



# Cystic echinococcosis in slaughtered cattle at Addis Ababa Abattoir enterprise, Ethiopia

Bersissa Kumsa

Addis Ababa University, Department of Parasitology, College of Veterinary Medicine, P.O Box 34, Bishoftu, Ethiopia



## ARTICLE INFO

### Keywords:

Addis Ababa Abattoir enterprise  
Cattle  
*Echinococcus granulosus*  
Hydatid cyst  
Postmortem examination

## ABSTRACT

Cystic echinococcosis, caused by larval stages of the tapeworm *Echinococcus granulosus*, is responsible for hydatid cysts in the lungs, liver and other organs of intermediate hosts. A cross-sectional Abattoir study was conducted from October 2015 to May 2016 at Addis Ababa Abattoir enterprise, Ethiopia. For this purpose a total of 1209 cattle were examined using the classical meat inspection procedure for the presence of hydatid cysts. An overall prevalence of 21% (254/1209) of hydatid cyst was recorded in cattle slaughtered at Addis Ababa Abattoir enterprise. The prevalence of hydatid cyst was statistically significantly higher ( $P < 0.05$ ) in cattle with the age group of  $> 6$  years than those cattle with all other age categories. The study showed that lungs and livers were the most affected organs of cattle. Significantly ( $P < 0.05$ ) higher overall number of hydatid cysts were observed in the lungs (63.9%; 1324/2071) than in the livers (35.4%; 734/2071). The study revealed the presence of an overall of 84.1% (333/396) sterile, 12.2% (48/396) calcified and 4.3% (17/396) fertile cysts. Of the total of 17 fertile hydatid cysts tested for viability, 17.6% (3/17) viable and 82.3% (14/17) nonviable cysts were observed. Overall, findings of the present study showed the widespread occurrence of hydatid cysts in internal organs of cattle that possibly incur significant economic losses through condemnation of edible organs rendering unfit for human consumption. Molecular studies on the role of intermediate host species, genotypes of *E. granulosus*, zoonotic impact and economic significance of echinococcosis are needed in different parts of Ethiopia.

## 1. Introduction

In Ethiopia, despite the huge population, the productivity of live-stock remains marginal due to high prevalence of animal diseases, malnutrition and management constraints. Parasitic diseases represent a major obstacle to the development of the livestock sector and hamper the poverty alleviation programs of the country. Cystic echinococcosis is one of the major parasitic diseases which affect the health and productivity of food animals in Ethiopia (Jobre, Lobago, Tiruneh, Abebe, & Dorchie, 1996).

Cystic echinococcosis, mainly caused by the metacestode of *Echinococcus granulosus*, is one of the most common zoonotic diseases associated with huge economic losses and great public health significance worldwide (Romig et al., 2011). The adult tapeworm in the definitive dog host is harmless unlike the hydatid cyst in the intermediate host animals that is responsible for immense economic and medical importance in infected hosts (Ibrahim, 2010).

Food animals such as cattle, sheep, goats, camels, buffaloes and pigs (intermediate hosts) acquire the infection through accidental ingestion of infective eggs with contaminated grass and water; the eggs later develop into the larval stage (metacestode) of the parasite in many

internal organs such as the liver, lung, spleen, heart and kidney, and ultimately cause the pathology associated with cystic echinococcosis (CE) (Singh, Dhand, Ghatak, & Gill, 2013). Man is also infected incidentally upon ingestion of infective eggs with contaminated water, vegetables and other foods or through direct contact with the dog. The transmission cycle is completed when dogs (definitive hosts) consume offal containing viable hydatid cysts (Budke, Deplazes, & Torgerson, 2006). The adult tapeworm is harmless to the dogs, unlike the hydatid cyst in intermediate hosts (Cardona & Carmena, 2013).

Losses in productivity such as 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 are the major economic impacts associated with cystic echinococcosis in food-producing animals (Otero-Abad, & Torgerson, 2013; Singh et al., 2013).

