REVIEW ON MAJOR METACESTODES OF CATTLE

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Abstract: Taeniasis and hydatidosis are parasitic zoonoses that present major public health problems in lower income countries. Hydatidosis (cystic echinococcosis) caused by the larval stage of Echinococcus granulosis's the most widespread parasitic zoonoses. The larval stage of this tapeworm has both public health and economic significance. Human cysticercosis is a neglected zoonotic disease caused by the larval stage of the parasite (Taenia solium). Bovine cysticercosis refers to the infection of cattle with metacestodes of the human tapeworm. The clinical effect of cysticercosis on infected animal is generally not significant, however, in addition to the effect on human health, economic losses may be high due to the condemnation of heavily infected carcasses and the necessity to freeze or boil infected meat, restriction of export and herd quarantine. Hydatidosis is a zoonotic infection caused by adult or larval stage of cestode belonging to the genus Echinococcus. Annual economic losses from hydatidosis, cysticercosis and taeniasis in beef considering losses from cost of organ and offal condemnation and from carcass weight. Diagnostic Techniques for Cestodes and Metacestodes includes, meat inspection, *Detection of antibodies by ELISA Serological test*, Molecular Diagnosis of Cestodes and Metacestodes. Controlled grazing, avoiding use of sewage effluent to fertilize pasture, prevents infection in cattle. Besides this, meat inspection, abstinence from eating raw meat and freezing the infected carcass for prevention of human infection was vital. Treatment varies with country and facilities available and includes: Freezing, heating, Steamed at moderate pressure, and salting.
[Asmamaw Aki, Adisu Muleta, Remedan Teshome. **REVIEW ON MAJOR METACESTODES OF CATTLE.** *Life Sci J* 2026;23(7):37-55]. ISSN 1097-8135 (print); ISSN 2372-613X (online). http://www.lifesciencesite.com. 03. doi:10.7537/marslsj230726.03

Key words: *C. bovis; metacestode; Hydatid cyst*

REVIEW ON METACESTODES

1.1. Taxonomy and morphology

Taenia saginata and its metacestode Cysticercus bovis, belong to the class Cestoda order Cyclophyllidea Family Taeniidae and Genus Taenia. Taenia saginata, the human tapeworm, is a large worm measuring 3-10 meters in length and rarely the adult measures up to 15 meters (Scott et *al*., 2024). It resides in the small intestine of humans where it attaches using its scolex and can survive for many years.
The adult is ribbon-shaped, multi-segmented and hermaphroditic flatworm its body divided into three distinct parts consisting of scolex (head), neck and strobila (Scott *et al*., 2024; Seppo *et al*., 2019). The scolex, measuring 1mm to 2mm in diameter, has four strong hemispherical suckers. There is no rostellum and hooks and the predilection site in the intestinal mucosa is in the proximal part of the jejunum (Romig *et al*.,2015; Jacobs *et al*., 2016). The neck is short unsegmented with a germinal structure immediately behind the scolex, which continuously produces proglottids ((Kira *et al*., 2013).

The strobila is a chain of segments made up of sexually immature and mature gravid segments in linear sequence. Each segment is called progllotid and strobilization occurs at the distal part of the neck (Kira R et al., 2013; Romig *et a*l.,2015). An adult T. saginata tapeworm has 600 to 2000 segments each of which is hermaphroditic with one set of reproductive organs and genital pores which open on the lateral margin(s) of the segment (Scott et al., 2024). Self and cross fertilization between and among proglottids is possible. The gravid proglottids are 15 to 35mm long and 5 to 7mm wide and filled with eggs which detach from the strobila singly. This implies that coproscopic examination has a limited value in the diagnosis of Taenia saginata infection (Scott *et al*., 2024; Meron, 2012; Muluneh *et al*., 2019). It is estimated that each graved segment can contain as many as 80,000 to 100,000 eggs and an infected person may shed about 24 - 50 million eggs daily (Beyene, 2019, Chenkual *et al*., 2011).

Eggs passed in feces or discharged from ruptured gravid segments are subspherical to spherical in shape. The egg consists of the hexacanth (6-hooked) embryo (oncosphere), thick dark brown to yellow in color. There is an outer oval membranous coat, the true egg shell, which is lost in fecal eggs (Muluneh *et al*., 2019). It measures 30-41 micrometers in diameter and 46 to 50 micrometers in length (Chenkual *et al*., 2011). The eggs survive up to 200 days in moist manure, 33 days in river water, 154 days on pasture and are resistant to moderate desiccation, disinfectants and low temperature (4-5°C) (Chenkual *et al*.,2011).

The larval stages (C. bovis), or metacestodes also referred to as "beef measles", are found in all striated muscles of the intermediate host. C. bovis is a small (pea-sized) oval in shape (Muluneh *et al*., 2019), semi-translucent cyst filled with dense white fluid containing an invaginated scolex. The metacestode is morphologically similar to the future adult tapeworm. It measures about 10 mm in diameter and 6 mm in length (Scott *et al*., 2024). When incised, the cyst may be viable containing a thin fibrinous capsule or degenerate showing cream or green colored calcification (Meron, 2012). The cysticerci are formed over a period of 3-4 months after the egg is ingested. This form may remain viable in the intermediate host for up to 9 months or even up to the entire life of the host. In the carcass, C. bovis can survive for about 15 day‟s at-5°C, 9 days at 10°C and 6 days at-15°C to -30°C (Scott *et al*., 20241). If a carcass is found to contain cysts, it is required to be frozen at –10o c for 10 days, however if the lesions are extensive, the entire carcass is condemned *(Scott et al*., 2024).

