Magnitude of Camel Hydatidosis, Associated Risk Factors and its Economic Significance at Jigjiga Municipal Abattoir, Eastern Ethiopia

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Abstract: A cross-sectional study was conducted from December 2017 to April 2018 at Jigjiga municipal abattoir to assess the status of hydatidosis, determine its associated risk factors, characterize the cyst and estimate the annual financial loss due to organ condemnation in camels. Out of 415 slaughtered camels examined for the presence of hydatid cysts in the visceral organs, 78(18.79%) harbored visible hydatid cysts. The odds at which cysts detected were higher ($p<0.05$) in old aged camels (≥10 years) (AOR 8.8, 95% CI: 2.92-26.64) and nearly four times higher in medium aged camels (6-9 years) (AOR 4.14, 95% CI: 1.37-12.56) than camels aged ≤5 years. No significant variation was observed in relation to sex of camels ($p>0.05$). Occurrence of hydatidosis was significantly associated with body condition score of camels ($p<0.05$). Camels with poor and medium body condition were nearly seven times (AOR 7.04, 95% CI: 3.21-15.42) and more than two times (AOR 2.65, 95% CI: 1.46-4.74) more likely to harbor hydatid cysts than camels with good body condition scores, respectively. A total of 134 cysts were collected and the organ level distribution of the cysts were 55.2% (74/134), 40.32% (54/134), 3.73% (5/134) and 0.75% (1/134) in lung, liver, spleen and kidney, respectively. Among the total 134 cysts collected, 36.6% (49/134) were calcified while the rest 63.4% (85/134) were non-calcified. Among those non-calcified cysts, 35.3% (30/85) were fertile containing protoscoleces while the remaining 64.7% (55/85) were sterile. Among the 30 fertile cysts; 53.3% (16/30) were viable while 46.7% (14/30) non-viable. Of the total 85 non-calcified hydatid cysts evaluated for size, 40% (34/85), 38.8% (33/85) and 21.2% (18/85) were small, medium and large, respectively. Assessment of annual financial loss due to hydatidosis in camels slaughtered at Jigjiga municipal abattoir as a result of offal condemnation was estimated at 142,133.55 Birr (5214.95 USD) per annum (1$(USD) = 27.255ETB). The result showed that hydatidosis is one of the common diseases causing organ condemnation and financial loss to the butchers at Jigjiga. Hence, we suggest prohibition of backyard slaughter, creation of public awareness and control of stray dogs in order to reduce infection by the parasite.

Keywords: *Abattoir, Camels, Financial loss, Hydatidosis, Risk factors.*

Introduction

Ethiopia is an agrarian country with huge livestock population in Africa possessing over 4.5 million heads of *Camelus dromedarius,* based on several more reliable and recent surveys for the Afar, Somali and Borena regions in the country (Shapiro *et al.,* 2017), although the official figure is set to 1.42 million, being mainly distributed in the Southern, Eastern and Northeast pastoral regions (CSA, 2018). Camels play a central role in providing draught power, meat and milk, and by determining the wealth and social status of pastoralists (Bekele, 2010).

Camel production in many parts of the country has been threatened by various constraints, among which the prevailing parasitic diseases represent a major drawback to its production and productivity (Bekele, 2010). Among parasitic diseases affecting camels, hydatidosis has a substantial economic and public health importance in many countries (Lahmar *et al.,* 2004) and is becoming more endemic in many African countries (Azlaf and Dakkak, 2006).

Hydatidosis (cystic *echinococcosis*) is a chronic cyst-forming parasitic disease of domestic and wild ungulates as well as human beings caused by infection with the larval (metacestode) stages of dog tapeworms belonging to the genus *Echinococcus* and family *Taeniidae* (Craig *et al.*, 2007). In Ethiopia, hydatidosis is the major cause of organ condemnation in local and export abattoirs causing huge economic losses (Nigatu *et al.*, 2009b). In livestock industry, it inflicts enormous economic losses due to condemnation of edible organs and lowering the quality and quantity of meat (Craig *et al.*, 2007; Abebe and Yilma, 2011). The magnitude of haydatidosis and its economic loss in ruminants had been reported from different parts of the country (Nigatu *et al.,* 2009a,b,c; Tadele *et al.*, 2009; Andualem *et al.*, 2010; Abebe and Yilma, 2011; Miheret *et al.*, 2013). Even though there are few reports on the prevalence and economic significance of hydatidosis in camels slaughtered at Jigjiga municipality abattoir (Moges *et al.*, 2001; Samuel, 2008; Muskin *et al.*, 2011; Bayleyegn *et al.*, 2013; Etana *et al.,* 2015), the increase in the number of camels slaughtered and the wide area coverage of the

