MEKELLE UNIVERSITY

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PREVALENCE, CYST VIABILITY AND FINANCIAL LOSS OF HYDATIDOSIS IN CATTLE SLAUGHTERED AT MAICHEW MUNICIPAL ABATTOIR, TIGRAY REGION, NORTHERN ETHIOPIA

By

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Declaration

I declare that this thesis entitled "**PREVALENCE, CYST VIABILITY AND FINANCIAL LOSS OF HYDATIDOSIS IN CATTLE SLAUGHTERED AT MAICHEW MUNICIPAL ABATTOIR**, **TIGRAY REGION, NORTHERN ETHIOPIA**" presents the work carried out by myself and does not encompass without the acknowledgment of any material previously submitted for a degree or diploma in any University. To the best of my understanding, it does not contain any materials previously published or written by another person except where due reference is made in the text; all substantive contribution by others to the work presented including jointly authored publication, is clearly acknowledged.

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LIST OF ABBREVIATIONS AND ACRONYMS

CE	Cystic Echinococcosis
CPHR	Current Mean Retail Price of Heart
CPKID	Current Mean Retail Price of Kidney
CPLI	Current Mean Retail Price of Liver
CPLU	Current Mean Retail Price of Lung
CPSP	Current Mean Retail Price of Spleen
CT	Computer Tomography
FAO	United Nations Food and Agriculture Organization
GDP	Growth Domestic Product
LOC	Loss Due to Organ Condemnation
MRI	Magnetic Resonance Imaging
NAS	Mean Number of Cattle Slaughter Annually
PHR	Percent Involvement of Heart
PKID	Percent Involvement of Kidney
PLI	Percent Involvement of Liver
PLU	Percent Involvement of Lung

ABSTRACT

Hydatidosis is one of the neglected parasitic diseases with both public health and economic importance worldwide. In Ethiopia it is one of the major parasitic diseases responsible for low productivity of livestock industry through imposing poor weight gains and condemnation of organs. Even though, the disease is well documented throughout the country, its current prevalence and economic impact was not known in cattle slaughtered at Maichew municipality abattoir. To fill the gap, a cross-sectional study was conducted from July 2021 to Oct 2023 to estimate the prevalence, cyst characterization and economic importance of bovine hydatid cyst in the Maichew municipal abattoir. To achieve these objectives, routine meat inspection, hydatid cyst count and characterization were performed. In the current study, out of 384 heads of cattle slaughtered and examined in the abattoir; 11.98% (46/384) were harboring hydatid cyst in the major vital organs of the host as follows: lungs, 46.2% (21/46) and liver, 41.8% (18/46). In the current study, these two organs were the most affected once. In addition, out of the total of 117 cysts examined for the fertility test, 46.2 % (54/117), 31.6% (37/117), and 22.2% (26/117) were found to be fertile, sterile, and calcified cysts, respectively. Furthermore, of the total 54 fertile cysts tested for viability, 63% (34/54) were viable and 37% (20/54) were non-viable cysts and the difference in prevalence among animals of different body condition score was statistically significant ($P < 0.05$). The prevalence was highest in poor body condition than medium and good body condition scores. This might be due to either the impact of the parasites in body condition losses or animal with poor body condition are less resistance to limit the development of the cyst in the vital organs. Lastly, this study revealed that the total annual economic loss due to bovine hydatidosis in Maichew municipal abattoir was estimated to be 461,164.96 ETB (13,974.7US$). The results of this study indicated that hydatidosis pose significant economic impact by causing condemnation of considerable numbers of organs, rendering them unfit for market. Therefore, initiation and implementation of control measures are very important in order to alleviate its economic impact as well as zoonotic risks to the human.

Key words: *Abattoir; Economic impact; Hydatidosis; Maichew; Prevalence*

CHAPTER I: INTRODUCTION

1.1. Background

Ethiopia is the richest country in Africa in terms of livestock population. An estimate describes that the country is home to about 31.3 million sheep, 60.39 million cattle, and 32.74 million goats (CSA, 2017/18). However, Ethiopian livestock potential is not properly exploited, mainly due to the prevailing limited genetic potential, rampant disease, serious problems, and traditional management systems. As a result, the contribution of the livestock sector to the national economy has been reported to be lower compared to its potential.

The occurrence of a huge number of infectious and parasitic diseases causes mortality, morbidity, and market restrictions, which drastically decrease animal production (Shapiro *et al*., 2015). Among animal diseases, parasitism represents a major constraint on the development of the livestock sector and hampers the poverty alleviation programs in the livestock farming system in Ethiopia. Among parasitic diseases, hydatidosis (Cystic echinococcosis) is the most important parasite that causes direct and indirect economic loss to livestock, particularly in cattle and sheep production systems (Okewole *et al*., 2000).

It is one of the major parasitic diseases of public health importance in Ethiopia and other parts of the world. It is associated with severe morbidity and is one of the world's most geographically widespread zoonotic diseases (Craig *et al*., 2007).

The disease is chronic and affects all kinds of food animals, including omnivorous and herbivorous mammals. It is characterized by the formation of variably sized cysts in the visceral organs of the intermediate host and tapeworms in the intestine of the definitive host (Eckert and Thompson, 1994). At its intermediate host, it forms cysts in the internal organs, especially the liver and lungs, and some infections can be fatal in humans if the cyst ruptures and causes anaphylactic shock (Efrem *et al*., 2015).

Hydatidosis is a zoonotic disease caused by the larval stage of *Echinococcus granulosus*, for which domestic intermediate hosts (goats, sheep's, camels, and cattle) are major reservoirs for the occurrence of human hydatidosis (Torgerson and Deplazes, 2009). Dogs are the major source of infection for humans, and the majority of recorded human Cystic echinococcus cases are caused by *E. granulosus*, with a life cycle that occurs mainly within a rural setting between shepherd dogs and sheep (Craig and Larrieu, 2006). It represents a significant global human disease burden in resource-poor communities (WHO, 2011). This multi-host parasite is prevalent globally, and annually, the economic loss in livestock due to this parasite is significant (Lahmar *et al*, 2004; Tappe *et al*, 2011).

This disease in ruminants causes enormous economic damage due to the reduction of milk, meat, and wool production and the condemnation of infected organs. The existence of sylvatic cycles perpetuates the disease and creates obstacles for control and eradication programs. Due to this, the risk of infection with *E. granulosus*, both in animals and humans, is expected to be high. The main reason for the high transmission of this disease is the habit of keeping dogs close to humans and the culture of feeding them inappropriately disposed offal from the nearby abattoir. Echinococcosis and its cysts impose an economic and public health problem globally and cause a particularly heavy burden in developing countries (Urquhart *et al*., 2003).

Though the status and economic impact of bovine hydatidosis have been studied in several regions of Ethiopia previously, its current prevalence and economic impact were not known in cattle slaughtered at the Maichew Municipality abattoir. Therefore, this study was designed with the following general and specific objectives:

1.2. Objectives of the Study

1,2.1. General Objective

- To assess the prevalence and economic significance of bovine hydatidosis in the Maichew municipal abattoir

1.2.2. Specific Objectives

- To determine the prevalence of bovine hydatidosis in the Maichew municipal abattoir
- To characterize cyst viability and fertility tests
- To assess the economic impact of the disease in the study area

1.3. Research Questions

- What is the impact of the disease on the study area?
- Does the disease have epidemiological significance in the study area?

1.4. Significance of the Study

- Provide baseline information on the prevalence and economic significance of bovine hydatidosis in the Maichew municipal abattoir.
- It can help in prioritizing the public health and economic importance of the disease.
- Provide basic information on the epidemiology of hydatidosis.

1.5. Limitations of the Study

Due to the war crisis in the region, the study was not completed on time. This might affect the value of the study. And also, the study couldn't include public health significance because it is difficult to get the document in the hospital.