1.2 Major Metacestodes in Abattoir

Humans are the only definitive host of the cestode Taenia saginata (beef tapeworm). The intermediate host of the larval form of T. saginata is mainly cattle. In cattle the eggs develop into the larval stage, Cysticercus bovis Non-viable cysticerci undergoing degeneration can vary in appearance depending on the degree of inflammation, necrosis, and mineralization in the resulting lesion bovine cysticercosis can inflict serious economic losses to the cattle industry. These are mainly due to condemnation, refrigeration and downgrading of infected carcasses. Histological evaluation of *T. saginata* cysticerci suspect lesions is still considered the only laboratory diagnostic tool suitable for routine confirmation of undiagnosed lesions during inspection procedures at slaughterhouse. There have been many studies to characterize the histopathology of cysticercosis; however none of them gave a practical and unbiased set of criteria in order to come to a sound based diagnosis (Gebretsadik, 2016).

The effect of the parasite in live small ruminants is insignificant unless it is complicated by the presence of concurrent infections. However, the presence of C. tenuicollis in ruminants is an indicator of the Bovine cysticercosis is a muscular infection of cattle and is caused by larvae of the human intestinal cestode Taeniasaginata. Its life cycle is entirely dependent on the link between man and cattle so that any break in this links can result in the total elimination of the parasite. Tapeworm infections have been recorded in history from 1500 BC and have been recognized as one of the earliest human parasites. Cysts of C. bovis can be found anywhere in the carcass or meat and viscera. The distribution of T. saginata is wider in developing countries where hygienic conditions are poor and where the inhabitants traditionally eat raw meat or insufficiently cooked meat. Forty percent (40%) of the cases were reported in Africa. Researchers reported that this disease is very common in developing countries like Ethiopia. It is associated with poor hygiene and local factors including cultural background, (eating raw meat "Kurt", Kitfo" semi cooked meat), economic condition and religious beliefs, close proximity of humans to cattle kept with little or no distinction between companion or utility functions (Chiesa , 2011).

1.2.1 Hydatid Cyst

Hydatidosis (Cystic echinococcosis) caused by the larval stage (metacestode) of Echinococcus granulosis's the most widespread parasitic zoonoses. The larval stage (Metacestode) of this tapeworm has both public health and economic significance. Despite the great efforts that have been put into the research and control of echinococcosis, it still remains a disease of worldwide significance. Dogs are the usual definitive hosts whilst a large number of mammalian species can be intermediate hosts, including domestic ungulates and man. The disease occurs throughout the world and causes considerable economic losses and public health problems in many countries; Hydatidosis causes decreased livestock production and condemnation of offal containing hydatid cysts in slaughterhouses (Tadesse, 2014).

Cystic Echinococcosis or cystic hydatidosis is a chronic helminthic zoonotic disease with a cosmopolitan distribution (Dutra, 2012) and is especially prevalent in the sheep-raising countries. The causative organism, the dog tapeworm

Echinococcus granulosus is transmitted cyclically between canines and numerous herbivorous livestock animals, which can serve as intermediate hosts. In herbivorous animals and in people who become infected by accidentally ingesting E. granulosus ova, the cystic larval form (Hydatid Cyst) develops and can cause serious morbidity (Fufa , 2011).

Morphology of hydatid Cyst*:* The larval stage of Echinococcus is a fluid-filled bladder or hydatid cyst that is unilocular, although communicating chambers also occur. Growth is expansive, and endogenous daughter cysts may be produced. Individual cyst may reach up to 30 cm in diameter and occur most frequently in liver and lungs but may develop in other internal organs. The infection with this stage is referred to as cystic hydatidosis. Hydatid cyst of E. granulosus is unilocular. Its growth is expansive by concentric enlargement. A well-developed cyst contains three layers; fibrous capsule of host origin. The middle one is the laminated membrane which is secreted by the thin (germinal) layer and therefore is of parasite origin. The germinal layer gives rise to the broad capsule and daughter cysts. The cysts are mainly found in the liver (and every possible organ: spleen, kidney, bone, brain, tongue and skin) and asymptomatic until their growing size produces symptoms or accidentally discovered (Fufa, 2011; Gebretsadik, 2016).

1.2.2 Cysticercus Bovis

Human cysticercosis is a neglected zoonotic disease caused by the larval stage of the parasite Taenia solium. This disease is responsible for severe health disorders such as seizures, and in some cases even death. T. solium cysticercosis is endemic in countries in Africa, Latin America and Asia where conditions such as inadequate hygiene, poor sanitary conditions, open defecation, free roaming pigs and poverty permit the transmission of the disease. Diagnostic tools are capable of detecting exposure to eggs and infection levels in a population through antibody and antigen detection, respectively. Understanding the epidemiology of cysticercosis in endemic regions will help expose information on the transmission, which could in turn be used to design appropriate control programs (Minnozz *et al*.,2002).

Cysticercus bovis is caused by the metacestode stage of *Taenia saginata*, a zoonotic Tapeworm of cattle and humans. Adult tapeworm develops in humans who consume undercooked beef infected with viable Metacestodes (Cuttell *et al*., 2013) tapeworm develops in humans who consume undercooked beef infected with viable Metacestodes (Cuttell *et al*., 2013; Silva., 2010).

The larval stage/Cysticercus bovis/: The cyst is round or oval in shape, and when fully developed, consists of a scolex, invaginated into a fluid-filled vesicle (tail bladder), which is surrounded by connective tissue capsule formed by the reaction of the tissue of the host. The cyst is seen as small whitish vesicle and is found between muscle fibers. It is transparent and contains translucent fluid. The invaginated scolex is visible in the form of whitish spot at one end of the pole of the cyst. As in the adult tapeworm, it has neither rostellum nor hooks (Cuttell *et al*.,2013).

1.2.3 Life Cycle of the zoonotic Taenia

In the life cycle, T. saginata has two different stages in which larval stage (Cysticercus bovis) occurs in heart and skeletal muscles of cattle as intermediate host and adult worm locates in intestine of human as final host (Garedaghi *et al*., 2012).