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source of camels slaughtered at the abattoir requires an up-to-date figures and information. Therefore, the present study is aimed at estimating the prevalence of hydatidosis in camels and the direct financial loss due to the rejection of organs caused by the infection in camels slaughtered at Jigjiga municipality abattoir.

Materials and Methods

Study Area and Animals

The study was conducted at an abattoir located in Jigjiga town which is situated between 08°44'N and 11°00'N longitude and between 40°22'E and 44°00'E latitude, at an altitude ranging between 1,760 and 2,300 meter above sea level. The study animals were one humped camels (*C. dromedarius*). The sources of the animals were Hadow, Shabelay, and Goljano *kebeles* of Jigjiga district, Somali National Regional State. Most part of this district is characterized by pastoralism and agro-pastoralism and with high camel production potential. The people in the district use camels for transportation, ploughing and traction purposes. Camels are also used as source of cash income, milk and meat (Yohannes *et al*., 2007).

Based on figures from the Central Statistical Agency, Jigjiga has an estimated total population of 98,076 of whom 50,355 are men and 47,721 are women. This city is the largest settlement in Jigjiga district. The climate of Jigjiga is semi-arid, with the influence of mountain climate, and hot and dry summer and cold winters (CSA, 2018).

Sample Size Determination

The sample size was calculated according to the formula given by Thrusfield and Christley (2018) indicated below by considering 23% of prevalence (Etana *et al.,* 2015) and 95% confidence level with a 5% desired absolute precision.

$$n = \frac{1.96^2 (p_{exp})(1 - p_{exp})}{d^2}$$

Where, n= total number of sample size; P_{exp} = Expected prevalence, d= Absolute precision.

The calculated sample size was 272, however considering a design effect and lose to slaughter after ante mortem examination, the sample was multiplied by a factor of 1.5 and thus a total of 415 camels were sampled and examined for the presence or absence of hydatid cysts.

Study Design and Methodology

A cross-sectional study was conducted from December 2017 to April 2018 to estimate the prevalence, determine the potential risk factors, characterize the cyst and evaluate the financial losses due to hydatidosis in camels slaughtered at Jigjiga municipal abattoir. During the period of the study, four visits were made per week out of 7 slaughter days in a week. On average 15 camels were slaughtered daily at the abattoir. Camels brought to the abattoir were selected by systematic random sampling and 8 animals were sampled per visit. The first animals were selected randomly and the rest with equal intervals and subjected to both ante mortem and detailed postmortem inspections. Cyst characterization and financial loss estimation were also carried out as per the condemned organs based on data from retail markets.

Ante-mortem Examination

Ante mortem inspection was conducted as recommended by Gracey (1986). The age, sex and body condition were recorded for each animal. The age of the camels were determined by dental eruption according to Khan *et al.* (2003) and grouped into three, namely ≤5 years, 6 to 9 years and ≥10 years. The body condition scoring for camels was conducted according to the guidelines given by Faye *et al.* (2001). The scoring was conducted by inspection at the back and flank and then classified as poor (0 and 1), medium (2 and 3) and good (4 and 5).

Post-mortem Inspection

Postmortem inspection was performed according to the procedures recommended by Food and Agricultural organization (FAO, 2000). Visceral organs, particularly the lung, liver, kidney and spleen were inspected with visual inspection, palpation and systemic incision of each organ. The infected organs from each positive camel were collected; the total number of hydatid cysts counted per infected organs and recorded on the sheet prepared for this purpose.

