MEKELLE UNIVERSITY

COLLEGE OF HEALTH SCIENCES, DIVISION OF
BIOMEDICAL SCIENCES, DEPARTMENT OF
MEDICAL PARASITOLOGY AND ENTMOLOGY

INVESTIGATING THE PREVALENCE AND RISK FACTORS OF CYSTIC ECHINOCOCCOSIS IN HUMANS AND SLAUGHTERED CATTLE IN PERI-URBAN DOG-OWNING SMALLHOLDER FARMS IN MEKELLE ZONE, TIGRAY REGION, NORTHERN ETHIOPIA.

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A RESERCH THESIS SUBMITTED TO THE DEPARTMENT OF MEDICAL PARASITOLOGY AND ENTOMOLOGY, DIVISION OF BIOMEDICAL SCIENCES, COLLEGE OF HEALTH SCIENCES, MEKELLE UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MEDICAL PARASITOLOGY

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Advisors' approval sheet

This is to certify that the research thesis entitled "**Investigating the prevalence and risk factors of cystic echinococcosis in humans and slaughtered cattle in peri-urban dog-owning smallholder farms in Mekelle zone, Tigray Region, Northern Ethiopia**" was conducted under our supervision. This research thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in "Medical Parasitology" and has been carried out by: Messele Gebremicael (BSc in Animal Health). The student has fulfilled the research thesis requirements and hence can be submitted to the department

External examiner

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Name of co-advisor	Rank	Signature	Date
Mr. Gessesew Bugusa	(PhD candidate, Assistant prof)	_________	____________

Assurance of Principal Investigator

I, the undersigned, agree to accept all responsibilities for the scientific and ethical conduct of the research project and for the provision of required progress reports as per the terms and conditions of the requirements of the department. I have provided timely progress report to my advisors and sought the necessary advice and approval from major advisor throughout the research.

Name of principal investigator: Messele Gebremicael (BSc in Animal Health).

Signature: ___________Date: ____________________

Declaration

I, Messele Gebremicael, do hereby declare that this thesis is my own original work, and that it has not been submitted previously, either in whole or in part, for the award of any degree or other academic qualification at this or any other university.

Signature: ___________________________

Date: _______________________________

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List of Abbreviations

AE	Alveolar Echinococcosis
CDC	Center of Disease Control
CE	Cystic Echinococcosis
CSA	Central Statistical Agency
CT-scan	Computed Tomography Scan
ELIETB	Enzyme Linked Immuno Electron Transfer Blot
ELISA	Enzyme-Linked Immunosorbent Assay
ETB	Ethiopian Birr
IH	Intermediate Host
M.A.S. L	Metres Above Sea Level
MRI	Magnetic Resonance Imaging
PCR	Polymerase Chain Reaction
PI	Principal Investigator
CSA	Central Statistic Authority
SPSS	Statistical Packages for the Social Sciences
RPM	Revolutions Per Minute
WHO	World Health Organization
WHO-IWGE	World Health Organization Informal Working Group for Echinococcosis

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Abstract

Background: Cystic Echinococcosis (CE), a zoonotic disease caused by the larval stage of *Echinococcus granulosus,* poses significant public health and economic challenges in Ethiopia. Despite its impact, data on its prevalence in humans, slaughtered cattle, and dogs particularly in the Tigray Regional State, remain limited.

Objective: Investigating the prevalence and risk factors of cystic echinococcosis in humans and slaughtered cattle in peri-urban dog- owning smallholder farms in Mekelle zone, Tigray Region, Northern Ethiopia.

Method: A cross-sectional study was carried out from March 2024 to March 2025 involving 832 human participants, 212 cattle, and 384 dogs. Human participants were selected using a stratified sampling technique, while the peri-urban smallholder farms owning dogs were purposively selected in the Mekelle Zone. Hydatidosis screening was performed using abdominal ultrasound, and laboratory analysis was conducted on specimens from slaughtered cattle and fecal samples from their dogs. Microscopic examination (40×) was used to detect hydatid cysts in cattle and taeniid eggs in dog feces. Data were analyzed using SPSS version 27, applying descriptive statistics and logistic regression to identify factors associated with CE at a significance level of $p < 0.05$.

Result: The overall prevalence of CE from six purposively selected sub-districts of Mekelle zone was found to be 0.24% (2/832) in humans, 22.64% (48/212) in cattle, and 17.45% (67/384) in dogs. The two human cases involved a 45-year-old male, and 50-year-old women. In cattle, distribution of cysts was primarily found (68.75%) in the lungs and (25.0%) in liver and (2.08%) each in the kidneys, heart, and spleen. Fertility and viability in cattle (68.8%) in lungs and (25.0%) in liver. CE prevalence was higher in male cattle (24.52%) than in females (16.0%), and poor body condition (40.0%) compared to those with medium (22.45%), and good (17.07%). Backyard-slaughtered cattle had a higher infection rate (34.69%) than those slaughtered in abattoirs (19.01%). Factors significantly associated with CE in cattle included age, sex, body condition, and slaughter location ($p < 0.05$). In the multivariate logistic regression analysis adult cattle (AOR = 2.57; 95% CI:1.501,4.400; P = 0. 001), cattle with poor body condition score (AOR = 4.07; 95% CI: 2.177,7.618; P = 0.000), and cattle slaughtered at backyard slabs (AOR = 2.26; 95% CI: 1.300,3.940; P = 0.004) were more likely to acquire hydatid cysts than the others. After adjusting for potential confounders, dogs with stray roaming behavior (AOR = 2.93; 95% CI: 1.11–7.71; $p = 0.029$) and feed raw offal (AOR = 2.86; 95% CI: 1.38–5.93; $p = 0.005$) had significantly higher odds of CE infection.

Conclusion: The present study showed that CE is a considerably prevalent disease in human, cattle and dogs in the study area. This emphasizes the need to avoid backyard slaughter practice, unsafe offal feeding of dogs, and proper waste disposal which requires public awareness on the use of abattoirs.

Keywords: Cystic Echinococcosis Prevalence, Hydatid Cyst, Echinococcus granulosus, Cattle, Dog, Human, Zoonosis, Mekelle, Tigray, Ethiopia.

1. Introduction

1.1. Background

Echinococcosis is a zoonotic disease that affects humans and is caused by the larval forms (metacestodes) of certain cestode species within the Echinococcus genus. (1). CE has a high veterinary and human public health impact on endemic communities. (2). CE is widespread across sub-Saharan Africa with foci in the eastern and southern parts of the region. Numerous recent studies addressed presence, frequency and host range of various *Echinococcus* species in eastern Africa, particularly in Sudan, Ethiopia and Kenya (3).

Echinococcus granulosus involves two mammalian hosts, the definitive (carnivores) and intermediate hosts (ungulates) to complete its life cycle (4). The adult cestode inhibits the small intestine of carnivores (definitive host) and produces eggs containing infective oncosphers. Cestodes segments, proglotids containing eggs (free eggs) released from the intestinal tract of final host in to the environment (5). Dogs acquire the parasite by ingesting raw offal of intermediate hosts containing infective echinococcal cysts, accessed mainly during domestic or non-regulated livestock slaughtering (6). The definitive hosts, in turn, acquire infection through eating cyst infected organs of the slaughtered animals (9). Human infections typically occur incidentally through ingesting the parasite eggs from infected definitive hosts (mainly dogs) or exposure to other sources. Humans are the dead-end (aberrant) hosts in this life cycle (7). In the intermediate host animals, the disease does not produce any clinical signs and is usually only discovered during meat inspection at the slaughterhouse where the viscera (mainly liver and lungs) are condemned (8).

The importance of hydatidosis can be evaluated from both the public health and economic point of view. Hydatidosis in livestock leads to considerable economic losses due to condemnation of edible offal, primarily liver, lung and other organs or even whole carcasses. In severe infection, the parasite may cause retarded performance and growth, reduced quality and yield of meat, milk or wool (9).

In Ethiopia, hydatidosis is a serious problem as the majority (about 85%) of the population is rural and mostly practice backyard slaughtering with improper disposal of affected organs with hydatid cysts. As a result, stray dog has a free access to infected organs of slaughtered animals. The absence of proper meat inspection procedures, presence of large population of stray dogs and lack of public awareness about the disease contribute significantly to the high prevalence of the disease in Ethiopia (10).

The magnitude of human echinococcosis is underestimated as most of the information is obtained from, retrospective studies which are fraught with limitations, under-reporting and limited knowledge on the disease (11). This together with poor surveillance system may impede the efforts of disease control as the exact burden of the disease is unknown. Control of any zoonotic infection is challenging and involves coordinated interaction between medical, veterinary, agricultural, and governmental bodies (12).

Therefore, the objective of this study was to investigate the prevalence and risk factors of cystic echinococcosis in humans and slaughtered cattle in peri-urban dog owning smallholder farms in Mekelle zone, Tigray, Northern Ethiopia.

1.2. Statement of the problem

Cystic echinococcosis (hydatidosis) remains a neglected zoonotic disease in Ethiopia, with its true burden incompletely quantified due to reliance on abattoir surveys, retrospective hospital records, and weak routine surveillance (13). Several retrospective studies have reported cases of human hydatidosis from various hospitals in Ethiopia (14,15,16,17,18). While numerous studies have documented the prevalence of bovine hydatidosis (19,20,21,22,23,24,25,26,27,28,29), only a few reports are available regarding infection in dogs (30,31).

Despite being a major public health and livestock production concern in Ethiopia, cystic echinococcosis has not been extensively investigated, and information on its prevalence remains inadequate, particularly in the Tigray region and Mekelle Zone**.** Therefore, this study was initiated to address these gaps and provide updated data on the prevalence of cystic echinococcosis in the current study.

Hence, taking the significant public health and veterinary impact into account, determining the prevalence and identifying the risk factors of both human and animal CE is essential for designing effective control strategies.

1.3. Significance of the study

Hydatidosis is a major public health and economic problem in Ethiopia, affecting humans, cattle, and dogs. Human cystic echinococcosis causes chronic disease, often requiring costly surgical or prolonged medical management. Many cases remain undiagnosed due to asymptomatic stages and poor diagnostic coverage. In Ethiopia, reported hospital cases underestimate the true burden, but available evidence confirms significant morbidity and mortality (32). Condemnation of infected organs and carcass weight loss result in millions of Ethiopian birrs lost annually, undermining food security and rural livelihoods (33). Dogs are the definitive host, shedding eggs into the environment. Surveys in Ethiopia show infection rates of 20–50% in owned and stray dogs, reflecting inadequate deworming, backyard slaughtering, and access to raw infected offal (34).

Therefore, investigating the prevalence and risk factors associated with cystic echinococcosis (CE) is critical for guiding public health policies and veterinary interventions. The outcomes of this study will provide vital insights for policymakers, veterinarians, and public health authorities for informed decision to design tailored intervention programs that address the unique epidemiological and socio-economic characteristics of Mekelle zone, Tigray, Northern Ethiopia

The prevalence of CE in peri-urban of Mekelle zone helps to identify risk factors by location, livestock types, and human populations vulnerable to infection. This knowledge is crucial for implementing control measures such as deworming campaigns for dogs, educating the public on hygiene practices, and improving livestock management. Furthermore, understanding the clinical burden of CE aids in the development of treatment protocols and strategies to reduce morbidity in humans and livestock.

1.4. Operational Definition

- **Cystic Echinococcosis (CE)** is a parasitic zoonotic disease caused by the larval stage of *Echinococcus granulosus*, characterized by the formation of fluid-filled cysts (hydatid cysts) primarily in the liver and lungs of intermediate hosts (e.g., humans, cattle, sheep). CE is diagnosed through clinical, imaging, serological, and molecular techniques and classified based on cyst stages and location.
- **Zoonosis:** Zoonosis, also called zoonotic disease refers to diseases that can be passed from animals, whether wild or domesticated to humans.
- **Cystic Echinococcosis in Cattle** is defined as an animal that, upon Post-Mortem and Antemortem Examination, harbors one or more hydatid cysts.
  - ✓ **Postmortem examination** refers to the examination of an animal after slaughter to confirm the presence of cystic echinococcosis (CE).
  - ✓ One or more hydatid cysts present in organs such as the liver, lungs, heart, spleen, or kidneys
  - ✓ Cysts confirmed as viable or non-viable through macroscopic and microscopic examination.
  - ✓ **Antemortem examination** refers to the pre-slaughter inspection of animals, especially livestock, to identify the presence of cystic echinococcosis (CE) before they are sent for slaughter
- **Fecal flotation** is a commonly used laboratory technique for detecting parasite eggs in the feces of animals, including dogs**.**
- **Ultrasound imaging** is a non-invasive, widely used method for diagnosing Cystic Echinococcosis (CE) in humans and animals, especially in endemic regions. It is particularly effective for detecting hydatid cysts in the liver, lungs**,** and other organs, where the cysts typically develop. Ultrasound provides real-time visualization of the cysts' size, shape, and location**,** which is essential for clinical management and determining the severity of the disease.
- **Attitude:** The way a community thinks and behaves toward Cystic echinococcosis.
- **Knowledge:** It is the awareness of the community about Cystic echinococcosis.
- **Practice:** The habitual community involvement to prevent Cystic echinococcosis.

1.5. Literature review

1.5.1. General characterized

Four species of the genus Echinococcus are recognized and regarded as taxonomically valid: E. granulosus (cystic hydatidosis), E. multilocularis (multivesicular hydatidosis), E. vogeli (polycystic hydatidosis) and E. oligarthrus (35). These four species are morphologically distinct in both the adult and the larval stages. In addition, several different strains of E. granulosus and E. multilocularis are recognized (36). The adult Echinococcus possesses an attachment organ, the scolex, which has four muscular suckers and two rows of hooks, only large and one small, on the rostellum (37).

The metacestode (=second larval stage) basically consists of a bladder with an outer acellular laminated layer and an inner nucleated germinal layer, which may give rise by asexual budding to brood capsules. Protoscoleces arise from the inner wall of the brood capsules. The structure and development of the metacestode differs between the four species of Echinococcus. Hydatid cysts grow slowly and usually take several years to develop to a size, where they may cause disease and symptom in animals (38). Echinococcus spp. requires two mammalian hosts for completion of its life cycle. Gravid proglottids or free eggs are passed along with the feces of the definitive host, a carnivore. The adult tapeworm is found in parts of small intestine of the definitive host, from where segments containing eggs are passed with the faeces. When the eggs are ingested by intermediate hosts like cattle, sheep, goats, pigs, and camel in which the metacestode develops, the onchospheres penetrates the wall of the small intestine (39).

The life cycle is completed when a dog ingests hydatid cysts containing protoscolices (35). The eggs enter into the intermediate hosts by the ingestion of contaminated grass, water, vegetables, and others. The definitive hosts are infected by the ingestion of offal's contaminated by fertile and viable hydatid cysts (40).

Hydatid cyst is typed according to their stage of development, namely primary and secondary cystic echinococcosis. The first occurs after the ingestion of eggs of E. granulosus and gives rise to the formation of hydatid cysts in different organs of the body, while the second occurs by the rupture of the primary CE due to trauma (41). The cyst of

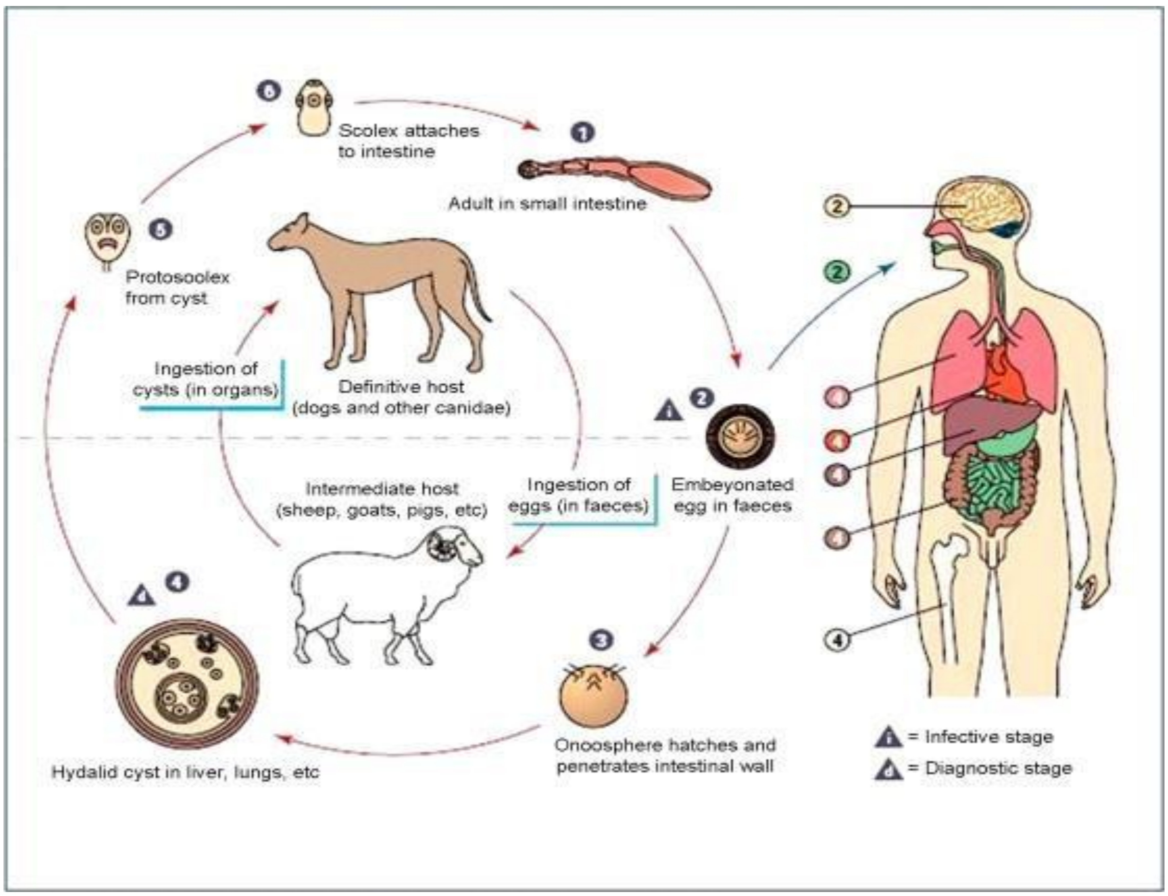
E. granulosus vary greatly in size and shape (typically unilocular, but sometimes multilobed or multilocularis), and may be present in large numbers in one or several organs. The location of cysts and cyst morphology is controlled not only by the host factors, but also by parasite factors such as the strain of E. granulosus involved (42). Disease with Echinococcus granulosus cyst in the intermediate hosts are typically asymptomatic, except for a small number of cases with chronic and heavy infection. The effect of hydatid cyst on the intermediate host depends on the size and location of the cyst (43). Rupture of cysts, particularly into serosal cavities, may cause acute and sometimes fatal anaphylactic reaction (44). The effect of hydrated cyst on the intermediate host depends on the size and location and location of the cyst (45).