These tapeworms have an indirect life cycle and are relatively host specific for both larval and adult stages. Humans are the only natural definitive hosts of the adult tapeworm. The adult tapeworm is fully developed and reproductively mature as early as 10-12 weeks (depending on species) after infection of the host. Once mature, the tapeworm regularly sheds its most posterior segments, called gravid proglottids, which are discharged from infected humans spontaneously or with defecation. These proglottids contain thousands of immediately infective eggs that can remain in the proglottid or be expelled free into the surrounding fecal matrix or environment. On average, a single T. saginata tapeworm releases six to nine proglottids daily.

Although multiple and mixed speciesinfections can occur, most taeniosis infections involve a single tapeworm. Upon ingestion by a suitable intermediate host, a hexacanth embryo, or oncosphere, hatches from the egg and uses its six hook lets to penetrate the intestinal mucosal within a few hours to enter the circulatory or lymphatic system. It

eventually reaches the tissue site (such as the lymphatic space in skeletal muscle) where it eventually develops into a cysticercus which is infective to a human final host after about 10-12 weeks or as early as 4 weeks for T. saginata asiatica (Fufa., 2011; Melaku ., 2012; . Oladele, *et al*., 2004).

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The intermediate hosts for T. saginata and T. saginata asiatica cysticerci are Taenia saginata asiatica cysticerci localize primarily on the serosal surface and within the Parenchyma of the liver of pigs, and occasionally in extrahepatic peritoneal sites. Experimental infections have also been reported for cattle, goats and monkeys. The normal intermediate host of T. solium is domestic swine, although a variety of other species, including humans and dogs, can serve as intermediate hosts. The cysticerci localize in the tissues of the tongue, skeletal muscle (particularly thighs), subcutis, and central nervous system of pigs. Human consumption of infected pork or beef completes the cycle

Bovine cysticercosis refers to the infection of cattle, while the adult tapeworms in the human small intestine cause taeniasis. Cattle are infected after ingestion of feed or water containing the eggs expelled by the human faeces. Although cysticercosis in cattle often has no clinical features, however, heavy infection may cause myocarditis. Human infection that occurs through consuming of infected raw or semi-cooked beef may results in epigastric pains, diarrhea, nausea, weakness or loss of appetite (Lees *et al*., 2002).

The life cycle and transmission of the parasite occurs most commonly in environments characterized by poor sanitation, primitive livestock husbandry practices, inadequate meat inspection management and control policies. Humans are the obligate final host and they become infected by ingesting infected meat that has been inadequately cooked or frozen. Most incidents arise in cattle as a result of direct exposure to proglottids shed from humans, but there have been some reports of large scale outbreaks resulting from sewage-contaminated feed or forage (Tesfaye *et al.*, 2012).

The tapeworm occurs in the small intestine of humans, and although it is generally 4-8 meters long, it can reach 15 meters. Like all tapeworms, its scolex (head) attached to the bowel wall and it has up to 2000 body segments. Each segment contains up to 80, 000 eggs. The end segments of the tape worm detach and are passed with faeces, they look like white fleshy capsules similar to a grain of rice. If the eggs in the segments find their way onto pasture, cattle may ingest the eggs which then hatch in the small intestine. Small embryos develop and penetrate the bowel wall. They are carried through the blood stream to various muscles where they develop into cysts, the muscles most commonly affected by Cysticercus bovis cysts are the heart, tongue, diaphragm and muscles of the jaw. The cysts may remain infective for up to 2 years (NSW, 2012).

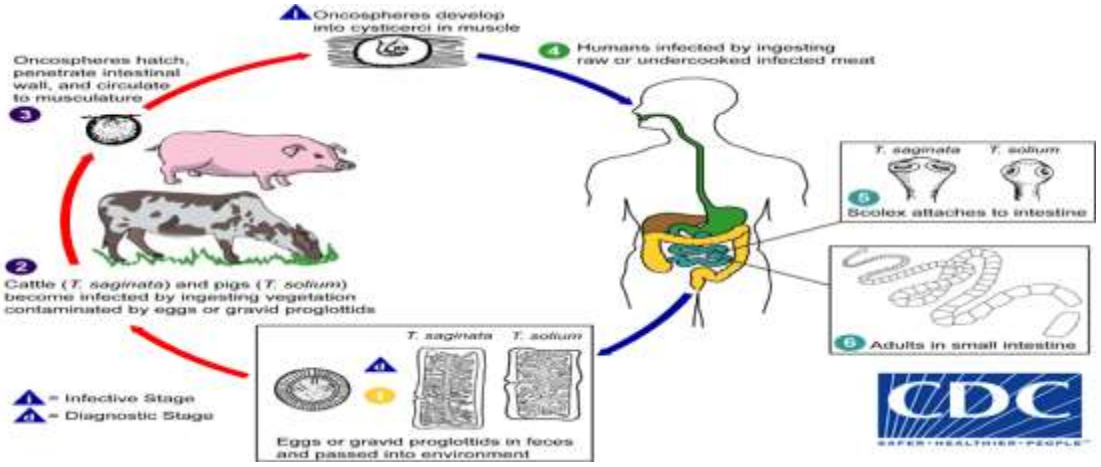

Figure 1: The Life cycle of Taenia saginata (CDC, 2024).

1.3 Epidemiology of Metacestodes in Ethiopia

In most countries, T. saginata is more common than T. solium. It is associated with areas of poor sanitation and high consumption of beef. Many of the cases seen in the United States are from immigrants who came from a country that has higher rates of beef tapeworm. The number of cases in the United States is much higher than that of T. solium. Eggs may remain viable in human feces for several weeks such that cattle who ingest them will become infected. Taenia saginata is distributed globally but the infection is particularly important in Africa, Latin America, and Asia as well as in some Mediterranean countries. The prevalence of T. saginata in humans can be roughly classified into

three groups: highly endemic regions with prevalence that exceed 10%; those with moderate prevalence; and those with prevalence below 0.1% or free from T. saginata taeniosis. Highly endemic areas include Central and East African countries (Ethiopia, Kenya, and Zaire), Argentina, Caucasian and South-Central Asian republics of the former USSR and in the Mediterranean Region (Syria, Lebanon and Yugoslavia). In some parts of Serbia and Montenegro, up to 65% of children have been reported to harbor T. saginata. Moderate prevalence is encountered in South East Asia (Thailand, India, Vietnam and Philippines), Japan as well as countries of Western Europe and South America while Canada, the USA, Australia and some countries of the Western Pacific have low prevalence (Tadesse *et al*.,2012).