CHAPTER II: LITERATURE REVIEW

2.1. Etiology

Hydatidosis is caused by the cystic stage of *Echinococcus* species, i.e., the hydatid cyst. Hydatid cyst is a large fluid-filled cyst lined with germinal epithelium from which invaginated scolices that lie free or in bunches are produced, surrounded by germinal epithelium (brood capsules); the contents of the cysts other than the fluid, i.e., scolices and brood capsules, are frequently described as 'Hydatid Sand,'occasionally also formed endogenously if the cyst wall ruptures exogenously (Taylor and Wall, 2003).

Hydatid cyst fluid is pale yellow with 17–200 mg protein per 100 ml. It has a striking similarity to the serum of the host and contains immunoglobulin (Soulsby, 1982). The outer covering of the hydatid cyst is formed by connective tissue, under which there is the germinal epithelium. Germinal layers are present both in large cysts and daughter cysts, from which the scolices arise (Mandal, 2006).

Four species of the genus *Echinococcus* are recognized and regarded as taxonomically valid*: E. granuloses* (cystic hydatidosis), *E. multilocularis* (multivesicular hydatidosis), *E. vogeli* (polycystic hydatidosis), and *E. oligarthrus* (Soulsby, 1982). These four species are morphologically distinct in both the adult and larval stages. In addition, several different strains of *E. granulosus* are recognized (Permin and Hansen .1994).

Echinococcus granulosus (E. granulosus) dwarf dog tape worm is a tapeworm found in the small intestine of definitive hosts and the cystic stage, i.e., hydatid cyst found in various organs (liver and lung) in the intermediate host, and occupies a large portion of functional tissues (Gessese, 2020). In sheep, about 70% of hydatid cysts occur in the lungs. In cattle and horses, more than 90% of cysts are usually found in the liver (Gessese, 2020).

It is only about 6.0 mm long and consists of a scolex and three or four segments, the terminal gravid one occupying about half the length of the complete tapeworm. Each segment has a single genital opening. The scolex has the rostellum, which is armed with hooks; the ovary is kidney-shaped (Mandal, 2006).

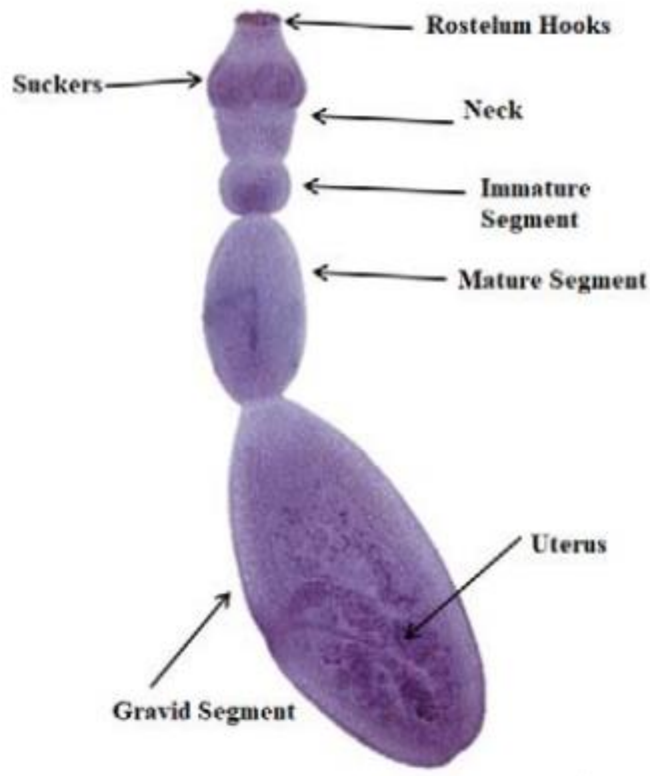

Figure 1: Morphology of the adult worm of *Echinococcus granulosus*

Source (Rahman, 2015)

The *Echinococus multilocularis (E. multilocularis)* dwarf fox tapeworm is a tapeworm found in the small intestine of the definitive hosts, and the larval stage is found mainly in the liver and also in the brain, lungs, muscles, lymph nodes, and other organs and tissues (Taylor and Wall, 2007). It is a very small tape worm (2–4 mm) and is generally similar to *E. granuloses*, but usually with 3–5 segments. (The terminal segment measures less than half the length of the whole worm.) The scolex has four suckers and possesses a double row of large and small hooks. The third segment of the adult tapeworm is sexually mature, and the genital pores are in front of the middle of each segment. (The uterus is saclike, with no lateral saculations in the terminal proglottid. The gravid segment contains around 200–300 spherical eggs (Gessese, 2020).

Echinococcus vogeli (*E. vogeli)* is a tapeworm found in the small intestine of definitive hosts, i.e., bush and domestic dogs. In the intermediate host, the cyst is found in the lungs, liver, and other visceral organs. It is a very small tapeworm (4–6 mm) and usually has 3 segments, with the terminal gravid segment being very long in comparison to the rest of the tapeworm. The metacestode has a polycystic structure (Taylor and Wall, 2007). It possesses up to 36 large and small rostella hooks on the scolex, distinguishing it from the other *Echinococcus* species (Gessese, 2020).

Echinococus oligarthus (E. oligarthus) is a tapeworm found in the small intestine of definitive hosts and in the viscera, musculature, and skin of intermediate hosts. It is an extremely small tapeworm (2.5–3.0 mm) and usually has three segments. The uterus is a sac like the gravid proglottid (Taylor and Wall, 2007).

2.2. Epidemiology of the Disease

2.2.1. Distribution

Echinococcus granules occurs globally, with the exception of a few countries such as Greenland and Iceland. Within an area, its distribution may be focal. Each strain or species has a distinct geographic range. The G1 sheep strain is cosmopolitan; it has been reported in Europe, the Middle East, Africa, parts of Asia, Australia, North and New Zealand, and South America (Ashenafi, 2013). But alveolar echinococcosis is confined to the northern hemisphere, in particular to regions of the Russian Federation, China, and countries in continental North America and Europe (Chebli *et al*., 2016).

Moreover, poor public awareness about the disease and the presence of few slaughter houses should have contributed to such a higher prevalence rate (Abiyot *et al*., 2011). In Ethiopia, hydatidosis has been reported in different parts of the country.

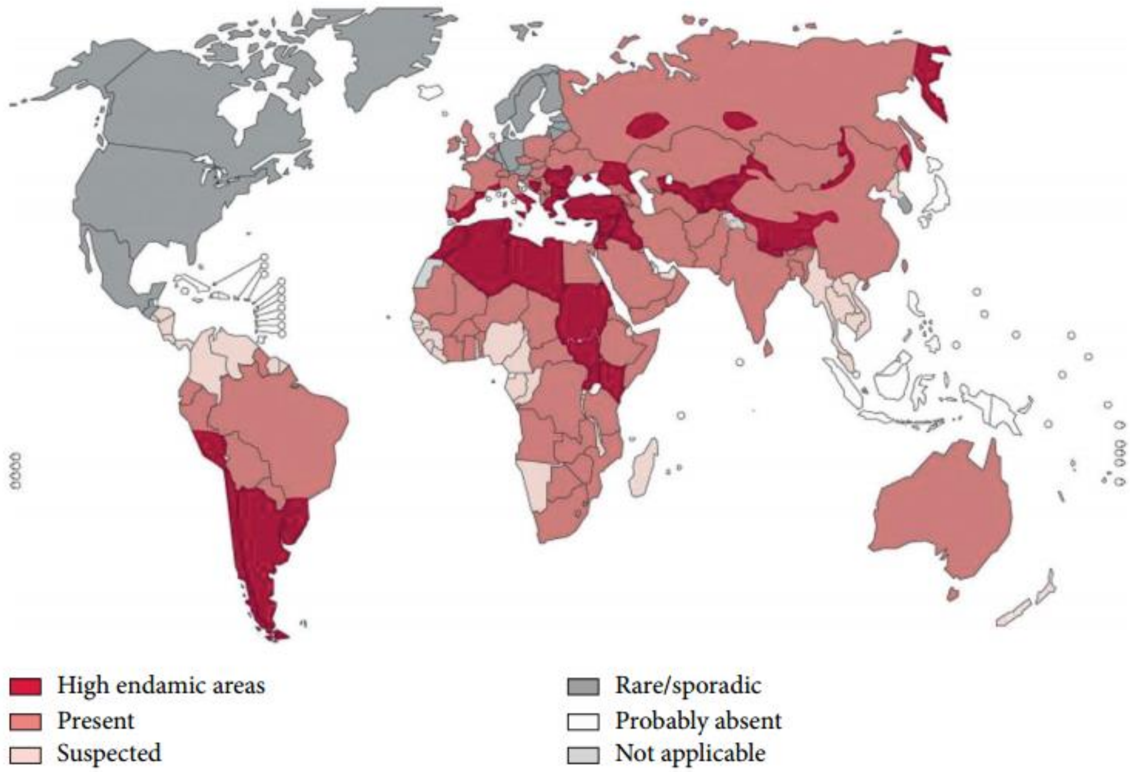

Figure 2: Worldwide distribution of *E. granulosus*

Source (WHO,2011)