Diagnosis of hydatid disease was improved due to the use of imaging techniques including ultrasonography, computed tomography (CT scanning) and magnetic resonance imaging (MRI) supported by immunological assays for confirmation of clinical diagnosis (46). In addition, there are also other recent trends of diagnosis which includes peroxidase micro-ELISA (Enzyme Linked Immuno Sorbant Assay), Avidin-borin-ELISA (Ab-ELISA) which is used in heparin binding lipoprotein (HBLP) for bovine fertile hydotid cyst. In man, the methods most commonly used are serologic tests such as complement fixation or immunoelectrophoresis; scanning techniques and cason's test are also used (47). Several ultrasound classifications of liver hydatid cysts based on the morphologic characteristics of the cyst have been proposed in the past. The ultrasound classification described by Gharbi et aI. seems to be most widely accepted. Based on cyst characteristics described in the Gharbi classification, the World Health Organization (WHO-IWGE) Informal Working Group on Echinococcosis proposed a new classification reflecting the functional state of the parasite that facilitates selection. of treatment modalities (48).

Dogs and cats can be treated with praziquantel or epsiprantel, but treatment of domestic intermediate hosts is not advised (49). In man, surgical removal offers the best mode of treatment where the cysts are accessible, but recurrence after surgery is common (50). Mebendazole, Albendazole, and Prazionlantel therapies have been reported to be effective. Surgery is indicated if it is feasible, which depends on the size, location, and manifestations of the lesion. Albendazole in the above dose can suppress the growth of inoperable lesions.

Liver transplantation has been life-saving in a few patients (49). Effective CE control programs are multi-pronged: regular praziquantel deworming of dogs (often at 4–6-week intervals in high-transmission settings), improved slaughterhouse inspection and safe offal disposal, community education on hygiene and dog-feeding practices, dog population management, and, where feasible, livestock vaccination (e.g., EG95 for sheep). Successful programs require sustained, coordinated One-Health action linking human health, veterinary services, and agricultural/policy stakeholders (51).

Figure 1: Life cycle of Echinococcus granulosus.



Source:(Reproduced from the centers for disease control and prevention at http://www.dpd.cdc.gov./dpdx/html/Echinoccosis.htm.

Table 1: WHO-IWGE Classification of Hydatid Cysts.

Cyst Stage	Ultrasound appearance	Stage description	Viability	Remarks
CL	Unilocular, anechoic lesion without visible wall	Cystic lesion	Uncertain	Early stage; differential diagnosis needed
CE1	Anechoic cyst with visible double line (cyst wall)	Active, unilocular	Viable	Early active stage
CE2	Multivesicular, multiseptated cyst	Active, daughter cysts visible	Viable	Progressive stage
CE3a	Detached endocyst (water-lily sign)	Transitional	Viability uncertain	Beginning degeneration
CE3b	Solid matrix with daughter cysts	Transitional	Viability uncertain	Cyst degeneration with mixed content
CE4	Heterogeneous or hypoechoic content, no daughter cysts	Inactive	Probably non-viable	Degenerating cyst
CE5	Thick calcified wall, arch-shaped shadows	Inactive	Non- viable	Dead cyst; chronic stage

Source: WHO Informal Working Group on Echinococcosis (WHO-IWGE), 2001. Ultrasound examination and classification of hydatid cysts. Bulletin of the World Health Organization, 79(6): 607–613.

1.5.2. Behavioral factors of hydatidosis

Hydatidosis transmission is strongly influenced by human and animal behaviors that sustain the parasite life cycle. These include:

Backyard slaughtering and offal disposal: In rural Ethiopia and other endemic regions, backyard slaughtering of livestock without veterinary supervision is common. Infected organs (liver, lungs) are often disposed of improperly or intentionally fed to dogs, facilitating infection (52).

Dog ownership and feeding practices: Keeping large numbers of dogs for guarding or herding, combined with the habit of feeding them uncooked viscera, increases the likelihood of *Echinococcus* transmission. Free-roaming and stray dogs commonly access slaughter waste (53).

Low deworming practices: Most households rarely deworm their dogs due to lack of awareness, cost, or availability of praziquantel. This allows continued shedding of *E. granulosus* eggs into the environment (54).

Poor hygiene and close contact with dogs: Human infection is facilitated by poor hand hygiene, particularly among children who play with dogs and then ingest infective eggs. Cultural acceptance of close contact with dogs (sleeping in the same compound, feeding by hand) increases exposure risk (55).

1.5.3. Prevalence of Hydatidosis

Human cystic echinococcosis (CE) is under-reported in Ethiopia due to limited diagnostic facilities and weak surveillance. Community based ultrasound surveys are rare, but hospital records and retrospective analyses show that CE is an important cause of surgical morbidity, particularly involving the liver and lungs. A systematic review confirmed that human CE is endemic across multiple regions of Ethiopia (52). In human the prevalence of CE detected in western China (1.5%), Morocco (1.9%) and the Cusco Region of the Peruvian Highlands (3.0%) (57).

Retrospective studies have reported from various hospitals of human hydatidosis in Ethiopia (14,15,16,17,18). The reported prevalence in slaughtered animals from India, Italy, Ethiopia, China, and Iran (56). Numerous abattoir based surveys in Ethiopia report high prevalence of hydatidosis in cattle (19,20,21,22,23,24,25,26,27,28,29). confirm that cattle and small ruminants carry a significant burden of hydatid cysts, which leads to considerable economic losses due to organ condemnation and reduced carcass value. Only a few reports are available regarding dogs in Ethiopia (30,31).

1.5.4. Risk Factors for hydatidosis

Hydatidosis is a zoonotic disease transmitted between dogs (definitive hosts) and livestock (intermediate hosts). Its prevalence is influenced by behavioral, environmental, and demographic factors that facilitate parasite transmission:

1. **Behavioral Factors:**

- **Backyard/home slaughtering**: Slaughtering animals at home without veterinary inspection increases exposure to infected offal.
- **Feeding raw offal to dogs**: Dogs consuming infected organs sustain the parasite life cycle.
- **Dog ownership and management**: Households with multiple dogs or free-roaming dogs show higher prevalence of canine infection.
- **Poor hand hygiene and close contact with dogs**: Increases human exposure to *Echinococcus* eggs.
- **Low knowledge, attitude, and practices (KAP)**: Many rural communities are unaware of the zoonotic risk, safe slaughtering, and proper disposal of offal (52).

2. **Environmental Factors**

- **Stray and free-roaming dog populations**: Provide continuous contamination of pastures and household environments with infective eggs.
- **Communal grazing**: Mixed grazing of infected and uninfected livestock facilitates environmental contamination.
- **Poor sanitation**: Contaminated water and soil increase the risk of human infection (53).

3. **Host-related Factors**

- **Age of livestock**: Older animals are more likely to harbor hydatid cysts due to cumulative exposure.
- **Species**: Cattle, sheep, and goats vary in susceptibility; sheep are often the most important intermediate host for *E. granulosus*.
- **Occupational exposure**: Farmers, butchers, and herders are at higher risk of human infection.

- **Gender and residence**: Some studies suggest rural males have higher exposure due to participation in livestock management and slaughtering activities (54,55).

1.5.5. Distribution of CE

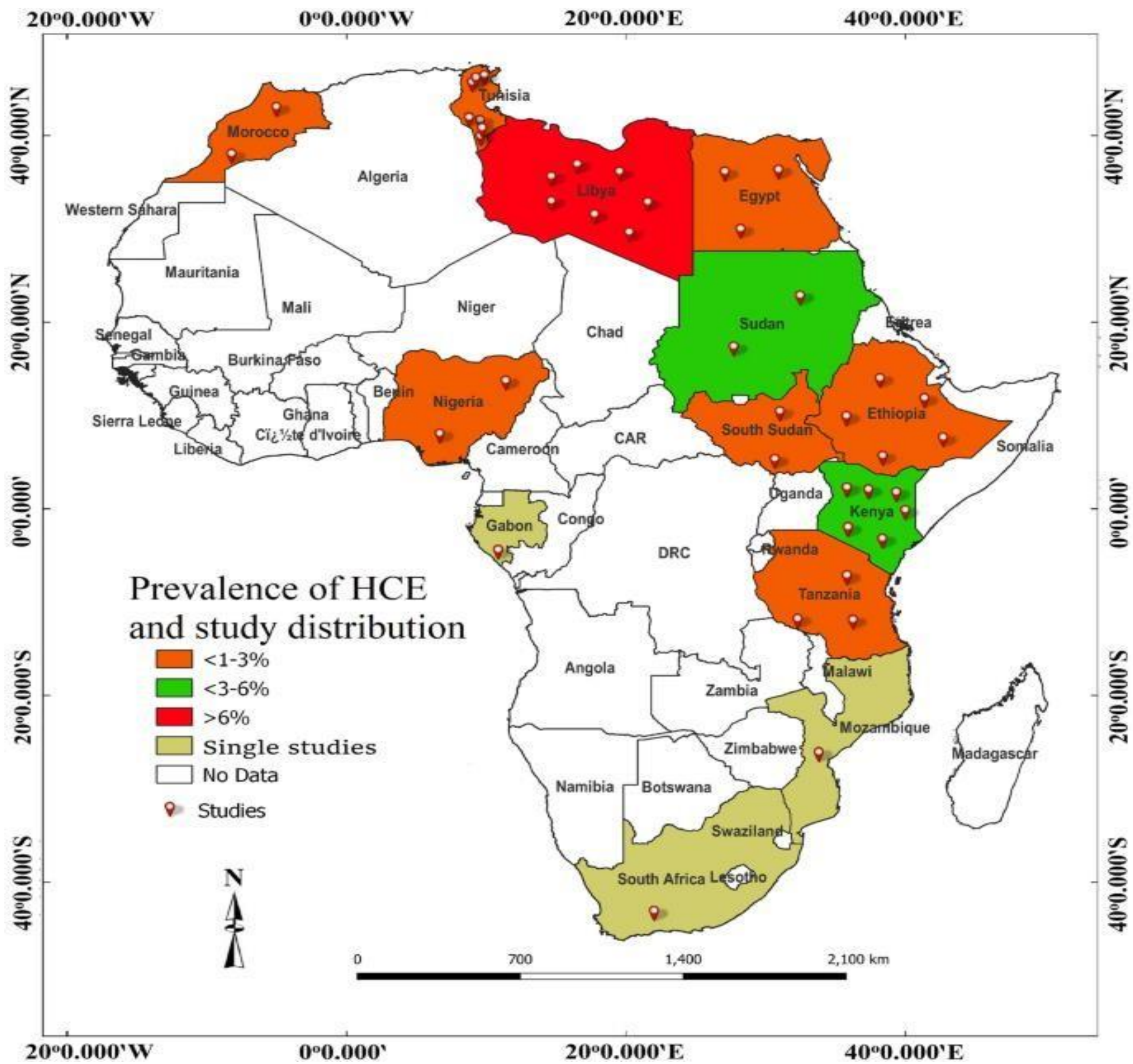
Cystic Echinococcosis has an extensive distribution with a broad range of hosts worldwide, it is highly endemic in the continents of Southern America, Africa, Asia and Australia. The infection represents a serious human and animal health concern in many rural, grazing areas of North, East and sub-Saharan Africa (58). *E. granulosus* has a worldwide geographical distribution; high prevalence has been reported from parts of Mediterranean region, Russian federation and adjacent independent states, the people republic of China, Africa (northern and eastern region), Australia and South America. High incidence rates or prevalence have also been recorded from countries, in northern and eastern Africa (prevalence up to >3%) and South America (Uruguay annual incidence of 6.5% per 100,000 population in 1997). A few islands are now free of E. granulosis (Iceland, Green land) or provisionally free of (New Zealand, Southern Cyprus) (59).

Table 2: Geographical distribution of Echinococus species.

Echinococcus Species	Geographical Distribution
Echinococosis granulosus	Mediterranean Cost, Middle East, South American, South Russia, North Africa and Australia
Echinococosis oligarthrus	Central and South America
Echinococosis multilocularis	North America, Middle East, India and Japan
Echinococosis vogeli	Central and South America

Source: The geographical distribution and prevalence of Echinococcus multilocularis in animals in the European Union and adjacent countries: a systematic review and meta-analysis (60).

Figure 2: Country-based prevalence and distribution on human cystic echinococcosis (HCE) in Africa.



Source: Africa-wide meta-analysis on the prevalence and distribution of human cystic echinococcosis and canine Echinococcus granulosus infections (61).

1.5.6. Economic Importance of CE

Cystic echinococcosis (CE) caused by larval stages of Echinococcus granulosus is one of the most common zoonotic diseases associated with severe economic losses and great public health significance worldwide (62). Echinococcus is seen as a human health hazard and is recognized to cause serious financial losses to the cattle industry around the world. The economic losses due to bovine Hydatidosis are mainly due to condemnation and down grading of infected carcasses. Financial losses from Hydatidosis are determined by disease prevalence, grade of animals infested, potential markets, prices of cattle and treatment costs for detained carcasses (63).

In Ethiopia studies conducted in different abattoirs indicated that cystic hydatidosis is prevalent and considerable economic loss is associated with it. Different financial losses were reported from different part of the country. The difference in the amount of financial loss in different regions or localities could be due to the variation in the prevalence of the disease, retail market price of organs and mean annual slaughter rate in different abattoirs (64).

Annual financial losses in the abattoirs due to carcass/ organ condemnation, ranges from minimum of 96,315 birr at Harar abattoir to maximum that cystic hydatidosis is prevalent and considerable economic loss is associated with it. Different financial losses were reported from different part of the country. The difference in the amount of financial loss in different regions or localities could be due to the variation in the prevalence of the disease, retail market price of organs and mean annual slaughter rate in different abattoirs (64). This is summation of the carcass weight loss and loss due to organ condemnation. But these losses and infection prevalence do not show the real estimates because these estimates are made by meat inspection in abattoirs only and many animals slaughtered at backyard are not been included (65).

Cystic echinococcosis in livestock causes considerable economic losses due to condemnation of affected animal organs at the slaughterhouse, production losses (reduction in live weight gain, yield of milk, fertility rates, value of hide and skin) and losses related to treatment of animals and humans (62).

The economic burden of CE on the global livestock industry alone has been estimated to be over $2 billion per annum, such losses are of particular importance in Ethiopia, which has low economic output with a per capita income of less than one US dollar per day.

Recent study recorded a loss of 287,179.99 ETB from organ condemnation and carcass weight loss in sheep and goats in Hashim Nur's export Abattoir in Debre Zeit (62).

1.5.7. Immune Response Against CE

Cystic echinococcosis (CE) is a zoonotic parasitic disease involving a complex interaction between the definitive host (dog), intermediate hosts (such as cattle), and humans as accidental hosts. The immune response to *Echinococcus granulosus* varies considerably among these species due to differences in parasite development, host physiology, and immune system engagement (66).

In humans**,** the immune response is more complex and is influenced by the stage and fertility of the cyst, as well as individual host factors. A dominant Th1-type immune response, characterized by cytokines such as interferon-gamma (IFN-γ) and interleukin-2 (IL-2), is generally associated with protective immunity and cyst inactivity. Conversely, active and growing cysts are often linked to a Th2-dominant profile, including elevated levels of IL-4, IL-5, and IL-10. In addition, regulatory T cells (Tregs) and cytokines like transforming growth factor-beta (TGF-β) contribute to immune tolerance, allowing the parasite to persist within host tissues for extended periods without triggering significant inflammation. Although antibody responses especially IgG subclasses are widely used in serodiagnosis, their sensitivity and specificity can vary depending on cyst location, viability, and the host's immune status [67,68].

In cattle**,** which serve as dead-end intermediate hosts, the immune response is both humoral and cellular. After ingestion of parasite eggs, the oncospheres penetrate the intestinal lining and migrate to visceral organs, predominantly the liver and lungs. Local immune responses around the cysts are typically more pronounced in sterile or calcified cysts, and involve macrophages, eosinophils, and lymphocytes. In contrast, fertile cysts often display minimal inflammatory response due to the parasite's immune evasion strategies. These include the formation of a laminated layer that physically separates the germinal layer from host tissues and the secretion of immunomodulatory molecules such as AgB. These factors contribute to dendritic cell suppression and promote a Th2-skewed cytokine profile [69,70].

In dogs**,** the definitive host, infection is typically asymptomatic. This is largely due to the parasite's ability to evade gut-associated immune mechanisms. Within the canine host, *E. granulosus* matures in the small intestine. Although antigenic components such as Eg95 and antigen B (AgB) can stimulate mucosal immune responses, these responses are often insufficient for long-term protection. As a result, dogs usually develop only weak immunity, allowing for persistent or repeated infections [71,72].