In Developing countries, cattle are reared on extensive scale, human sanitation is of comparatively lower standards and the inhabitants traditionally eat raw or inadequately cooked beef. The prevalence of Taeniasis is over 20% in certain areas of these countries. Based on routine carcass inspection the infection rate of bovine cysticercosis is often around 30-60% although, the real prevalence is considerably high. T. saginata infections also occur in developed countries, where standards of sanitation are high and meat is carefully inspected and generally thoroughly cooked. Taeniasis/cysticercosis spreads in developed areas of the world through tourists enjoying the consumption of lightly grilled meat, mass migration of labor and the export of meat unreliably passed by ‘’eye or knife’’ inspection or from live animals imported from endemic areas. Prevalence in these parts of the world is less than 1%. Occasionally, however, cysticercosis “storms” have been reported on particular farms. The cause of the storm has been attributed to the use of human sewage on pasture and the use of migrant labor. In developed countries, cattle of any age, are susceptible to infection since they generally possess no acquired immunity (Melaku , 2012).

Cystic echinococcosis (CE or hydatid disease) is a zoonotic infection caused by the larval stage of the taeniid tapeworm *Echinococcus granulosus*. The parasite’s life cycle is maintained through dogs (which harbor the adult worm in their small intestine) and a range of domestic livestock that serve as intermediate hosts. *E. granulosus* eggs are excreted in the faeces of infected dogs and may thus contaminate soil, grass and water. Ungulates (hoofed animals) can become infected by grazing on pasture contaminated with dog faeces. Ingested eggs hatch inside the intestine, penetrate the gut wall and are carried by the bloodstream to different organs and tissues (mainly the liver and lungs) where they develop into cysts (metacestodes) that can eventually cause severe pathological damage. Humans can become infected by ingesting eggs through consuming contaminated food or water or from handling the faeces of infected dogs.

Veterinary world to estimate the annual economic losses from hydatidosis in cattle considering losses from cost of organ condemnation and from carcass weight. The retail market price of average size offal (lung, liver, kidney, heart and spleen) and the cost of one kg beef were obtained from information gathered from local butchers. Annual economic loss due to organ condemnation was determined by considering annual slaughter rate of cattle and prevalence of hydatidosis per organ and an estimated 5 % carcass weight loss was considered. Average carcass weight of Ethiopian local breed cattle is estimated as 108 kg. The total economic loss was calculated as the summation of cost of offal condemned plus the cost of carcass weight losses (Getachew *et al*., 2022).

2. STATUS OF BOVINE METACESTODES IN ETHIOPIA

2.1 Bovine Cysticercosis

The cultural habit of eating raw meat in form of “Kourt” meat cubes and “Kitffo” minced meat in Ethiopia, has favoured the spread of this disease (Fufa, 2006). The reported prevalence of bovine cysticercosis in cattle populations across various regions of Ethiopia was reported to range between 2.2% to 26.3% (Kumar and Tadesse, 2011). Belachew and Ibrahim (2012) in Hawassa municipal abattoir in 2012, from 384 ante and post examinated cattle, 22.9% of bovine cysticercosis were recorded. Of the total cysticerci collected, 55 (62.5%) were found to be viable while 33 (37.5%) were non-viable. The percentage of Cysticercus bovis cysts in different organs was observed as 67.74% in tongue, 52% in shoulder, 60% in heart and 75% in masseter muscle, respectively. The prevalence of taeniasis among interviewed respondents of Hawassa town was 44%. For the years 2008 and 2009, a total worth of 184, 406 ETB was estimated from a sale of 92, 203 adult taenicidal drugs.

Another study was conducted in 2009 to estimate the prevalence of Cysticercosis in animals, Taeniasis in human and estimate the worth of taeniasis treatment in Jimma town, Ethiopia (Megersa *et al.*, 2010). Of the total of 500 inspected animals, 22 animals had varying number of Cysticercus bovis, an overall prevalence was 4.4%. Anatomical

distribution of the cyst showed that highest proportions of Cysticercus bovis were observed in shoulder muscle, followed by tongue, heart and masseter muscle. Of the total of 114 Cysticercus bovis collected during the inspection, 49 (42.9%) were found to be a live while others (57.1%) were degenerative cyst (Megersa *et al*., 2010).

Tolosa *et al*. (2009) conducted study to determine the prevalence of bovine cysticercosis from October in 2008 in cattle slaughtered at the Jimma municipal abattoir. Cyst distribution and viability of bovine cysticercosis were determined. A total of 512 carcasses were inspected of which 15 (2.93%) were infected with Taenia saginata metacestodes. From a total of 109 cysticerci collected from infected carcasses, 47(43.12 %) were viable. The anatomical distribution of the cysticerci was, shoulder muscle (39.5 %), heart (33.9 %), neck muscle (13.8 %), tongue (10.1 %), masseter muscles (1.8 %) and diaphragm (0.9 %).

In another study, post-mortem examination of 3711 cattle done at three municipal abattoirs at Mekelle, Wukro and Adigret in Tigray region for detecting infection of Cysticercus bovis revealed 308 (8.29%) cattle positive for this infection. The cysts were observed either at one or more than one sites in the carcass with variable numbers. The sites showing cysts included tongue 0.61%, masseter muscles 0.59%, shoulder muscles 0.26%, heart 0.26% and liver 7.45% (Kumar and Berhe, 2008).