2.2.2. Host Range

Echinococcus granulosus has two biotypes (*E. granulosus* and *E. granulosus. equines*) that are host-adaptive. Red fox, dogs, and many wild canids are the most common definitive hosts. The intermediate stage of *E. granulosus* occurred in domestic ruminants, pigs, men, and wild ruminants, whereas donkeys and horses are resistant. The larval stage of *E. granulosus equines* occurs in donkeys and horses but not in humans (Gessese, 2020).

Foxes serve as the principal definitive hosts for the adult of *E. multilocularis*, but cats, dogs, and coyotes can also serve that function. Larval forms are found in various rodents, chiefly voles, field mice, shrews, and ground squirrels. Humans can also be infected (Ten houten, 2014).

Echinococcus vogeli is a parasite of the bush dog and occasionally domestic dogs, with an intermediate stage in pacas and other rodents and, on occasion, humans (Ten houten, 2014).

Wild felids like the cougar, jaguar, and ceros are important definitive hosts of *E. oligarthus*, and the larval stage occurs in agoutis, rodents, spiny rat, paca, and man, who can be an accidental host (Taylor and Wall, 2007).

2.3. Mode of Transmission to Intermediate Hosts

Primary cystic echinococcosis infections are acquired by humans through oral uptake of *E. granulosus* eggs shed by infected dogs or other animals (Budke and Torgerson, 2006). Handling diseased definitive hosts, egg-containing excrement, or egg-contaminated soil or plants, followed by direct hand-to-mouth transmission, can all lead to infection. Birds, wind, beetles, and flies can contaminate food, drinking water, and surfaces with *Echinococcus* eggs, making them a possible source of infection for humans and cattle (Eckert and Pawlowski, 2002).

The eggs enter the intermediate hosts through the ingestion of contaminated water, grass, vegetables, and others (Fig. 2). It has been shown that flies and possibly other insects contaminated during feeding may mechanically transport the eggs over considerable distances. The definitive hosts are affected by the ingestion of offal's contaminated by fertile and viable hydatid cysts (Carmena and Cardona, 2013).

Unhygienic practices play a major role in the maintenance and transmission of the disease in humans and domestic ruminants. This is particularly true in sub-Saharan African countries, including Ethiopia. In developing countries, due to backyard slaughter practices and a lack of effective meat inspection, the hydatid cyst-infected viscera are deliberately left for home and stray dogs' consumption. In these areas, the infection rate with *E. granuloses* in dogs was reported to be between endemic and hyperendemic (Dhakka, 2010).

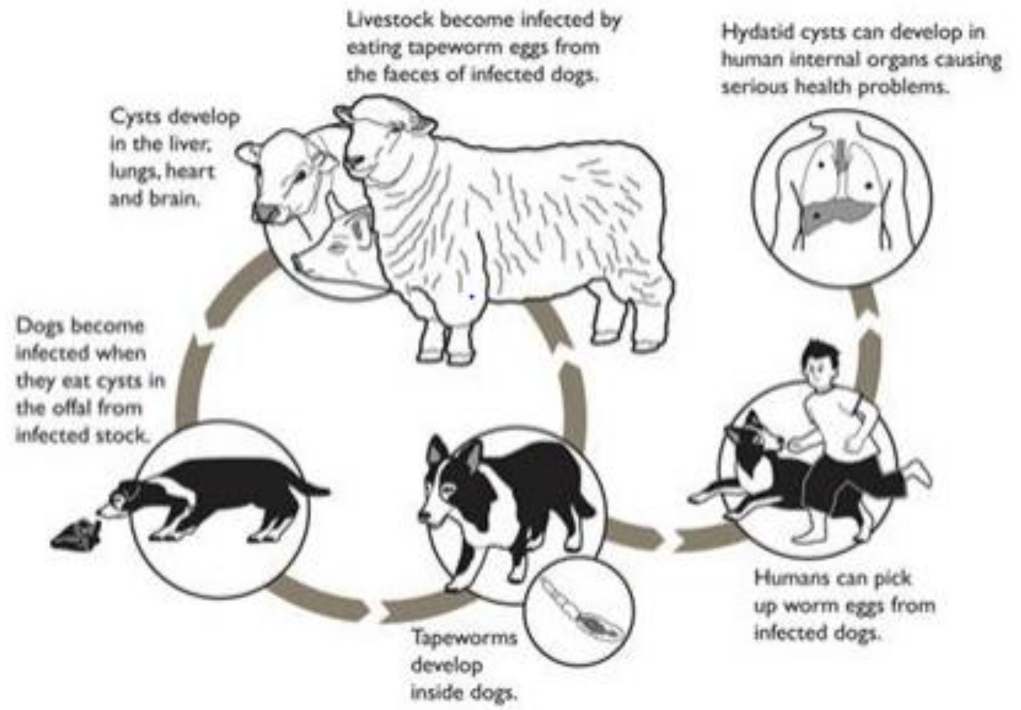

Figure 3: Transmission of hydatidatidosis

Source (Eryıldız, 2010).

2.4. Life Cycle

The life cycle of *E. granulosus* is complex; it requires two mammalian hosts to complete its life cycle. The life cycle of the parasite is complete when dogs ingest hydatid cysts containing fully developed protoscoleces, which are subsequently released and attach themselves to the intestinal lining of the host. The protoscoleces start to develop into mature adult tapeworms within 32–80 days, depending on the species and the parasite strain. Humans are described as dead end ‘hosts for the parasite, since the life cycle is usually completed when carnivores eat affected herbivores (Eckert and Thompson, 2017).

The life cycle of *Echinococcus*, which is shown in the figure below (Fig. 4), is discussed as follows: The adult tapeworm is found in parts of the small intestine of the definitive host, from where segments containing eggs are passed with the faces. When intermediate hosts like cattle, sheep, goats, and pigs ingest the eggs and camels in which the metacestode develops, the oncosphere’s penetrates the wall of the small intestine. A hormonal secretion from the oncospheres aids the penetration into the intestine. Upon gaining access to a venue, the oncospheres are passively transported to the liver, where some are retained, others reach the lungs, and a few may be transported further to the spleen, kidney, brain, muscles, and other visceral organs (McManus and Bartley, 2003).

