Parasite Epidemiology and Control 25 (2024) e00355

Contents lists available at ScienceDirect

Parasite Epidemiology and Control

journal homepage: www.elsevier.com/locate/parepi

Epidemiological study on bovine cystic echinococcosis: Abattoir survey, cyst characterization and its economic impact at Mekaneyesuse municipality abattoir, Northwest Ethiopia

Belete Sendekie [a,b], Beyenech Gebeyehu [b], Abebe Mihret [b], Tesfu Kassa [c], Nigatu Kebede [c,*]

[a] Amhara Livestock Resource Development, South Gondar Zone, Amhara National Regional State, Ethiopia
[b] Department of Veterinary Medicine, Bahir Dar University, Bahir Dar, Ethiopia
[c] Aklilu Lemma Institute of Pathobiology, Addis Ababa University, Addis Ababa, P.O.Box 1176, Ethiopia

ARTICLE INFO

Keywords:
Cattle
Cystic echinococcosis
Echinococcus granulosus s.l.
Risk factors
Epidemiology
Ethiopia

ABSTRACT

Cystic echinococcosis (CE) is a major medical and veterinary concern in the world. It is one of the significant diseases in livestock farming communities managed under extensive grazing system like Ethiopia. Domestic intermediate hosts are an important reservoir for the disease spread. A cross-sectional study was conducted to determine the occurrence and economic losses associated with CE in cattle slaughtered at Mekaneyesuse Municipality abattoir, South Gondor zone of Amhara Region, North West Ethiopia. Ante-mortem inspection, postmortem examinations of organs, hydatid cyst characterization and financial loss estimations were conducted. The study was conducted on 384 cattle. The involvement of different organs was as follows: lungs (46.09%), liver (45.22%), heart (6.09%), and kidneys (2.6%). Out of the total of 115 cysts observed, small cysts constituted 57.39%, medium-sized were 34.78%, and large cysts accounted for 7.83%. Of these 115 cysts, 53.9% were fertile which included both viable (29%) and non-viable (71%) cysts. Furthermore, 46.1% cysts were non fertile, 62.3% were sterile and 37.7% were calcified. Based on the origin of animal, the prevalence of hydatid cysts was recorded to be 31.25%, 24%, 22.05% and 14.25% in Tachgayent, Semada, Andabet and Estie district, respectively. Higher cyst occurrence was observed in animals with poor body condition (51.56%) followed by medium (13.7%) and good body condition scores (8.25%). The total annual economic loss due to the direct condemnation of organs and indirect losses were estimated to be 851,252.68 ETB ($16,061.06). This study revealed that CE is economically important disease at Mekaneyesuse, South Gondar Zone, Amhara Region, Northwest Ethiopia. A more comprehensive investigation is required on prevalence and genotyping of *Echinococcus granulosus s.l.* cysts is important also to identify and estimate the relative contribution of each species or genotype to the disease in this area. Moreover, efforts to enhance public awareness in the area should also be pursued.

1. Introduction

Cystic echinococcosis (CE), mainly caused by the metacestode of *Echinococcus granulosus* sensu lato (Vuitton et al., 2020), is one of

* Corresponding author.
E-mail address: nigatukebede@yahoo.com (N. Kebede).

https://doi.org/10.1016/j.parepi.2024.e00355
Received 11 December 2022; Received in revised form 25 April 2024; Accepted 29 April 2024
Available online 1 May 2024

the most common zoonotic diseases associated with huge economic losses and has great public health significance worldwide (Ahmadic and Meshkerhar, 2011; Romig et al., 2011; Akeberegn et al., 2017). The adult tapeworm in the definitive host is harmless unlike the hydatid cyst in the intermediate host animals that is responsible for huge economic and medical significance in infected hosts (Ibrahim, 2010). In some areas of the world where low levels have been reported previously, CE caused by *E. granulosus s.l.* is re-emerging due to favorable transmission conditions (Thompson and McManus, 2002; Torgerson and Budke, 2003; Zewdu et al., 2010). For example CE was reported re-emerged in Bulgaria, wales (Eckert et al., 2000; Moro and Schantz, 2009), Kazakhstan and the People's Republic of China (Eckert et al., 2000; Romig et al., 2006).

Causative agent of CE is the larval stage (metacestode) of *E. granulosus s.l.* Dogs are the usual definitive hosts, whereas a large number of mammalian species are intermediate hosts, including domestic ungulates (Adane and Guadu, 2014; Worku, 2017; Guduro and Desta, 2019) and man is dead end host (Romig et al., 2017; Vuitton et al., 2020). Intermediate host animals and man gets infected through ingestion of parasite eggs in contaminated food, water or soil, or after direct contact with animal hosts (Cook, 1989; Soulsby, 1982).The definitive hosts are infected through the consumption of viscera of intermediate hosts that contain the parasite larvae (WHO, 2021). *Echinococcus granulosus s.l.* infection is common in East and South Africa, Central and South America, South Eastern and Central Europe, Middle East, Russia and China. In many countries south of the Sahara and in Northern Africa occurrence of cystic echinococcosis also has been reported (Azlaf and Dakar, 2006; Assefa and Tesfay, 2014).CE is still common in cattle herding areas of the world and is a public health problem in Mediterranean, Middle East, Asia, South America and Africa, including Ethiopia (Hagos et al., 2006; Romig et al., 2015; Ben-Shimol et al., 2016; De Nguyen et al., 2020; Vaidya et al., 2018).

Different studies in East Africa have reported varying prevalence rates of CE in cattle (25.8%), sheep (16.5%) and goats (10.8%) of Maasailand, southern Kenya (Addy et al., 2012). In Uganda, goats showed a prevalence of 33.33%, and sheep had a prevalence of 42.5% (Nyero et al., 2015). The overall prevalence in Tanzania was reported as 47.9% (Ernest et al., 2009). In Ethiopia, cystic echinococcosis is recognized and documented since the 1970s and it is one of the major causes of organ condemnation in most abattoirs and leads to huge economic losses (Kebede et al., 2009a, 2009b; Getaw et al., 2010; Fromsa and Jobre, 2011 and Hossein et al., 2014). It is potentially a zoonotic parasite in areas where cattle, sheep, and goats are still slaughtered traditionally and offal is easily available to scavenging dogs and other wild carnivores. Furthermore, absence of proper meat inspection, poor management of food animals, traditional practices of backyard farming system, backyard slaughtering, lack of sufficient awareness about food-borne diseases, and presence of large stray dog population are believed to contribute significantly to the prevalence of the disease in Ethiopia (Kebede et al., 2009a, 2009b; Akeberegn et al., 2017; Belachew et al., 2019).