Teklemariam *et al*., (2015) studied bovine cysticercosis in 2015 on 384 zebu cattle slaughtered at Batu municipal abattoir to estimate the prevalence and associated risk factors. Out of 384 inspected animals, 10 animals had variable number of Cysticercus bovis giving an overall prevalence of 2.6%. Anatomical distribution of the cyst showed that the highest proportions of Cysticercus bovis cyst were observed in tongue 10 (41.66%) followed by heart 7 (29.17%), masseter 5 (20.83%) and triceps muscle 2 (8.33%).

In developing countries, taeniasis/ bovine cysticercosis constitutes a serious but less recognized public health problem. Due to the habit of eating raw or undercooked beef dishes such as kourt and kitffo, taeniasis in human is common in Ethiopia. A high (89.41%) prevalence of human infection in different agro-climatic zones of the country has been reported. Low availability of taenicides is a constraint and the use of herbal drugs do not eliminate this parasite from human population and the proglottids are passed out with the faecal matter resulting in cysticercosis in the cattle. In Ethiopia prevalence rate changing between 13.7 to 72.44% in cattle and 9.9 to 35% in sheep was described. Ethiopia is divided into nine ethnically based administrative regions and three chartered cities and bovine cysticercosis has been reported from different parts of the country (Table 3) Christine (2009).

Table 1: Status of Bovine Cysticercosis in different part of Ethiopia

Location /place	Prevalence in %	Reference
Batu municipal abattoir	2.6	Teklemariam *et al*., 2015
Jimma municipal abattoir	2.93	Tolosa *et al*. 2009
Hawassa municipal abattoir	22.9	Belachew and Ibrahim, 2012
Jimma	4.4	Megersa *et al*,2010
Awassa	26.25	Abunna et al. 2008
Central Ethiopia	3.1	Tembo, 2001
East Shoa	17.5	Hailu, 2005
Gonder meat factory	9.7	Amsalu, 1989
Gonder	4.9	Dawit, 2004
Luna export abattoir in East Showa	27.6	Hailu, 2005
Nekemte	21.7%	Ahemed, Ibrahim, 1990
North westen Ethiopia	18.49	Negatu, 2008
Tigray	21	Berhe, 2009
Wolaita Soddo (Southern Ethiopia)	11.3 %	Alemayehu Regassa et al., 2009
Bahir Dar (Amhara region)	19.4%	Alemu Mulugeta, 1997
Ethiopia	18.49%	Nigatu Kabede, 2008
People's Region (Southern Ethiopia) Amhara National Regional State,	26.25%	Fufa Abunna et al., 2008
Mekelle (Tigray region) Southern Nations Nationalities	7.23%	Abay Getachew, 2008

Mekelle, Adigrat, Wukro (Tigray region)	8.29%	Kumar and Gebretsadik Berhe, 2008
DebreZeit, Oromia	13.85%	Getachew Belayneh, 1990
Addis Ababa, Ethiopia	2.2%-3.3%	Gebro-Emanuel Teka, 1997 Mulageta Alemu, 1997
Addis Ababa, Ethiopia Nigatu	13.3%	Kebede et al., 2009

2.2 Distribution of Bovine Hydatidiosis in Ethiopia

The prevalence of hydatid cyst in cattle, sheep in Greece, China, İtaly, Ethiopia, India, Azerbaijan and Pakistan have been reported to be 100%. In Iran many studies have been performed; in Sanandaj area, western Iran and Kashan area, results indicated an infection rate of 51.9%. In some areas of the world, cystic echinococcosis caused by *E. granulosus* is a reemerging disease in places where,it was previously at low levels. Hydatid disease is a problem in Asia, the Mediterranean, South America and Africa and also the prevalence of the disease has increased in Europe and North America in recent years. In Africa E. granulosus has been recognized from most countries including Ethiopia. Previous and recent report has described the endemic occurrence of E. granulosus in dogs and livestock (Tadesse., 2014**).**

According to Ermias G, (2019) in Debire Birhan municipal abattoir, centeral Ethiopia, of 384 examined Cattle, 110 (28.6%) were harboring visible hydatid cysts in cattle slaughtered. Significantly higher infectison was detected in cattle's with poor (48.40%) than animals with medium (24.10%) and good body condition (20.30%). The prevalence of the parasite in male and female was 29.83 and 29.8% respectively. The prevalence was not statistically different between local (30.10%) and cross (19.20%) breeds. Hydatid cyst infections of the lung, liver, kidney and heart were 52.50, 38.10, 5.00, and 4.40%, respectively. Of the total 160 hydatid cysts counted, 64 (40.00%) were fertile, 80 (50.00%) sterile, and 16 (10.00%) were calcified. Of the 64 fertile cysts subjected for viability test, 24 (37.50%) were viable while 40 (62.50%) were nonviable (Ermias., 2019).

Biniamin Taha* and Anwar Hassen (2018) in sebeta slaughterhouse indicated, the prevalence of hydatid cysts were 176.55% and 74 visceral organs, harboring one or more hydiatid cysts. The lung was found to be the most commonly affected organ, but Spleen and heart were found to be less commonly affected organ. The numbers of cysts obtained from single lung ranges 1-20. Cyst fertility assessment yielded 65(52%) sterile, 23(18.4%) fertile and the rest 37(29.6%) calcified cysts, 69.6% of the fertile cysts being confirmed viable cysts and the rate of calcification is higher in the liver than in the lungs, while most fertile cysts were recovered from the lung.

Table 2: Bovine Hydatid cyst in different parts of Ethiopia.

Place	**Animal**	**Prevalence**	**Reference**
Sebeta, Ethiopia	cattle	176.55%	Biniamin Taha* and Anwar Hassen., 2018
Debire Birhan municipal abattoir, central Ethiopia	cattle	28.6%	Ermias G, (2019)
Jimma municipal abattoir	cattle	49.74%,	Getachew Derbew1* , Fuad Mohamme.,2022
Shashemene Municipal abattoir	cattle	50.1%	Nebyou Mo, et al., 2014
Debre Tabour municipal abattoir	cattle	16.5%	Kindye A and , Getinet A., 2019
Addis Ababa Abattoir	Cattle	40.50%	Terefe, D., 2012.
Kara-Aloabattoir PLC	Cattle	25.70%	Demissie, G. and J. Kemal, 2014.
Assela	Cattle	62.38%	Hussen, W., 2013.
Nekemte	Cattle	17.10%	Tadesse, B., 2014
Ambo	Cattle	29.69%	Zewdu, E., 2010.