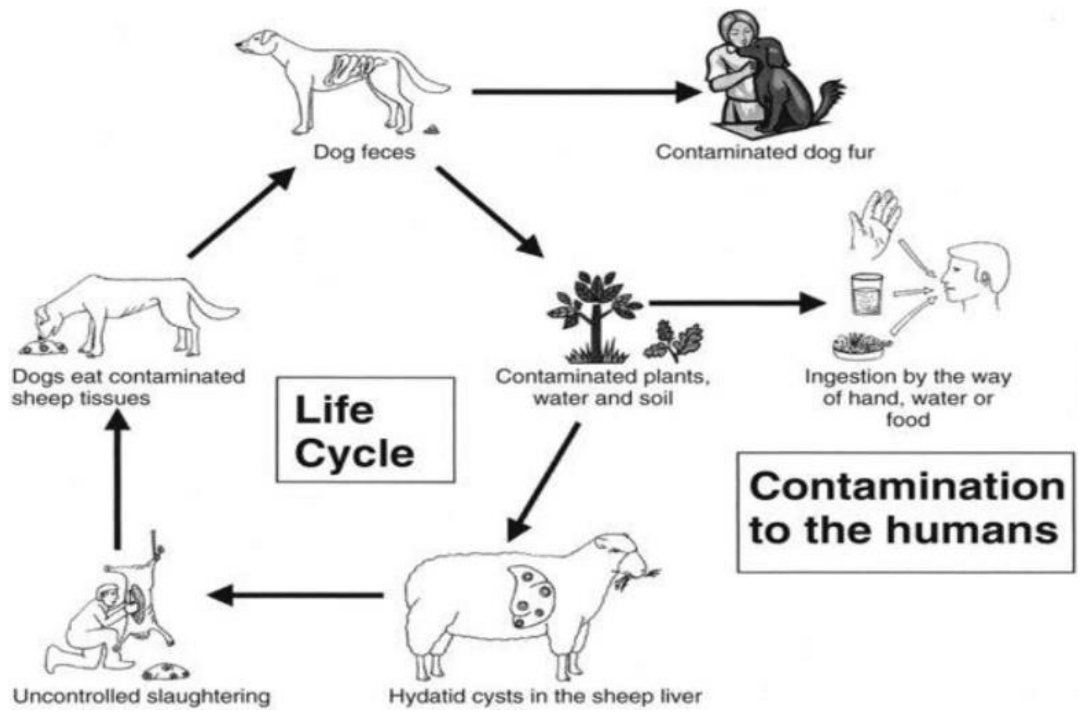

Figure 4: Life cycle of hydatidosis

Source (Hailu and Bishoftu, 2018)

2.5. Pathogenesis

The pathogenesis of hydatidosis heavily depends on the extent and severity of the infection and the organ on which it is situated. The occasional rupture of hydatid cysts often leads to sudden death due to anaphylaxis, hemorrhage, and metastasis (Kebede *et al.,* 2009). *Echinococcus* infection causes an imbalance of the immune response within the hepatic tissue, leading to severe destruction of the architecture due to intensive inflammatory cell infiltration and the development of fibrosis (Zhang *et al*., 2003).

Experimental murine models of liver injury highlight the involvement of Kupffer cells in initiating and propagating this inflammatory response by releasing pro-inflammatory cytokines, including tumor necrosis factor (TNF)-α, interleukin (IL)-6, and IL-1 β, and activating other non-parenchymal liver cells (e.g., endothelial or hepatic stellate cells). Many of these pro-inflammatory mediators can activate hepatocytic cell death pathways and can also activate protective signaling pathways via nuclear factor kappa β (NF-κβ). Studies conducted in mice indicate that macrophage activity is largely dependent on the recruitment of monocytes into the liver as precursors of tissue macrophages (Zimmermann *et al*., 2012).

Macrophages play a key role in the initiation and progression of fibrosis (Heymann *et al.*, 2009). Resident macrophages have been shown to play a role in initiating an inflammatory response during tissue injury, while infiltrating monocyte-derived macrophages are associated with chronic liver inflammation and fibrogenesis (Tacke and Zimmermann, 2014). The involvement of Kupffer cell-derived cytokine production is underscored by findings that liver regeneration is impaired in the absence of IL-6, TNFreceptor-1, and NF-k β signaling (Wyler *et al.*, 2016).

The chronic stage of an *Echinococcus* infection occurs once the hydatid cyst is fully formed, which is characterized by a more Th2 and T regulatory-dominant immune response (Gottstein *et al*., 2017).

2.6. Risk Factors

Certain deep-rooted traditional activities have been described as factors associated with the spread and high prevalence of the disease in some areas. These factors include the wide spread of backyard slaughter of animals, the corresponding absence of rigorous meat inspection procedures, the long-standing habit of feeding domesticated dogs with condemned offal, keeping a large number of dogs, and failure to treat dogs with anthelmintics (Getaw *et al.*, 2010*)*.

This can facilitate the maintenance of the life cycle of *Echinococcus granulosus,* which is the causative agent of cystic hydatidosis, and consequently the high rate of infection of susceptible hosts (Biffa *et al.*, 2006). Risk factors for human hydatidosis include a history of dog ownership, an occupation, a poor educational background, eating habits, age, sex, and a drinking water source (McManus *et al.*, 2009).

2.7. Economic Importance

Hydatid disease is widely spread. Parasite diseases infecting a large number of domestic animals, both wild and humans, are considered one of the major causes of economic losses and the productivity of livestock in both the developing and industrialized worlds (Oryan *et al.*, 2012).

In livestock, it causes considerable economic losses due to the destruction of affected animal organs at the slaughterhouse and production losses due to reductions in live weight gain, yield of milk, fertility rates, and the value of hide and skin (Roming *et al.*, 2011).

It is implicated that the economic burden on the global livestock industry alone has been estimated to be over $2 billion per year. Such losses are of particular importance in Ethiopia, which has low economic output and a per capita income of less than one US dollar per day (Scala *et al.*, 2006).

Hydatid disease not only results in the loss of millions of dollars, but it also worsens the protein deficiency for human consumption in terms of condemned organs and lowers the productivity of infected animals. The difference in economic losses agreed with the variation in the prevalence of the disease, the mean annual slaughter rate in different abattoirs, and the variation in retail and market prices of organs. In humans, hydatidosis is responsible for direct monetary costs such as those incurred by hospitalization, diagnosis, surgical or percutaneous treatments, post-treatment care, therapy, and travel for patients and family members. Indirect costs include mortality, suffering, and the social consequences of disability, as well as the loss of a working day (Fasih *et al.*, 2012).

2.8. Public Health Significance

Hydatidosis in humans is an infection produced by the larval stage, the metacestode of *Echinococcus* species, and can range from asymptomatic to severe disease that can be fatal (Fig.5). It is a significant public health issue in certain nations, and it may be emerging or reemerging in others. Worldwide, it is estimated that approximately 2-3 million human cases occur. The most frequent type of the disease in humans and domesticated animals is cystic echinococcosis, which is caused by *E. granulosus* sensuous (Fasih *et al.*, 2012).

Hydatid cysts cause a life-threatening disease in humans, caused by the ingestion of eggs passed by dogs and then the development of a cyst or cysts within the human body. This can be a particular risk in children with close contact with pet dogs where there has been less attention to hygiene (hand washing). In humans, the removal of cysts may require major surgery, and life-threatening complications can occur when cysts develop in critical parts of the body such as the liver, lungs, or brain (Lozano, 2012).

It occurs in most areas of the world and currently affects about one million people. In some areas of Africa, South America, and Asia, up to 10% of certain populations are affected (WHO, 2014). In 2010, it caused about 1200 deaths globally (Lozano, 2012). The economic cost of the disease for diagnosis, chemotherapeutic treatment, surgery, hospitalization, and lost working days is estimated to be around 3 billion USD a year (WHO, 2014).

The occurrence of the disease in humans in Ethiopia was described earlier by Graber (1978). However, the situation of the disease in humans has not been well documented and explored so far in the country. Clinical and serologic tests conducted among the Dasante and Nyangatom pastoralist tribes of the southern western part of the country revealed a prevalence of 15% hepatomegaly, 4.8% palpable abdominal cysts, and 31.7% positive hydatid skin tests (Fuller and Diane, 1981).

In Hamar pastoralist tribes of southwest Ethiopia, a prevalence of 0.5%–0.7% was reported (Macpherson *et al.*, 1989; Klungsøyr, 1993). Prevalence rates of 1.6% and 0.5% have been reported in southern parts of Ethiopia (Eckert J *et al.*, 2002).