Cyst Characterization

Individual cyst was grossly examined for any evidence of degeneration and calcification. The size of cysts was determined by measuring the diameter and classified as large (diameter >10 cm), medium (5 to 10 cm) and small (< 5 cm). The collected cysts were carefully incised and examined for protoscoleces, which looks like white dots on the germinal epithelium or in hydatid fluid via microscope, so as to classify cysts as fertile or infertile. The infertile cysts were further classified as sterile (fluid filled cysts without any protoscoleces) or calcified as indicated by Macpherson (1985). Fertile cysts were further subjected to viability test. A sediment containing protoscoleces were placed on the microscope glass slide and covered with cover slip and observed for amoeboid like movement at 40× objective (Smyth and Barrett, 1980).

Assessment of Financial Loss

To study the financial losses due to hydatidosis, only direct losses were considered and the calculation was based on condemned organs. In calculating cost of condemned edible organs, 10 different meat retailers and 2 meat inspectors were interviewed randomly to establish the price per unit organ and determine the average organ price and price index was used to calculate the loss.

Data Management and Analysis

Data was recorded on specially designed formats and entered in to Microsoft Excel. Then the data was exported into STATA version 14 (STATA, 1985-2015) for data processing and analysis. Descriptive statistics such as frequencies and proportions were used to present the findings. Binary logistic regression was run to measure the strength of the association between the different risk factors and hydatidosis and odds ratio was determined. In an attempt to control for potential confounding variables, multivariate logistic regression analysis was run and adjusted odds ratio was determined. Collinearity between variables was also checked by standard error and model fitness was assured by Hosmor and Lemshow test. Throughout the data presentation, P-value less than 0.05 (i.e. $P < 0.05$) was considered statistically significant.

The financial losses due to the parasite was estimated by multiplying the average retail market price of the organs, by the average annual number of camels slaughtered, percentage of hydatidosis per organ and prevalence of hydatidosis in that study. Thus, the loss resulted from organs condemnation at the abattoir was assessed using;

ADFLC = (ACS* Ph*PLi* ACLi) + (ACS*Ph*PLu* ACLu) + (ACS*Ph*PKi* ACKi) + (ACS*Ph*PSpl* ACSpl)

Where ADFLC = Annual direct financial loss due to organ condemnation, Ph= Prevalence of hydatidosis, ACS = Average number of camels slaughtered per year at Jigjiga municipal abattoir, ACLi = Average cost of liver, PLi = Percentage of hydatidosis in liver, ACLu = Average cost of lung, PLu= Percentage of hydatidosis in lung, ACKi = Average cost of kidney, PKi = Percentage of hydatidosis in kidney, ACSpl = Average cost of spleen, PSpl= Percentage of hydatidosis in spleen.

Results

Prevalence of Camel Hydatidosis and Risk Factors

Out of 415 camels examined, 78(18.79%) were positive for hydatid cysts. The occurrence of hydatid cysts followed different pattern among the age groups and camels aged ≥10 years had more cysts (AOR, 8.8, 95% CL 2.92, 6.64) than medium and younger aged camels. Likewise, camels with poor body condition are more likely to have more cysts (AOR 7.04, 95% CI: 3.21-15.42) than camels with good and medium body condition scores. However, significant variation was not observed in relation to sex ($p>0.05$) (Table 1).

Table 1. Univariate and multivariate logistic regression analysis of risk factors association with the occurrence of camel hydatidosis at Jigjiga municipality abattoir

Risk factors	Category	No. examined	No. affected (%)	Crude OR (95 % CI)	P- value	Adjusted OR (95 % CI)	P-value
Sex	Male	363	68(18.73)	1.00		1.00	
	Female	52	10(19.23)	1.03(0.49-2.16)	0.931	1.27(0.14-3.17)	0.291
Age	≤5 years	70	4(5.71)	1.00		1.00	
	6-9 years	204	30(14.7)	2.84(0.96-8.39)	0.058	4.14(1.37-12.56)	0.012
	≥10 years	141	44(31.2)	7.48(2.57-21.83)	< 0.001	8.83(2.92-26.64)	< 0.001
BCS	Good	236	28(13.46)	1.00		1.00	
	Medium	140	30(21.42)	2.02(1.15-3.56)	0.014	2.63(1.46-4.74)	0.001
	Poor	39	20(51.28)	7.81(3.72-16.41)	< 0.001	7.04(3.21-15.42)	< 0.001

BCS= Body condition score; OR= Odds ratio; CI= Confidence interval.