3. Diagnostic Techniques for Cestodes and Metacestodes

3.1 Meat Inspection

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

might be palpable in the tongue but, both in the living animal and on post-mortem examination or meat Inspection, tongue palpation is of diagnostic value only in cattle heavily infected with metacestode (Wubie, 2004).

Predilection sites are heart, tongue, masseters and diaphragm, presumably because they receive the greatest circulation. Nonetheless, cysts may be found in any muscle of the body (OIE, 2008). Cattle with cysticercosis are unlikely to exhibit clinical signs, and detection is made during post-mortem carcass examination. In most parts ofthe world where regulated post-mortem screening for these parasites occurs, examination of so-called "predilection sites" is conducted during routine meat inspection. However, such procedures are insensitive, particularly for lightly infected carcasses. Despite its limitations, visual inspection of carcasses remains the most common method of diagnosing bovine cysticercosis. The metacestode are readily visible in the organs or musculature at autopsy and therefore diagnosis of bovine cysticercosis usually made during postmortem examination in abattoirs and packing plants. The effectiveness of meat inspection in the detection of C.bovis depends on the procedure used (Wubie, 2004).

According to Meat Inspection Regulation Notice Number 428, 1972 by Government of Ethiopia (MoA, 1972), the routine inspection of carcass is to be done as per the procedure stated below:

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

However, minor infections are difficult to detect irrespective of the skill of the inspector. If a Cysticercus is found in any of these sites and organs, thorough inspection of the whole carcass and offal should be done. The location, nature and number of cysts should be recorded (Kumar and Tadesse, 2011).

3.2 Detection of antibodies by ELISA Serological test

Enzyme-linked Immunosorbent Assay (ELISA) was available for use on live animals. The immune response against taeniid parasites is reported to be antibody-mediated. A positive antibody ELISA indicates that the animals have been exposed to the infection, but may not necessarily have a current infection. However, it is a useful method for epidemiological studies to indicate the spread of the infection in outbreaks or high-infected areas (Kandil *et al*., 2012). Studies have indicated that antigen detection by ELISA (Ag-ELISA) is 2-10 times more sensitive than routine meat inspection and that this technique may therefore be recommended for epidemiological surveys. The sensitivity of Ag-ELISA has been shown to vary with the live cyst burden, in addition due to its unexplained false positive and negative reactions it can at best be used as a screening test and not as a diagnostic test (Asaava *et al*., 2009).

Immunodiagnosis is a useful complementary diagnostic tool for the identification of infection and disease (Kandil *et al*., 2012). Nevertheless, infections with different taeniid species and antigenic cross-reactivity between these related parasites and the low level of specific antibody response to infection problems with poor specificity and sensitivity of serological tests (Ogunremi, Benjamin , 2010).

3.3 Molecular Diagnosis of Cestodes and Metacestodes

In Bovine and Porcine Cysticercosis, the most widely used approach for DNA identification of Taenia taxa has been to target the nucleotide sequences of fragments of s elected genes using pairs of concerned PCR primers (Cuttell *et al*., 2013). The variable segment between the primers is PCR amplified for a particular Taenia sample and then directly sequenced(Rawson, Burton., 2006).

3.4 Differential Diagnosis

In cattle Cysticercus bovis should be differentiated from the following parasites.
Cysticercus dromedaries (C. cameli):The identification of C. cameli by double row of hooks on the lateral invaginatedscolex and its length being twice as large as C. bovismeasuring 12-18 mm in length and pearly white in color (Wubie, 2004).
Sarcocystis bovi felis (Sarcocystis hirusta): Is a soft bradizoite cyst which is very large and visible to the naked eye whitish streaks running in the direction of the muscle fibers. The cyst ranges from 0.5 mm to 5mm in length, localized in the esophagus, heart, in different muscular tissue (Minozzo *et al*., 2002).

Onchocerca dukei :The cyst ranges from3mm to 6mm in diameter, forms intra-muscular and subcutaneous nodules that are firm to touch and reveals worms surrounded by pus when sectioned (Wubie., 2004).

3.5 Control and Prevention of Bovine metacestodes

Improper use of latrine or open field defecation leads to contamination of grazing lands. The use of latrine reduces spread of Taenia saginata eggs and public education to avoid consumption of raw meat, improve standards of human hygiene (Kebede *et al*., 2009). Farmers should be awared of the life cycle of T. saginata and potential risk factors for cattle to become infected (Boone *et al*., 2007).
Controlled grazing, avoiding use of sewage effluent to fertilize pasture, prevents infection in cattle (Engels *et al*., 2003; Worku., 2017). Adequate meat inspection, abstinence from eating raw or inadequately cooked beef (thorough cooking of meat at a temperature of 56 - 60 0C) and freezing the infected carcass at-100 c for 10 days prevent human infection.
Chemotherapy in humans reduces the spread of eggs and infection in cattle (Solusby.,1982). In Africa, inadequate health education and scarcity of Taenicides are the major obstacles for the control of the disease (Rabi *et al*., 2010). The inspection of meat, which is the most important public health control measure, identifies only a minor fraction of heavily infected animals, and also only when it is too late to avoid losses. (Wanzalaa *et al.*, 2002).
During meat inspection heavily infected carcass, all meat, offal and blood must be condemned. The description of a heavy infection varies, but generally it is the detection of cysts at two of the predilection sites plus two sites in the legs. In the case of a lesser infection, the infected parts and surrounding tissues are removed and condemned. Even a single dead cyst requires that the carcass and edible viscera must then be treated and this is justifiable as about 10% of lightly infected carcasses were found on dissection to have both dead and viable parasites within them (OIE, 2008).
Treatment varies with country and facilities available and includes (OIE, 2008):