The prevalence, economic and public health impact of cystic echinococcosis is higher in rural communities of developing countries where there is close contact between dogs, intermediate host species and man (Ibrahim, 2010; Romig et al., 2011). In Ethiopia cystic echinococcosis is an endemic disease and has enormous medical and

E-mail address: [bersissak@yahoo.com](mailto:bersissak@yahoo.com).

<https://doi.org/10.1016/j.vas.2019.100050>

Received 30 December 2018; Received in revised form 22 January 2019; Accepted 30 January 2019

Available online 31 January 2019

2451-943X/ © 2019 The Author. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

veterinary importance due to suitable factors such as predominant home slaughtering of cattle, sheep, goats and camels with improper disposal of affected organs. Moreover, uncooked carcass wastes and offals are traditionally fed to dogs and cats in the country. As a result cystic echinococcosis is implicated as one of the major causes of organ condemnation and carcass weight loss in slaughtered animals in Ethiopia. Cystic echinococcosis in cattle has been reported from some parts of the country (Abebe, Beyene, & Kumsa, 2013; Kumsa, 1994; Mersie, 1993; Negash, Beyene, & Kumsa, 2013). Thus, comprehensive and up-to-date information is needed for the effective control and prevention of cystic echinococcosis in the country (Jobre et al., 1996; Magambo, Njoroge, & Zeyhle, 2006).

Despite its great economic and public health significance, there is lack of updated information on cystic echinococcosis of cattle slaughtered at Addis Ababa Abattoir enterprise in Ethiopia. Hence, the objectives of the present study were to determine the prevalence, organ distribution and fertility of hydatid cysts in cattle slaughtered at Addis Ababa Abattoir enterprise in Ethiopia. In addition, the effects of factors like breed, agroecology, production system, sex and age of animals on the prevalence of the hydatid cyst was assessed.

## 2. Materials and methods

### 2.1. Study area

The study was carried out in Addis Ababa Abattoir Enterprise. Addis Ababa is the capital city of Federal Democratic Republic of Ethiopia and is situated at 11°1'48"N and 39°37'59.83"E. The city has an area of 51,000 ha in the central highlands with an average altitude of 2000–2560 meters above sea level. The area is characterised by bimodal type of rainfall with an average of 1100 mm. The highest percentage of rainfalls occurs during the long rainy season from June to September while the short rainy season is from February to April. The minimum and maximum average annual daily temperature ranges from 8 °C to 22 °C, respectively and the relative humidity varies from 70% to 80% during the rainy season and is from 40% to 50% during the dry season. Addis Ababa has an estimated human population of 3.15 million (CSA, 2016).

### 2.2. Study animals

Cattle were brought from different parts of the country and livestock marketing areas like Borana, Arsi, Wollega, Kaffa, Southern part of the country (Woljeta, Gamogofa, Kambata, Hadiya and Gurage), Wollo, Kerruy, Afar, Harrarge, Addis Ababa and its peripheries for slaughter at Addis Ababa Abattoir enterprise (Fig. 1). The internal organs of slaughtered cattle including lungs, liver, heart, spleen and kidney were carefully examined for the presence of hydatid cysts. The origin, breed, production system, sex and age of each study animal were recorded during the abattoir survey. The information obtained from the abattoir indicated that the abattoir has an average annual slaughtering capacity of 200,000 food animals per year. The study involved both sexes of local breeds of cattle that were brought from different agroecological zones of the country for slaughter at Addis Ababa Abattoir enterprise.

### 2.3. Sample size and study design

A total of 1209 cattle were examined to determine the presence of hydatid cysts by postmortem examination of different visceral organs (liver, lung, heart, kidney and spleen). This sample size was calculated as indicated by Thrusfield (1995), on the basis of 50% expected prevalence and a 95% confidence interval with 5% desired absolute precision.

A cross-sectional study was conducted to determine the prevalence, organ distribution and characteristics of hydatid cysts in cattle slaughtered at Addis Ababa Abattoir enterprise. For this purpose three

slaughtering-day visits per week were made to Addis Ababa Abattoir enterprise from October 2015 to July 2016. All cattle slaughtered on each visit-day were examined for hydatid cysts.