A mean annual incidence rate of approximately 2.3 cases per 100,000 per year was also reported in Bahir Dar by Kebede *et al.* (2010), a 4-year retrospective study. In another retrospective study by W. Kebede *et al*. (2009), of the six zonal hospitals in Tigray Region, eight cases of human CE since 2000 were reported. Three cases of cerebral CE were also reported by Kassa (2012). Besides, during 1995 and 2005, 234 patients were operated on for hydatid disease at Tikur Anbessa Hospital in Adis Ababa (Minas *et al*., 2007). Out of them, 137 patients during 1994–2006 were treated for hepatic hydatidosis (Hagos *et al*., 2006). Overall, these few findings show the huge magnitude of the problem.

Figure 5: A boy with abdominal distention due to cystic echinococcosis of the liver as shown by ultrasound imaging

Source (Moro and Schantz, 2009)

2.9. Diagnosis

Adult tapeworm infection in dogs is not simple to diagnose since the segments are tiny and only shed sparingly (Urquhart *et al., 1996).* Microscopic egg detection in fecal samples cannot be used to diagnose *E. granulosus* infection because these eggs are morphologically identical to those of *Taenia* species (Alemu *et al.*, 2013*).*

An egg can be found in fecal samples using the standard flotation technique or on the perineal skin using clear adhesive tape that is pushed to the skin, transferred to a microscopic slide, and studied. If in good condition, proglottids of *E. granulosus* spontaneously expelled by dogs and identified predominantly on the surface of fecal samples may allow a proper morphological diagnosis (Urquhart, 1996).

In humans, the diagnosis is confirmed by imaging (computer tomography (CT), X-rays) and identification of the typical or worrisome cyst structure (Bernhaler *et al.*, 2009). Cysts are diagnosed using imaging techniques such as CT scans, ultrasonography, and magnetic resonance imaging (MRI), and once a cyst is found, serological testing may be utilized to confirm the diagnosis in humans (McManus *et al*., 2012).

2.10. Treatment of Cystic Echinococcosis

Echinococcus tapeworms are more difficult to eradicate than other *Taenia*, although numerous extremely effective medicines, most notably praziquantel, are now available. Following treatment, it is recommended that dogs be confined for 48 hours to allow for the collection and disposal of contaminated feces. In humans, hydatid cysts can be surgically removed, although mebendazole, albendazole, and praziquantel therapy have been shown to be effective (Taylor and Wall, 2003).

The treatment of hydatidosis in humans is determined by the location and size of the hydatid cyst(s) in the body. In humans, surgery is still the only reliable method of treating hydatid cysts, and chemotherapy, particularly albendazole, is indicated only when surgery is not an option. A combination of surgery and benzimidazole, mebendazole prevents protoscoleces from developing into hydatid cysts and keeps the cyst dry. Membrane collapse if the medicine was administered to the patient prior to surgery (Sinan *et al.*, 2002).

2.11. Prevention and Control

Because prevention is preferable to cure, it is preferable to prevent hydatidosis before it causes significant damage that necessitates additional expenses and efforts to remove it. The disease is controlled by removing hydatid tapeworms from dogs using the appropriate control procedures. The infection of dogs with tapeworms, as well as the spread of the disease to other animals, including humans, can be avoided (Yücesan, 2020).

At least five of ten *E. granulosus* genotypes are infective to humans in sub-Saharan Africa. Most human cases of CE are caused by the sheep strain (GI) and camel strain (G6) of *E. granulosus*. Other strains occurring in sub-Saharan Africa may include a lion strain, the horse strain (G4 or *E. equinus),* and the cattle strain G50 or *E. ortleppi* (Japhet *et al*., 2006). Cystic hydatidosis continues to be a substantial cause of morbidity and mortality in many parts of the world. Elimination is difficult to obtain, and it is estimated that, using current control options, achieving such a goal will take around 20 years of sustained efforts (Craig *et al*., 2007).

Vaccinating sheep with an *E. granulosus* recombinant antigen (EG95) offers promising preventative and control potential. The abolition of sheep farm slaughter reduces the possibility of canines becoming infected from this source (Craije and Nieto, 2007). Dogs are pivotal in *E. granulosus* transmission to humans, and dog vaccination provides a very practical and cost-effective prevention strategy.

A study conducted by Wenbao *et al*. (2006) revealed that vaccination of dogs with soluble native proteins isolated from the protoscoleces of *E. granulosus* will induce significant suppression of worm growth and egg production. Besides vaccination, control strategies need to focus on careful analysis of the local situations (particularly concerning the particularities of the cycle, ecology, and etiology of the animal hosts and the behavioral characteristics of the population at risk).

The use of newly developed tools both in animals and humans (immunology, molecular biology, and imaging) and the association of traditional control measures (control of slaughtering, antiparasitic treatment and control of the definitive hosts, and health education) with more recent developments such as vaccination of the intermediate hosts (Nakao *et al*., 2013).

Control of hydatidosis is less effective without the support of dog owners, and this support can only be obtained if people have a clear understanding of the disease (Heath *et al*., 2006). In an area where home slaughter is practiced, dosing of dogs with a suitable taeniacide will be an important component in the hydatid control programs (Watson-Jones and Macpherson, 1988). In developing countries, effective west disposal and prohibition of the entrance of animals like dogs, cats, birds, and other wild animals to abattoirs will play a crucial role in reducing the incidence of the disease (Kassa, 2012).

Stray-dog control, registration of all owned dogs, spaying of bitches, and medication of all (or most) dogs with praziquantel at predetermined intervals, such as every 6 or 8 weeks, are all specific control measures. These steps are supplemented by improvements in meat inspection, abattoir hygiene, proper slaughter offal disposal, public health education, and other initiatives (Pal, 2007). Control efforts in several nations have demonstrated that the attack phase may be completed successfully in less than 15 years if the essential steps are carried out without substantial re-strains and financial constraints (Craig *et al.*, 2007).

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CHAPTER III: MATERIALS AND METHODS

3.1. Study Area

The study was conducted in the Maichew municipal abattoir from July 2021 to October 2023. Machew, also Maichew (in Tigrigna meaning "salt water"), is a town and Woreda in the Tigray Regional State of Ethiopia. It is located 665 km north of Addis Ababa along the Ethiopian highway that runs to Mekelle (the capital city of Tigray regional state) at an altitude of 2479 m above sea level. According to Ethiopia's agroecological setting, Maichew and its environment are classified under the Weinadega (semi-temperate zone). Maichew is located in the endoergic basin of the Afar Triangle, and the streams near Maichew do not reach the ocean.

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this town has a total population of 23,419, of whom 11,024 are men and 12,395 are women. 95.28% of the population said they were Orthodox Christians, and 4.24% were Muslims. The Maichew municipal abattoir provides fresh meat for different organizations, such as hotels, restaurants, universities, and butcheries.

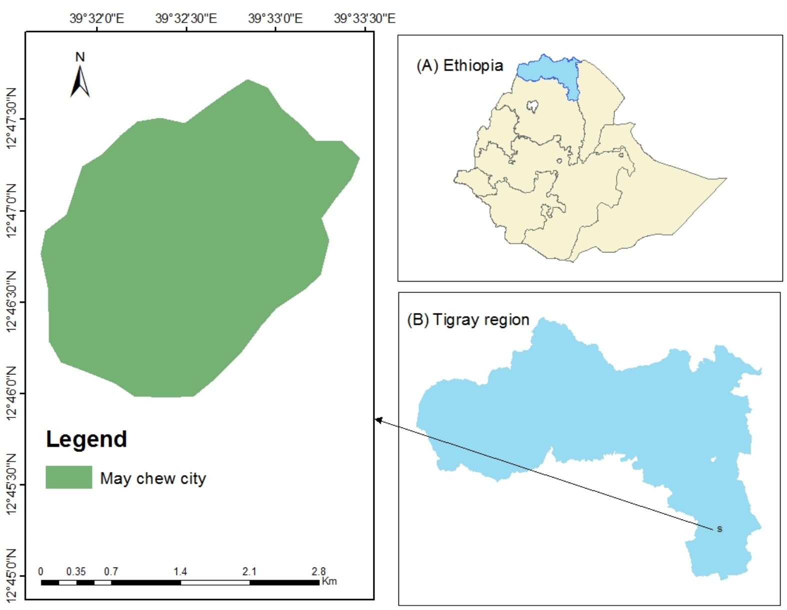

Figure 6: Map of the study area

3.2. Study Population

The study population includes all cattle brought for slaughter to Maichew municipal abattoir comprising different breed, sex, age composition and originating from different districts of the zone including Ofla, Raya Alamata, Raya-azebo, Dela, Endamhoni, Alaje,Korem and Neksege.