2. **Research questions**

1. What is the current prevalence of CE in humans, slaughtered cattle, and dogs in peri-urban Mekelle Zone?
2. What are the major risk factors associated with CE in cattle, dogs and humans in the selected sub-districts of Mekelle Zone?
3. What is the level of awareness among smallholder farmers and dog owners regarding CE prevention in the selected sub-districts of Mekelle Zone?

3. Objectives

3.1. General Objective

Investigating the prevalence and risk factors of cystic echinococcosis in humans and slaughtered cattle in peri-urban dog- owning smallholder farms in Mekelle zone, Tigray Region, Northern Ethiopia.

3.2. Specific objective

- To determine the prevalence of CE in humans, cattle, and dogs in the selected sub-districts of Mekelle zone
- To identify the major risk factors associated with CE in cattle, dogs and humans in the selected sub-districts of Mekelle Zone.
- To assess the level of awareness among small holder farmers and dog owners regarding CE prevention in the selected sub- districts of Mekelle zone.

4. Methods and Materials

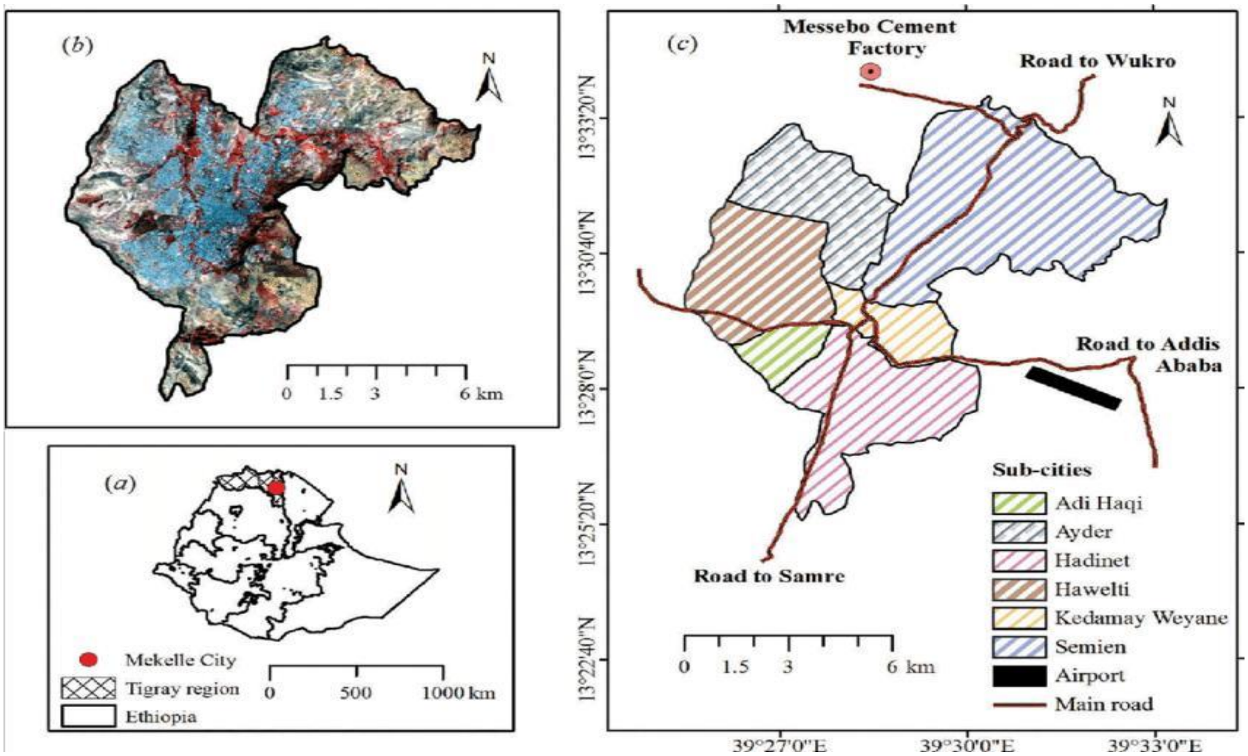
4.1. Study area

The study was conducted from March, 2024 to March, 2025 in sub-districts of Mekelle zone. Mekelle is a special zone and capital of the Tigray region, in Northern Ethiopia. It is located around 783 Km north of the Ethiopian capital, Addis Ababa. Geographically; it is located at 13°24’30” latitude and 39°25’30” longitude. It lies in an altitude range of 2000-2200 meters above sea level. The average annual minimum and maximum temperatures are 11.8°C and 29.9°C, respectively. The annual rainfall is 579mm-650 mm. Based on the livestock population (2009, MAZO (Mekelle zonal Agricultural Office)) (73), the projected estimated livestock population in the area in 2025 includes a total of includes a total of 53,387 cattle, 13,313 shoats, 1,003 horses, 251 mules, 3,866 donkeys, 126 camels, 91,570 poultry and 4,043 dogs. This represents a growth of 2.4% cattle, 1.5% shoat, horses, mules, and donkeys, 1.5% camels,3.5% poultry, and 2.0% dogs as shown in data from Estimated Annual Growth Rates for Ethiopia (FAO & CSA-based approximations).

Mekelle city exhibits a significant pace of urban expansion, making it one of Ethiopia’s fastest growing cities (UN-Habitat, 2020) (74). Based on the population, housing, and census data of 2008 (CSA, 2008), the projected population of Mekelle city in 2025 is around 637,226 people. This represents a growth of 4.19% compared to previous years, as shown in data from Population Stat and World Population Review. Administratively, Mekelle is considered a Special Zone, which is divided into seven sub-cities; Adi Haqi, Ayder, Hadnet, Hawelti, Kedamay Weyane, Quiha, and Semein. Mekelle is surrounded by the Southeastern zone of the Tigray regional state, inside the boundaries of Enderta district, where the city grows. Eight of the 17 sub districts that make up the Enderta district are connected to the four Mekelle sub-cities of Hadnet, Adi-Haqi, Ayder, and Quiha (75).

The study was carried out in peri-urban areas of Mekelle city. Peri-urban areas of the six sub-districts of the city were chosen for the study – Adi Haqi, Hadnet, Ayder, Hawelti, Quiha, and Semein according Tigray Regional Bureau of Agriculture (Figure 3).

Figure 3: Map of the study areas of Mekelle zone.



Source: (Location map of the study area (a) – country map including Mekelle City and Tigray region, (b) – false colour composite Landsat image of 2014, and (c) – sub-cities of Mekelle City) (75).

4.2. Study design and period

A cross-sectional study was conducted from March ,2024 to March ,2025 with the aim to determine the prevalence of cystic echinococcosis (CE) in humans, dogs and cattle in peri-urban areas of Mekelle city.

4.3. Study population

The study population consisted of dog-owning small holder farmers, dogs and cattle originating from the peri-urban areas of six sub districts of Mekelle city and slaughtered at Abergelle international export slaughterhouse and slaughter slabs or backyard slabs.

Human participants: From the same geographical area individuals were selected for ultrasound examination based on their proximity to and interaction with dogs, particularly dog owners, shepherds, and individuals involved in livestock rearing.

The target population for this interview survey comprised selected farming households that owned both cattle and dogs. These households were specifically selected because the presence of both species increases the probability of parasite transmission (hydatidosis), given that cattle act as intermediate hosts and dogs as definitive hosts.

Study animals (cattle and dogs):

Cattle: The cattle included in the study were both male and female, local and cross breeds slaughtered at the Abergelle abattoir and backyard slabs.

Dogs: The study was conducted on local and exotic dogs of various ages, sexes, and residing in the selected study area. Both owned (restricted), and stray dogs were included to assess the overall prevalence of Taeniid *eggs.*

4.4. Sample size determination and sampling technique

The sample size for human and animal studies (cattle and dogs) was determined using 50% expected prevalence,5% desired absolute precision, and 95% confidence interval based on the formula indicated by Thrusfield (Thrusfield, 2018) (74).

$$n= \frac{Z^2.p. (1 - P)}{d^2}$$

Where: n = required sample size,

Z = Z-score for 95% confidence level (1.96),

p = expected prevalence (assumed 50% or 0.5 to get the maximum sample size), and

d= margin of error (5% or 0.05).

$$n= \frac{(1.96)^2.0.5. (1 - 0.5)}{(0.05)^2} = \frac{3.8416*0.25}{0.0025} =384.16 \approx 384$$

According to the formula described by Thrusfield (2005), the sample size was calculated using an expected prevalence of 16.54%, a 95% confidence level, and an absolute precision of 5%.

$$n = \frac{(1.96)^2 \cdot (0.1654)(1-0.1654)}{(0.05)^2} = 212$$

Based on this calculation, the required sample sizes were 212 cattle (for post-mortem examination of CE-infected organs) and 384 dogs (for fecal examination). For the human study component, the calculated sample size was 832 individuals, which was proportionally allocated among households owning smallholder farms. Furthermore, sample sizes for each sub-district were proportionally distributed according to the number of households. Independent samples were then drawn from each household using a stratified sampling approach, and the proportional allocation formula was applied as described by Rajiv and Med (2008) (76).

$$n_i = \frac{N_i}{N} \times n \qquad i = 1, 2, 3 \ldots k$$

Where, k is the number of strata

n_i is sample size of the i^{th} stratum

N_i is number of households of the i^{th} stratum

$n=n_1+n_2+\ldots+n_k$ is the total sample size (832)

$N= N_1+N_2+\ldots+N_k$ is the total number of households

The sample size from each household was determined using proportional allocation. Let n1,n2,n3,n4,n5,n6 represent the sample sizes drawn from the respective strata (sub-districts) of households in the Mekelle Zone. The number of samples taken from each stratum was proportional to the size of the stratum relative to the total number of households in the sub-district. The total sample size for the human component of this study was 832 individuals (n), while the population size of each stratum was denoted as Ni. Accordingly, the sample size for each stratum (ni) was calculated as:

Based on this data proportion sample size for each sub- district was calculated as:

n_1 (Hawelti) = 832×81/334=202

n_2 (Hadnet) =832×85/334=212

n_3 (Ayder) =832×63/334=157

n_4 (Quiha) = 832×47/334=117

n_5 (Adi-Haqi) =832×31/334=77

n_6 (Semien) =832×27/334=67

A total of 832 human participants were selected for the study and subjected to abdominal ultrasound examination and a questionnaire survey. The study areas and participants were chosen using a proportionate stratified probability sampling technique from six sub-districts of the Mekelle Zone. In addition, 384 dogs were purposively selected from smallholder farming households within the study areas. Furthermore, 212 cattle originating from the six sub-districts and slaughtered either at the Abergelle export abattoir or at backyard slaughter slabs were also included in the study.

4.5. Eligible criteria

4.5.1. Inclusion criteria

Human participants: Inclusion criteria included voluntary consent, residency in the area for at least six months, and willingness to be interviewed and provide abdominal ultrasound scanning for parasitological examination. Besides, people who have had direct or indirect exposure to livestock (e.g., farmers, shepherds, butchers, animal traders, & veterinary workers) and those who consume raw or undercooked offal from slaughtered animals.

For cattle: All local and exotic breeds of cattle (young and old) that originated from peri-urban Mekelle zone regions for slaughter purposes (cattle) in Abergelle international export slaughterhouse and slaughter slabs.

For dogs: All local and exotic breeds of dogs cohabiting with livestock-keeping communities and free-roaming ones in the study areas and who may have access to raw offal.

4.5.2. Exclusion criteria

For human:

- ✓ **Health Conditions**: Individuals with other chronic parasitic or infectious diseases (e.g., malaria or tuberculosis, liver abscess, tumors) or those with a history of severe liver or kidney conditions.
- ✓ **Other Studies**: Participants already enrolled in another clinical trial or epidemiological study that may interfere with the study's outcomes.
- ✓ **Geographical Location**: Individuals who do not dwell in the study area (peri-urban areas of Mekelle Zone).
- ✓ **Refusal to Participate**: Those who refuse to give informed consent.

For cattle and dogs: Animals originated out of the selected peri-urban Mekelle zone.

4.6. Study variables

4.6.1. Dependent variables

- Cystic Echinococcosis (Hydatidosis)

4.6.2. Independent variables

For human: Age, sex, occupation, educational level, contact with cattle, dog ownership, hygiene practices, handling of livestock and dog feces, and habit of feeding dogs' raw offal.

For cattle: Age, Sex, body Condition Score (BSC), and types of slaughter (Abattoirs & Backyard slabs) and proximity to dogs.

For dogs: Age, sex, breed, husbandry system (restricted & stray dogs), feeding raw offal, and deworming history.

4.7. Data collection tools

4.7.1. Questionnaire:

The Human Survey: A total of 832 human participants were involved in the study to determine the prevalence of CE and identify the associated risk factors. The participants involved in the study were farming household owning cattle and dogs and those who had close contact with livestock (butchers, livestock traders, etc.). A semi-structured questionnaire was used to collect data on socio-demographic characteristics, knowledge and attitude of the participants on the disease. The socio-demographic information included hydatidosis is strongly linked with human behaviors and cultural practices were

behavioral factors: Dog ownership and the habit of feeding dogs' raw offal are common risk factors, close interaction with dogs, backyard slaughtering, improper disposal of infected viscera, Poor personal hygiene, particularly lack of regular hand washing and consumption of unwashed vegetables or fruits.

Cultural (religious)factors: home slaughtering during festivals, and nomadic or pastoral lifestyles, low levels of awareness and inadequate knowledge about the transmission of hydatidosis of the farmers owning dogs and cattle.

4.7.2. Specimen collection, transporting, and processing:

4.7.2.1. Human subjects ultra-sound examination:

Abdominal ultrasound screening sessions were performed from March, 2024 to March, 2025 on 832 voluntary people belonging to the six peri-urban areas selected for the study: including Adi Haqi, Hadnet, Ayder, Hawelti, Quiha, and Semein by using a portable ultrasound at field level. Abdominal ultrasound screening was conducted in the field using portable ultrasound to detect CE cysts. The liver, pancreas, spleen, and kidneys were carefully examined and recorded. CE was differentiated from other cystic lesions if one or more of the characteristic diagnostic criteria of CE were present, namely, a laminated membrane and/or daughter cysts. All CE cysts were classified according to their size, morphology, and echotomographic appearance. Ultrasound gel was used to create uniform optical medium between the surface of the participants' abdomen and the probe. The images were carefully observed and categorized as CE1-CE5 based on the WHO CE classification. Patients' ultrasound images were interpreted in accordance with the WHO-IWGE classification. Based on this classification, liver cysts were categorized as cystic echinococcosis in stages 1-5 (CE1-CE5). CE stages 1 and 2 are considered as active disease stages, CE3 is transitional (Transitional Cysts (Partially Degenerating) CE3a (Cyst with Detached Membrane/Floating Water Lily Sign), CE3b (Predominantly Solid Cyst with Few Daughter Cysts), and CE4 Inactive (Degenerating or Calcified) Cysts), and CE5(Calcified Cyst, Completely Inactive) as inactive stages in the WHO-IWGE guidelines (77).

4.7.2.2. Survey of dogs:

Both restricted and stray dogs originating from the six peri-urban areas were included in the study. Fecal samples (~10 g) were collected directly from the rectum of restrained dogs or from freshly passed feces on the ground using clean gloves to minimize contamination (78). Inclusion criteria were based on the availability of fresh fecal samples and the apparent health status of the dogs, regardless of deworming history. Samples were placed in labelled plastic containers containing 70% ethanol. During sampling sex, age, origin, and husbandry system were recorded then samples were brought to Mekelle University, College of Veterinary Science parasitological diagnostic laboratory for examination. The fecal samples were examined after applying a coverslip under 10x and 40x magnification for round, thick-walled Taeniid eggs (30–40 µm in diameter) with a characteristic oncosphere (79). The taeniid eggs were recovered using the floatation technique described by Huttner et al. (2009) (80). A positive sample was considered if it had a typical taeniid egg that was ovoid, brown striated appearance with characteristic hooklets (WHO/OIE2001) (81). Taeniid eggs were detected using centrifugal flotation with zinc sulfate ($ZnSO_4$) solution. The mixture was centrifuged at 2500 rpm for 4 minutes, and the supernatant was examined microscopically (78).

4.7.2.3. Slaughter house survey:

A slaughterhouse survey was conducted to assess the health status of cattle and detect the presence of hydatid cysts in their organs. Systematic ante-mortem and post-mortem examinations were performed to estimate the prevalence of cystic echinococcosis (CE). Regular visits were made three days per week (Mondays, Thursdays, and Fridays) to the Abergelle export slaughterhouse and selected backyard slaughter slabs during the early morning hours (6:00–9:00 a.m.), which correspond to the peak slaughtering period (82).

4.7.2.3.1. Antemortem examination:

Anti-mortem inspection on individual animals included animal origin, body condition and age determination. During the antemortem examination the age, sex, origin, and body condition score (BCS) of the animals was recorded. Body condition scoring was done according to Nicholson and Butteworth, (1986), and classified into three categories: poor, medium, and good (83). The animal's age was categorized into adult (below or equal to 5 years) and old (above 5 years) based on dental eruption (82).

4.7.2.3.2. Postmortem examination:

Postmortem examination comprised visual inspection, palpation and incision of the lungs, liver, heart, spleen and kidneys of each animal for the presence and distribution of hydatid cysts. When present, cysts were carefully removed from each infected organ of all affected animals and collected in clean containers, labelled and transported in cold boxes to the Mekelle University College of Veterinary Science parasitology diagnostic laboratory for examination. The total number of hydatid cysts were counted and recorded (84). The diameter of collected hydatid cysts was measured using ruler and classified as small cyst (if the diameter of the cyst is less than 4 cm), medium cyst (diameter between 4-8cm) and large cyst (diameter greater than 8 cm in diameter) (85).