### 2.4. Antemortem examination

During antemortem examination an identifying number was painted on the body of each study animal before slaughtering. The age, sex, breed, production system and origin of each animal was recorded, and each animal was categorised into one of three age groups: Group 1 (cattle <2 years old), Group 2 (cattle 2–4 years old), or Group 3 (cattle 4–6 years old) or Group 4 (cattle >6 years old). The age of each study cattle was estimated based on the dentition formula described by Pace and Wakeman (2003). All laboratory studies were conducted at Veterinary Parasitology Laboratory of College of Veterinary Medicine of Addis Ababa University based at Bishoftu town 45 km to the east of direction

### 2.5. 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. Cysts were carefully removed from each infected organ of all affected animals and collected in clean containers, to allow determination of their number and characteristics of the cysts. The total number of hydatid cysts were counted and recorded. The size of the diameter of collected hydatid cysts was measured and classified as small (diameter less than 5 cm), medium (diameter from 5 cm to 10 cm) and large (diameter greater than 10 cm) as described before (Abebe et al., 2013; Kumsa, 1994; Negash et al., 2013).

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 characterised 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.

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. 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 (Negash et al., 2013). The technique differentiates between dead (red stained) and alive (unstained) protoscolices.

### 2.6. Data analysis

Data obtained from antemortem and postmortem findings were entered into a Microsoft Excel 2003 database, and then analyzed using SPSS V.15. Chi square ( $\chi^2$ ) test was used to compare the prevalence of hydatid cysts among cattle of different sex, age, breed, origin and production system. The infection pressure of hydatid cysts and number of hydatid cysts in cattle of different age groups was investigated by fitting the prevalence into the asymptotic relationship ( $Prev = 1 - \exp(-B \cdot T)$ ) as has been used previously (Torgerson & Heath, 2003; Torgerson et al., 2003) A statistically significant association between variables is considered to exist if the *P* value is less than 0.05 at 95% confidence interval.



Fig. 1. Map of Ethiopia showing origin of cattle slaughtered (stars) at Addis Ababa Enterprise.

### 3. Results

#### 3.1. Prevalence of hydatid cysts

An overall prevalence of 21% (254/1209) of hydatid cyst was recorded in cattle slaughtered at Addis Ababa Abattoir enterprise (Table 1). The prevalence of hydatid cyst was 20.9% (132), 22.4% (85) and 18.7% (37) in Borana, Arsi and Abyssinian Zebu breeds of cattle, respectively (Table 1). The prevalence of hydatid cysts in cattle from midland 21.6% (124) and lowland 20.5% (130) was recorded. The study also showed the prevalence of hydatid cyst of 20.8% (132) and 21.3% (122) in cattle kept under pastoral and mixed crop livestock production system, respectively (Table 1). Statistically significant variation in the prevalence of hydatid cysts in cattle of various breeds, agroecologies and kept under production systems was not observed ( $p > 0.05$ ). The prevalence of 0.3% (1), 2.6% (11), 37.1% (125) and 95.9% (117) in cattle with the age group of < 2, 2–4, 4–6 and > 6 years was recorded. The prevalence of hydatid cyst, infection pressure and

Table 1

Prevalence of hydatid cyst in relation to potential risk factors in cattle slaughtered at Addis Ababa abattoir enterprise.

Factors	No examined	No positive (%)	
Breed			
Borana	631	132	20.9
Arsi	380	85	22.4
Abyssinian zebu	198	37	18.7
Origin			
Midland	575	124	21.6
Lowland	634	130	20.5
Sex			
Male	1198	253	21.1
Female	11	1	11.1
Production system			
Pastoral	636	132	20.8
Mixed crop livestock	573	122	21.3
Age*			
< 2 years	328	1	0.3
2 – 4 years	422	11	2.6
4 - 6 years	337	125	37.1
> 6 years	122	117	95.9
Overall	1209	254	21

\* Significant variation,  $p < 0.001$ .

number of hydatid cysts was statistically significantly higher ( $p < 0.001$ ) in cattle with the age group of > 6 years than those cattle with all other age categories (Table 1).