Proportions of Animals and Organs Affected

Cyst detections involved both single and multiple organs. Out of the total 78 camels harboring hydatid cysts, 65 (83.3%) had only single organ infection whereas the remaining 13(16.7%) infected camels had multiple organ infection (Table 2).

Table 2. Organ distribution of hydatid cysts in camels slaughtered at Jigjiga municipality abattoir

Infected organs	No. of infected animals	Proportion (%)
Lung	40	51.28
Liver	25	32.05
Lung and liver	7	8.97
Lung and spleen	2	2.56
Liver and kidney	1	1.28
Lung, liver and spleen	3	3.84
Total	**78**	**100**

Cyst Characteristics

Out of 134 cysts collected and evaluated, 30 were fertile while the remaining 55 and 49 were sterile and calcified cysts, respectively (Table 3). The majority of the 85 non-calcified cysts were categorized into small and medium size (Table 4).

Table 3. Feature of hydatid cysts collected from different visceral organs of camels slaughtered at Jigjiga municipality abattoir

Examined organs	Number of cysts examined	Fertile cysts			Sterile cysts (%)	Calcified cysts (%)
		Viable (%)	Non-viable (%)	Total (%)		
Lung	74(55.2%)	13(17.6)	8(10.8)	21(28.4)	35(47.3)	18(24.3)
Liver	54(40.32%)	3(5.6)	6(11.1)	9(16.7)	14(25.9)	31(57.4)
Spleen	5(3.73%)	0	0	0	5(100)	0
Kidney	1(0.75)	0	0	0	1(100)	0
Total	**134 (100%)**	**16 (11.9)**	**14 (10.4)**	**30 (22.4)**	**55 (41.0)**	**49 (36.6)**

Table 4. Size variability of hydatid cysts collected from different organs of camels slaughtered at Jigjiga municipal abattoir

Organs affected	No. of non-calcified cyst	Cyst size		
		Small	Medium	Large
Lung	56	13 (23.2%)	28 (50.0%)	15 (26.8%)
Liver	23	16 (69.6%)	4 (17.4%)	3 (13.0%)
Spleen	5	4 (80.0%)	1 (20.0%)	0
Kidney	1	1 (100%)	0	0
Total	**85**	**34 (40%)**	**33 (38.8%)**	**18 (21.2%)**

Direct Financial Losses

Average market price of camel's lung, liver, spleen and kidney at Jigjiga town were 5, 394, 5 and 50 Birr, respectively. The abattoir record show that the mean annual number of camels slaughtered during the past five years was 4065. Annual direct monetary loss was estimated considering annual slaughter rate of camel and prevalence of hydatidosis per organ and was estimated to be 142,133.55 Birr (5214.95 USD) per annum (on April 5, 2018, 1$(USD) = 27.255 Birr) (Table 5).

Table 5. Estimated annual direct financial losses due to offal condemnation in camels slaughtered at Jigjiga municipal abattoir

Infected organs	Number infected	Proportion affected	Prevalence of hydatidosis	AANCS	AMP in Birr	ADFL in Birr (USD)
Lung	40	51.28% (40/78)	18.79%	4065	5	1958.42(71.86)
Liver	25	32.05% (25/78)	18.79%	4065	394	96452.08(3538.88)
Lung and liver	7	8.97% (7/78)	18.79%	4065	399(5+394)	27337.11(1003.01)
Lung and spleen	2	2.56% (2/78)	18.79%	4065	10(5+5)	195.54(7.17)
Liver and kidney	1	1.28% (1/78)	18.79%	4065	444(394+50)	4340.90(159.27)
Lung, liver, and spleen	3	3.84% (3/78)	18.79%	4065	404(5+394+5)	11849.50(434.76)
Total						**142, 133.55 (5214.95)**

AANCS= Average annual number of camels slaughtered; AMP= Average market price; ADFL= Annual direct financial loss; USD= United States Dollar.

