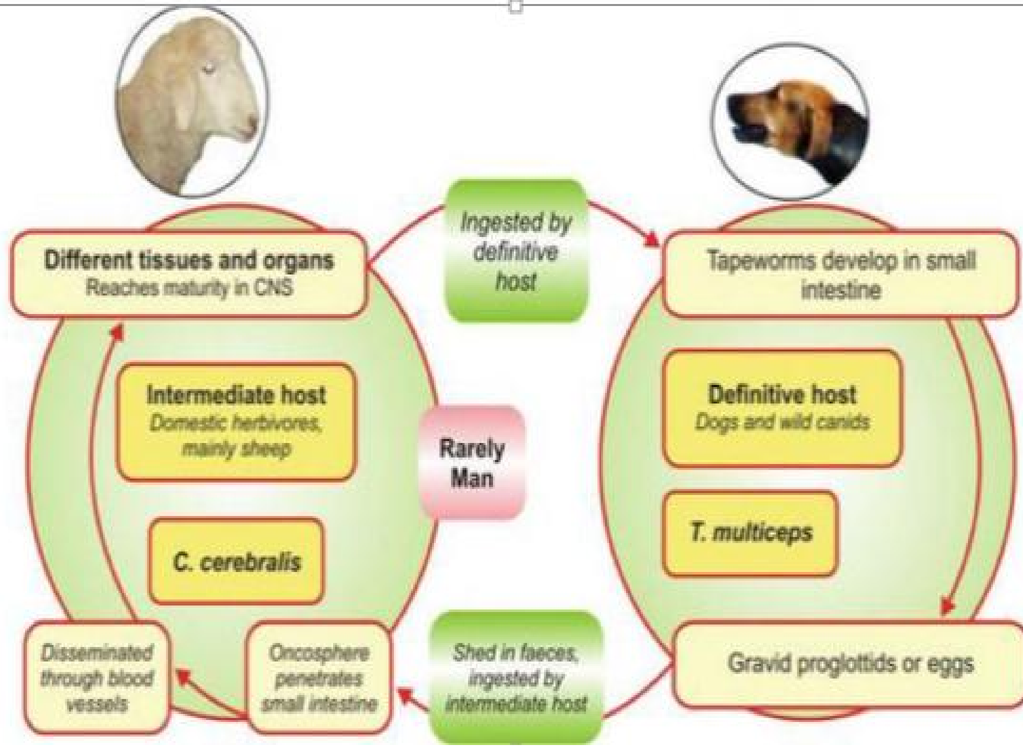


Figure 5: life cycle of *C. cerebralis* involving intermediate and definite host
Source: Dhaliwal and Julal (2013).

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 suchcyst 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).

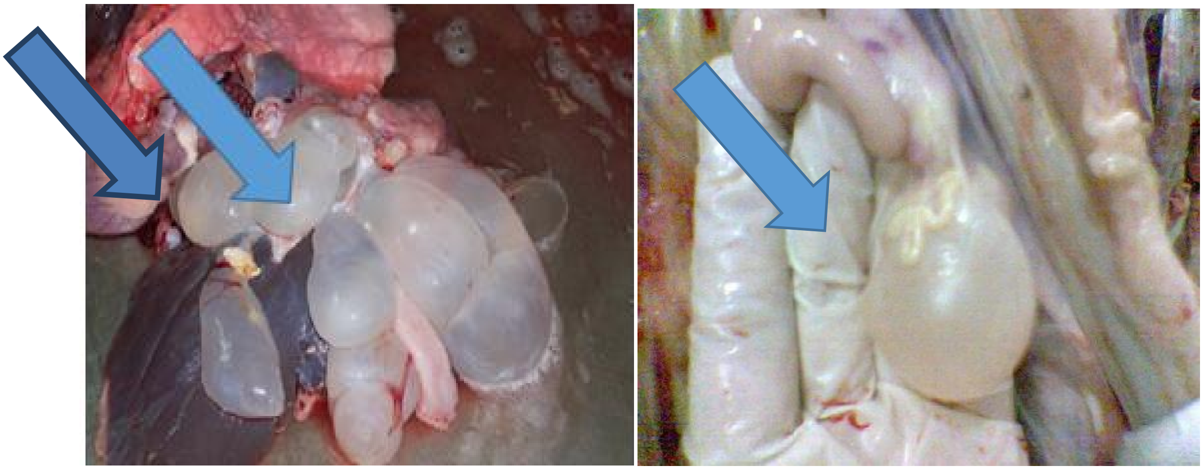


Figure 6: *Taenia hydatigena* cysts attached to the visceral surface of a sheep (A= liver, B= ovary). **Sources:** Anteneh et al. (2011).

Cysticercus Ovis

Cysticercus ovis isthe 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).

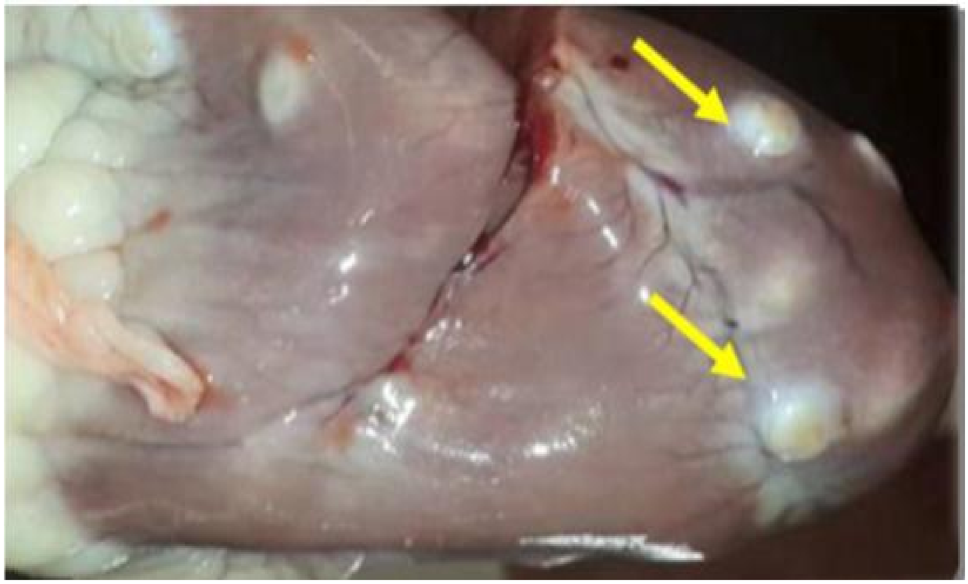


Figure 7: Heart of sheep showing *C. ovis* (arrow)
Source: Ahmed et al. (2017)

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).

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). Thereforediagnostic 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 amonoclonal 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 *Taeniidspecies* 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 theavailability 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).

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).

Public Health Importance

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).

Economic Impacts

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.

Status of Small ruminants Metacestodes 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.

Conclusion and Recommendations

The occurrence of metacestodes in small ruminants originated from different locations in Ethiopia particularly from slaughtered animals at abattoirs. Besides their animal and public health risks, these metacestodes attributed meaningful financial losses from organ condemnation. Major predisposing factors which contribute to persisting of the diseases in the country are 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. Therefore, effective control strategies against metacestodes should be designed and implemented. Focused awareness creation program is also 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 programs 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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