The major economic impacts associated with cystic echinococcosis in food-producing animals are reduction in carcass weight, milk production, fleece and wool value, fertility, hide value, birth rate and fecundity, delayed performance and growth, condemnation of organs, especially liver and lungs and costs for destruction of infected viscera (Otero-Abad and Torgerson, 2013; Singh et al., 2013). In Ethiopia from different parts of the country several reports indicated that CE is widespread in livestock (Weldegiorgis et al., 2008; Yetnayet, 2010; Fromsa and Jobre, 2011; Bezuayehu et al., 2014; Nuraddis et al., 2017; Akeberegn et al., 2017).

In Ethiopia, prior studies have revealed the prevalence of bovine hydatidiosis to be 6.5% in Debre Berhan (Nuraddis et al., 2017), 63.7% in Assela (Akeberegn et al., 2017), 22.1% in Tigray (Kebede et al., 2009a, 2009b), 52.5% in Adama (Mandefro et al., 2019), and 62.96% in the vicinity of Bale (Polydorou, 1981) municipal abattoirs. The absence of proper meat inspection procedures and the presence of large stray dog population are thought to contribute significantly to the prevalence of the disease in Ethiopia. Hence,

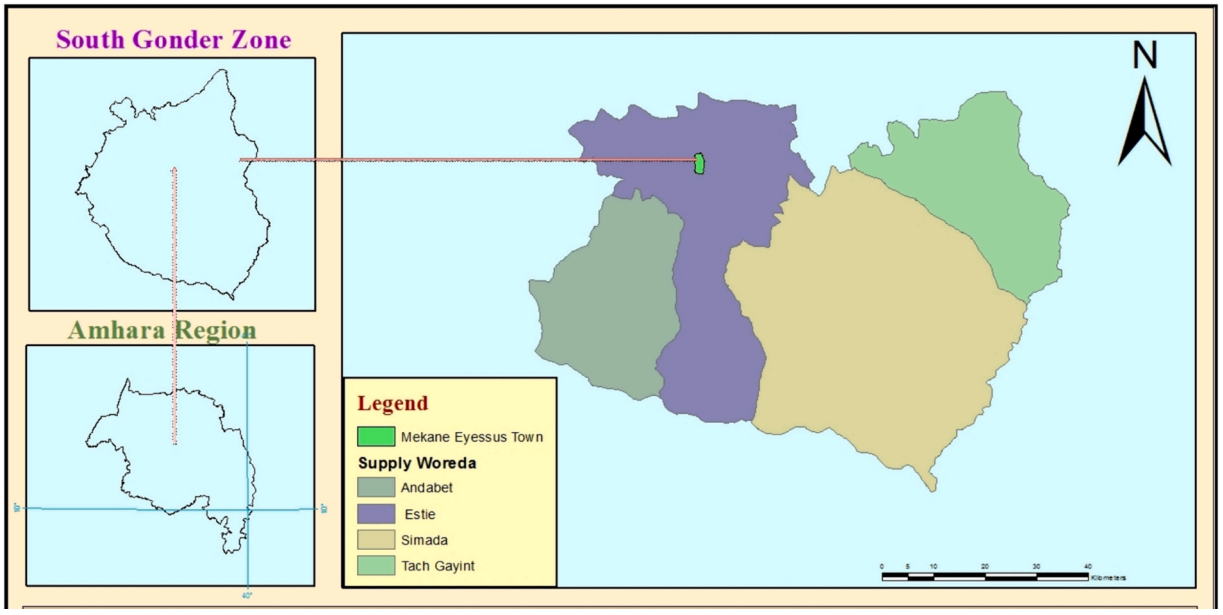

Fig. 1. Location of the study area.

obtaining baseline data concerning prevalence of cystic echinococcosis in cattle and associated economic loss would have paramount significance in justifying the need of an effective control scheme (Oku et al., 2004).Therefore, the aim of this study was to determine the occurrence in animals, cyst characterization and to estimate economic losses of cystic echinococcosis in cattle slaughtered at Mekaneyesuse municipality abattoir, Northwest Ethiopia.

2. Materials and methods

2.1. Study area

This study was conducted at Mekaneyesuse municipality abattoir which is found in Amhara region south Gondar zone and located in North West part of Ethiopia at about 706 Kilometers from Addis Ababa, and its location is 11° 24' North Latitude and 37° 57′ East Longitude with an altitude elevation of 2400 m above sea level, and annual temperature range from 17 °C to 18.5 °C.The area is characterized by two seasons, the rainy season ranges from June to September and dry season from October to May (Fig. 1).

2.2. Study animals

The study was undertaken on local breeds of cattle brought from different districts such as Estie, Andabet, Semada and Tachgayent to slaughter at Mekaneyesuse municipality abattoir.

2.3. Sample size determination and sampling strategy

A total of 384 animals were examined. Systematic random sampling technique was used to identify study animals from those registered for slaughter. Due to the absence of previous study on bovine cystic echinococcosis in the study area, sample size for this study was determined using the formula described by Thrusfield (2007), with the assumption of 50% expected prevalence, and desired precision level 5% and 95% confidence level.

The formula $n = \frac{1.962\ \mathrm{p}\ exp.(1 - \mathrm{p}\ exp)}{\mathrm{d2}}$ was used.

where

n = number of animals to be sampled

P exp = expected prevalence

d = desired absolute precision

Accordingly, the minimum sample size required was 384.

2.4. Study design and methodology

2.4.1. Study design

A cross sectional survey was conducted from December 2020 to April 2021 at Mekaneyesuse municipality abattoir. Both ante-mortem and postmortem inspection were conducted.