4.7.2.3.3. Laboratory examination of cyst:

The fertility of each cyst was determined after reduction of the pressure of the cyst fluid using a sterile hypodermic needle. Then the cyst was incised with a sterile scalpel blade, and the content poured into a glass petridish and examined. The presence of protoscolices, which look like white dots on the germinal epithelium, attached to the germinal layer in the form of a brood capsule or in the cyst fluid was considered suggestive of fertility. Sterile hydatid cysts were characterized by their smooth inner lining, usually with a slight turbidity of the contained fluid whereas cysts identified as calcified produce a gritty sound feeling up on incision (86). Fertile cysts were subjected to viability test. A drop of the sediment containing the protoscolices were placed on the microscopic slides and covered with cover slips and observed for amoeboid like peristaltic movements with 40x objective (87).

For clear vision a drop of 0.1% aqueous eosin solution was added to equal volume of sediment containing protoscolices in hydatid fluid on microscopic slide with the principle that viable protoscolices should completely or partially exclude the dye while the dead ones take it up. The technique differentiates between dead (red stained) and alive (unstained) protoscolises (84).

4.8. Data management and quality control

Before data processing, all completed questionnaires were manually checked to ensure completeness, accuracy, and consistency. This step was essential to verify that all relevant information was properly collected and recorded. Any missing or unclear responses were reviewed and corrected where possible. All collected data, including questionnaire responses and laboratory results, were entered into a Microsoft Excel spreadsheet for storage and initial processing. Double data entry was performed to minimize errors during data transcription.

4.9. Data analysis and management

The data obtained from ante-mortem (origin, sex, age, breed, and body condition) and post-mortem findings were coded and entered into a Microsoft Excel spreadsheet for proper organization and storage. The cleaned dataset was then exported to SPSS Version 27 for statistical analysis. Variables that were statistically significant ($p < 0.05$) in the bivariate analysis were entered into a multivariate logistic regression model to identify independent predictors. To determine the association between different variables and the prevalence of cystic echinococcosis (CE) in cattle, and dogs the following statistical methods were applied:

- **Chi-square (χ^2) test**: Used to assess categorical associations between independent variables (sex, age, breed, origin) and CE prevalence.
- **Bivariate logistic regression**: Conducted to identify whether individual risk factors were significantly associated with CE.
- **Multiple logistic regression analysis**: Performed to adjust for potential confounders and determine independent predictors of CE infection. A p-value <0.05 at a 95% confidence interval (CI) was considered statistically significant, indicating a meaningful association between the examined variables and CE prevalence.

4.10. Ethical considerations

Before commencing data collection, ethical approval was obtained from the Institutional Review Board (IRB) of the College of Health Sciences, Mekelle University. Additionally, permission was secured from the Abergele export abattoir slaughterhouse management to collect hydatid cysts from slaughtered cattle and fecal sample were collected from dog owner's household of selected area. The ultrasound examination was conducted by trained radiologists using a portable ultrasound machine equipped with a convex transducer (3–5 MHz frequency) for abdominal imaging. No-invasive samples were collected from humans. The liver, lungs, and other organs were systematically scanned for the presence of cystic structures suggestive of hydatid disease, based on (WHO-IWGE) classification**.** Participants were informed about the purpose of the ultrasound examination, and verbal consent was obtained before screening. Verbal informed consent was obtained from farmers before conducting interviews, collecting hydatid cysts from their cattle, and obtaining fecal specimens from dogs. The purpose and significance of the study were clearly explained to the farmers to ensure their voluntary participation.

Furthermore, it was assured that the findings of the study would be communicated to the farmers through community service initiatives, helping them understand the impact of cystic echinococcosis and promoting preventive measures.

5. Results

5.1. Socio-demographic characteristics of human participants

A total of 832 individuals participated in the study, with males comprising the majority (82.0%) and females representing (18.0%). The largest proportion of participants were aged 26–45 years (59.4%), followed by 16–25 years (14.6%).

Nearly half of the participants had attained secondary education (47.7%), while 28.6% had primary education, 12.2% were illiterate. Regarding occupations were predominantly farmers (31.0%) and pastoralists (26.3%), reflecting high levels of contact with livestock.

Participants were drawn from several sub-districts, with the largest numbers from Hadnet (55.1%) and Hawelti (52.7%), followed by Ayder (40.8%), Quiha (30.5%), Adi-Haqi (20.0%), and Semien (17.5%) (Table 3).

Table 3: Socio-demographic characteristics of the human subjects selected from the sub- districts of Mekelle zone, Tigray, Northern Ethiopia, 2025(N=832).

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	683	82.0
	Female	149	18.0
Age group	6-15 years	26	3.1
	16-25 years	121	14.6
	26-45 years	494	59.4
	46-60 years	119	14.3
	Greater than 60 years	72	8.6
Educational status	Illiterate	102	12.2
	Primary (Grades 1-8)	238	28.6
	Secondary (Grades 9-12)	397	47.7
	Diploma and above	95	11.5
Occupation	Farmer	258	31.0
	Trader	100	12.0
	Pastoralist	219	26.3
	Housewife	110	13.3
	Abattoir Workers/Butcher	54	6.5
	Laborer	91	10.9
Residence(sub-districts)	Quiha	117	30.48
	Adi-Haqi	77	20.04
	Semien	67	17.48
	Hadnet	212	55.12
	Hawelti	202	52.66
	Ayder	157	40.82

5.2. Questionnaire Survey on Knowledge, Attitude, and Practice Regarding Cystic Echinococcosis (Hydatidosis)

Out of the total 832 participants, the assessment of knowledge revealed that awareness of cystic echinococcosis (CE) among participants was generally low. Only 21.0% were aware that CE affects both humans and animals, 23.0% knew how CE is transmitted. Regarding attitudes, 33.1% of participants recognized dogs as a source of infection, while 44.7% home slaughtering and offal disposal. Practices regarding CE, 56.9% of participants feeding dogs raw offal, 52.0% did not wash vegetables and fruits before consumption (Table 4).

Table 4: Questionnaire Survey on Knowledge, Attitude, and Practice Regarding Cystic Echinococcosis in peri-urban areas of six selected sub-districts of Mekelle Zone, Tigray, Northern Ethiopia, 2025 (N = 832).

variable	Question	Category	Frequency(n)	Percentage (%)
knowledge	Awareness of CE in humans and animals?	Yes	175	21.00
		No	657	79.00
	Do you know how CE is transmitted?	Yes	188	23.00
		No	644	77.00
	Preventive measures?	Yes	201	24.15
		No	631	75.85
Attitudes	Dogs as a source of infection?	Yes	275	33.05
		No	557	66.95
	home slaughtering / offal disposal?	Yes	372	44.71
		No	460	55.29
	Do you think CE is a serious public health problem?	Yes	173	20.79
		No	659	79.21
Practices	Do you feed dogs raw offal?	Yes	473	56.85
		No	359	43.15
	Do you wash your hands after handling dogs or livestock?	Yes	584	70.19
		No	248	29.81
	Do you wash vegetables and fruits before consumption?	Yes	433	52.04
		No	399	47.96
	dog deworming?	Yes	487	58.53
		No	345	41.47

5.3. **Prevalence of human CE based on abdominal ultrasound scanning**.

In the present study, the prevalence of human CE among the 832 participants of the study who were subjected to abdominal ultrasound examination was just 0.24 % (2/832). This was a 45-year-old male patient residing in the Semien sub-district who was diagnosed with a hepatic hydatid cyst. Imaging studies revealed a cystic lesion consistent with the WHO-IWGE CE4 stage of cystic echinococcosis, which is characterized by a heterogenous appearance with degenerative contents and no detectable daughter cysts. The cyst measured less than 5 cm in diameter and was located in the right lobe of the liver**.** The clinical presentation was non-specific, and the diagnosis was confirmed through abdominal ultrasound only. The patient reported non-specific symptoms, including intermittent right upper quadrant abdominal discomfort and fatigue. There was no history of jaundice, fever, or weight loss. This presentation aligns with typical late-stage hepatic CE characterized by degenerative features that do not show any clinical symptoms**.** No infections were detected on other organs of subjects investigated. A 50-year-old female from Quiha presented with right upper quadrant abdominal pain and discomfort of hepatic CE. Ultrasound imaging revealed that the calcification of the cyst wall is indicative of a chronic, inactive cyst stage. The calcified cyst wall observed in this patient indicates an inactive or degenerating stage of CE**.** According to the WHO-IWGE ultrasound classification**,** calcified cysts are categorized as CE5 (inactive stage)**,** characterized by a thick, arch-shaped calcified wall producing strong posterior acoustic shadowing on ultrasound.

5.4. Prevalence of Cystic Echinococosis (CE) in cattle.

The overall prevalence of cystic echinococcosis (CE) in cattle originating from peri-urban areas of the six sub-districts of Mekelle was 22.64 % (48/212). As summarized in Table 5, the study showed that age, sex, and body condition score of cattle and slaughter type were significantly associated with CE infection ($p < 0.05$). Accordingly, the prevalence of CE infection males (24.52%) was more affected than females (16.0%), and the difference was statistically significant **(**$X^2 = 6.52$; $p = 0.012$**).** Adults (32.3%) had a higher prevalence than young cattle (18.36%). This association was significant ($X^2 = 9.43$; $p = 0.002$). Poor body condition animals had the highest prevalence (40.0%), followed by medium (22.45%) and good (17.07%). The difference was highly significant ($X^2 = 16.94$; $p < 0.001$). Animals slaughtered at slabs (34.69%) had a significantly higher prevalence compared to those slaughtered at the Abergelle export abattoir (19.01%) ($X^2 = 10.81$; $p = 0.001$). Those didn't dewormed cattle (34.55%) were more affected than those dewormed (19.16%) ($X^2 = 8.75$; $p = 0.004$**)** (Table 5).

Table 5: Prevalence of CE in cattle based on sex, age, body condition score and breed in selected sub-districts of Mekelle zone, Tigray northern Ethiopia ,2025(N=212).

Variables	Category	Number of Inspected Animals	Number of Positive Animals	Prevalence	(X^2)	P-Value
Sex	Male	155	38	24.52	6.52	0.012
	Female	57	9	16.00		
Age	Young	147	27	18.36		
	Adult	65	21	32.30	9.43	0.002
Body Condition Score (BSC)	Poor	40	16	40.00	16.94	0.000
	Medium	49	11	22.45		
	Good	123	21	17.07		
Breed	Local	159	38	23.89	0.26	0.613
	Exotic	53	10	18.86		
Slaughter type	Abergele	163	31	19.01		
	Slaughter slab	49	17	34.69	10.81	0.001
Deworming history	Yes	167	32	19.16	8.75	0.004
	No	45	16	34.55		
Total		212	48	22.64		

5.5. Distribution of hydatid cysts in different organs based on their size in cattle in Abergelle export slaughterhouse and slaughter slab in Mekelle zone, Tigray, Northern Ethiopia, 2025 (N=212).

The present study showed that the overall prevalence of CE in cattle was 22.64 %; (48 /212). infected with hydatid cysts**,** the distribution and cyst size were as follows: Lungs were the most commonly affected organ (33 cases; 68.75%**).** Among these, small cysts were the most frequent (45.5%), followed by medium (33.3%) and large cysts (21.2%). Liver was the second most affected organ (12 cases; 25.0%). Heart, kidney, and spleen were rarely involved, each with 1 case (2.08% each)**.** Overall, of the total cysts observed, small cysts were most prevalent (52.08%)**,** followed by medium cysts (31.25%), and large cysts were least frequent (16.66%). The lung and liver were the major predilection sites for hydatid cysts, while the heart, kidney, and spleen were rarely affected in my study. Smaller cysts were more common than medium and large cysts (Table 6).

Table 6: Distribution of hydatid cysts in different organs based on their size in cattle in Abergelle export slaughterhouse and slaughter slab in Mekelle zone, Tigray, Northern Ethiopia,2025(N=212).

Organ affected	Number of affected	Small cyst (%)	Medium cyst (%)	Large cyst (%)
Lung	33	15(45.5%)	11(33.3 %)	7(21.2%)
Liver	12	7(58.3 %)	4(33.3%)	1(0.5%)
Heart	1	1(100 %)	0(0%)	0(0%)
Kidney	1	1(100 %)	0(0%)	0(0%)
Spleen	1	1(0%)	0(0%)	0(0%)
Total	**48**	25(52.08%)	15(31.25%)	8(16.66%)

5.6. Fertility and Viability of Cyst in Different Organs of cattle in Abergelle export slaughterhouse and in slaughter slab, in Mekelle zones, Tigray, Northern Ethiopia,2025 (N=212).

A total of 48 hydatid cysts were examined from different organs for fertility and viability status. Lungs (33 cysts, 68.8%) were the major site. Liver (12 cysts, 25%) showed higher (41.7%) were calcified cysts**.** Heart, kidney, and spleen each contributed one cyst (2.08% each). Overall**,** across all examined cysts: (15%) were viable cysts**,** (23%) non-viable cysts (44%) Sterile cysts were the most frequent, and (19%) calcified cysts. Sterile cysts were the most common type, followed by non-viable and calcified cysts, while viable cysts constituted the smallest proportion. This indicates that many of the detected hydatid cysts were non-fertile (Table 7).

Table 7: Fertility and Viability of the cyst in different organs of cattle in Abergelle export slaughter house and in slaughter slab, in Mekelle zone, Tigray, Northern Ethiopia,2025 (N=212).

Affected organs	Number of cysts examined	Cyst characterization			
		Viable (%)	Non-viable (%)	Sterile (%)	Calcified (%)
Lung	33	6((18%)	7(21.2 %)	16(48.5%)	4(12 %)
Liver	12	1(8 %)	4(33.3%)	2(16.7%)	5(41.7 %)
Heart	1	0(0%)	0(0%)	1(100%)	0(0%)
Kidney	1	0(0%)	0(0%)	1(100%)	0(0%)
Spleen	1	0(0%)	0(0%)	1(100%)	0(0%)
Total	48	7(15%)	11(23%)	21(44%)	9(19%)

5.7. **Bivariable logistic regression analysis results for factors potentially associated with CE infection among slaughtered cattle**.

Bivariate logistic regression analysis results for factors potentially associated with CE infection among slaughtered cattle is summarized in Table 8. Potential risk factors included age, sex, body condition score, slaughter house type, and history of deworming. Adult cattle were 2.15 times more likely to be CE infected than the younger ones (OR = 2.15; 95% CI: 1.312,3.545; P = 0.002), whereas the odds of infection among females was 2.06 times higher than the males (OR = 2.06; 95% CI:1.175,3.636; P = 0.012). Cattle with poor body condition were 3.31 times more likely to acquire hydatid cysts than those with good body (OR = 3.31; 95% CI:1.842,5.957; P = 0.000). Similarly, cattle slaughtered at backyard slabs had 2.38 times higher odds of testing positive for CE than those at the abattoir OR = 2.38; 95% CI:1.407,4.034); P = 0.001). Overall, bivariable analysis revealed that age, sex, body condition score, slaughter house type, and history of deworming were significantly associated with CE infection ($p < 0.05$). Breed and hand washing practices were not significantly associated with CE infection in this analysis ($p < 0.05$) (Table 8).

Table 8: Bivariate logistic regression analysis for factors potentially associated with CE infection among slaughtered cattle in selected sub-districts of Mekelle zone, Tigray, Northern Ethiopia,2025(N=212).

Variables	Category	CE (%)		OR (95%CI)	P-value
		Positive (%)	Negative (%)		
Age	Young	27(12.73%)	120(56.60%)	Ref	
	Adult	21(9.90%)	44(20.75%)	2.15(1.312,3.545)	0.002
Sex	Male	38(17.92%)	117(55.18%)	Ref	
	Female	9(4.24%)	48(22.64%)	2.06(1.175,3.636)	0.012
Breed	Local	38(17.92%)	121(57.07%)	Ref	
	Exotic	10(4.71%)	43(20.28%)	1.18(0.613,2.290)	0.613
Body Condition	Poor	16(7.54%)	24(11.32%)	3.31(1.842,5.957)	0.000
Score	Medium	11(5.18%)	38(17.92%)	1.47(0.802,2.723)	0.210
	Good	21(9.90%)	102(48.11%)	Ref	
Slaughter house	Abattoir	31(14.62%)	132(62.26%)	Ref	
type	Slaughter slab	17(8.01%)	32(15.09%)	2.38(1.407,4.034)	0.001
Hand washing	Yes	32(15.09%)	135(63.67%)	Ref	
After animal contact	No	16(7.54%)	29(13.67%)	1.13(0.677,1.896)	0.633
History of	Yes	32(15.09%)	135(63.67%)	Ref	
Deworming	No	15(7.07%)	30(14.15%)	2.23(1.300,3.829)	0.004

5.8. Multivariate logistic regression analysis results for factors potentially associated with CE infection among slaughtered cattle.

After adjusting for potential confounders, female cattle had 2.16 times higher odds of CE infection than the males (AOR= 2.16; 95% CI: 1.192,3.914; P = 0. 011) and cattle with poor body condition were 3.31 times more likely to acquire hydatid cysts than those with good body condition score (AOR = 4.07; 95% CI: 2.177,7.618; P = 0.000). In contrast to the bivariate analysis, adults had 2.57 times higher odds of CE infection than the younger ones (AOR=2.57; 95% CI: 1.501,4.400; P=0.001), which was stastically significant at ($p< 0.05$). On the other hand, as with bivariate logistic regression analysis, cattle slaughtered at the backyard slabs had 2.26 times higher odds of CE infection than those slaughtered at the abattoir (AOR = 2.26; 95% CI: 1.300,3.940; P = 0.004). Overall, the multivariate analysis revealed that age, sex, body condition score (poor BSC acquire hydatid cysts than good BCS). and slaughter house type, were significantly associated with CE infection. However, medium body condition and deworming history did not exhibit a significant correlation with CE infection in the final model ($p < 0.05$) (Table 9).