#### 3.2. Distribution, intensity and size of hydatid cysts

The study showed that lungs and livers were the most affected organs of cattle (Table 2). Significantly ( $p = 0.000$ ) higher overall number of hydatid cysts were observed in the lungs (63.9%; 1324/2071) than in the livers (35.4%; 734/2071) as shown in Table 2. The number of hydatid cysts was also significantly higher in the livers than both in the kidneys and hearts of the examined cattle (Table 2). During the study period a total of 2071 cysts were collected from affected organs and differentiated into small, medium or large size cysts (Table 2). The study revealed that small (48.6% (1007/2071)) size cysts were with highest proportion than those with medium (34.3% (711/2071)) and large (17% (353/2071)) size cysts (Table 2).

#### 3.3. Characteristics of hydatid cysts

Morphological characterization of a total of 396 hydatid cysts of cattle revealed the presence of 4.3% (17/396) fertile, 84.1% (333/396) sterile and 12.2% (48/396) calcified cysts (Table 3). Of the total of 17

Table 2

Cyst size and count in relation to involved organs in cattle examined at Addis Ababa abattoir enterprise.

Organs	Type of hydatid cysts						Total	
	Small No.	%	Medium No.	%	Large No.	%	No.	%
Lung*	590	28.5	466	22.5	268	12.9	1324	63.9
Liver*	404	19.5	245	11.8	85	4.1	734	35.4
Kidney	10	0.5	0	0	0	0	10	0.5
Heart	3	0.2	0	0	0	0	3	0.1
Total	1007	48.6	711	34.3	353	17	2071	100

$\chi^2 = 31.84, P = 0.000.$

\* significance.

**Table 3**  
Condition of hydatid cysts in different organs of infected cattle slaughtered in Addis Ababa abattoir.

Organs	No of cysts examined	Fertile		Viable		Non viable		Sterile		Calcified	
		Total No. of fertile No.	%	No.	%	No.	%	No.	%	No.	%
Liver*	171	3	1.7	0	0	3	100	137	80.1	31	18.1
Lung*	212	14	6.6	3	21.4	11	78.6	187	88.2	11	5.2
Kidney	10	0	0	0	0	0	0	9	90	1	10
Heart	3	0	0	0	0	0	0	0	0	3	100
Total	396	17	4.3	3	17.6	14	82.3	333	84.1	48	12.2

For fertility:  $\chi^2 = 26.15$ ,  $P = 0.000$ ; for viability:  $\chi^2 = 0.097$ ,  $P = 0.76$ .

fertile hydatid cysts tested for viability, 17.6% (3/17) viable and 82.3% (14/17) nonviable cysts were observed. Greater proportion of the hydatid cysts in cattle were sterile type cysts.

#### 4. Discussion

The present study reported the occurrence of hydatid cysts in cattle of various breed, age group, sex, origin, and management systems that were slaughtered at Addis Ababa Abattoir enterprise. This observation is in agreement with the previous work of Kumsa (1994) and Jobre et al. (1996). The finding of an overall prevalence of 21% (254/1209) of hydatid cyst in cattle slaughtered at Addis Ababa abattoir enterprise is in line with some previous reports from elsewhere in Ethiopia; for example, the previous reports of 20.5% in cattle slaughtered at Gondar Elfora Abattoir in northern Ethiopia (Abebe, Beyene, & Kumsa, 2013), 17.5% in the Tigray region (Gebremeskel & Kalayo, 2009) and 29.7% in Ambo (Zewdu, Teshome, & Makwoya, 2010). In other studies from Ethiopia, hydatid cyst prevalence in cattle has been reported as lower than that in our study (8.5% in Gofa and 15.5% in Woliata by Regassa, Abunna, Mulugeta, & Megersa, 2009) or higher (84.3% in Gondar, 68.9% in Injibara, 73.4% in Finoteselam by Kebede (2010) and 49.5% in cattle slaughtered at Shashemane Municipal Abattoir in Oromia (Negash et al., 2013).