2.4.2. Ante-morteminspection

During ante-mortem inspection individual animal origin, body condition, age and health status were noted. Each animal was given a code number for identification and age estimation was conducted according to Lahunta and Habel (1986). Those cattle less than or equal to five years of age were grouped under adult and those cattle greater than five years were categorized as old (Pasquini and Spurgeon, 2003). Body condition scoring was made into three categories as lean/poor (Score 1, 2 and 3), medium (score 4, 5 and 6), and fat/good (7, 8 and 9), according to Nicholson and Butterworth (1986).

2.4.3. Postmortem inspection

Postmortem inspection was carried out according to the procedures recommended by food and agricultural organization (FAO, 2003). During post mortem inspection lung, liver, heart and kidney were inspected, palpated and incised. The number of hydatid cysts found per organ and per animal was recorded. Hydatid cysts were transported in ice box to Andabet veterinary clinic laboratory for further laboratory examination to determine the fertility and viability of the collected hydatid cysts.

2.4.4. Characterization of hydatid cysts

The size of the diameter of collected hydatid cysts were measured and classified as small (Diameter <5 cm), medium (Diameter between 5 cm and 10 cm) and large (Diameter >10 cm) (Oostburg et al., 2000, Daryani et al., 2007, Kebede et al., 2009a, 2009b, Kumsa and Mohammedzein, 2012).

Gross examination of individual cyst for any evidence of degeneration and calcification was made. *Fertility* and *viability* test was also conducted on the collected cysts. Individual hydatid cyst was carefully incised and the content poured in to a clean glass Petri dish and examined under a microscope (40×) for the presence of protoscolices, which if present, seen as white dots on the germinal epithelium

or brood capsule or hydatid sands within the suspension; such cysts were characterized as fertile cysts. Then the fertile cysts were further subjected to viability test. A drop of the sediment containing the protoscolices was placed on the microscope glass slide and a drop of 0.1% aqueous eosin solution was added to equal volume of hydatid fluid on the microscope slide and then covered with cover slip and observed under microscope (40×) with the principle that viable protoscolices should completely or partially exclude the dye while the dead (nonviable) ones absorb it (Daniel, 1995). Moreover, infertile cysts were further classified as sterile or calcified. Sterile hydatid cysts were characterized by their smooth inner lining usually with slightly turbid fluid in their content. Typically calcified cysts produce a gritty-sound heard at incision (Soulsby, 1982).

2.5. Financial loss estimation

Direct and indirect losses were the basis for the estimation of the annual economic losses. Direct loss was calculated on the basis of condemned organs, whereas the indirect loss was estimated on the basis of live weight loss caused by cystic echinococcosis (Kebede et al., 2009a, 2009b; Kumsa and Mohammedzein, 2012, Getaw et al., 2010).

Direct loss was calculated as follows:

$$DL = (AS \times CLu \times PLu) + (AS \times CLi \times PLi) + (AS \times CKid \times PKid) + (AS \times CHr \times PHr)$$

where DL = direct losses associated with cystic echinococcosis, AS = estimated mean annual slaughter; CLu = local retail price of a lung; PLu = percent involvement of the lung;CLi = local retail price of a liver; PLi = percent involvement of the liver; CKid = local retail price of a kidney; PKid = percent involvement of the kidney; CHr = local retail price of a heart; PHr = percent involvement of the heart.

$$\text{Indirect losses (IL)} = 5\%NAS \times PH \times CPB \times 126\ \text{kg}$$

where 5% = A reduction of 5% in meat production due to cystic echinococcosis established by Polydorou (1981); NAS = average number of cattle slaughtered annually; PH = prevalence of cystic echinococcosis; CPB = current average price of 1 kg of beef at Mekaneyesuse; 126 kg is the dressed average carcass weight of adult Zebu cattle (Regassa et al., 2010).

$$\text{Total economic loss (TL)}$$

The total economic loss can be evaluated by considering both DL and IL as follows:

$$TL = DL + IL$$

3. Results

3.1. Occurrence of bovine cystic echinococcosis in slaughtered animals

The overall prevalence of cystic echinococcosis among cattle slaughtered and examined at Mekaneyesuse municipality abattoir was found to be 18.5% (71/384). There was no significant association ($P > 0.05$) in hydatid cyst prevalence and risk factors such as breed and sex of cattle. However, significant association was observed among age, body condition and origin of cattle ($P < 0.05$).Cyst occurrence was recorded (31.25%) in old and (9.4%) adult age group of cattle. Higher cyst occurrence was recorded in cattle with poor (51.56%) followed by medium (13.7%) and good body condition scores (8.25%).Based on the origin of cattle, hydatid cyst occurrence

Table 1
Occurrence of bovine cystic echinococcosis on the basis of breed, sex, age, body condition and origin at Mekaneyesuse municipal abattoir.

Variables	Categories	No. examined	No. +ve	Prev %	*p*-value	Chi-square($\chi 2$)
Breed	Local	350	64	18.28		
	Cross	34	7	20.58		
	Total	384	71	18.5	0.373	0.793
Sex	Male	281	51	19.4		
	Female	103	20	18.14	0.419	0.734
	Total	384	71	18.5		
Age	Adult	224	21	9.4	0.00*	27.343
	Old	160	50	31.25		
	Total	384	71	18.5		
Body condition	Poor	64	33	51.56	0.00*	56.540
	Medium	211	29	13.7		
	Good	109	9	8.25		
	Total	384	71	18.5		
Origin	Estie	230	33	14.35	0.029*	9.05
	Andabet	68	15	22.05		
	Semada	54	13	24		
	Tachgayent	32	10	31.25		
	Total	384	71	18.5		

* indicate significant variable.

was 31.25% in Tachgayent, 24% in Semada, 22.05% in Andabet and 14.25% in Estie (Table 1).

In majority of animals harboring hydatid cyst, the cysts had the tendency to be located more in lungs and liver than in other organs such as heart and kidneys (Table 2).

3.2. Distribution, intensity and size of hydatid cysts

The involvement of lung, liver, heart, and kidney was found to be 46.09%, 45.22%, 6.09%, and 2.6%, respectively. From the total of 115 cysts counted, 57.39% (66), 34.78% (40) and 7.83% (9) were small, medium, and large, respectively (Table 3).