Table 9: Multivariate logistic regression analysis for factors potentially associated with CE infection among slaughtered cattle in selected sub-districts of Mekelle zone, Tigray, Northern Ethiopia,2025(N=212).

Variables	Category	CE (%) Positive (%)	Negative (%)	OR (95%CI)	P-value
Age	Young	27(12.73%)	120(56.60%)	Ref	
	Adult	21(9.90%)	44(20.75%)	2.57(1.501,4.400)	0.001
Sex	Male	38(17.92%)	117(55.18%)	Ref	
	Female	9(4.24%)	48(22.64%)	2.16(1.192,3.914)	0.011
Body Condition Score	Poor	16(7.54%)	24(11.32%)	4.07(2.177,7.618)	0.000
	Medium	11(5.18%)	38(17.92%)	1.42(0.751,2.718)	0.276
	Good	21(9.90%)	102(48.11%)	Ref	
Slaughter House type	Abattoir	31(14.62%)	132(62.26%)	Ref	
	Slaughter slab	17(8.01%)	32(15.09%)	2.26(1.300,3.940)	0.004

5.9. Overall Prevalence of CE in dogs.

A total of 384 dog fecal samples were analyzed, revealing an overall taeniid egg prevalence of 17.45%. The prevalence was significantly higher in female dogs (29.27%) compared to males (16.03%) (χ^2 = 4.452, p = 0.035). Similarly, exotic breeds exhibited a greater prevalence (38.89%) than local breeds (16.39%) (χ^2 = 6.027, p = 0.014). Stray dogs showed a significantly increased prevalence (19.75%) than those confined (7.14%) (χ^2 = 6.311, p= 0.012). Dogs feeding raw offal had a higher prevalence (27.27%) than those didn't feed raw offal (9.25%) (χ^2 = 9.522, p = 0.002). Additionally, non-dewormed dogs were more frequently infected (57.14%) than those dewormed dogs (19.47%) (χ^2 = 5.797, p = 0.016). Overall, sex, breed, roaming behavior, access to feed raw offal, and deworming status were significantly associated with taeniid egg positivity (p < 0.05), while age showed no significant association (Table 10).

Table 10: Prevalence of taeniid eggs in dogs in relation to various factors (age, sex, breed, and roaming behavior) in selected sub-districts of Mekelle zone, Tigray, Northern Ethiopia,2025(N=384).

Variables	Category	Number of Inspected Animals	Number of Positive Animals	Prevalence	(X^2)	p- value
Age	Young	79	14	17.72	0.005	0.943
	Adult	305	53	17.38		
Sex	Male	343	55	16.03	4.452	0.035
	Female	41	12	29.27		
Breed	Local	366	60	16.39	6.027	0.014
	Exotic	18	7	38.89		
Roaming	Confine	70	5	7.14	6.311	0.012
behavior	Stray	314	62	19.75		
Feeding	Yes	57	209	27.27	9.522	0.002
raw offal	No	10	108	9.25		
History of	Yes	59	303	19.47	5.797	0.016
deworming	No	8	14	57.14		
Total		384	67	17.45		

5.10. Bivariable logistic regression analysis for factors potentially associated with CE infection among dogs.

A total of 384 dogs were included in the analysis, and the association between various explanatory variables and CE infection was assessed using bivariate logistic regression. Female dogs had 2.16 times higher odds of CE infection than males (OR = 2.17, 95% CI: 1.042,4.505, p = 0.038). Similarly, exotic breeds had 3.24 times higher odds of CE infection than local breeds (OR = 3.24, 95% CI: 1.209,8.709; p = 0.019).in addition stray dogs had higher odds of getting infected than the confined ones (OR= 3.19, 95% CI: 1.235, 8.279, p = 0.017), dogs feeding raw offal had 2.94 times higher than those didn't fed raw offal(OR = 2.94, 95% CI: 1.446, 5.996), p = 0.003), and non- dewormed dogs had 2.93 times higher odds of CE infection than those dewormed ones (OR=2.93, 95% CI: 1.178, 7.307, p=0.021). In this study, the bivariate logistic regression analysis revealed that factors significantly associated with CE infection among dogs were sex, breed, roaming behavior, feeding raw offal, and deworming history. However, the prevalence of CE in relation to age showed no significant association (Table 11).

Table 11: Bivariate logistic regression analysis for factors potentially associated with CE infection among dogs in selected sub-districts of Mekelle zone, Tigray, Northern Ethiopia,2025(N=384).

Variables	Category	CE (%)		OR (95%CI)	P-value
		Positive (%)	Negative (%)		
Age	Young	153(13.80%)	252(65.62%)	Ref	
	Adult	4(3.65%)	65(16.93%)	1.02(0.535,1.959)	0.943
Sex	Male	55(14.32%)	288(75.00%)	Ref	
	Female	12(3.13%)	29(7.55%)	2.16(1.042,4.505)	0.038
Breed	Local	60(15.62%)	306(79.70%)	Ref	
	Exotic	7(1.82%)	11(2.86%)	3.24(1.209,8.709)	0.019
Roaming	Confine	5(1.30%)	65(16.93%)	Ref	
behavior	Stray	62(16.14%)	252(65.63%)	3.19(1.235,8.279)	0.017
Feeding	Yes	10(2.60%)	108(28.13%)	2.94(1.446,5.996)	0.003
raw offal	No	57(14.84%)	209(54.43%)	Ref	
History of	Yes	59(15.36%)	303(78.91%)	Ref	
deworming	No	8(2.08%)	14(3.65%)	2.93(1.178,7.307)	0.021

Note: **OR** = Odds Ratio; **CI** = Confidence Interval; **Ref** = Reference category.

5.11. Multivariate logistic regression analysis for factors potentially associated with CE infection among dogs.

After adjusting for potential confounders, dogs of exotic breed were 3.55 times more likely to be infected with CE than the local breeds (AOR = 3.55, 95% CI: 1.265–9.977, p = 0.016). Dogs that were allowed to stray had a higher odd of CE infection than those confined (AOR = 2.93, 95% CI: 1.114–7.712, p = 0.029). Similarly, dogs with feeding raw offal were 2.86 times significantly more likely to be infected than those didn't fed raw offal (AOR = 2.86, 95% CI: 1.381–5.929, p = 0.005). Moreover, dogs non- dewormed were 2.88 times more likely to be infected than those dewormed (AOR = 2.88, 95% CI: 1.129–7.351, p = 0.027).

The results revealed that breed, roaming behavior, feeding raw offal, and deworming history were significantly associated with CE infection. Age dogs were not stastically significant (Table 12).

Table 12: Multivariate logistic regression analysis for factors potentially associated with CE infection among dogs in selected sub-districts of Mekelle zone, Tigray, Northern Ethiopia,2025(N=384).

Variables	**Category**	**CE (%)**		**AOR (95%CI)**	**P-value**
		Positive (%)	**Negative (%)**		
Breed	Local	60(15.62%)	306(79.70%)	Ref	
	Exotic	7(1.82%)	11(2.86%)	3.55(1.265,9.977)	0.016
Roaming behavior	Confine	5(1.30%)	65(16.93%)	Ref	
	Stray	62(16.14%)	252(65.63%)	2.93(1.114,7.712)	0.029
Feeding raw offal	Yes	57(14.84%)	209(54.43%)	2.86(1.381,5.929)	0.005
	No	10(2.60%)	108(28.13%)	Ref	
History of deworming	Yes	59(15.36%)	303(78.91%)	Ref	
	No	8(2.08%)	14(3.65%)	2.88(1.129,7.351)	0.027

6. Discussion

This study aimed to assess the prevalence and risk factors of cystic echinococcosis (CE) among humans, cattle, and dogs in peri-urban areas of Mekelle Zone, Tigray region, Northern Ethiopia. The findings indicate that CE continues to pose a significant public health and economic burden in the region, with evidence of active transmission among definitive (dogs) and intermediate hosts (cattle and humans).

Based on abdominal ultrasound screening, this study has shown that, the prevalence of cystic echinococcosis (CE) among individuals from selected peri-urban areas of Mekelle Zone was low (0.26%). A 45-year-old male from Semien sub-district was diagnosed with a hepatic cyst (< 5 cm) in the right liver lobe, identified as a CE4-stage cyst per WHO-IWGE classification, indicating a degenerative, inactive form, suggesting non-viability and favoring conservative management. A 50-year-old female from Quiha presented with right upper quadrant abdominal pain and discomfort of hepatic CE. Ultrasound imaging revealed that the calcification of the cyst wall is indicative of a chronic, inactive cyst stage (88).

The observed prevalence of CE in humans in the present study (0.26%), which is equivalent to 260 cases per 100,000 population, is higher than many previous hospital-based reports. In Ethiopia human hydatidosis infection was reported from different part of the country such as Nekemte and Bahir Dar hospitals. For instance, a study in Bahir Dar hospital in 2006 reported an incidence of 2.3 per 100,000 population. (89). A single organ involvement was seen in the majority of patients. The cysts were most frequently found in the liver (55.7%), followed by the lungs (22.8%), and other organs (16.4%) (90).

A study in the South Omo Zone of the Southern Nations, Nationalities, and Peoples' Region (SNNPR) reported a higher prevalence of 2.0% (2000/100,000) based on ultrasound examinations, indicating a more significant presence of CE in that region (91). This was higher than from a retrospective study conducted at St. Paul's Hospital Millennium Medical College in Addis Ababa (21.9 %) which analyzed 42 patients operated on for intra-abdominal hydatid cysts between 2011 and 2015. The liver was the primary site involved (71.4%), particularly the right lobe (73%) (92). Human cystic echinococcosis data in Tigray is limited. A retrospective review of 525,148 ultrasound examinations from 2014 to 2018 identified only 7 CE cases, indicating a prevalence of 1.34 per 100,000 people. Most cases (4) were from Kahsay Abera General Hospital, 2 from Welkayit Clinic (which had the highest rate at 0.00879%), and 1 from Selam Surgical Specialty Clinic. All cysts were located in the liver (93).

Retrospective survey of human hydatidosis in Bahir Dar City, north-western Ethiopia, between January 2002 and December 2006, identified a total of 24 human cystic echinococcosis (CE) cases from 36,402 ultrasound examinations. Most cases were from Gambi Clinic (12 cases), which had the highest rate among 19,160 patients examined. The liver was the most commonly involved organ (79.2%), followed by the spleen (20.8%) (94). In Ethiopia, the annual surgical incidence rates ranged between 0.03 and 2.3 cases per 100,000 people (94).

A systematic review and meta-analysis estimated the overall human cystic echinococcosis (CE) prevalence in Africa at 1.7% (95% CI: 1.1–2.6%), with higher rates in Eastern Africa, including Ethiopia. From 2000 to 2022,76 human CE cases were reported in the Greater Horn of Africa (GHA). Ethiopia accounted for the highest proportion (47.3%, 36 cases), followed by Sudan (30.3%), Kenya (10.5%), Tanzania (5.3%), South Sudan and Somalia (2.6% each), and Eritrea (1.3%) (95). In the present study, the majority of the study participants were males (82.0%), in the age group of 26-46 years (60%), with secondary school education (48%). However, the results showed that regarding occupations were predominantly farmers (31.0%) and pastoralists (26.3%)**,** reflecting high levels of contact with livestock.

The current study revealed that the overall prevalence of cystic echinococcosis (CE) in slaughtered cattle examined at Abergele International Slaughterhouse and backyard or slaughter slabs, in peri-urban areas of Mekelle city was (22.64%). This finding is similar to that reported by in Tigray regional state (22.1%;1146/5194) (96). The current result is higher than the findings reported in other parts of the region and country such as in Adigrat municipal abattoir (18.6%) (97), in Addis Ababa (21%) (98), in Bedele town municipal Abattoir (18%) (99), in Nekemte municipal Abattoir (17.1%)(100),in Southern Wollo (17.4%)(101),in Eastern Hararghe (17.5%)(102).However, the current prevalence is lower than the ones reported in Shire municipal abattoir (32%)(103), in Debre Zeit Elfora export abattoir (42.86%)(104), in Jimma (30.7%)(105),in Gonder Elfora abattoir (31.0%)(106),in Meki municipal abattoir (42.7%)(107), in North Shewa Zone(56.8%)(108), in Bishoftu municipal abattoir (38.3%)(109),and in Bedeno municipal abattoir (27.8%) (110). The lungs and the liver of cattle were the most affected organs and the present study. This is consistent with several studies, where the lungs and liver are predominantly infected (108) (110) (100) (113). In the current study, majority of the hydatid cysts in cattle were small (50%), which is consistent with the findings of studies conducted in Addis Ababa (49.5%) (111), Dessie (78.5%) (112), and Adama municipal abattoir (72%) (113), although relatively higher percentages were reported from the latter two abattoirs. The observed variation in CE prevalence among regions may be attributed to differences in livestock management practices (such as free grazing and improper carcass disposal), the efficiency of abattoir inspection, environmental conditions that support the survival of *Echinococcus granulosus* eggs, the extent of dog access to infected offal, and the level of community awareness and implementation of control measures. These factors directly influence the intensity and continuity of the parasite's life cycle in both intermediate and definitive hosts. For instance, in areas where slaughter waste is not properly disposed of, dogs may easily ingest infected organs, thereby perpetuating the transmission cycle. Additionally, inadequate veterinary infrastructure and lack of deworming programs further exacerbate the situation.

The prevalence of CE in dogs in this study (17.45 %). This finding closely aligns in Tigray regional state (16.67%:3/18) (114), in Palestine (18%;17/93) (115). was higher compared to the prevalence rates reported from Hawassa City of Sidama Region (5.47%;21/38) (116), Moroto and Bukedea districts in Uganda (14.9%;39/261) (79), Lagos State, Nigeria (6.0%;13/217) (118), Kerman, south-eastern Iran using Copro-PCR prevalence (11.07%; 34/307) (119).The variation in CE prevalence among regions may be due to differences in dog management (e.g., presence of stray dogs), slaughterhouse hygiene, environmental conditions (temperature and humidity favoring egg survival), and the level of veterinary services and public awareness on parasite control. Therefore, the high prevalence of CE infection observed in humans, cattle, and dogs in this study is mainly associated with limited public awareness, improper slaughter practices, unsafe disposal of infected organs, irregular dog deworming, and poor hygiene.

7. Conclusion and Recommendations

The study revealed low overall awareness and misconceptions about cystic echinococcosis (CE) among participants. The present study the prevalence of (0.24%) in human, (22.6%) cattle, and (17.5%) in dogs in the peri-urban areas of Mekelle zone. Hydatid cysts were predominantly found in the lungs and liver in slaughtered cattle.

Although a small proportion recognized its zoonotic nature and transmission routes, risky attitudes and practices such as feeding dogs raw offal, inadequate offal disposal, and poor hygiene were common. Despite the public health significance of cystic echinococcosis, participants demonstrated poor knowledge, risky attitudes, and unsafe practices, particularly concerning dog management, slaughtering habits, and food hygiene factors.

Therefore, the findings of this study indicate that cystic echinococcosis (CE) is relatively common among cattle and dogs in the study area. This emphasizes the need to avoid backyard slaughter practice, unsafe offal feeding of dogs, and proper waste disposal which requires public awareness on the use of abattoirs.

Based on the findings of this study, the following evidence-based recommendations are proposed to mitigate the burden of *cystic echinococcosis (CE)* among humans, dogs, and cattle in the study area:

- ❖ Implement targeted health education programs to raise awareness about CE transmission, symptoms, and prevention methods, particularly in high-risk peri-urban communities.
- ❖ Enforce routine deworming of both owned and stray dogs using effective anthelmintics (e.g., praziquantel), in coordination with veterinary authorities.
- ❖ Implement humane population control programs for stray dogs through neutering and responsible ownership campaigns.
- ❖ Ensure all slaughtering is conducted under veterinary supervision with routine meat inspection to detect and safely dispose of infected organs.

- Encourage behavioral change through community-led initiatives aimed at improving hygiene, promoting safe slaughtering practices, and discouraging the feeding of raw offal to dogs.
- Strengthen surveillance systems and encourage early diagnosis and reporting of human CE cases using improved diagnostic tools such as imaging and serological assays.
- Foster collaboration between medical professionals and veterinarians to design integrated strategies addressing zoonotic transmission of CE.
- Enforce existing meat hygiene laws and policies regulating backyard slaughter to minimize informal slaughtering and offal contamination.

8. Limitations of the study

- Fecal diagnostics and limitations-Echinococcus granulosus eggs in dogs cannot be identified at the species level using fecal flotation methods due to the morphological similarity shared with other taeniid eggs. Consequently, alternative fecal diagnostic methods were considered, though their effectiveness in identifying CE-specific infections remains a challenge.
- Sample size and generalizability-The relatively small sample size and the narrow focus of this study limit its generalizability. The findings do not provide a comprehensive understanding of CE in humans, particularly in broader populations. A larger, more diverse sample is required to gain a more accurate and generalizable assessment of CE prevalence and associated risk factors.
- Logistical constraints in sample collection-Sample collection were affected by logistical constraints, including limited access to certain study areas and inadequate resources for recruitment, particularly for human cases. These constraints reduced the number of participants and cases available for analysis, potentially impacting the overall findings.
- Statistical power and association detection-The small sample size may have limited the ability to detect statistically significant associations between CE and various risk factors. Further research with larger sample sizes is necessary to strengthen the statistical power of the findings and provide a clearer understanding of the factors influencing CE infection rates in humans.
- Lack of retrospective data and published literature-There is a limited body of published literature on CE in humans in the Mekelle Zone, and this lack of historical data limited comparisons and a more thorough analysis of CE trends and disease burden in the region.
- Financial constraints-financial limitations presented a significant challenge in conducting a more comprehensive study. Insufficient funding restricted the ability to carry out more extensive sample collection, advanced diagnostic tests, and broader community engagement efforts.