This variation in prevalence of cystic echinococcosis among cattle of different areas in Ethiopia could be attributed to factors including differences in agroecology, the times at which studies took place, stocking rates and movements of animals, animal husbandry systems, awareness, culture and religion of the society, and attitude to dogs in different regions of the Country (Abebe et al., 2013; Kumsa, 1994; Romig et al., 2011).

The absence of significant variation in the prevalence of hydatid cysts in cattle of various breeds, agroecologies and production systems most probably suggests that cystic echinococcosis is widely distributed with high adaptability to different environments, breeds of cattle and production systems due to the presence of high population of freely scavenging stray dogs as well as wild canids in close association with the family and farm animals in all agroecological zones in Ethiopia as has been suggested before (Abebe et al., 2013; Negash et al., 2013). In addition, the widespread occurrence of hydatid cysts in cattle in Ethiopia is favoured by several factors including common practice of backyard and roadsides slaughtering of ruminants, the widespread tradition of offering uncooked infected offals to dogs and cats, poor public awareness about the disease, the absence of proper fencing and disposal pits for slaughter houses that allows easy access of dogs and other carnivores, lack of habit of disposing dead wild or domestic animals and unburied and left over for scavenging carnivores that create favorable condition for environmental contamination by maintaining the life cycle of *E. granulosus* in stray dogs and wild carnivores (Kebede et al., 2009; Regassa et al., 2009; Zewdu et al., 2010).

The observation of significantly higher ( $p < 0.001$ ) infection pressure, higher number of hydatid cysts and prevalence of hydatid cysts in cattle with the age group of > 6 years than all the other age categories is in agreement with several previous studies in Ethiopia (Kumsa, 1994;

Zewdu et al., 2010) and elsewhere in other countries (Adinehbeigi, Radfar, & Rahmani, 2013; Cardona & Carmena, 2013). The most likely explanation is that the more prolonged exposure of older animals favours the accumulation of more number of infective stages, the development of hydatid cysts and progressive infection over longer duration of time in older age than in young cattle and a higher prevalence of cysts also suggests an absence of immunity to this parasite (Cardona & Carmena, 2013).

The findings of highest prevalence and largest number of hydatid cysts in the lungs than all the other organs followed by livers in our study are in agreement with several earlier reports (Jobre et al., 1996; Kumsa, 1994; Mersie, 1993; Omer et al., 2010; Zewdu et al., 2010). This finding could be explained by the fact that livers and lungs possess the first great capillary sites encountered by the migrating oncospheres of this parasite during their portal vein route that are primarily subjected to hepatic and pulmonary filtering system before the involvement of any other peripheral organ (Kumsa & Mohammedzein 2012). Furthermore, it is possible for the hexacanth embryo to enter the heart and lungs so that the lungs may be infected before or instead of liver as has been proposed earlier (Cardona & Carmena, 2013; Ibrahim, 2010).

The observation of highest proportion and numbers of both medium and large size hydatid cysts in the lungs than all the other organs could be associated to the softer consistency of the lung tissue whereas the finding of highest percentage of calcified cysts in liver is attributed to the previous argument (Kumsa & Mohammedzein, 2012) related to the relatively higher reticuloendothelial cells and abundance of connective tissue reaction in the liver than the other organs (Abebe et al., 2013).

The overall finding of 84.1% sterile, 12.2% calcified and 4.3% fertile hydatid cysts recorded in the present study generally suggests that the majority of hydatid cysts in cattle are not infective to the final host. This finding supports the previous arguments by several investigators who have argued that sheep play the greatest role as the intermediate host of cystic echinococcosis than cattle in Ethiopia (Kebebe, Girma, & Kumsa, 2010; Kumsa & Mohammedzein, 2012). However, when considering the high prevalence of 21% and fertility of 4.3% of cysts in cattle slaughtered at Addis Ababa Abattoir enterprise reported in this study imply that cattle still have some potential source of infection to dogs and other definitive hosts of this parasite. This observation agrees with the previous findings (Kumsa, 1994).