3.3. Characterization of hydatid cyst

From 115 hydatid cysts, 62(53.9%) of them were fertile, and 53(46.1%) were infertile; out the fertile cysts, 18 (29%) were viable and 44 (71%) non-viable; again, among the infertile, 33 (62.3%) sterile and 20 (37.7%) calcified (Table 4).

3.4. Economic losses

From the total of 384 cattle examined, 71 (18.5%) were found harboring hydatid cysts. Among them, 53 (20%), 52 (4.52%), 7 (0.32%) and 3(0.98%) of the hydatid cysts were located in the lungs, liver, heart and kidneys, respectively. The overall occurrence of cystic echinococcosis and percentage involvement of lung, liver, heart and kidney were used as input to estimate the financial loss attributable to organs condemned in the present study.

In Mekaneyesus town average market price of cattle lung, liver, kidney, heart, and a kilogram of beef was found to be 20, 20, 25, 30, and 240 Ethiopian Birr (ETB) respectively. The mean annual numbers of cattle slaughtered at Mekaneyesuse municipal abattoir during the last two years was 2830, and the overall occurrence of cystic echinococcosis was found 71/384(18.5%) during the study period. Hence, direct financial losses due to condemnation of organs and indirect financial losses due to carcass weight loss were calculated as follows on annual basis.

$\mathrm{DL} = (\mathrm{AS} \times \mathrm{PLu} \times \mathrm{CLu}) + (\mathrm{AS} \times \mathrm{PLi} \times \mathrm{CLi}) + (\mathrm{AS} \times \mathrm{PKid} \times \mathrm{CKid}) + (\mathrm{AS} \times \mathrm{PHr} \times \mathrm{CHr})\ (2830 \times 20 \times 0.481) + (2830 \times 20 \times 0.3924) + (2830 \times 25 \times 0.038) + (2830 \times 30 \times 0.0886).\mathrm{DL} = 27,224.6 + 22,209.84 + 2688.5 + 7522.14 = \underline{59,645.08\mathrm{ETB}}.$

where DL = direct losses associated with cystic echinococcosis, AS = estimated mean annual slaughter; PLu = percent involvement of the lung; CLu = local retail price of a lung; PLi = percent involvement of the liver; CLi = local retail price of a liver; PKid = percent involvement of the kidney; CKid = local retail price of a kidney; PHr = percent involvement of the heart; CHr = local retail price of a heart.

$\text{Indirect losses (IL)} = 5\%\mathrm{NAS} \times \mathrm{PH} \times \mathrm{CPB} \times 126\ \mathrm{kg}\ (0.05 \times 2830 \times 0.185 \times 240 \times 126) = \underline{791,607.6\mathrm{ETB}\ (\$14,935.99)}.$

where 5% = A reduction of 5% in meat production due to cystic echinococcosis; NAS = average number of cattle slaughtered annually; PH = prevalence of cystic echinococcosis; CPB = current average price of 1 kg of beef at Mekaneyesuse; 126 kg is the dressed average carcass weight of adult cattle.

Total economic loss (TL)

The total economic loss can be evaluated by considering both DL and IL as follows:

$\mathrm{TL} = \mathrm{DL} + \mathrm{IL}\ (59,645.08 + 791,607.6) = \underline{851,252.68\ \mathrm{ETB}\ (16,061.3\mathrm{USD})}.$

(Table 5)

Table 2
Hydatid cyst infected organs in relation to breed, sex, age, body condition and origin at Mekaneyesuse municipal abattoir.

Variables	Categories	Lung	Liver	Heart kidney	Lung & liver	Lung & Heart	Liver & heart	Total
Breed	Local	35	20	6 3	4	2	1	71
	Cross	3	3	1 0	1	0	0	8
Sex	Male	24	19	7 1	4	2	1	58
	Female	14	4	0 2	1	0	0	21
Age	Adult	8	10	2 1	1	1	1	24
	Old	30	13	5 2	4	1	0	55
Body condition	Poor	22	9	0 2	3	0	0	36
	Medium	13	11	4 1	1	2	1	33
	Good	3	3	3 0	1	0	0	10
Origin	Estie	17	11	3 2	3	1	0	37
	Andabet	9	3	2 1	1	0	0	16
	Semada	6	5	2 0	1	1	1	16
	Tachgayent	6	4	0 0	0	0	0	10

Table 3
Number and size of bovine hydatid cysts observed in different organs at Mekaneyesuse municipal abattoir.

Organ	Large		Medium		Small		Total count	
	No	%	No	%	No	%	No	%
Lung	6	11.32	19	35.85	28	52.83	53	46.09
Liver	3	5.77	20	38.46	29	55.77	52	45.22
Heart	0	0	1	14.29	6	85.71	7	6.09
Kidney	0	0	0	0	3	100	3	2.6
Total	9	7.83	40	34.78	66	57.39	115	100

Table 4
Bovine hydatid cyst fertility and viability in different organs at Mekaneyesuse at municipal abattoir.

Organ	Fertility 62(53.9%)		Non fertility 53(46.1%)		Total
	Viability	non Viability	Sterile	Calcified	
Lung	8	28	4	13	53
Liver	10	13	22	7	52
Heart	0	3	4	0	7
Kidney	0	0	3	0	3
Total	18(29%)	44(71%)	33(62.3%)	20(37.7%)	115

4. Discussion

The overall occurrence of cystic echinococcosis in cattle slaughtered in Mekaneyesuse municipal abattoir during the study period was 18.5%. This CE prevalence aligns with the results reported by Kebede et al. (2009a, 2009b) who found a prevalence of 16% in Wolita Sodo, Assefa and Tesfay (2014) with 18.61% in Adigrat, as well as Alebie et al. (2016) with a prevalence of 17.97% in Debrezeit. The present CE prevalence was greater than the previous works reported by Bezuayehu et al. (2014)11.3% in Harar; Ochi et al. (2016) 3.99% in Juba, South Sudan; Abera and Teklebran (2017) 11.21% in Wolayta; Akeberegn et al. (2017) 6.5% in Debre Berhan. However, the current finding was lower than the findings of Kebede et al. (2009a, 2009b)34.5% in Bahir Dar, 52.69% Regassa et al. (2010) 52.69% in Hawassa, Nuraddis et al. (2017) 63.7% in Asella, Kebede and Mekonnen (2020)) 40.2% in Dodola. In a recent systematic review in the horn of Africa by Aregawi et al. (2024) reported prevalence ranges of CE in cattle 0.9–25.8% in Kenya, 3.9% in South Sudan, 2.5–6.1% in Sudan and 1.6–48.7% between 2000 and 2022.