3.3. Sample Size Determination

As anchored in the previous survey, an expected prevalence of 50% was taken to calculate the required sample size. The sample size was determined using Thrusfield's (2007) formula, setting the 95% confidence level (CI) and 5% accepted error.

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

Where Pexp is the expected prevalence (50%), n is the required sample size, and d is the desired absolute precision (5%). Accordingly, based on the above formula, a sample size of 384 cattle was considered.

3.4. Study Design and Methods of Data Collection

In the present study, a cross-sectional study was implemented. Data was collected using both ante-mortem and post-mortem meat inspections, respectively. During the PM study, infected organs were incised using a standard protocol stated by FAO (2003). For CE-positive animals, the cysts were subjected to systematic size measurement (diameter) using a ruler and classified as small cysts (<3cm), medium cysts (3-5 cm), and large cysts (>5cm) (Dalimi *et al.*, 2002). The total number of mature cysts obtained per organ was counted in different organs. The fertility and sterility of the hydatid cyst were recorded in order to investigate the viability of the cyst as per Tsimoyiannis *et al. (*2000).

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3.4.1. Ante Mortem Inspection

During the ante-mortem examination, age, sex, breed, and body condition were recorded. The body condition of the study population was classified into three main categories: poor (score 1, 2, 3), medium (score 4, 5, 6), and good (score 7, 8, 9) based on observation of muscle mass and fat cover on the ribs, hips, between hooks, pins, spine, and transverse processes (Nicholson and Butterworth, 1986). Concurrently, their age was categorized in years (≤2, 2-4, and ≥5) as per De-Lahunta and Habel's (1986) recommendation principles.

3.4.2. Post Mortem Examination

The inspection procedures used during the postmortem examination consisted of primary and secondary examinations. The primary examination involved visual inspection and palpation of the viscera and organs. The secondary examination involved further incisions into each organ if a single or more cysts occurred. The liver, lung, kidney, and heart of each animal were examined grossly. Each organ was incised once or twice with a knife. Whenever and wherever cysts were present, they were removed, put in polythene bags separately, labeled, and then taken to Raya Azebo Veterinary Clinic Mini-Lab for further fertility and viability studies.

3.4.3. Cyst Fertility and Viability Testing

For confirmation of cyst fertility and viability, cysts were collected purposively from positive organs and taken to the Raya Azebo Clinic Mini-Lab. During cyst sample collection, individual cysts were grossly examined for any evidence of degeneration and calcification, and then the non-calcified cyst that was thought to have adequate hydatid fluid was selected. The contents of the cyst were checked by transferring them to a sterile slide and examined microscopically (40x) for the presence of protoscolices. Based on the presence or absence of protoscolices in hydatid fluid, the cyst was identified and classified as fertile (if it has protoscolices) or non-fertile (if it has no protoscolices).

The fertile cysts were further subjected to a viability test where a sediment containing protoscolices was placed on the microscope glass slide, covered with a cover slip, and observed for amoeboid-like peristaltic movement with a 40x objective. For clear vision, a drop of 0.1% aqueous eosin solution was added to an equal volume of protoscolices in hydatid fluid on the microscope slide, with the principle that viable protoscolices completely or partially exclude the dye while the dead ones take it up (Dalimi *et al.*, 2002).

3.4.4. Assessment of Monetary Loss

The direct and indirect economic loss, due to bovine hydatidosis, in Maichew municipal abattoir was estimated. Direct financial loss was calculated on the basis of condemned organs, whereas indirect financial loss was estimated on the basis of live weight reduction due to hydatidosis. In calculating the cost of condemned edible organs, meat inspectors and residents were interviewed randomly to establish the price per unit organ, and the average organ price was determined, and this price index was used to calculate the loss (Denbarga *et al.*, 2011). Thus, the mean retail price of liver, kidney, lung, spleen, and meat (1 kg) in Maichew town during the study period was estimated at 450, 160, 120, 10, and 320 Ethiopian Birr (ETB), respectively. During the study period, 1 United States dollar (USD) was also estimated to be 33 ETB.

Lung, liver, and kidney were condemned due to hydatidosis. The annual cost of the condemned organs due to bovine hydatidosis was assessed by the following formula set by Ogunrinade (1980). The annual slaughter capacity of the abattoir should be stated here.

$$LOC = NAS\ [(Plu \times Cplu) + (phr \times Cphr) + (pli \times Cpli) + (psp \times Cpsp) + (pki \times Cpki)]$$

Where:

LOC = Loss due to organ condemnation

NAS = Mean number of cattle slaughter annually,

Plu = Percent involvement of lung cases,

Cplu = Current mean retail price of lung,

Phr = Percent involvement of heart,

Cphr = Current mean retail price of heart,

Pli = Percent involvement of liver,

Cpli=Current mean retail price of liver,

Psp=Percent involvement of spleen,

Cpsp=Current mean retail price of spleen,

Pkid = Percent involvement of kidney,

Cpkid = Current mean retail price of kidney.

The indirect financial loss from carcass weight reduction due to hydatidosis in cattle was also assessed according to the equation (Polydorous, 1981). The annual cost of carcass weight loss due to hydatidosis (ACC) was estimated by the product of the total number of cattle slaughtered annually (Ns) at Maichew, the overall prevalence of hydatidosis (OP), the carcass weight loss in individual animals due to hydatidosis (CWL) at this abattoir, and the average market price of 1kg carcass cattle carcass (AMP) in Maichew town, and this is represented as.

ACC = Ns x OP x CWL x AMP

Therefore, the economic loss from both direct and indirect loss equals the sum of the two that is LOC + ACC

3.5. Data Management and Analysis

Abattoir data was collected and recorded on Microsoft Excel. The outcome variables for the abattoir study were cases of “Echinococcosis” detected during routine postmortem inspection at the abattoir. The STATA software version 13 program (2014) was applied for the statistical analysis of the data obtained from the study. The prevalence of hydatidosis was calculated as the number of positive observations divided by the total sample size multiplied by 100. Logistic regression was used to express results and compare risk factors. (age, sex, breed, and body condition). A statistically significant association between variables was said to exist if the P value was less 0.05 at a 95% confidence interval.

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CHAPTER IV: RESULTS

4.1. Prevalence

From the total of 384 heads of cattle slaughtered and examined, 11.98% were infected with hydatid cysts, harboring one or more cysts involving different visceral organs (spleen, lung, liver, heart, and kidney). There is a statistically significant difference ($P< 0.05$) in the prevalence of hydatid cysts among animals of different body conditions. The prevalence was higher in poor body conditions than in medium and good body conditions.

Table 1: The prevalence of bovine hydatidosis in the Maichew municipal abattoir with respect to different variables

Variables	Categories	Animal examined	Positive	Prevalence (%)	P value	OR	95% CI
Sex	Male	373	45	12.06	.766	1.371	0.171, 10.971
	Female	11	1	9.09	_	_	_
Age	young	16	1	6.3	_	_	_
	Adult	155	11	7.1	.831	1.258	0.131, 10. 363
	Old	213	34	15.7	.335	2.75	0.351, 21.533
Breed	Local	368	45	12.22	.481	2.089	0.269, 16.202
	Exotic/ Cross	15	1	6.25	_	_	_
BCS	Good	97	5.15	4.2	_	_	_
	Medium	150	10	6.67	.628	1.314	0.435, 3.969
	Poor	137	31	22.63	.001	5.381	2.009, 14.409
Total		384	46				

From apparently healthy animals, 384 cattle were randomly selected, and postmortem examination was carried out through visual inspection, palpation, and incision of visceral organs. During the study period, 46 (11.98%) were found infected with hydatid cysts in the abattoir, harboring one or more cysts in different visceral organs (kidney, lung, liver, heart, and spleen). Out of 46 cattle found positive, 21 (45.65%) had hydatid cysts merely in the lungs, 18 (39.13%) in the liver, 4 (4.34%) in the kidney, 1 (2.17%) in the heart, and 4 (9.69%) in the spleen.