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

Vaccines against Bovine Cysticercosis:
Vaccination, when available, is undoubtedly the most cost effective means of preventing and controlling, and even eradicating, infectious diseases. A vaccine against sheep cysticercosis has been developed experimentally and may lead to the development of similar vaccines to control bovine cysticercosis and thus Taenia saginata infestation in humans (Paul-Pierre, 2009).
Lightowlers M 2000 and Rickard and Adolph, (1976) vaccinated calves with antigens collected during cultivation of the larval stages of Taenia saginata. In-vitro, and challenged 4 weeks later with 4, 000 Taenia saginataeggs. Calves vaccinated with Taenia saginata antigen were highly resistant to the challenge infection.
Sheiba and Zein Eldin, (1987) vaccinated four Zebu calves subcutaneously with hatched ova of Taenia saginata. The immunity elicited protected the animals from subsequent oral infections with this cestode as manifested by the early degeneration of the metacestodes and failure to attain maturity in three of four animals. Lightowlers *et al.*, (2000) used the recombinant antigens in vaccine trials in cattle. Vaccination with a combination of two antigens, designated TSA-9 and TSA-18, induced up to 99.8% protection against experimental challenge infection with Taenia saginata eggs.

3.6 Treatment (Chemotherapy)

The drug of choice in treating Taeniasis is niclosamide (Niclocide, Yomesan). Adult dose rate of 2000 mg is effective in damaging the worm to such an extent that a purge following therapy often produces the scolex. Praziquantel (Bilitricide) at a dose rate of 5 to 10 mg per kg also has been reported highly effective (Wanzala *et al*., 2002; Boone et al., 2007) but the scolex is partially digested and often not recovered (Lightowlers *et al*., 2000). Other drugs used in the treatment of T. saginata are mebendazole (Doyle *et al.*, 2000).

In animals, treatment with compounds such as albendazole (50mg per kg), praziquatel (50mg per kg), and mebendazole (50mg per kg) can be given but they are considered not to be fully effective. Praziquantel is effective at 50mg / kg / day for four days but this treatment is impractical because of its high cost (Desta, 2004). In Ethiopia people used traditional medicaments to cure from *T. saginata* infection. Kebede *et al*., 2009 ; Ahmed, (1990) reported that most people, especially rural inhabitants use different types of traditional herbal drugs to routine self-de worming practices.

3.7 Judgments for Bovine metacestodes

The final judgement exercised by member countries of the European Union, Canada, United States of America, South Africa and Australia have been described by Gracey *et al*. (1999). The Kenyan Meat Control Act, 1977 recommended that only carcasses with no cyst should be passed on directly for human consumption, 1–5 cysts should be retained, frozen at −10°C for at least 10 days and released "unconditionally", 6–20 cysts should be similarly treated as above but released conditionally to schools/institutions where proper cooking is expected to be practiced, those with over 20 cysts should be totally condemned.

Developed countries are stricter than developing countries in putting the judgment for bovine cysticercosis. In United States of America, there is a recommendation of total condemnation of carcass if the infestation is extensive (cysts are found in at least two of the sites viz. heart, tongue, muscles of mastication, diaphragm and its pillars, oesophagus and musculature that is exposed during dressing operations and in at least two of the sites exposed by incision into the rounds and forelimbs) during routine primary inspection while slightly infested carcass(infestation lesser than extensive infestation) may be passed for human food after removal and condemnation of the lesions with surrounding tissues. From less infested carcasses, the cysts and surrounding tissues shall be removed and condemned while the carcass or the meat derived there from shall be held in a freezer under inspectional control at a temperature not exceeding -10^{oC} for not less than 10 days; or the meat is heated throughout, under inspectional control, to a temperature of at least 60o C. Edible viscera and offal shall be disposed off in the same manner as the rest of the carcass from which they were derived, unless any lesion of C. bovis is found in these by-products, in which case they shall be condemned (Gracey *et al*., 1999).

Though Meat Inspection Regulation Notice Number 428, 1972 by Government of Ethiopia has described the technique of routine meat inspection for bovine cysticercosis, yet final judgement is perhaps followed on the same lines as in other African countries.

4. Economic Importance

Veterinary world to estimate the annual economic losses from hydatidosis, cysticercosis and taeniasis in cattle/beef/ considering losses from cost of organ and offal condemnation and from carcass weight (Tadesse, 2014). The retail market price of average size offal (lung, liver, kidney, heart and spleen) and the cost of one kg beef were obtained from information gathered from local butchers. Annual economic loss due to organ condemnation was determined by considering annual slaughter rate of cattle and prevalence of hydatidosis per organ and an estimated 5 % carcass weight loss was considered. Average carcass weight of Ethiopian local breed cattle is estimated as 108 kg. The total economic loss was calculated as the summation of cost of offal condemned plus the cost of carcass weight losses (Christine, 2009).

The economic significance due to hydatidosis in Ethiopia, significant degrees of monetary losses was estimated at various levels in different locations. Such reported estimates indicate annual losses of 25,608 ETB (2,807.89 US$) by Kebede in Tigray; 1,791,625.89 ETB (131,737.19 US$) in cattle slaughtered at the Hawassa municipal abattoir (Regassa *et al*., 2010); 473, 173.75 ETB (51,883 US$) by Kebede in cattle slaughtered at the Debre Markos abattoir; and 52,828 ETB (5,869.8 US$) in cattle slaughtered at the Adama abattoir (Kebde *et al*., 2008).