The lower occurrence of hydatid cyst in the present study might be due to poor visualization facilities where there is frequent interruption of power, inspection conducted in poor light or not at all due to darkness, that the haydatid cyst could pass the inspection unnoticed. Furthermore, backyard slaughter is practiced in the area reducing the number of animals brought to slaughter in the abattoir. During backyard slaughter infected organs are left unburied in the field accessed for dogs and other carnivores which favor the transmission cycle of cystic echinococcosis. The culture and tradition of inhabitants in the study area favor the keeping of dogs in periurban are as (urban and rural households) often in close association with the family and farm animals. Almost all cattle owners, shepherds and urban dwellers keep at least 1 dog to safeguard their properties from wild carnivores and thieves. These in the areas studied are considered to be conducive to the maintenance and further propagation of cystic echinococcosis (Kebede et al., 2010). This study indicated that there was no association in breed of animals and cystic echinococcosis infection rate. This may be due to indiscriminate exposure of animals to risk factors regardless of their sexes and breed. The management of cattle was the same regardless breed and age in an open range land subjected to equal chance of infection.

Higher infection of cystic echinococcosis was registered in old cattle (>5 years old) 31.5% compared to adult cattle (less than or equal to5 years) 9.4% with variable number of hydatid cysts observed among different organs examined. This is in line with the reports of Zewdu et al. (2010) 22.91% old and 6.78% adult; Mandefro et al. (2019) 66.1% old and 29.5% adult; Akeberegn et al. (2017) 8.71% old and 2.8% adult; Kebede and Mekonnen (2020) 43.4% old and 19.0%. The higher CE prevalence in older cattle than the younger ones might be due to the persistence prolonged exposure to *E. granulosus s.l.* eggs, the development of hydatid cysts and reduced immune status as a result of longer exposure time to the eggs of the parasite in old than younger cattle. Cattle with poor body condition

Table 5
Financial loss assessment in cattle due to cystic echinococcosis at Mekaneyesuse municipal abattoir during study period.

Organ	No of organ condemned	Price per organ		Total price (ETB)
Lung	38	48.1%	20	760
Liver	31	39.24%	20	620
Heart	7	3.86%	25	175
Kidney	3	3.8%	30	90
Total	79	100		1645

are highly infected followed by medium and good body conditions and this result is in agreement with the findings of Melaku et al. (2012) and Bezuayehu et al. (2014). Based on the origin of slaughtered cattle occurrence of bovine hydatid cyst was lower in Estie district compared to the other study districts due to the fact that the municipality of Estie district was frequently using strychnine poisoning to remove stray dogs in a program to reduce rabies outbreak in the district. This might have resulted in reducing contamination of pasture by stray dogs.

In the current study cystic echinococcosis was frequently encountered in the lungs, liver than heart and kidneys. This is explained by the fact that lungs and livers possess the first great capillaries sites encountered by the migrating echinococcusoncosphere (hexacanth embryo) which adopt the portal vein route and primarily negotiate hepatic and pulmonary filtering system sequentially before any other peripheral organ is involved (Kebede et al., 2009a, 2009b). In addition, the lungs were mostly affected than any other organ this is most probable due to the fact that ruminants are slaughtered at older age**.** During this period the liver capillaries are dilated and most cysts directly pass to the lungs. Additionally, it is possible for the hexacant embryo to enter the lymphatic circulation and be carried via the thoracic duct to the heart and lungs in such a way the lungs may be infected before or instead of the liver (Arene, 1985). This finding can also be explained by the species causing CE in cattle. Usually *E. ortleppi* which uses cattle as the main intermediate host, occurs predominantly as fertile cysts in cattle lungs (Romig et al., 2017). *E. ortleppi* is rare in Ethiopia but has been reported in pig, sheep and cattle (Tigre et al., 2016; Terefe et al., 2019; Aregawi et al., 2024).

In the current study the predominant size of the hydatid cysts was seen to be small. The high proportion of small cysts may indicate late infection of the animals due to immunological response of the host which might preclude expansion of cyst size. The fertility rate of cysts was higher in lungs than liver due to softer consistency of lung tissue which allows easier development of the cysts and favors their fertility rate (Getaw et al., 2010).

The economic loss due to cystic echinococcosis in the current study was the sum of direct economic loss, the loss associated with condemned organs and the indirect economic loss that is the loss associated with reduced carcass weight. The total annual economic loss was estimated to be 851,252.68 ETB ($16,061) which is important to establish a health center in one district. The indirect economic loss in this study was significantly higher than direct economic loss indicating the widespread nature of hydatid cyst and moderate degree of livestock infestation rate in Mekaneyesuse town. Backyard slaughter, poor veterinary services, resistance to the commonly used anthelmintics (Schantz et al., 1982; Enrico Brunetti, 2023), the abundant nature of stray dogs, and wandering of animals in an open pasture allowing contact with dogs might be associated as major reasons for the exaggerated economic loss documented in the current study.

Different economic losses regarding bovine cystic echinococcosis were also reported from different parts of Ethiopia (Zewdu et al., 2010), 160,000.00 ETB at Ambo Municipal abattoir (Terefe et al., 2012), 19,847,704.50 ETB at Addis Ababa abattoirs enterprise *(*Bizuwork et al., 2013), 920,378 ETB at Debra Tabor Municipal abattoir (Nasr and Pal, 2016), 1,848,849.765ETB at Kombolcha abattoir; (Hussen et al., 2017), 12,590.00ETB at Shashemene Municipal abattoir and Mandefro et al. (2019) reported an annual total loss of 894,505.612 ETB at Adama Municipal abattoir. These differences in various abattoirs or regions may be due to variation in the occurrence of the disease, mean annual slaughtered cattle in different abattoirs and differences in the retail market price of liver, lungs, heart, kidneys and beef.