Discussion

The prevalence (18.79%) of hydatidosis in camels slaughtered at Jigjiga is in agreement with that of Ahmed (1998) and Moges *et al.* (2001) who reported a prevalence rate of 18.6% and 18.86%, respectively in Eastern Ethiopia. A slightly higher prevalence rate (23%) was reported at Jigjiga municipal abattoir (Etana *et al.,* 2015). Hydatidosis has a negative economic impact as the disease causes not only losses in yield in terms of internal organs and other products like milk and meat, but also productivity of camels in general. It is also expensive and complicated to treat echinococcosis as well as it require extensive surgery and/or prolonged drug therapy (Velasco-Tirado *et al.,* 2018). The disease also impacts public health especially in areas where there is poor veterinary service coverage, low awareness and low level of sanitation. In contrast to the present result, higher prevalence were previously reported in different parts of Ethiopia (Muskin *et al.*, 2011; Bulto *et al.*, 2013; Bayleyegn *et al.*, 2013; Dawit *et al.*, 2013; Abdiselam *et al.*, 2014), Kenya (61.4%) (Njoroge *et al.*, 2002), Iran (35.25%) (Ahmadi, 2005) and Saudi Arabia (32.85%) (Ibrahim, 2010). These variations owe to several factors. The eggs of *Echinococcus* excreted in the feces of the definitive hosts such as dogs and foxes, are sensitive to desiccation and are destroyed quickly if exposed to direct sunlight (Eckert *et al.,* 2001). Hence, the dry, hot, and semi-arid climate of the study area may have limited the survival and infectivity of the eggs. Although there are less strict means of handling condemned hydatid cyst harbored organ at the slaughterhouse, the small number of slaughtered camels, the few numbers of dogs and wild carnivores, the less likelihood of these definitive host's

interact with the camels, and the nomadic nature of the camel rearing community to relatively dog-free areas, may limited the accessibility of the infective stage of the parasite eggs by the intermediate host, camels, and thereby break the lifecycle of the parasite. However, the backyard camel slaughtering practices and the extensive nature of the pastoral grazing in the study area (Samuel, 2008) allows contact with the definitive hosts and thereby maintained the infection to the reported magnitude level of this study.

Increased rate of infection with advanced age of camel observed in the present study were also reported by others in Akaki (Bulto *et al.,* 2013) and Jigjiga (Etana *et al.,* 2015) municipal abattoirs. The high rate of infection in older camels may be explained by many years of exposure to eggs of *E. granulosus*. The chronic nature of the disease also favors the animals to keep cysts for prolonged time, making the cyst to get larger and easily detectable (Dadkhah *et al.,* 2011). Moreover, most of the camels are slaughtered at old age when the productivity of the animal is reduced and when they are sick (Bulto *et al.,* 2013). The high number of cysts count in poor body condition camels indicate that moderate to severe infection of the parasite causes live weight loss, reduced quality and quantity of meat and milk (Polydorou, 1981), which could partially explain the greater association of poor body condition with higher cyst burden. Similar results were recorded in previous studies (Bulto *et al.,* 2013; Etana *et al.,* 2015).

The high prevalence of hydatid cysts in the lung (55.2%) and liver (40.32%) agreed with previous findings (Njoroge *et al.,* 2002; Eckert and Deplazes, 2004; Bayleyegn *et al.,* 2013; Elmajdoub and Rahman, 2015). Camels are infected when grazing on contaminated ground with *Echinococcus* egg. The eggs then hatched to oncosphere (hexacanth embryo) by the aid of digestive juices. As the immature parasites have no selective affinity for any particular organ, their location is controlled by the filtering action of capillaries. Thus, the greater prevalence of the cyst in the lung and liver could be due to the fact that the oncospheres in the gut can easily penetrate the wall of the intestine with the hooklets and carried by the bloodstream to these vital organs through the radicles of the portal vein primarily to visceral dense capillary beds, usually the hepatic and pulmonary filtering system consecutively before any other peripheral organ is involved. The migrating *Echinococcus* oncosphere that are carried by the hepatic portal vein to the liver are arrested in the sinusoidal capillaries, the liver acting as the first filter, and some embryos pass through the hepatic capillaries, leaves the liver through the hepatic veins, join the inferior vena cava, enter the pulmonary circulation, and filter out in the pulmonary capillary beds, the lungs acting as the second filter (Morar and Feldman, 2003).