The greater prevalence and the higher proportion of (4.3%) fertile hydatid cysts in lungs than in the liver (0%) and all the other organs recorded provides reliable indicators of the importance of lungs as a potential source of infection to dogs than all the other organs. Fertility of cysts could be affected by differences in strain of *E. granulosus* (Njoroge et al., 2002; Romig et al., 2011). Cysts, depending on the geographical situation, host, site, size and type of cyst may have different rates of fertility (Ibrahim, 2010). Moreover, the fertility of hydatid cysts in the intermediate hosts may be also genotype dependent, but unfortunately genotype studies are not available for any host in Ethiopia. In view of the highest prevalence and fertility of pulmonary hydatid cysts than all the other organs in our current study and the practices of feeding uncooked lungs to dogs and cats in Ethiopia strengthen the great role of lungs in cystic echinococcosis than any

other organ in the country.

In conclusion, the findings reported herein show that cystic echinococcosis is widespread in cattle slaughtered at Addis Ababa Abattoir enterprise. The observation of fertile cysts in examined organs suggests that cattle still play some role in the life cycle of this serious zoonosis and presents potential risks of transmission to other intermediate hosts and human population of the study area. Hence, safe disposal of affected offal and community education about cystic echinococcosis in the area will help reduce the transmission from slaughter houses to potential hosts of the area. In detail epidemiological studies on the role of intermediate host species, definitive hosts, genotypes of strains from different host species, zoonotic impact and economic significance of cystic echinococcosis are needed in different parts of Ethiopia.

### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.vas.2019.100050](https://doi.org/10.1016/j.vas.2019.100050).