5. Conclusion

In conclusion the present study showed bovine cystic echinococcosis to be moderately widespread disease in Mekaneyesuse town and surrounding districts. The overall prevalence of the disease in this study area was 18.5%. Lung and liver were the major organs harboring hydatid cyst than other visceral organs and most of the cysts were found to be fertile. Among the study variables considered, age, body condition and origin of animals were identified as important risk factors for the occurrence of cystic echinococcosis in cattle. Furthermore, occurrence of fertile cysts in examined organs was high suggesting that cattle play an important role in the life cycle of this serious zoonosis and the presence of potential risks of transmission to other intermediate hosts. Moreover, the economic losses due to bovine cystic echinococcosis was estimated to be 851,252.68ETB ($16,061). Hence, cattle husbandry practice should be improved such as zero-grazing, establishment of policy on dog keeping and handling including registration, treatment and elimination of stray dogs, promoting construction of abattoirs with their appropriate disposal pits and conduct an obligatory meat inspection services and further detailed investigation into genetic characterization and the basic local epidemiological factors governing the spread of cystic echinococcosis in the region to establish regional control strategy are recommended.

Authors' contribution

All authors contributed to study design. BS, AM, NK and BG contributed to all parts of the study. NK and TK collaborated in the analysis and interpretation of data. BS, BG and NK collaborated in the manuscript writing and revision. All the authors commented on the drafts of the manuscript and approved the final version of the article.

Funding

This study was supported by Aklilu Lemma Institute of Pathobiology, Addis Ababa University.

Ethics approval and consent to participate

This study was approved by Bahir Dar University of College of Veterinary Medicine Ethics Committee.

Consent for publication

Not applicable.

CRediT authorship contribution statement

Belete Sendekie: Data curation, Formal analysis, Investigation, Methodology. **Beyenech Gebeyehu:** Conceptualization, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Abebe Mihret:** Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Tesfu Kassa:** Conceptualization, Formal analysis, Investigation, Methodology, Resources, Writing – review & editing. **Nigatu Kebede:** Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Resources, Writing – review & editing.

Declaration of competing interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Data availability

All data during study are included in this manuscript.

Acknowledgement

We want to express our great thanks to Addis Ababa University, Aklilu Lemma Institute of Pathobiology for funding this work. We are also grateful to the study participants. This paper is issued from MSc thesis of Belete Sendeke, MSc student of Veterinary Parasitology at Bahir Dar University.

References

Abera, A., Teklebran, T., 2017. Study on prevalence and cyst characterization of hydatidosis in cattle slaughtered at WolaytaSoddo municipal abattoir. Int. J. Res. Granthaalayah 5 (7), 60–78. https://doi.org/10.5281/zenodo.827202.
Adane, M., Guadu, T., 2014. Bovine Hydatidosis: occurrence, economic and public health importance in Gondar ELFORA abattoir. Eur. J. Appl. Sci. 6 (2), 11–19.
Addy, F., Alakonya, A., Wamae, N., Magambo, J., Mbae, C., Mulinge, E., Zeyhle, E., Wassermann, M., Kern, P., Roming, T., 2012. Prevalence and diversity of cystic echinococcosis in livestock in Maasailand, Kenya. Parasitol. Res. 111, 2289–2294.
Ahmadic, N., Meshkerhar, M., 2011. An abattoir- based study on the prevalence and economic losses due to cystic echinococcosis in slaughtered herbivores in Ahwaz, southwestern Iran. J. Helminthol. 85, 33–39.
Akeberegn, D., Alemneh, T., Kassa, T., 2017. The prevalence of bovine Hydatidosis among slaughtered cattle at DebreBerhan municipal abattoir, North Shewa Zone, Ethiopia. J. Veter. Sci. Med. 51, 5.
Alebie, M., Girma, K., Tilahun, Z., Tadele, K., Addisu, D., 2016. Prevalence of bovine Hydatidosis and its cyst characterization in DebreZeitElfora export abattoir, Oromia regional state, Ethiopia. NatSci 14, 87–93.
Aregawi, W., Levecke, B., Ashenafi, H., Byaruhanga, C., Kebede, N., Mulinge, E., Wassermann, M., Romig, T., Dorny, P., Dermauw, V., 2024. Epidemiology of Echinococcus granulosus sensu lato in the greater horn of Africa: A systematic review. PLoS Negl. Trop. Dis. 18, e0011894.
Arene, F.O.I., 1985. Prevalence of hydatidosis in domestic livestock in the Niger Delta. Trop. Anim. Hlth. Prod. 17, 3–4.
Assefa, A., Tesfay, H., 2014. Hydatidosis in cattle slaughtered at Adigrat municipal abattoir, Ethiopia. Int. J. Trop. Dis. Helminthol. 4, 52–61.
Azlaf, R., Dakar, A., 2006. Epidemiological study of cystic echinococcosis in Morocco. Vet. Parasitol. 137, 83–93.
Belachew, T., Abay, M., Gunse, T., 2019. Bovine hydatid cyst: prevalence, characterization, public health and economic importance at Adama abattoir, Central Ethiopia. Int. J. Vet. Sci. Res. 5 (1), 014–018.
Ben-Shimol, S., Sagi, O., Houri, O., Bazarsky, E., Berkowitz, A., Bulkowstein, S., Barrett, C., Greenberg, D., 2016. Cystic echinococcosis in Southern Israel. Acta parasitologica 6, 178–186.
Bezuayehu, L., Tsegalem, A., Befikadu, U., Ayalew, N., Abebe, A., 2014. Prevalence of bovine Hydatidosis and its economic significance in Harar municipality abattoir, eastern Ethiopia. Am. Eur. J. Sci. Res. 9 (5), 143–149.
Bizuwork, A., Kebede, N., Jibat, T., Tilahun, G., Kassa, T., 2013. Occurrences and financial significance of bovine cystic echinococcosis in southern Wollo, northeastern Ethiopia. J. Vet.Med. Anim. Hlth. 5, 51–56.
Brunetti, E., 2023. Echinococcosis Hydatid Cyst Medication. Updated Nov, 2023. https://emedicine.medscape.com/article/216432-medication?form=fpf. accessed on 4 March 2024.
Cook, B.R., 1989. The epidemiology of Echinococcus in Great Britain. Ann. Trop. Med. Parasitol. 83, 51–61.
Daniel, F., 1995. Economic Importance of Organ Condemnation due to Fasciolosis and Hydatidosis in Cattle and Sheep Slaughtered at Dire Dawa Abattoir, FVM, AAU, Debrezeit, Ethiopia.
Daryani, A., Alaei, R., Arab, R., Sharif, M., Dehghan, M.H., Ziaei, H., 2007. The prevalence, intensity and viability of hydatid cysts in slaugh-tered animals in the Ardabil Province of Northwest Iran. J. Helminthol. 81, 13–17.
De Nguyen, Van, Ngoc Minh, Pham, Van Duyet, Le, Ngoc Bich, Nguyen, Nam Son, Trinh, Jung, Bong-Kwang, Chai, Jong-Yil, 2020. Two Human Cases of Echinococcus ortleppi Infection in the Lung and Heart in Vietnam. Korean J Parasitol. 58 (4), 451–456.
Eckert, J., Conraths, F.J., Tackmann, K., 2000. Echinococcosis: an emerging or re-emerging zoonosis? Int J Parasitol. 30, 1283–1294.
Ernest, E.M., Nonga, H., Kassuku, A.A., Kazwala, R.R., 2009. Hydatidosis of slaughtered animals in Ngorongoro district of Arusha region, Tanzania. Trop. Anim. Hlth. Prod. 41, 1179–1185.
FAO, 2003. Diagnostic Manual on Meat Inspection for Developing Countries, 12–38.