In the present study, the camel's lung is the most infected organ by hydatid cysts, as similarly reported by other workers (Ibrahim and Gusbi, 1997; Ibrahem and Craig, 1998; Ahmadi, 2005; Craig *et al.,* 2007; Bayleyegn *et al.,* 2013; Elmajdoub and Rahman, 2015). This might be because camels are slaughtered at older age, during which period the liver capillaries are dilated and most oncosphere escape directly to the lungs. The presences of large capillary beds in the lung also benefit the oncospheres to lodge in lung than any other organs. Moreover, the tissue of camel liver is tough and solid, making it difficult for the oncosphere to grow normally, whereas, the lung tissue is smoother and softer, making it easier for the oncosphere to grow faster and enhance their visibility and detection at a time of examination (Collins and Huey, 2015). The *Echinococcus* oncosphere may also enter the lymphatic circulation and carried via the thoracic duct to the heart and the lung in such a way that the lung may be infected before the liver (Arene, 1985). Furthermore, camels lack well developed bile duct structures that possess an arterial plexus, which makes easier the entry of onchospheres into the liver from blood in the hepatic artery along with the arterial blood that course throughout the liver parenchyma within portal triads from the marginal vessels derived from the postero-superior pancreaticoduodenal artery (Vellar, 1999).

Greater hydatid cysts number in the lung than liver were also observed by other researchers from different parts of Ethiopia (Moges *et al*., 2001; Muskin *et al*., 2011; Bayleyegn *et al*., 2013; Dawit *et al*., 2013) and from other countries such as Pakistan (Anwar and Khan, 1998), Libya (Ibrahem and Craig, 1998), Jordan (Sharrif *et al*., 1998) and Iran (Ahmadi, 2005). As camels get older, the capillaries of the liver get dilated and release most cysts to the lungs through the portal vein (Nigatu e*t al*., 2009b). The lung tissue favors the fast growth of the oncosphere due to its smooth and soft parenchyma. Since liver tissue is tough and solid, it does not allow the oncospheres to grow to large size (Elmajdoub and Rahman, 2015).

Greater count of fertile cysts in lungs than liver was similar to that observed by other workers (Ahmadi, 2005; Muskin *et al.,* 2011; Bulto *et al.,* 2013; Etana *et al.,* 2015). The relatively soft consistency of the lung tissue and the ability of the tissue to resist infection may impact the cyst fertility rate (Collins and Huey, 2015). The fertility rates observed in the present study is relatively low. However, it can maintain the life cycle of hydatidosis when infected raw offal are fed to dogs or leftovers during backyard slaughter are eaten by wild carnivores (Bulto *et al.,* 2013).

The reason for higher percentage of medium and large sized cysts in lungs might be related to the spongy consistency of the lung, which allows easier development of the cyst. The relatively higher proportion of small cysts in liver is attributed to immunological response of the host, which could preclude expansion of cyst size, while the higher yield of calcified cysts in liver could be credited to relatively higher reticuloendothelial cells and abundant connective tissue reaction of the organ (Ibrahim and Gusbi, 1997). Some researchers reported that strain

differences may also account for this phenomenon (Pangi and Ould 1991; Ibrahim and Gusbi, 1997).

The present study revealed that the significant financial loss is attributable to direct effect due to organ condemnation by hydatidosis, which amounts to 5214.95 USD annually. This finding is higher than that reported by Abdiselam *et al.* (2014) at Dire Dawa municipal abattoir, the difference being attributed to variation in the prevalence of the disease, retail market price of organs and mean annual slaughter rate. The current estimation only involved a direct loss without considering the indirect losses like reduced carcass weight.

Conclusion

Hydatidosis was one of the most important parasitic diseases in camels slaughtered at Jigjiga town incurring a considerable financial loss through condemnation of offal's such as liver, lung, spleen and kidney at slaughter houses. Therefore, it warrants enforcement of legislation that will put an end to roadside slaughtering practices, establishment of policy in dog keeping and handling and awareness creation about hydatidosis effect to farmers, animal attendants, abattoir workers and butchers.

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Conflict of Interests

The authors declare that they have no competing interests.

References

Abdiselam Mohammed Hayer, Mersha Chanie Kebede & Ismail Warsame (2014). Prevalence, economic and public health significance of camel hydatidosis in Dire Dawa municipal abattoir, Eastern Ethiopia. *Acta Parasitologica Globalis,* 5: 98-106.