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10.Annexes

ANNNEX 1: Information sheet/ English version Name of research institution: Mekelle University College of Health sciences (MUCHS)

Participant Information Sheet English Version

Title of the project:" Investigating the prevalence and risk factors of cystic echinococcosis in humans and slaughtered cattle: in peri-urban dog- owning smallholder farms in Mekelle zone, Tigray Region, Northern Ethiopia"

Principal Investigator: Messele Gebremicael (BSC in Animal Health).

Advisors: Mekonnen Yohannes (PhD, Associate prof), and Mr. Gesesew Bugssa (PhD candidate, Assistant professor).

Department: Department of Medical Parasitology and Entomology, Division of Biomedical Science, College of Health sciences, Mekelle University.

Name of the Sponsor: Mekelle university

Introduction: "My name is Messele Gebremicael, and I am an MSc student in Medical Parasitology at Mekelle University, College of Health Sciences. I am conducting research on the Investigating the prevalence and risk factors of cystic echinococcosis in humans and slaughtered cattle: in peri-urban dog- owning smallholder farms in Mekelle zone, Tigray Region, Northern Ethiopia"

Purpose: To determine the prevalence of CE in humans, cattle, and dogs in the selected sub- districts of Mekelle zone

Procedure and participation: Ethical clearance and the information sheet will be explained by the investigator to the cattle and dog's attendant and other responsible individuals. Informed consent will be obtained from all human participants before participation. The consent form will explain the study's purpose, procedures, potential risks, and confidentiality measures. Individuals who are at risk of CE due to their occupation (e.g., farmers, shepherded, livestock handlers) or close contact with dogs or livestock. A structured questionnaire will collect demographic data, medical history, and risk factors (e.g., contact with livestock, dog ownership, consumption of raw offal). Informed consent will be obtained from cattle and dog owners. The purpose of the study, procedures, and risks will be clearly explained to the owners, and their consent will be obtained before any sample collection. Post-mortem examination of cattle will be performed at slaughterhouses to inspect the liver, lungs, and other organs for hydatid cysts. The cysts will be collected, examined for viability, and classified according to the WHO classification for CE stages. Fecal samples will be collected from the dogs and processed using flotation techniques to detect Taeniid eggs (which indicate the presence of the parasite). Questionnaires will be filled out by farm owners live in peri-urban areas. The study will be conducted in accordance with ethical guidelines for human and animal research**.**

Confidentiality: All data collected from participants (human, cattle, and dogs) will be kept confidential and used solely for the purposes of this study. Your name will not be mentioned in any report; instead, code number will be used. All of your answers and test results will keep confidential and will not be given to other institution and/ or person except for the principal investigator of this study. Your information will be used only for above mentioned purpose.

Benefits: Participants in this study will receive the benefit of having their laboratory results reported directly to their physician. If any significant findings are detected, the presence of Cystic Echinococcosis (CE), this will aid in the appropriate treatment and management of their condition. The results could potentially lead to improved health outcomes through early detection and intervention.

Risk: There are no expected risks associated with sample collection or any part of the study process. The procedures involved, such as fecal sampling, ultrasound examination, and serological tests, are standard and non-invasive. The study will be conducted with strict adherence to ethical guidelines, ensuring the safety and well-being of all participants, both human and animal.

Incentives: There are no financial incentives for participation in this study. However, the results of the tests may provide valuable health information that could assist in the early detection and management of potential health issues.

Results Dissemination: The results of this study will be shared with all relevant stakeholders, including health institutions and the Tigray Regional Health Bureau. The findings will be presented at Mekelle University's scientific community and at national and international scientific conferences. Furthermore, the study manuscript will be submitted to an appropriate peer-reviewed journal for publication. Throughout the dissemination process, no personal information related to your identity will be included, ensuring your confidentiality is maintained.

Freedom to Withdraw: Your participation in this study is completely voluntary. You have the right to withdraw at any time without any impact on the medical services or care you receive. Your decision to participate or withdraw will not affect your relationship with the healthcare providers or the services you seek.

Person to Contact: If you have any questions, would like more information, or wish to inquire further about this project, please feel free to contact the following individuals.

- ✓ Mekelle University, College of Health Sciences, Institute of Biomedical Sciences Institutional Review board Office Tel=+251-0344-40-66-80.
- ✓ **Principal Investigator Name and Address**: Messele Gebremicael (BSc) Tel. phone: +251927607870 and E-mail: messele209@gmail.com.
- ✓ **Advisor's Name and Address-** Mekonnen Yohannes (PhD, Associate professor) Email: mekonnenyohannes@yahoo.co.uk and Tel: phone: +251 914708927
- ✓ **Mr. Gesesew Bugssa** (PhD candidate, Assistant professor)

  E-mail: bugssag@gmail.com and Tel: phone: +251-914-25-22-05

ANNEX 2: Participant Information Sheet Tigrigna Version:
ናይ ምርምር ፅንዓት መብራህርሂ ቅጥዒ/ትግርኛ ቅዳሕ

ናይ ምርምር ርእሲ፦" ዝርገሐን ሓደጋን ሲስቲክ ኢቺኖኮኮሲስ ኣብ ሰብን ኣብ ዝተሓርደ ከብትን ምምርማር: ኣብ ዞባ መቐለ፣ ትግራይ፣ ሰሜን ኢትዮጵያ ኣብ ዝርከቡ ኣብ ኣናእሽቱ ሕርሻታት ከልቢ ዘለዎም ኣብ ከባቢ ከተማታት ዝርከቡ ሓረስቶት"

ፅንዓት ዘካይድ ሽም፦ መሰለ ገብረሚካኤል

ኣማከርቲ፦መኮነን ዮሃንስ (ዶ/ር ፣ተሓባባሪ ፕሮፌሰር) ፣ ገሰሰው ቡግሳ (ሕፁይ ዶ/ር፣ ተሓጋገዚ ፕሮፌሰር)

ዲፓርትመንት፦ናይ ሜዲካል ፓራሳይቶሎጅን ኢንቶሞሎጅን ክፍሊ ትምህርቲ፣ ጥዕና ሳይንስ ኮሌጅ፣

መቐለ ዩኒቨርሲቲ

መእተዊ ፦ሽመይ መሰለ ገብረሚካኤል ይበሃል ኣብ መቐለ ዩኒቨርሲቲ ናይ ድሕረ ምረቃ ተማሃራይ እንትኮን፥ ናይ መመረቅያ ፅሑፈይ'' ዝርገሐን ሓደጋን ሲስቲክ ኢቺኖኮኮሲስ ኣብ ሰብን ኣብ ዝተሓርደ ከብትን ምምርማር፡ ኣብ ዞባ መቐለ፣ ትግራይ፣ ሰሜን ኢትዮጵያ ኣብ ዝርከቡ ኣብ ኣናእሽቱ ሕርሻታት ከልቢ ዘለዎም ኣብ ከባቢ ከተማታት ዝርከቡ ሓረስቶት''

ዓላማ ናይዚ መፅናዕቲ: ኣብ ዝተመረፁ ንኡሳን ወረዳታት ዞባ መቐለ ኣብ ደቂ ሰባትን ከብትን ብተወሳኺ ኣብ ኣኽላባትን ዝርገሐ ሲስቲክ ኢቺኖኮኮሲስ ንምፍላጥ እዩ::

ኣሰራርሓን ተሳትፎን እቲ ፅንዓት ፦ዝተዓለመሉ ሽቶ ንኽወቅዕ ብመጀመርያ ቃለ መሕተት ክንገብርሎም ኢና። መጠን ስርጭት እቲ ሕማም ንምፍለጥ እዩ:: ካብዚ ብምቅፃል ንላበራቶሪ ምርመራ ዝከውን ናሙና ክህቡ/ባና እዮም።ብተወሳኺ ካብ ከብትኻን እውን ቅድሚን ድሕሪን ምሕራድ ከምኡ'ውን ካብ ኣኽላባትካ ናሙናታት ሰገራ ክውሰድ እዩ።

ሚስጥር ምሕላው፦ኩሉ ካብ ተሳተፍቲ (ሰብ፡ ከብትን ኣኽላባትን) ዝተኣከበ መረዳእታ ምስጢራዊ ክኸውንን ንዕላማታት እዚ መጽናዕቲ ጥራይ ክውዕልን እዩ። ስምኩም ኣብ ዝኾነ ጸብጻብ ኣይክጥቀስን እዩ፤ ኣብ ክንድኡ ቁጽሪ ኮድ ክጥቀም እዩ። ኩሉ መልስታትካን ውጽኢት ፈተናኻን ምስጢራዊ ክኸውንን ብዘይካ ቀንዲ መርማሪ ናይዚ መጽናዕቲ ንኻልእ ትካልን/ወይ ሰብን ኣይወሃብን እዩ። ሓበሬታኹም ኣብ ላዕሊ ዝተጠቕሰ ዕላማ ጥራይ እዩ ዝውዕል።

ረብሓታት፦ ተሳተፍቲ ናይዚ መጽናዕቲ፡ ውጽኢት ላበራቶሪኦም ብቐጥታ ናብ ሓኪሞም ምሕባር ረብሓ ክረኽቡ እዮም። ዝኾነ ትርጉም ዘለዎ ርኽበት እንተተረኺቡ፡ ህላወ ሲስቲክ ኢቺኖኮኮሲስ ፥ እዚ ኣብ ግቡእ ሕክምናን ምሕደራን ኩነታቶም ክሕግዝ እዩ። እቲ ውጽኢት ብኣግኡ ብምፍላጥን ምትእትታውን ንዝተመሓየሸ ውጽኢት ጥዕና ከስዕብ ይኽእል።

ሓደጋ፦ ምስ ምእካብ ናሙና ወይ ዝኾነ ክፋል መስርሕ መፅናዕቲ ዝተኣሳሰር ትፅቢት ዝግበረሉ ሓደጋታት የለን። እቶም ዝሳተፉ ኣገባባት ከም ናሙና ሰገራ ምውሳድ፡ መርመራ ኣልትራሳውንድን ደረጃ ዘለዎምን እዮም። እቲ መጽናዕቲ ብጥብቂ ስነ-ምግባራዊ መምርሒታት ብምኽባር ዝካየድ ኮይኑ፡ ድሕነትን ጽቡቕ ሂወትን ኩሎም ተሳተፍቲ፡ ሰብን እንስሳን ዘረጋግጽ እዩ።

መተባብዒታት፦ ኣብዚ መጽናዕቲ ንምስታፍ ዝኾነ ፋይናንሳዊ ምትብባዕ የለን። ይኹን እምበር፡ ውጽኢት ናይቲ መርመራታት፡ ንኽመጽእ ዝኽእል ጸገማት ጥዕና ብኣግኡ ንምፍላጥን ንምምሕዳርን ክሕግዝ ዝኽእል ጠቓሚ ሓበሬታ ጥዕና ክህብ ይኽእል እዩ።

ምዝርጋሕ ውፅኢት፦ ውፅኢት እዚ መፅናዕቲ ምስ ኩሎም ዝምልከቶም ኣካላት፣ እንኾላይ ትካላት ጥዕናን ቢሮ ጥዕና ክልል ትግራይን ክንገር እዩ። እቲ ርኽበት ኣብ ማሕበረሰብ ሳይንሳዊ ዩኒቨርሲቲ መቐለ ከምኡ'ውን ኣብ ሃገራውን ዓለምለኻውን ሳይንሳዊ ዋዕላታት ክቐርብ እዩ። ካብዚ ሓሊፉ እቲ ናይ መጽናዕቲ ጽሑፍ ንኽሕተም ናብ ዝምጥን ብሚዛኑ ዝግምገም መጽሔት ክቐርብ እዩ። ኣብ ምሉእ መስርሕ ምዝርጋሕ፡ ምስ መንነትካ ዝተኣሳሰር ዝኾነ ይኹን ውልቃዊ ሓበሬታ ኣይክካተትን እዩ፡ እዚ ድማ ምስጢርካ ከም ዝሕሎ የረጋግጽ።

ናይ ምንስሓብ ናጽነት፦ ኣብዚ መጽናዕቲ እዚ ተሳትፎኻ ምሉእ ብምሉእ ብወለንታኻ እዩ። ኣብ ዝኾነ እዋን ኣብቲ እትረኽቦ ሕክምናዊ ኣገልግሎት ወይ ክንክን ዝኾነ ጽልዋ ከይገበርካ ናይ ምንስሓብ መሰል ኣሎካ። ክትሳተፍ ወይ

ክትስሕብ ዝወሰድካዮ ውሳነ ምስቶም ወሃብቲ ክንክን ጥዕና ወይ ምስቶም እትደልዮ ኣገልግሎታት ዘለካ ርክብ ኣይጸልዎን እዩ።

ክትረኽብዎ ዘለኩም ሰብ፡ ዝኾነ ሕቶታት ምስ ዝህልወኩም፡ ተወሳኺ ሓበሬታ ምስ እትደልዩ፡ ወይ ብዛዕባ እዚ ፕሮጀክት ዝያዳ ክትሓቱ ምስ እትደልዩ፡ ነዞም ዝስዕቡ ውልቀሰባት ክትረኽብዎም ትኽእሉ ኢኹም።

ዋና ተማራማሪ ሽምን ኣድራሻን፡-

መሰለ ገብረሚካኤል (ኢመይል-messele209@gmail.com; ስልኪ ቁፅሪ: +251927607870)

ናይ ኣማከርቲ ሽምን ኣድራሻን፡-

- መኮነን ዮሃንስ (ዶ/ር ፣ተሓባባሪ ፕሮፌሰር ፣ ኣድራሻ: - email: mekonnenyohannes@yahoo.co.uk and ስልኪ ቁፅሪ: +251 914708927) ፣ ገሰሰው ቡግሳ (ሕፁይ ዶ/ር፣ ተሓጋገዚ ፕሮፌሰር ፣ ኣድራሻ: - email: bugssag@gmail. ፣ ስልኪ ቁፅሪ: +251-914-25-22-05)

ANNEX 3: Informed Consent/English version Name of the research institute:

Mekelle University College of Health Sciences. **Principal investigator**: Messele Gebremicael **Research topic:** Investigating the prevalence and risk factors of cystic echinococcosis in humans and slaughtered cattle: in peri-urban dog- owning smallholder farms in Mekelle zone, Tigray Region, Northern Ethiopia" Detailed information about the study was explained to me in my own language/ I have understood from the information sheet. I had the opportunity to ask questions and clearly understood the objective of the study, advantages and disadvantages of being involved in the study. Participation is completely on my own interest; I decided to participate in this study and to give all the necessary data and sample.

Mekelle University, College of Health sciences Institutional board Office Tel. +251-0344 406680.

Principal Investigator Name and Address: Messele Gebremicael (BSc) Tel. phone: +251927607870, and E-mail: messele209@gmail.com.

I have read this form, or it has been read to me in a language I understand. I fully comprehend the conditions outlined above. Therefore, I willingly agree to participate in this study and confirm my consent by signing below.

Participant Information:

ID number of the attendant: Signature ________________Date: ______________________

Name of investigator/Interviewer: Signature ____________Date: ______________________

Research Team Information:

Name of Advisor: ______________________Signature: __________Date: __________

Name of Investigator: __________________Signature: __________Date: __________

Thank you!

ANNEX 4: Informed Consent Tigrigna version ናይ ፍቓደኛ መረጋገፂ ቅጥዒ (ትግርኛ ቅዳሕ):
መቐለ ዩኒቨርስቲ ኮሌጅ ሳይንስ ጥዕና። ዋና መርማሪ፡ መሰለ ገብረሚካኤል ኣርእስቲ መጽናዕቲ፡

ዝርገሐን ሓደጋን ሲስቲክ ኢቺኖኮኮሲስ ኣብ ሰብን ኣብ ዝተሓርደ ከብትን ምምርማር: ኣብ ዘባ መቐለ፣ ትግራይ፣ ሰሜን ኢትዮጵያ ኣብ ዝርከቡ ኣብ ኣናእሽቱ ሕርሻታት ከልቢ ዘለዎም ኣብ ከባቢ ከተማታት ዝርከቡ ሓረስቶት”ብዛዕባ እቲ መጽናዕቲ ዝርዝር ሓበሬታ ብቋንቋይ ተገሊጹኒ/ ካብቲ ሓበሬታ ወረቐት ተረዲአ ኣለኹ። ሕቶታት ክሓትት ዕድል ረኺበ ዕላማ ናይቲ መጽናዕቲ፡ ኣብቲ መጽናዕቲ ምክፋል ዘለዎ ብልጫን ጉድኣትን ብንጹር ተረዲኡኒ። ተሳትፎ ሙሉእ ብሙሉእ ብረብሓይ እዩ፤ ኣብዚ መጽናዕቲ ክሳተፍን ኩሉ ዘድሊ ዳታን ናሙናን ክህብን ወሲነ።

ነዚ ቅጥዒ ኣንቢበዮ ኣለኹ፡ ወይ ብዝርድኣኒ ቋንቋ ተነቢቡለይ ኣሎ። ኣብ ላዕሊ ዝተዘርዘሩ ኩነታት ምሉእ ብምሉእ ይርድኣኒ እዩ። ስለዚ ኣብዚ መፀናዕቲ ክሳተፍ ብፍቓደይ ተሰማሚዐ ኣብ ታሕቲ ብምፍራም ፍቓደይ ከረጋግፅ።

ሓበሬታ ተሳታፊ:

መለለዪ ቁጽሪ ናይቲ ኣገልጋሊ ______________________ ፌርማ ________________ ዕለት ______________

ስም መርማሪ/ሓታቲ _____________________ ፌርማ _____________________ ዕለት _________________

ሓበሬታ ጉጅለ መጽናዕቲ:

ስም ኣማኻሪ፡ __________________________ ፌርማ፡ ____________________ ዕለት፡ _____________

ስም መርማሪ፡ ______________________ ፌርማ፡ _________________________ ዕለት፡ ____________

የቕንየለይ!