Fromsa, A., Jobre, Y., 2011. Infection prevalence of hydatidosis (*Echinococcusgranulosus*, Batsch, 1786) in domestic animals in Ethiopia: a synthesis report of previous surveys. Ethiopian Vet. J. 15 (2), 11–33.
Getaw, A., Beyene, D., Ayana, D., Megersa, B., Abunna, F., 2010. Hydatidosis: prevalence and its economic importance in ruminants slaughtered at Adama municipal abattoir, Central Oromia, Ethiopia. Acta Trop. 113 (3), 221–225.
Guduro, G., Desta, A., 2019. Cyst viability and economic significance of Hydatidosis in southern Ethiopia. J. Parasi. Res. 2019, 7. Article ID 2038628.
Hagos, B., Mesfin, M., Abebe, B., 2006. Hydatid disease of the liver: A 12 year experience of surgical management. East Centr. Afri. J. Surg. 11, 54–60.
Hossein, M., Ebrahim, S., Dezaki, F., Kheirandish, B., Ezatpour, S., Jahanbakhsh, M., Fasihi, H., 2014. Scolicidal effects of black cumin seed (*Nigella sativa*) essential oil on HydatidCysts. Korean J. Parasitol. 52 (6), 653–659.
Hussen, A., Jelalu, K., Alemayehu, R., 2017. Prevalence, organ distribution, cyst viability and financial losses of bovine Hydatidosis in Shashemene municipal abattoir, Ethiopia. J. Sci. Sust. Dev. 5 (1), 57–71.
Ibrahim, M., 2010. Study of cystic echinococcosis in slaughtered animals in Al Baha region, Saudi Arabia: interaction between some biotic and abiotic factors. Acta Trop. 113, 26–33.
Kebede, T., Mekonnen, K., 2020. Prevalence and Economic Significance of Hydatidosis in Cattle Slaughtered at Dodola Municipality Abattoir,WestArsi Zone, Oromia, Ethiopia. Eur. J. Appl. Sci. 12 (4), 128–138.
Kebede, N., Mitiku, A., Tilahun, G., 2009a. Hydatidosis of slaughtered animals in Bahir Dar abattoir, Northwestern Ethiopia. Trop. Anim. Health Prod. 41 (1), 43–50.
Kebede, W., Hagos, A., Girma, Z., Lobago, F., 2009b. Echinococcosis/hydatidosis: its prevalence, economic and public health signifcance in Tigray region, North Ethiopia. Trop. Anim. Health Prod. 41 (6), 865–871.
Kebede, N., Mitiku, A., Tilahun, G., 2010. Retrospective survey of human hydatidosis in Bahir Dar, northwestern Ethiopia. EMHJ 16 (9), 937–941.
Kumsa, B., Mohammedzein, A., 2012. Prevalence, organ distribution, risk factors, and financial losses of hydatid cysts in sheep and goats slaughtered in restaurants in Jimma, south western Oromia. Comp. Clin. Pathol. 21 (5), 1–9.
Lahunta, A., Habel, R.E., 1986. Applied Veterinary Anatomy, 330pp. Cornell Univ, Ithaca, NY 14853, USA.
Mandefro, M., Tilahun, B., Bayu, Y., Zeryehun, T., 2019. Prevalence of bovine hydatidosis and its economic importance in Adama municipal abattoir, Eastern Ethiopia. Eth. Vet J. 23 (1), 24–41.
Melaku, A., Lukas, B., Bogale, B., 2012. Cyst viability, organ distribution and financial losses due to hydatidosis in cattle slaughtered at Dessie municipal abattoir, north-eastern Ethiopia. Vet. World 5, 213–218.
Moro, p., Schantez, P.M., 2009. Echinococcosis: a review. Int. J. Infect. Dis. 125–133.
Nasr, W., Pal, M., 2016. Prevalence, cyst viability, fertility and economic significance of bovine Hydatidosis in an abattoir at Kombolcha, Ethiopia. Haryana Vet. 55, 17–22.
Nicholson, M., Butterworth, M., 1986. A Guide to Condition Scoring of Zebu Cattle.International Livestock Centre for Africa. Addis Ababa.
Nuraddis, I., Aman, Y., Yosef, D., 2017. Prevalence and economic importance of bovine Hydatidosis at Asella municipal abattoir south eastern Ethiopia. Glob. Vet. 19, 491–499.
Nyero, D., Zirintunda, G., Ekou, J., 2015. Prevalence of Hydatid Cysts in Goats and Sheep Slaughtered in SorotiManucipal Abattoir, Eastern Uganda.
Ochi, E.B., Akol, D.A., Lukaw, Y.S., 2016. A review on epidemiology of Hydatidosis in livestock and humans in South Sudan. IJRSB 4 (10), 4–10.
Oku, R., Benavidezb, U., Carmonab, C., Kamiyac, H., 2004. Control program against hydatidosis and the prevalence in Uruguay. Int. Cong. 98–104.
Oostburg, B.F.J., Vrede, M.A., Bergen, A.E., 2000. The occurrence of polycystic echinococcosis in Suriname. Ann. Trop. Med. Parasitol. 94, 247–252.
Otero-Abad, B., Torgerson, P., 2013. A systematic review of the epidemiology of echinococcosis in domestic and wild animals. PLoS Negl. Trop. Dis. 7 (6), e2249.
Pasquini, S., Spurgeon, T., 2003. Anatomy of Domestic Animals: Systemic and Regional Approach, 10th ed. Sudz Publishing, USA.