### References

- Abebe, A., Beyene, D., & Kumsa, B. (2013). Cystic echinococcosis in cattle slaughtered at Gondar Elfora export Abattoir, Northwest, Ethiopia. *Journal of Parasitic Diseases*, *107*, 229–234.
- Adinehbeigi, K., Radfar, M. H., & Rahmani, M. (2013). The role of cattle in the epidemiology of *Echinococcus granulosus* in Kerman area, southeast of Iran. *Comparative Clinical Pathology*, *22*, 233–238.
- Budke, C. M., Deplazes, P., & Torgerson, P. R. (2006). Global socioeconomic impact of cystic echinococcosis. *Emerging Infectious Diseases*, *12*(2), 296–302.
- Cardonaa, G. G., & Carmena, D. (2013). A review of the global prevalence, molecular epidemiology and economics of cystic echinococcosis in production animals. *Veterinary Parasitology*, *192*, 10–32.
- Central Statistical Authority, CSA. (2016). *Agricultural sample survey report on livestock and livestock characteristics, II*. Ethiopia: Addis Ababa.
- Gebremeskel, B., & Kalayo, K. (2009). Prevalence, viability and fertility study of bovine cystic echinococcosis in Mekelle city, Northern Ethiopia. *Revue de Médecine Vétérinaire*, *160*, 92–97.
- Ibrahim, M. M. (2010). Study of cystic echinococcosis in slaughtered animals in Al Baha region, Saudi Arabia: Interaction between some biotic and abiotic factors. *Acta Tropica*, *113*, 26–33.
- Jobre, Y., Lobago, F., Tiruneh, R., Abebe, G., & Dorchie, P. (1996). Hydatidosis in three selected regions in Ethiopia: An assessment trial on its prevalence, economic and public health importance. *Revue de Médecine Vétérinaire*, *147*, 797–804.
- Kebebe, E., Girma, Z., & Kumsa, B. (2010). Hydatidosis of sheep and goats slaughtered at Addis Ababa Abattoir: Prevalence and risk factors. *Tropical Animal Health and Production*, *42*(5), 803–805.
- Kebebe, N., Abuhay, A., Tilahun, G., & Wossene, A. (2009). Financial loss estimation, prevalence and characterization of hydatidosis of cattle slaughtered at Debre Markos Municipality abattoir, Ethiopia. *Tropical Animal Health and Production*, *41*, 1787–1789.
- Kebebe, N. (2010). A retrospective survey of bovine hydatidosis in three abattoirs of Amhara National Regional State, north-western Ethiopia. *Tropical Animal Health and Production*, *42*, 323–325.
- Kumsa, B. (1994). *Hydatidosis in Nekemet: Prevalence in slaughtered cattle and sheep estimated economic loss and incidence in stray dog*. DVM Thesis. Debre Zeit, Ethiopia: Addis Ababa University, Faculty of Veterinary Medicine.
- 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. *Comparative Clinical Pathology*, *11*, 333–339.
- Magambo, J., Njoroge, E., & Zeyhle, E. (2006). Epidemiology and control of echinococcosis in Sub-Saharan Africa. *Parasitology International*, *55*, S193–S195.
- Mersie, A. (1993). Survey of echinococcosis in Eastern Ethiopia. *Veterinary Parasitology*, *47*, 161–163.
- Negash, K., Beyene, D., & Kumsa, B. (2013). Cystic echinococcosis in cattle slaughtered at Shashemane Municipal Abattoir, South central Oromia, Ethiopia: Prevalence, cyst distribution and fertility. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *107*, 229–234.
- Njoroge, E. M., Mbithi, P. M. F., Gathuma, J. M., Wachira, T. M., Gathura, P. B., Magambo, J. K., et al. (2002). A study of cystic echinococcosis in slaughter animals in three selected areas of Northern Turkana, Kenya. *Veterinary Parasitology*, *104*, 85–91.
- Omer, R. A., Dinkel, A., Romig, T., Mackenstedt, U., Elnahas, A. A., Aradaib, I. E., et al. (2010). A molecular survey of cystic echinococcosis in Sudan. *Veterinary Parasitology*, *169*, 340–346.
- Otero-Abad, B., & Torgerson, P. R. (2013). A systematic review of the epidemiology of echinococcosis in domestic and wild animals. *PLoS Neglected Tropical Diseases*, *7*(6), e2249. <https://doi.org/10.1371/journal.pntd.000224>.
- Pace, J. E., & Wakeman, D. L. (2003). *Determining the age of cattle by their teeth*. CIR253. Florida cooperative extension service. Gainesville, FL: Institute of Food and Agricultural Sciences. University of Florida.
- Regassa, A., Abunna, F., Mulugeta, A., & Megersa, B. (2009). Major metacestodes in cattle slaughtered at Wolaita Soddo Municipal abattoir, Southern Ethiopia: Prevalence, cyst viability, organ distribution and socioeconomic implications. *Tropical Animal Health and Production*, *41*, 1495–1502.
- Romig, T., Omer, R. A., Zeyhle, E. T., Hüttnera, M., Dinkela, A., Siefert, L., et al. (2011). Echinococcosis in sub-Saharan Africa: Emerging complexity. *Veterinary Parasitology*, *181*, 43–47.
- Singh, B. B., Dhand, N. D., Ghatak, S., & Gill, J. P. S. (2013). Economic losses due to cystic echinococcosis in India: Need for urgent action to control the disease. *Preventive Veterinary Medicine*, *113*(1), 1–12. <https://doi.org/10.1016/j.prevetmed.2013.09.007>.
- Thrushfield, M. (1995). *Veterinary epidemiology* (2nd ed.). Black Well Science.
- Torgerson, & Heath, D. D. (2003). Transmission dynamics and control options for *Echinococcus granulosus*. *Parasitology*, *127*, S143–S158.
- Torgerson, P. R., Burtisurnov, K. K., Shaikenov, B. S., Rysmukhambetova, A. T., Abdybekova, A. M., & Ussenbayev, A. E. (2003). Modeling the transmission dynamics of *Echinococcus granulosus* in sheep and cattle in Kazakhstan. *Veterinary Parasitology*, *114*, 143–153. [https://doi.org/10.1016/S0304-4017\(03\)00136-5](https://doi.org/10.1016/S0304-4017(03)00136-5).
- Zewdu, E., Teshome, Y., & Makwoya, A. (2010). Bovine hydatidosis in Ambo Municipal Abattoir. *Ethiopian Veterinary Journal*, *14*(1), 1–14.