Table 2: Prevalence of hydatidosis in different organs of cattle slaughtered in the Maichew municipal abattoir.

Organs examined	**No of examined**	**No of positive**	**Percent %**
Lungs	384	21	5.5%
Liver	384	18	4.7%
Kidney	384	2	0.5%
Spleen	384	4	1%
Heart	384	1	0.3%

4.2. Cyst Characterization

A total of 117 cysts were counted, and 58, 39, 5, 7, and 8 of the total cysts were found on the lung, liver, heart, kidney, and spleen, respectively (Table 3). In this study, 45 small, 26 medium, and 18 large cysts were detected. The result revealed that small cysts represent the highest proportion, while large cysts are the least in terms of their prevalence (Table 3).

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Table 3: Distribution of cysts in different organs based on their size

Organs	No of small cysts (%)	No of medium cysts (%)	No of large cysts (%)	No of calcified cysts (%)	Total No of cysts (%)
Lungs	24(41.4%)	15 (25.9%)	12 (20.7%)	7 (11.1%)	58(49.6%)
Liver	14(36.9%)	9(23.1%)	5 (12.8%)	11 (30.8%)	39 (33.3)
Spleen	3 (37.5%)	1 (12.5%)	0 (0 %)	3 (50%)	8 (6.8%)
Kidney	2 (28.6%)	0 (0%)	1 (14.3)	3 (57.1%)	7 (6%)
Heart	2 (40 %)	1 (20%)	0 (0%)	2 (40%)	5(4.3%)
Total	45(38.5%)	26 (22.2%)	18(15.4%)	26 ((22.2)	117

Morphological characterization of a total of 117 hydatid cysts in cattle revealed the presence of 46.2% (54/117) fertile, 31.6% (37/117) sterile, and 22.2% (26/117) calcified cysts. Of the total of 54 fertile cysts tested for viability, 63% (34/54) were viable, and 37 20% (20/54) nonviable cysts were observed, as indicated in Table 4.

Table 4: Cyst fertility and viability test in different organs slaughtered in study area

Examined organs	No of cysts examined	Fertility test			Viability test	
		Fertile (%)	Sterile (%)	Calcified (%)	Viable (%)	Nonviable (%)
Lung	58	28 (48.3%)	23 (39.7)	7 (12%)	18(64.3%)	10(35.7%)
Liver	39	16 (40 %)	12 (30.8)	11 (28.2%)	12(75%)	4 (25%)
Kidney	7	4(57.1)	0(0%)	3 (57.1%)	1(25%)	3(75%)
Heart	5	3(60%)	0 (0%)	2(40%)	2(66.7)	1(33.3%)
Spleen	8	3 (37.5%)	2(25%)	3 (37.5%)	1(33.3%)	2(66.7%)
Total	117	54(46.2%)	37 (31.6%)	26 (22.2)	34 (63%)	20(37%+)

4.3. Economic Loss Assessment

In the current study, 21 lungs, 1 heart, 18 livers, 2 kidneys, and 4 spleens were condemned due to bovine hydatidosis during the study period, with an economic loss of 34237.5, 2278.5, 272814.3, 91140, and 40740 ETB, respectively. In the present study, the total annual direct economic loss due to bovine hydatidosis was found to be 231,724 ETB per year (Table 5).

Table 5: Local Prices of Offal's and Carcass in Maichew City

Offal's/Carcass	Local price/organ ETB
Current price of one lung	120
Current of one liver	450
Current price of one heart	240
Current price of one spleen	10
Current price of one kg carcass	320
Current price of kidney	160

Table 6: Direct economic loss due to bovine hydatidosis in the Maichew municipal abattoir

Examined Organs	% of organs condemned	Local price/organ ETB	Average annual Slaughter of cattle	Total price (birr)
Spleen	4 (9.7 %)	10	950	921.5
Liver	18 (39.1%)	450	950	167,152.5
Heart	1 (2.2%)	240	950	5,016
Kidney	2 (4.3 %)	160	950	6,536
Lung	21 (45.7 %)	120	950	52,098
Total	46(100)			231,724

The annual indirect bovine hydatidosis financial loss in the Maichew municipal abattoir was estimated at the average annual slaughtered cattle (950), prevalence of hydatidosis (11.98%), current price of 1 kg of carcass (320 ETB), dressed average carcass weight of adult Zebu cattle is 126 kg (Regassa *et al*., 2010), and the reduction of 5% in meat production due to hydatidosis was considered, and it could be 229440.96 ETB annually. The total annual financial loss due to bovine hydatidosis in the Maichew municipal abattoir was calculated as the sum of the direct annual financial losses due to organ condemnation and indirect annual financial losses from carcass weight loss, which could be 461,164.96 ETB (13,974.6957US$) per annum.

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CHAPTER V: DISCUSSION

In the present study the prevalence of bovine hydatidosis at Maichew Municipal abattoir was found to be 11.98% which was comparable with the results of 11.3% in Harar Lema *et al.* 2014 ,11.88 in Bako Mitiku and Amenu (2017), this study was much higher compared to the prevalence reported by Kebede (2009b) 7.5% in Shire Municipal abbatoir and Akeberegn *et al*. 2017 (6.51%) at Debre Berhan Municipal abattoir, 'but, it is much lower compared to the prevalence of 28.09% at Mekelle municipal abattoir (Dawit *et al*., 2013), 22.57% at konso Municipal abattoir (Fikre *et al*.,2012), 30.7% at Jimma municipal abattoir (Abebe, 2015), 40.5% at Addis Ababa Abattoirs Enterprise (Terefe *et al*., 2012) and 62.38% at Asella municipal abattoir(Mitiku and Amenu, 2017).

Generally, the difference in the prevalence of bovine hydatidosis among cattle slaughtered at different areas in Ethiopia might be ascribed to factors including differences in socio-economical activities ,agroecology, difference in sample size, age of slaughtered animals, stocking rates and movements of animals, husbandry systems, awareness, culture and religion of the society, and attitude to dogs in different regions of the Country (Fromsa and Jobre, 2012; Kumsa, 2019; Belachew,2019) , the strain difference of Echinococcus granuloses that exist in different geographical locations (McManus, 2006), differences in environmental conditions, hygienic status of slaughter houses, climatic conditions, contamination rate in the intermediate host, number of dogs in each place, slaughtering manner, feeding status of animals, livestock stocking intensity and livestock movement (Dawit *et al*., 2013).

In our study, an assessment of bovine hydatidosis was made to see the relationship between age, body condition, and sex of the affected animals. The study showed that there was a statistically significant difference in the infection rates among different body conditions ($p<0.05$). Animals in poor body condition were more likely to acquire the diseases than those in medium and good body condition. This could be mainly due to the fact that animals with poor body condition have low immunity to combat the disease, and poor body condition is probably a reflection of the effect of a relatively high cyst burden. However, this finding disagrees with the finding of Guduro *et al*. (2019), who reported the existence of no statistically significant difference in Echinococcal infection between the different body conditions of affected animals.

Attempts were made to evaluate the relationship between the infection rate and the sex of the animals. The result indicated that no statistically significant association exists between sex and the occurrence of the disease; this agrees with the finding of Berihu and Toffik (2015). This might be due to indiscriminate exposure to risk, irrespective of sex, in the management of the study area.

In reverse, it disagrees with the findings of Mebrahtu and Mesele (2012), who reported that the disease had occurred more in females than males. The reason behind this is that female animals are not slaughtered at younger ages as long as they are fertile. Female animals are slaughtered after milking and getting calves for years. It is very clear that among the affected organs involved, lungs and livers are the most commonly infected organs by haydatid cysts due to the fact that lungs and livers possess the first large capillary sites encountered by the migratory echinococcus oncospheres (Hexacanth embryo).