Polydorou, K., 1981. Animal health and economics. Case study: echinococcosis with a reference to Cyprus (dog). Bull. In. Epis. 93 (5–3), 981–992.
Regassa, F., Molla, A., Bekele, J., 2010. Study on the prevalence of cystic hydatidosis and its economic significance in cattle slaughtered at Hawassa municipal abattoir, Ethiopia. Trop. Anim. Health Prod. 42, 977–984.
Romig, T., Dinkel, A., Mackenstedt, U., 2006. The present situation of echinococcosis in Europe. Parasitol Int. 55 (Suppl), S187–S191.
Romig, T., Omer, R.A., Zeyhle, E.T., Hüttnera, M., Dinkela, A., Siefert, L., 2011. Echinococcosis in sub-Saharan Africa: emerging complexity. Vet. Parasitol. 181, 43–47.
Romig, T., Ebi, D., Wassermann, M., 2015. Taxonomy and molecular epidemiology of Echinococcus granulosus sensu lato. V. et Parasitol. 213 (3-4), 76–84.
Romig, T., Deplazes, P., Jenkins, D., Giraudoux, P., Massolo, A., Craig, P., Wassermann, M., Takahashi, K., de la Rue, M., 2017. Ecology and life cycle patterns of Echinococcus species. Adv. Parasitol. 95, 213–314.
Schantz, P.M., Van den Bossche, H., Eckert, J., 1982. Chemotherapy for larval echinococcosis in animals and humans: report of a workshop. Z. Parasitenkd. 67, 5–26.
Singh, B., Dhand, D., Ghatak, S., Gill, S., 2013. Economic losses due to cystic echinococcosis in India: need for urgent action to control the disease. Prev. Vet. Med. 113 (1), 1–12.
Soulsby, C.J.C., 1982. Helminthes, Arthropods and protozoa of Domestic Animals, 7th edition, p. 123. U.S.A, Philadelphia, lea and Fibiger.
Terefe, D., Kebede, K., Beyene, D., Wondimu, A., 2012. Prevalence and financial loss estimation of hydatidosis of cattle slaughtered at Addis Ababa abattoirs enterprise. J. Vet. Med. Anim. Hlth. 4 (3), 42–47.
Terefe, Y., Addy, F., Alemu, S., Mackenstedt, U., Romig, T., Wassermann, M., 2019. Genetic characterization of Echinococcus species in eastern Ethiopia. Vet. Parasitol. Reg. Stud. Rep. 17, 100302.
Thompson, R.C.A., McManus, D.P., 2002. Towards a taxonomic revision of the genus *Echinococcus*. Trends in Parasitology 18 (10), 452–457.
Thrusfield, M., 2007. Surveys. In: Veterinary Epidemiology, 3rd ed. Blackwell Science, Edinburgh, Great Britain, pp. 233–245.
Tigre, W., Deresa, B., Haile, A., Gabriel, S., Victor, B., Pelt, J.V., Devleesschauwer, B., Vercruysse, J., Dorny, P., 2016. Molecular characterization of Echinococcus granulosus s.l. cysts from cattle, camels, goats and pigs in Ethiopia. Vet. Parasitol. 215, 17–21.
Torgerson, P., Budke, C., 2003. Echinococcosis–an international public health challenge. Res. Vet. Sci. 74 (3), 191–202.
Vaidya, V.M, Zende, R.J, Paturkar, A.M, Gatne, M.L, Dighe, D.G, Waghmare, R.N, Moon, S.L, Bhave, S.S, Bengale, K.G, Nikale, N.V, 2018. Cystic echinococcosis in animals and humans of Maharashtra State, India. Acta Parasitol 63 (2), 232–243.
Vuitton, D.A., DP, McManus, Rogan, M.T., Romig, T., Gottstein, B., Naidich, A., Tuxun, T., Wen, H., Menezes da Silva, A., the World Association of Echinococcosis, 2020. International consensus on terminology to be used in the field of echinococcoses. Parasite (Paris, France) 27, 41.
Weldegiorgis, K., Ashenaf, H., Zewdie, G., Lobago, F., 2008. Echinococcosis/hydatidosis: its prevalence, economic and public health signifcance in Tigray region, North Ethiopia. Trop. Anim. Health Prod. https://doi.org/10.1007/s11250-008-9264-9.
WHO, 17 May 2021. Echinococcosis. https://www.who.int/news-room/fact-sheets/detail/echinococcosis#:~:text=The%20two%20most%20important%20forms,direct%20contact%20with%20animal%20hosts. Accessed on 4 Feb 2023.
Worku, E., 2017. Major Metacestodes of Cattle, Sheep and Goats Slaughtered at BishoftuElfora Export Abattoir, Community Perception and Public Health Significance of Zoonotic Cestodes. Addis Ababa University, College of Veterinary Medicine and Agriculture, pp. 1–27. MSc Thesis, Bishoftu, Ethiopia.
Yetnayet, G., 2010. Prevalence and Economic Significance of Bovine Hydatidosis in Cattle Slaughtered at Gondar ELFORA Abattoir, North Gondar. DVM thesis,. Faculty of Veterinary Medicine, University of Gondar, Gondar, Ethiopia.
Zewdu, E., Teshome, A., Makwoya, K., 2010. Bovine Hydatidosis in Ambo Municipality Abattoir,WestShoa, Ethiopia. Ethiop. Vet. J. 14 (1), 1–14.