Bovine Cysticercosis has little effect on animal health, but it is economically important disease as it causes carcass condemnation arising from heavy infestation with the cysticerciof Taenia saginata as well as the cost of inspecting

meat, the necessity to freeze or boil infected meat and losses may also occur from restriction of exports of live animals and animal products (Belachew and Ibrahim., 2012).
Evaluation of the economic impact of taeniasis / cysticercosis is very difficult particularly in developing countries like Ethiopia, where necessary information is so scant and considerable proportions of infected people treat themselves with traditional herbal drugs like "kosso" and others. (Abuna *et al*., 2007). While ill-health caused by the adult worms in humans gives rise to high medical costs, the economic losses due to bovine cysticercosis are mainly due to condemnation, treating beef and downgrading of infected carcasses. Economic losses from cysticercosis are determined by disease prevalence, grade of animals infested, potential markets, prices of cattle and treatment costs for detained carcasses. For the African continent, an annual loss was reported to be US$ 1.8 billion under an overall infestation rate of 7% (Kumar and Tadesse, 2011).

Khaniki *et al*., (2010) reported that the economic losses of infected carcasses were calculated from the treatment of carcasses and the carcasses condemnations. The costs of carcasses treatment included the expenses of freeze storage and the weight loss during freezing.
The economic impact of the disease in the cost implication can be broken down in to those involved in treating human taeniosis and cattle carcasses (cost of freezing, boiling) or condemned, as well as the costs involved in the inspection procedures amount to millions of dollars (Nunes, 2003). In the meat industry, economic losses are closely associated with the status of infection. In a heavy infestation or generalized cysticercosis carcass must be totally condemned. Light infection or localized cysticercosis leads to condemnation of the infected parts, furthermore, the carcass must be kept in cold storage at a temperature not exceeding-7°C for up to 3 weeks to inactivate existing parasites (Abuseir *et al*., 2006).

5. Public Health Significance

Cysticercus bovisis of great public health significance especially in developing countries where it invades the tissues of the eye as well as brain and spinal cord causing ocular and neurocysticercosis respectively (Engels *et al.*, 2003). A number of reports in Ethiopia indicated that, certain groups who had easy access to raw meat and meat products (Butchers and abattoir workers) and those people with low level of formal education were reported to be more infected with parasitic zoonosis than those who had low access to raw meat and those with better education. This implies that the frequency of raw beef consumption is higher in these groups of people (Nigatu *et al*., 2009; Adugna *et al*., 2012).

The tongue, masseter muscles, cardiac muscles, triceps muscles and thigh muscles are the main predilection sites of the cysts. The cysts of bovine cysticercosis can alsobe identified on the spleen, intercostal muscles, diaphragm and liver (Garedaghi *et al*., 2011). Sometimes the gravid proglottids of Taenia saginata migrate to different organs appendix, pancreatic duct, nasopharyngeal pathways and bile ducts producing obstruction and inflammation of the affected organs (Adugna *et al*., 2012).
Tapeworms can also cause intestinal obstruction (Doyle *et al*., 1997). The most noticeable symptom is the spontaneous discharge of one or several proglottids, which often show individual muscular activity. These may creep out of the anus onto the perianal skin and even migrate over clothes of the distraught host or on the ground, shedding eggs as they go (Oryan *et al*., 1998). Taenia saginata in the small intestine of man absorbs digested food (Kebede *et al*., 2009). From the day the cysticercus is ingested it may take 2-3 months for the parasite to produce ripe segments. As long as the scolices are attached to the intestinal mucosa of the victim new segments will continually grow to replace those, which are being detached from the worm (Teka, 1997). Generally, according to WHO (2013), adult Taenia parasites located in the intestinal tracts of people can pose a variety of problems including:

- Non-specific intestinal disturbances-tapeworms can produce some non-specific signs of intestinal discomfort and pain (e. g. colic signs) in humans. Vomiting may also result.
- Non-specific appetite changes-tapeworms can cause some people to go off their food or to become fussy or picky about their eating habits (this appetite loss is possibly the result of such factors as abdominal pain and nausea). In contrast, certain other individuals develop a ravenous appetite in the face of heavy tapeworm infestations because they are competing with the parasite/s for nutrients (they need to physically eat more to provide enough nutrition for both themselves and the worms).
- Body weakness, headaches, dizziness, irritability and delirium
- Malnutrition-very large numbers of adult Taenia tapeworms present in the intestinal tracts of man can result in the mal-absorption of nutrients. This can cause the tapeworm-parasitized individual to not receive the

nutrition it needs (i. e. to not absorb its food properly), resulting in malnourishment, weight loss, ill-thrift and poor growth.

- Poor hair quality-severe malnutrition and malabsorption of vitamins, minerals and proteins can result in reduced quality of the hair.
- Intestinal irritation-when an adult tapeworm inhabits the small intestine of human, it finds a suitable site along the lining of the intestinal lumen and grasps on to it using suckers. This spiky tapeworm grip is irritating to the wall of the small intestine, creating discomfort for the host and alterations in intestinal motility. Note that T. saginata, sometimes called the 'unarmed tapeworm', lacks a spiny rostellum so is not quite so damaging to the human intestine.
- Intestinal blockage-it is possible for massive tapeworm infestations to block up the intestines of children, producing signs of intestinal obstruction (e. g. vomiting, shock and even death). This is not common, but it can occur if worm burdens are large and/or if someone deworms the infested children, killing all of the worms in one hit (the tapeworms all die and let go of their intestinal attachments at the same time, resulting in a vast mass of deceased tapeworms flowing down the intestinal tract all at once and causing blockage)
- .Intestinal perforation-rarely, adult Taenia saginata can perforate the intestinal wall, ending up inside of the host's abdominal cavity. This can result in lifethreatening abdominal inflammation and infection and septicemia.
- Appendicitis, biliary obstruction, and pancreatitisrarely, adult Taenia saginata (beef tapeworms) can migrate up into the duct systems of the pancreas and biliary tract (bile duct), producing blockages and painful inflammation of these regions. Some may even enter the appendix and cecum, causing nasty inflammation of these regions (termed appendicitis and typhlitis respectively). This can result in life-threatening complications that may require surgical correction.

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