The finding of the present study is also similar to the above reason, although a higher incidence rate of haydatid cysts was present in the lungs and livers of the examined animals. The findings of the highest prevalence and largest number of hydatid cysts in the lungs compared to other organs, followed by livers, in the study are in agreement with several reports. Similar findings were obtained by investigators (Kumsa, 2019; Guduro and Desta, 2019).

In the present study, the lung (45.65%) and liver (39.13%) were the most commonly affected organs. The spleen, kidney, and heart (4.97%), 2 (4.34%), and 1 (2.17%) were the least infected organs in the examined animals. This could be mainly due to the fact that the lung and liver possess the first great capillaries encountered by the migrating Echinococcus oncosphere (hexacanth embryo), which adopt the portal vein route and primarily negotiate the hepatic and pulmonary filtering systems sequentially before any other peripheral organ is involved (Urquhart *et al*., 1996). In the present study, the lung was found to be the most commonly infected organ, followed by the liver, which might be due to the presence of greater capillary beds in the lungs than other organs (Mohamadin and Abdelgadir, 2011).

In the current study, the overall findings showed that 46.2%, 31.6%, and 22.2% of hydatid cysts were fertile, sterile, and calcified cysts. This finding supports the previous arguments by other investigators in Ethiopia that assume sheep have greater fertile cysts and a greater role than cattle as an intermediate host of cystic echinococcosis (Negash *et al.*, 2013; Regassa *et al*., 2009). However, in the present study, the overall prevalence (11.98% of cattle) and high fertility (46.2%) of hydatid cysts, in line with previous findings (Romig *et al.* 2011; Getaw *et al.* 2010), imply that cattle are still important as a potential source of infection for dogs and other definitive hosts of this parasite.

In our study, of the total of 117 hydatid cysts examined, 45 (38.5%) were small, 26 (22.2%) medium, and 18 (15.4 % large). The highest proportion of small and medium cysts is an indicator of the immunological response of the hosts that minimizes the expansion of cyst size. This study also indicated that a higher number of medium- to large cysts were formed on the lung. This is due to the fact that a high percentage of medium and large cysts in the lung might be due to the softer consistency of the lung, which allows easier development and expansion of the cyst. Small cysts were found to be more calcified than medium and large cysts, which can be due to the host defense mechanism dealing with parasites more efficiently at the early larval stage of development (Himonas, 1987). However, the developing and fully developed Metacestode are said to be able to escape anti-oncosphere immunity (Thompson, 2002).

In the present study, an assessment of annual economic loss due to bovine hydatidosis was done at the Maichew municipal abattoir. Losses from organ condemnation and carcass weight loss in affected cattle were calculated and estimated at 461,164.96 ETB (13,974.6957US$). The current estimation is greater than estimates done by Lemma *et al*. and Agonafir (2014): 96315 ETB in Harar municipal abattoir; Mulatu *et al. (2013):* 54679 ETB in Shire municipal abattoir; however, it is lower than 4.00 million ETB in Nekemte municipal abattoir that was estimated by Tadesse *et al*. (2014).

The variation in economic loss estimation in various abattoirs might be due to differences in the prevalence of disease, the annual number of cattle slaughtered in various abattoirs, and variations in the retail market price of organs. Considering the present result, bovine hydatidosis is an important disease of cattle in and around Maichew, causing substantial visible and invisible losses when we take into account the local economic environment. It causes considerable economic losses in livestock due to the condemnation of organs and the reduced weight gain of affected animals. Losses like decreasing milk production were not considered; hence, it might be that the actual economic loss due to bovine hydatidosis is higher than what was recorded during the current study.

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6. CONCLUSION AND RECOMMENDATIONS

Bovine hydatidosis is a disease of highly considerable importance from both an economic and a public health point of view. The present study indicated that bovine hydatidosis is a major cause of organ condemnation at the Maichew Municipality abattoir. The prevalence of hydatidosis and the associated financial losses need serious attention.

Therefore, based on the above conclusion, the following recommendations are forwarded:

- Stray dogs have to be restricted.
- Effective control and prevention mechanisms in animal population should be done.
- There must be legislation that will strictly prevent backyard slaughtering practice.
- Veterinarians should work with medical professionals and reach the rural areas; schools and other public institutions have to teach society at large.
- Proper and strict disposal of condemned organs due to hydatidosis to reduce dogs accessing them
- Fencing off abattoirs to minimize access by dogs
- Continuous education should be given to butchers, abattoir workers, meat sellers and dog owners about hydatidosis as zoonosis is important
- Traceability study on the origin of the parasite could be important as the source can also be from wild carnivores like fox in addition to dog.
- Lastly, further study on molecular and genetic characterization of echinococcus isolates from various intermediate hosts are needed

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8. ANNEXES

Annex 1. Determining the Age of Cattle by the Teeth

Age	Features
At birth to one month	Two or more of the temporary incisor teeth present. Within first month, entire 8 temporary incisors appear.
2 years	As a long-yearling, the central pair of temporary incisor teeth or pinchers is replaced by the permanent pinchers. At 2 years, the central permanent incisors attain full development.
2-1/2 years	Permanent first intermediates, one in each side of the pinchers, are cut. Usually these are fully developed at 3 years.
3-1/2 years	The second intermediates or laterals are cut. They are on a level with the first intermediates and begin to wear at 4 years.
4-1/2 years	The corner teeth are replaced. At 5 years the animal usually has the full complement of incisors with the corners fully developed.
5 to 6 years	The permanent pinchers are leveled, both pairs of pinchers are partially leveled, the corner incisors show wear.
7 to 10 years	At 7 or 8 years the pinchers show noticeable wear; at 8 or 9 years the middle pairs show noticeable wear; and at 10 years, the corner teeth show noticeable wear.
12 years	After the animal passed the 6th year, the arch gradually loses its rounded contour and becomes nearly straight by the 12th year. In the meantime, the teeth gradually become triangular in shape, distinctly separated, and show progressive wearing to stubs

Source: Vigneron and Johnson (1999)

Annex 2. Description of Body condition scores in Zebu Cattle

Score	Condition	Features
1	EmaciatedL-	Marked emaciation (animal would be condemned at ante mortem examination).
2	Very thinL	Transverse processes project prominently, neural spines appear sharply.
3	ThinL +	Individual dorsal spines are pointed to the touch; hips, pins, tail-head and ribs are prominent. Transverse processes visible, usually individually.
4	BorderlineM-	Ribs, hips and pins clearly visible. Muscle mass between hooks and pins slightly concave. Slightly more flesh above the transverse processes than in L +.
5	BoarderlineM	Ribs usually visible, little fat cover, dorsal spines barely visible.
6	Good M +	Animal smooth and well covered; dorsal spines cannot be seen, but are easily felt.
7	Very good F -	Animal smooth and well covered, but fat deposits are not marked. Dorsal spines can be felt with firm pressure, but feel rounded rather than sharp.
8	Fat F	Fat cover in critical areas can be easily seen and felt; transverse processes cannot be seen or felt
9	Very fat F+	Heavy deposits of fat clearly visible on tail-head, brisket and cod; dorsal spines, ribs, hooks and pins fully covered and cannot be felt even with firm pressure.

Source: Nicholson and Butterworth (1986)

Annex 3. Recording sheet for abattoir survey
Animal type: cattle
Date--------------

ID No	Age	Sex	Breed	Body condition	Examined organs					Type of examined cysts			
										Fertile		Ster	Cal
					Liv	Lu	H	Kid	Spl	Vc	Non Vc		

Key: ID- animal Identification Number, Vc- Viable Cyst, Cal - Calcified Cyst, Liv- Liver, Lug- Lung, H- Heart, Kid- Kidney, Spl- Spleen, Non vi -None viable,
Ster- Sterile

Annex 4 . Important Pictures of the Study

1.Hydatid Cyst in the Lung

2. Location of the Slaughter House nearby the Raya University

3. Liquid wastes of the Abattoir

4. Dry wastes of the Abattoir

5. The track of the abattoir used to meat transport