ANNEX 5: Assurance of Principal Investigator:

I, the undersigned, agree to accept all responsibilities for the scientific and ethical conduct of the research project and for the provision of required progress reports as per the terms and conditions of the requirements of the department. I will provide timely progress report to my advisors and seek the necessary advice and approval from my major advisor in the course of the research.

Name of the Master's student: Messele Gebremicael

Signature: ________________________________Date: __________________________

Name of the main-advisor: Dr. Mekonnen Yohannes (PhD; Associate Professor)

Signature: ________________________________Date: __________________________

Name of the co-advisor: Mr. Gessessew Bugssa (PhD candidate: Assistant Professor)

Signature: ________________________________Date: _________________________

ANNEX 6: መረጋገፂ ዋና መርማሪ:

ኣነ ኣብ ታሕቲ ዝፈረምኩ፡ ሳይንሳውን ስነ-ምግባራውን ኣሰራርሓ ፕሮጀክት መጽናዕትን፡ ብመሰረት ውዕላትን ቅጥዕታትን ናይቲ ክፍሊ ጠለባት፡ ዘድሊ ጸብጻብ ምዕባለታት ንምቕራብን ኩሉ ሓላፍነት ክቕበል ይሰማማዕ። ንኣማኸርተይ እዋናዊ ጸብጻብ ምዕባለ ክህብን ኣብ መስርሕ እቲ መጽናዕቲ ካብቲ ዋና ኣማኻሪየይ ኣድላዪ ምኽርን ፍቓድን ክሓትትን እየ።

ሽም ተማሃራይ ናይ ማስተርስ ፡ መሰለ ገብረሚካኤል: ፊርማ፡ __________ዕለት፡ __________

ሽም ዋና ኣማኻሪ: መኮነን ዮሃንስ (ዶ/ር ፣ተሓባባሪ ፕሮፌሰር: ፊርማ፡ _____ዕለት፡ ___________

ሽም ሓጋዚ ኣማኻሪ: ገሰሰው ቡግሳ (ሕፁይ ዶ/ር፣ ተሓጋገዚ ፕሮፌሰር: ፊርማ፡ _____ዕለት፡ ______

ANNEX 7: Description of Body Condition Score of cattle:

Score	Condition	Features
1	L-	Marked emaciation (animal would be condemned at ante mortem examination)
2	L	Transverse process project prominently, neural spines appear Sharply
3	L+	individual dorsal spines are pointed to touch, hips, pins, tail head and ribs are prominent transverse process visible, usually individually
4	M-	Ribs, hips, and spines clearly visible muscle mass between hook and pins slightly concave, slightly more flesh above the transverse processes than in L+
5	M	Ribs usually visible. Little fat cover, dorsal spines barely visible
6	M+	Animal smooth and well covered, dorsal spines cannot be seen, but are easily felt
7	F-	Animal smooth and well covered, but fat deposits are no marked. Dorsal spines can be felt with firm pressure, but rounded rather than sharp
8	F	Fat cover in critical areas can be easily seen and felt, transverse processes cannot be seen or felt
9	F+	Heavy deposits of fat clearly visible on tail head, brisket, dorsal spines, ribs, hooks and pins fully covered and cannot be felt even with firm pressure

(**Source:** Nicholson and Butterworth (1986).

Note: body condition scores:

- 1, 2, 3, are poor body condition
- 4, 5, 6, are medium body condition
- 7, 8, 9, are good body condition.

ANNEX 8: Estimating Cattle Age Using Dentition formula:

Age (year)	Characteristic change
1 ½-2	I1 erupts
2-2 ½	I2 erupts
3	I3 erupts
3 ½ -4	I4 erupts
5	all incisor and canine are in wear
6	I1 is level and the neck has emerged from the gum
7	I2 is level and the neck is visible
8	I3 is level and the neck is visible I4 may be level
9	I4 is level and the neck is visible
10	the dental stare is square in I2 and in all teeth by 12 years
15	The teeth that are not fallen out are reduced small round.

Source: De-Luata and Habel (1986)

Note: The canine of ruminants is usually considered the fourth incisor.

ANNEX 9: Ante Mortem Examination data collection format:

Code	Sex		Age		Body Condition Score (BSC)			Breed	
	Male	Female	Young	Old	Poor	Medium	Good	Local	Exotic

Note: Young = Age ≤ 5 Years; Old = Age Greater than 5 Years.

Body Condition Score (BSC)

- Poor: Visible ribs, spine, and hip bones; poor muscle tone
- Medium: Ribs and spine are not easily visible, but the animal is not overweight
- Good: Well-nourished, ribs and spine not visible, good muscle tone

Breed

- Local: Indigenous or locally raised animals

Exotic: Non-native or crossbred animals.

ANNEX 10: Laboratory Data Collection Format for Fertility and Viability Test:

Organ	**Fertile cysts**		**Non -fertile cysts**		**Total**
	Viable	**Non-viable**	**Sterile**	**Calcified**	
Lung					
Liver					
Heart					
Spleen					
Kidney					
Total					

Note: **Fertile Cysts**: Cysts that contain **protoscolices** capable of developing into new tapeworms.

- ✓ **Viable**: Cysts with living protoscolices.
- ✓ **Non-Viable**: Cysts with dead protoscolices that cannot develop into new tapeworms.

Non-Fertile Cysts: Cysts that do not contain protoscolices or contain sterile ones.

- ✓ **Sterile**: Cysts that do not have any reproductive structures.
- ✓ **Calcified**: Cysts that have undergone calcification and are no longer viable.

Source: Yildiz K, Gurcan S. (2003) (70).

ANNEX 11: Method for the determination of fertile and viable cystic hydatidosis:

1. Obtain/collect non-degenerated hadatid cyst from infected organs of slaughtered animals.
2. Take the cysts to laboratory in cool box.
3. Aspirate hydatid fluid from the cyst by a sterile 18-gauge needle and transfer to a test tube.
4. The protoscolices allowed to sediment in the fluid for 20-30 minutes which indicates fertility and the supernatant discarded.
5. Confirm the fertility of the cyst by microscope examination of sediment protoscoliices.
6. A drop of sediment contained protoscolices on microscopic glass slide and cover with the cover slip; observe for amoeboid like peristaltic movements with high power objective.
7. For clear vision a drop of 0.1% aqueous eosine solution added to equal volume of protoscolices in Hydatid fluid on the microscopic slide with the principle that viable protoscolices should completely or partially exclude the day while the did ones take it up.
8. Furthermore, infertile cysts where further classified as sterile and calcified. Sterile Hydatid cysts were characterized by their smooth inner lining

usually with slightly turbid fluid in its content while typical calcified cysts produce a gritty sound feeling up on incision.

(**Source:** Macpherson et al., (1985)

ANNEX 12: Centrifugal Fecal Flotation Procedure:

This is the preferred technique for the standard fecal flotation test regardless of the flotation solution used. It is particularly important to use this procedure with Sheather's sugar and 33% ZnSO4 flotation solutions to ensure that the flotation is effective:

1. Mix 3–5 g (about 1 teaspoonful) of feces with a small amount of flotation solution in a paper or plastic cup. Cat feces and small ruminant pellets, which are sometimes too hard to break up easily, can be ground with a mortar and pestle or allowed to soak in water until they become softer. If the sample appears to contain a large amount of fat or mucus, an initial water wash is performed, and water should be used in Step 1. The water wash can be eliminated for most fecal samples of normal appearance.
2. Strain the mixture of feces and flotation solution (or feces and water if a water wash is per formed) through a double layer of cheesecloth or gauze. A tea strainer can also be used.
3. Pour the mixture into a 15-mL centrifuge tube. If the rotor on the centrifuge is not angled (i.e., if the tubes hang straight when not spinning), the centrifuge tube can be filled with flotation solution until a reverse meniscus is formed and a coverslip is added. The tube is spun with the coverslip. The centrifugal force generated by the centrifuge will hold the coverslip in place. If the centrifuge has an angled rotor, fill the tube as full as possible and place in the centrifuge.
4. Spin the mixture in a benchtop centrifuge for about 5 minutes at approximately 500–650

× g (650 × g is 2500 rpm on a 4-in. rotor), regardless of whether the feces have been mixed with water or with the flotation solution. If a specific g force and speed setting cannot be determined, spinning the tube at the same speed used to separate serum from blood cells is sufficient. If the initial spin is a water wash, the supernatant should be discarded, the sediment resus pended with flotation solution, and Steps 3 and 4 repeated.

5. Allow the centrifuge to stop without using the brake. The slight jerking that results from the use of the brake may dislodge parasites from the surface layer.
6. Following centrifugation, there are several ways to harvest the surface layer of fluid containing parasite eggs. If the tube has been spun with the coverslip in place, lift the coverslip off the tube and quickly place it on a microscope slide. When the tube is spun without the coverslip, remove the tube from the centrifuge after spinning and place in a test tube rack. Fill the tube with additional flotation solution to form a reverse meniscus. Place a coverslip on the tube and allow it to sit for an additional 5–10 minutes before removing the coverslip and placing it on a slide.

Alternatively, after the centrifuge comes to a stop, gently touch the surface of the fluid in the tube with a glass rod, microbiologic loop, or base of a small glass tube and then quickly touch the rod to a microscope slide to transfer the drop or two of adhering fluid. This procedure will be less efficient than allowing the tube to stand with a coverslip in place (Zajac AM.,2012) (39).

ANNEX 13: Questionnaire format:

General Profile:

- Region: ________________Zone: ________________Sub-Districts: _______________
- Name of the Abattoir(site): ___________Date of Sampling: __________Code No: ________
- Address: ________________Telephone: ________________Email: ____________________

1. **Demographic data**

1.1. Respondent's Age

1: 6-15 years 2: 16-25 years

3: 26-45 years 4: 46-60 years 5: greater than 60 years

1.2. Respondent's Sex: 1: Male 2: Female
1.3. Marital Status: 1: Married 2: Single
1.4. Religion: 1: Christian 2: Muslim 3: Other (Specify):
1.5. Owner's education level

1: Illiterate 2: Primary (Grades 1-8)

3: Secondary (Grades 9-12) 4: Diploma and above

1.6. Occupation Status

1: Farmer 2: Merchant 3: Shepherd

4: Civil Servant 5: Student 6: Laborer

2. **General Sample Collection for Cattle and Dogs**

2.1. Age of Cattle? 1: Young 2: Adult
2.2. Sex of Cattle? 1: Male 2: Female
2.3. Breed of Cattle? 1: Local 2: Exotic
2.4. Body Condition Score of Cattle (BSC)? 0: Medium 1: Poor 2: Good
2.5. Age of Dogs? 1: Young 2: Adult
2.6. Sex of Dogs? 1: Male 2: Female
2.7. What is the breed of the dog? 1: Local 2: Exotic

3. **Medical History**

3.1. Have you ever heard of hydatid disease (echinococcosis)? 1: Yes 2: No
3.2. Do you have a past history of cystic echinococcosis (CE) or other parasitic infections? 1: Yes 2: No
3.3. Have you previously received any treatment for cystic echinococcosis? 1: Yes 2: No
3.4. Current Symptoms:

1: Abdominal pain 2: Nausea/Vomiting 3: Weight loss

4: Asymptomatic 5: Other (Specify): ____________________________

3.5. Duration of Symptoms:

1: Less than 6 months 2: 6 months to 1 year 3: More than 1 year

3.6. Do you know people with the disease? 1: Yes 2: No
3.7. Cyst Size (Ultrasound Findings)? 1: Less Than < 5 Cm 2: Between 5-10 cm
3: Larger than 10 Cm

3.8. CE Stage (WHO Classification)? 1: CE1 2: CE2 3: CE3a
4: CE3b 5: CE4 6: CE5

3.9. Anatomical Site of CE**?** 1: Liver 2: Lung 3: Other Specify__________

4. Risk Factors

4.1. Have you observed hydatid cysts in the viscera of slaughtered livestock? 1: Yes 2: No

4.2. Do you slaughter cattle at home? 1: Yes 2: No

4.3. Type of Slaughterhouse for cattle?1: Municipal (Abattoir) 2: Backyard (Slaughter Slab).

4.4. History of deworming of cattle? 1: Yes 2: No

4.5. If you answered 'Yes' to Question 4.2, how often do you slaughter cattle at home?
1: Rarely 2: Occasionally 3: Regularly

4.6. Do you have separate housing for dogs? 1: Yes 2: No

4.7. Do you think that dogs pose health risks to you or other animals?1: Yes 2: No

4.8. Access to raw offal for dogs? 1: Yes 2: No

4.9. Type roaming behavior? 1: Confine (restricted) 2: Stray (free-roaming)

4.10. Deworming history of dogs? 1: Yes 2: No

4.11. Do you discard infected organs at the site of slaughtering? 1: Yes 2: No

4.12. Do you touch your dogs? 1: Yes 2: No

4.13. If you answered 'Yes' to Question 4.8, do you wash your hands afterward? 1: Yes 2: No

4.14. Do any of your family members have close contact with your dogs? 1: Yes 2: No

4.15. Do you wash vegetables before raw consumption? 1: Yes 2: No

4.16. Do you wash your hands before eating food? 1: Yes 2: No

4.17. Do you have a latrine in the area? 1: Yes 2: No

4.18. Do you share water sources with your livestock and dogs? 1: Yes 2: No

4.19. Do you consume raw or undercooked meat? 1: Yes 2: No

4.20. Do you provide regular treatments for your dogs? 1: Yes 2: No

4.21. If you answered 'Yes' to Question 4.16, what types of treatment do you provide to your dogs? 1: Traditional Remedies 2: Anthelmintic Drugs (for deworming) 3: None 4: Other (Specify): ___________

4.22. How often do you provide medical treatments to your dogs? 1: Once a year
2: Twice a year 3: I do not treat 4: Other (Specify): ________

4.23. Do you know how this disease is transmitted? 1: Yes 2: No

4.24. If you answered 'Yes' to Question 4.19, how is the disease transmitted? 1: Via insects 2: Via animals 3: From God 4: Via bewitching

4.25. If you answered 'Yes' to Question 4.19, by what type of animal is the disease transmitted? 1: Livestock 2: Dogs 3: Wild animals 4: Birds

4.26. Do you know that this disease can be transmitted from dogs to humans?
1: Yes 2: No

4.27. Do your livestock receive veterinary treatment when they are sick? 1: Yes 2: No

4.28. Do you think that early diagnosis enhances treatment effectiveness and outcomes? 1: Yes 2: No

4.29. Do you believe that this disease can be effectively cured?
1: Agree 2: Disagree 3: Neutral

4.30. Are your dogs' feces properly disposed? 1: Yes 2: No

4.31. Do you handle dog feces using your bare hands? 1: Yes 2: No

4.32. Do you have a waste management system? 1: Yes 2: No

4.33. How would you evaluate your waste management practices?

1: Poor 2: Good 3: Excellent 4: Unknown

4.34. Is it possible to prevent hydatidosis? 1: Yes 2: No
4.35. Have you received any training on preventing echinococcosis? 1: Yes 2: No
4.36. What measures do you take to prevent the spread of cystic echinococcosis on your farm? (Specify):
1: Regular deworming of dogs
2: Avoid feeding dogs contaminated offal
3: Proper disposal of infected organs
4: Adequate management of stray dogs
5: Public awareness and education
4.37. What do you suggest to improve human and animal health care?
1: Regular human and veterinary check-ups

2: Proper handling of cattle and other farm animals

3: Safe slaughter practices and waste management

4: Enhanced veterinary service

5: Washing your hands properly with clean water and soap before and after meals.

ANNEX 14: Questionnaire format (Tigrigna version):

ሓፈሻዊ መሕተቲ

ክልል: ______________________ዞባ___________________________ወረዳ _______________
ስም ናይቲ መሕረዲ እንስሳ: ______ናሙና ዝተወሰደሉ ዕለት: __________ቁጽሪ ኮድ: ______________
ኣድራሻ፡ ቴለፎን: ________________ ኢመይል: ____

1. **ዲሞግራፊካዊ መረዳእታ**

1.1. ዕድመ

1: ካብ 6-15 ዓመት 2: ካብ 16-25ዓመት

3: ካብ 26-45ዓመት 4: ካብ 46-60 ዓመት 5: ካብ 60 ዓመት ልዕሊኡን

1.2. ጾታ? 1: ተባዕታይ 2: ኣንስተይቲ
1.3. ኩነታት ሓዳር? 1: በዓል ሓዳር 2: ዘይተመርዓዉ
1.4. ሃይማኖት**:** 1: ክርስትያን 2: እስልምና 3: ካልእ (ግለጽ):___________
1.5. ደረጃ ትምህርቲ 1: ዘይተማህረ 2: መባእታ (1-8)

3: ካልኣይ ደረጃ (9-12) 4: ዲፕሎማን ልዕሊኡን።

1.6. ናይ ሞያ ኩነታት

1: ሓረስታይ 2: ነጋዳይ 3: ጓሳ 4: ሰራሕተኛ መንግስቲ 5: ካልእ (ግለጽ):________

2. ሓፈሻዊ መአከቢ ናሙና ንከብትን ኣኽላባትን

2.1. ዕድመ ከብቲ? 1: ንእሽተይ 2: ዓብይ

2.2. ጾታ ከብቲ? 1: ተባዕታይ 2: ኣንስተይቲ

2.3. መበቆል ናይቲ ንሕርዲ ዝውዕል እንስሳ? 1: ከበሳ 2: ቆላ

2.4. ኩነታት ኣካላት ከብቲ? 1: ድኹም 2: ማእኸላይ 3: ፅቡቕ
2.5. ዕድመ ከልቢ? 1: ንእሽተይ 2: ዓብይ
2.6. ጾታ ከልቢ? 1: ተባዕታይ 2: ኣንስተይቲ
2.7. ምሕብሓብ ኣኽላባት? 1: ዝተዓጽወ 2: ተንቀሳቓሲ
2.8. ናይቲ ከልቢ ዓሌት? 1: ናይ ከባቢ ዓሌት 2: ናይ ወፃእ ዓሌት

3. ሕክምናዊ ታሪኽ (Medical History)

3.1. ብዛዕባ ሕማም ሃይዳቲድ (ሲስቲክ ኤቺኖኮኮሲስ) ሰሚዕኩም ትፈልጡ ዶ? 1: እወ 2: ኣይፋልን

3.2. ሕሉፍ ታሪኽ ሲኢ (CE) ወይ ካልእ ጵግዕተኛ ረኽሲታት? 1: እወ 2: ኣይፋልን
3.3. ቅድሚ ሕጂ ን CE ዝኾነ ሕክምና ጌርኩም ዶ? 1: እወ 2: ኣይፋልን
3.4. እዋናዊ ምልክታት? 1: ቃንዛ ከብዲ 2: ምሕንካስ/ምፍሳስ 3: ክብደት ሰብነት ምጉዳል 4: ምልክታት ዘይብሎም 5: ካልኦት ምልክታት: ___________________
3.5. ንውሓት ግዜ ምልክታት? 1: ትሕቲ 6 ወርሒ 2: ካብ 6 ወርሒ ክሳብ 1 ዓመት 3: ልዕሊ 1 ዓመት
3.6. እቲ ሕማም ዘለዎም ሰባት ትፈልጡ ዶ? 1: እወ 2: ኣይፋልን
3.7. ዓቐን (ውጽኢት ኣልትራሰውንድ)? 1: ትሕቲ < 5 ሴንቲ ሜተር 2: ኣብ መንጎ 5-10 ሴንቲ ሜትር 3: ካብ 10 ሴንቲ ሜተር ዝዓቢ
3.8. CE ደረጃ (WHO ምደባ)? 1: CE1 2: CE2 3: CE3a 4: CE3b 5: CE4 6: CE5
3.9. ኣናቶሚካዊ ቦታ CE? 1: ጸላም ከብዲ 2: ሳንቡእ 3: ካልእ ግለጽ__________________

4. ሓደጋ ዘስዕቡ (Risk Factors)

4.1. ኣብ ውሽጣዊ ኣካላት ናይ ዝተሓረዳ ጥሪት ሃይድቲድ ሲስት (hydatid cyst) ርኢኹም ዶ? 1: እወ 2: ኣይፋልን

4.2. ኣብ ገዛኻ ዲኻ ከብቲ ትሓርድ? 1: እወ 2: ኣይፋልን

4.3. ዓይነት መሕረዲ ከብቲ? 1: ሕጋዊ መሕረዲ ቤት 2: ዘይሕጋዊ: ኣብ ከቢብካ (መሕረዲ ቤት)

4.4. ኩለን ከብቲ መድሃኒት ወሲዶም ድዮም? 1: እወ 2: ኣይፋልን።

4.5. ንሕቶ 4.4 እወ ኢልካ እንተመሊስካ፡ ክንደይ ግዜ ኣብ ገዛኻ ከብቲ ትሓርድ? 1: ሳሕቲ 2: ሓሓሊፉ 3: ብስሩዕ
4.6. ንኣኽላባት ዝኸውን ፍሉይ መንበሪ ኣለካ ድዩ? 1: እወ 2: ኣይፋልን
4.7. ኣኽላባት ንዓኻ ወይ ንኻልኦት እንስሳታት ሓደጋ ጥዕና ኣለዎም ዶ ትብል? 1: እወ 2: ኣይፋልን
4.8. ንኣኽላባት ዝተኸልከለ ስጋ ትምግቦም ዲኻ? 1: እወ 2: ኣይፋልን
4.9. ዓይነት ኩነታት መነባብሮ ኣኽላባት? 1: ዝተገደበ (ዋንነት ኣለዎም) 2: ዋንነት ዘይብሎም
4.10. ኣኽላባትኻ መድሃኒት ወሲዶም ድዮም? 1: እወ 2: ኣይፋልን።
4.11. ኣብቲ ቦታ መሕረዲ ዝተለኽፉ ኣካላት እንስሳ ምድርባይ? 1: እወ 2: ኣይፋልን
4.12. ኣኽላባትካ ትትንክፎም ዲኻ?1: እወ 2: ኣይፋልን
4.13. ንሕቶ 4.12. እወ ኢልካ እንተመሊስካ፡ ብድሕሪኡ ኣእዳውካ ትሕጸብ ዲኻ? 1: እወ 2: ኣይፋልን
4.14. ዝኾነ ኣባል ስድራቤትካ ኣለዎ ድዩ ምስ ከልብኻ ብቐረባ ርክብ ምግባር? 1: እወ 2: ኣይፋልን
4.15. ቅድሚ ምብላዕካ ኣሕምልቲ ምሕጻብ ፈጺምካ ዲኻ? 1: እወ 2: ኣይፋልን
4.16. ቅድሚ ምብላዕካ ኢድካ ትሕጸብ ዲኻ? 1: እወ 2: ኣይፋልን
4.17. ኣብቲ ከባቢ ሽቓቕ ኣለካ ድዩ? 1: እወ 2: ኣይፋልን
4.18. ምንጪ ማይ ምስ ናትካ ጥሪትን ኣኽላባትን ትካፈል ዲኻ? 1: እወ 2: ኣይፋልን
4.19. ጥረ ወይ ዘይበሰለ ስጋ ትበልዕ ዲኻ? 1: እወ 2: ኣይፋልን
4.20. ንከልብኻ ብስሩዕ ትሕክሞ ዲኻ? 1: እወ 2: ኣይፋልን
4.21. ንሕቶ 4.20 እወ እንተኾይኑ ዝሃብካዮ መልሲ: ንከልብኻ እንታይ ዓይነት ሕክምና ትህቦ?

1: ባህላዊ መድሃኒታት 2: ጸረ-ሄልሚንቲክ 3: ኩሉም ኣይኮኑን 4: ካልእ (ግለጽ): ___________

4.22. ክንደይ ግዜ ኢኻ ሕክምና ከልቢ ዝተውሃበ? 1: ኣብ ዓመት ሓደ ግዜ 2: ኣብ ዓመት ክልተ ግዜ 3: ፈጺመ ኣይሃብኩን 4: ካልእ (ግለጽ): ________________________

4.23. እዚ ሕማም ብኸመይ ከም ዝመሓላለፍ ትፈልጡ ዶ? 1:እወ 2: ኣይፋልን

4.24. ሕቶ 4.23 እወ እንተኾይኑ ከመይ?1: ብሓሰኻ 2: ብእንስሳታት 3: ካብ ኣምላኽ 4: ብጥንቆላ ስራሕ

4.25. ሕቶ 3.24 እወ እንተኾይኑ በየናይ ዓይነት እንስሳ ድዩ? 1: ጥሪት 2: ኣኽላባት 3: እንስሳ ዘገዳም 4: ኣዕዋፍ

4.26. እዚ ሕማም ካብ ኣኽላባት ናብ ሰብ ከም ዝመሓላለፍ ትፈልጡ ዶ?1: እወ 2: ኣይፋልን

4.27. ጥሪትካ ኣብ ዝሓመማሉ እዋን ናይ እንስሳታት መድሃኒት ይወስዳ ድየን?1: እወ 2: ኣይፋልን

4.28. ብኣግኡ ምርመራ ምግባር ነቲ ሕክምናን ውጽኢትን ዘመሓይሽ ዶ ይመስለካ? 1: እወ 2: ኣይፋልን

4.29. እቲ ሕማም ክፍወስ ዝኽእል ዶ ይመስለኩም? 1: ይሰማማዕ 2: ኣይሰማማዕን 3: ገለልተኛ

4.30. ሰገራ ኣኽላባት ብግቡእ ተደርብዩ ድዩ?1: እወ 2: ኣይፋልን

4.31. ንሰገራ ከልቢ ብጥራሕ ኢድካ ትሕዞ ዲኻ? 1: እወ 2: ኣይፋልን

4.32. ግቡእ መጉሓፍ ጎሓፍ ኣለካ ድዩ? 1: እወ 2: ኣይፋልን

4.33. ንኣሰራርሓ ምሕደራ ጎሓፍካ ብኸመይ ትመዝኖ? 1: ድኹም 2: ጽቡቕ 3: ብሉጽ 4: ዘይፍለጥ

4.34. ምክልኻል ሃይድቲዶሲስ ይከኣል ድዩ? 1: እወ 2: ኣይፋልን

4.35. ብዛዕባ ምክልኻል ኤቺኖኮኮሲስ ዝኾነ ስልጠና ወሲድኩም ዶ? 1: እወ 2: ኣይፋልን።

4.36. ሲስቲክ ኢቺኖኮኮሲስ ንኸይዝርጋሕ ኣብ ምፍራይ ቦታ እንታይ ስጉምትታት እንተዝውሰድ ትብል? ግለጽ

A: ስሩዕ ምውጋድ መትሎ ኣኽላባት

B: ንኣኽላባት ዝተበከለ ስጋ ካብ ምምጋብ ኣውግድ

C: ዝተለኽፉ ኣካላት ብግቡእ ምጉሓፍ

D: እኹል ምሕደራ ተንቀሳቓሲ ኣኽላባት

E: ኣፍልጦ ምሃብ ን ህዝብ ምስ ትምህርትን

4.37. እንታይ ሓሳብ ኢኻ ትህብ ንምምሕያሽ ክንክን ጥዕና ሰብን እንስሳታትን?

A: ስሩዕ ናይ ሰብን እንስሳን ምርመራታት።

B: ግቡእ ኣተሓሕዛ ከብትን ካልኦት ናይ ሕርሻ እንስሳታትን

C: ብኣገባብምሕራድንፅቡቅምሕደራጎሓፍን ምፍፃም።

D: ዝተመሓየሸ ኣገልግሎት ሕክምና እንስሳታት ምሃብ።

E: ቅድሚ ምግቢን ድሕሪ ምግቢን ኣእዳውና ብጽሩይ ማይን ሳሙናን ብግቡእ ምሕጻብ።

ANNEX 15: Parasitological Images:

Images of hydatid cysts obtained
during postmortem inspection at Abergelle abattoir



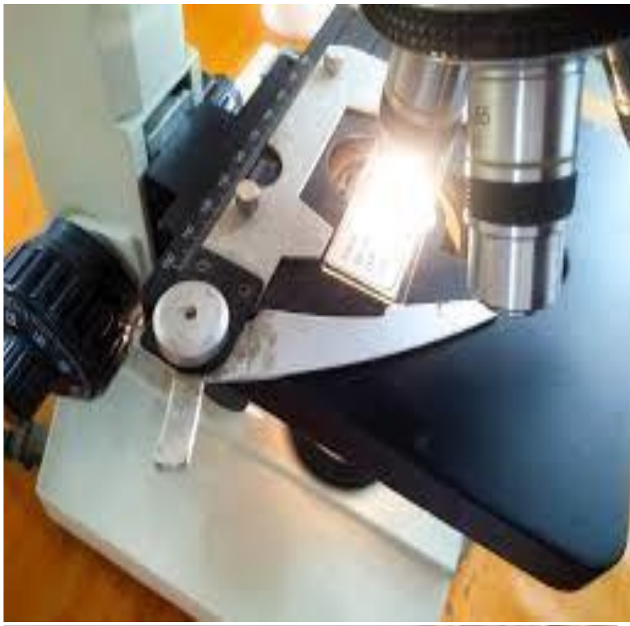


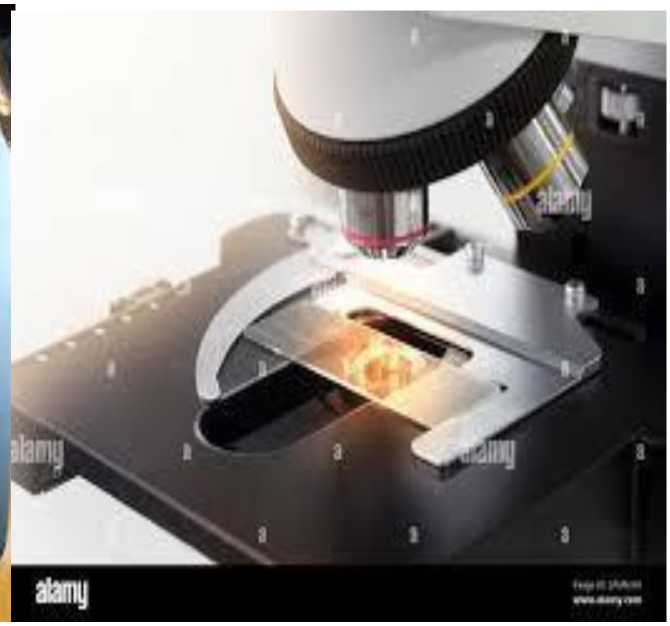
Lab equipment

Flotation Solution($ZnSO_4$)

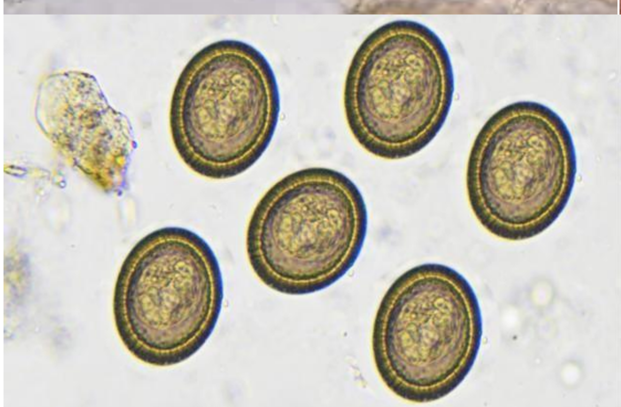
Eosin solution

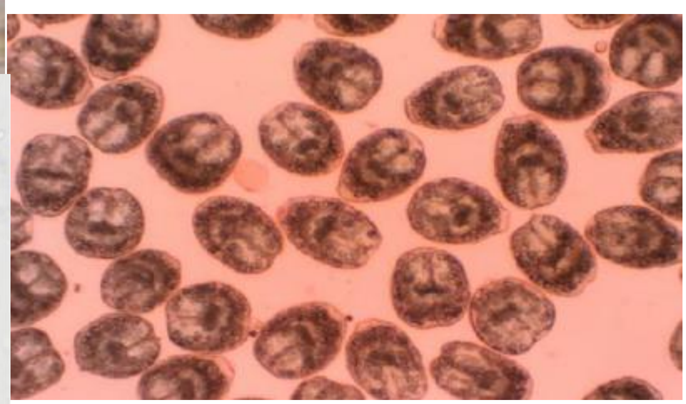
(Essential laboratory chemicals used during the study)





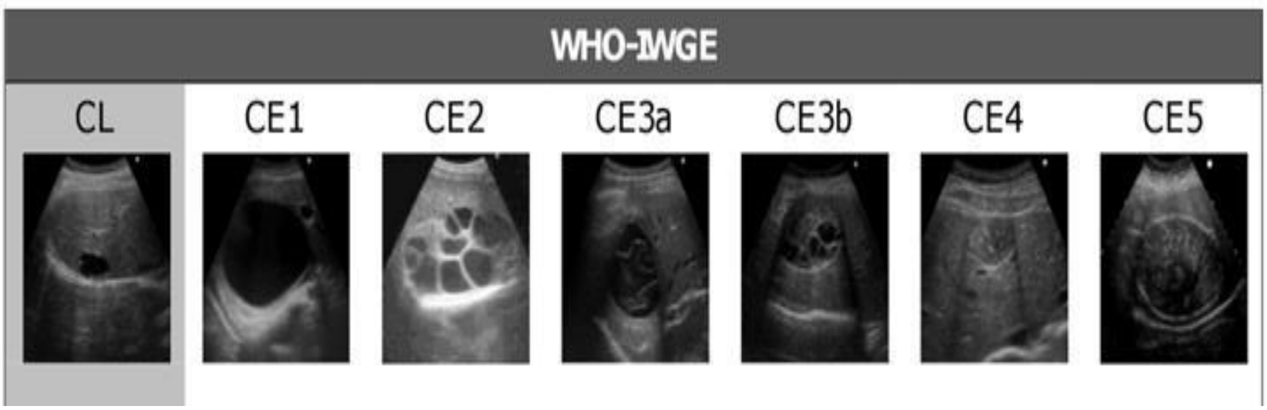
Taenia spp. eggs (40x) from dog feces, showing thick, radially striated wall and central oncosphere.



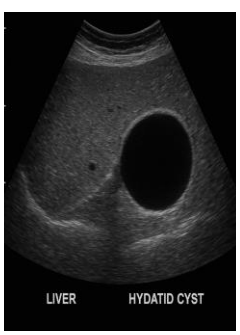


Live protoscolex of hydatid cysts (0.1% eosin stained)

Figure 4: WHO-IWGE ultrasound classification of echinococcal cysts. CE1 and CE2 (active cysts), CE3A and CE3B (transitional cysts), and CE4 and CE5 (inactive cysts):



Source: Long-term Sonographic and Serological Follow-up of Inactive Echinococcal Cysts of the Liver: Hintsfora ''Watch-and-Wait' 'Approach (38).



(A 45-year-old male from Semien had a small,

inactive liver hydatid cyst (CE4)) Ultrasonographic image of a human