Abebe Fromsa & Yilma Jobre (2011). Infection prevalence of hydatidosis (*Echinococcus granulosus*, Batsch, 1786) in domestic animals in Ethiopia: A synthesis report of previous surveys. *Ethiopian Veterinary Journal,* 15: 11-33.

Ahmadi, N. A. (2005). Hydatidosis in camels (*Camelus dromedarius*) and their potential role in the epidemiology of *E. granulosus* in Iran. *Journal of Helminthology,* 79: 119-125.

Ahmed, I. (1998). Preliminary investigation on major diseases of camels in Eastern Ethiopia, Abattoir and field survey, DVM Thesis, Addis Ababa University, Faculty of Veterinary Medicine, Deber ziet, Ethiopia.

Andualem Getaw, Desta Beyene, Dinka Ayana, Bekele Megersa & Fufa Abunna (2010). Hydatidosis: prevalence and its economic importance in ruminants slaughtered at Adama municipal abattoir, Central Oromia, Ethiopia. *Acta Tropica,* 113: 221-225.

Anwar, A. H. & Khan, M. N. (1998). Parasitic fauna of camel in Pakistan. In: The proceedings of the third annual meeting for animal production under arid conditions, United Arab Emirates University, 2: 69-76.

Arene, F. O. I. (1985). Prevalence of hydatid cysts in domestic livestock in the Niger Delta. *Tropical Animal Health and Production,* 17: 3–5.

Azlaf, R. & Dakkak, A. (2006). Epidemiological study of the cystic echinococcosis in Morocco. *Veterinary Parasitology,* 137: 83-93.

Bayleyegn Gizachew, Fikadu Kibru & Biruhtesfa Asrade (2013). Camel hydatidosis: prevalence and economic significance in pastoral regions of Ethiopia. *Journal of Parasitology and Vector Biology,* 5: 90-95.

Bekele Megersa (2010). An epidemiological study of major camel diseases in the Borana lowland, Southern Ethiopia. DCG report No. 58, Drylands Cooperation Group, Oslo, pp: 1-62.

Bulto Giro Boru, Yacob Hailu Tolossa, Getachew Tilahun & Hagos Ashenafi (2013). Study on prevalence of hydatidosis and cyst characterization in camels (*Camelus dromedarius*) slaughtered at Akaki abattoir, Ethiopia. *Journal of Veterinary Medicine and Animal Health*, 5: 329-333.

Collins, D. S. & Huey, R. J. (2015). Gracey's meat hygiene. Oxford: Wiley-Blackwell, 11th ed., pp: 215.

Craig, P. S., McManus, D. P., Lightowlers, M. W., Chabalgoity, J. A., Garcia, H. H., Gavidia, C. M., Gilman, R. H. & Gonzalez, A. E. (2007). Prevention and control of cystic echinococcosis. *Lancet Infectious Disease,* 7: 385-394.

CSA (Central Statistical Agency) (2018). Federal Democratic Republic of Ethiopia; *Agricultural Sample Survey Report on Livestock and Livestock Characteristics*, Addis Ababa. Ethiopia. Statistical bulletin, 2:16.

Dadkhah, M. A., Yeganehzad, M. & Nadery, B. (2011). Survey on hydatid cyst infestation in Sarab city (Northwest of Iran) using epidemiological and seroepidemiological criteria. *Journal of Animal and Veterinary Advances,* 10: 2099-2101.

Dawit Gebremichael, Aklilu Feleke, Getachew Terefe & Matios Lakew (2013). Infection rates, risk factors and cyst fertility of hydatid cyst disease in camels in Ayssaita district, Northeastern Ethiopia. *Global Veterinaria*, 11: 465-471.

Eckert, J. & Deplazes, P. (2004). Biological, epidemiological and clinical aspects of echinococcosis a zoonosis of increasing concern. *Clinical Microbiology Reviews*, 17: 107-135.

Eckert, J., Gottstein, B., Heath, D. & Liu, F. J. (2001). Prevention of echinococcosis in humans and safety precautions. In: J. Eckert, M. A. Gemmell, F. X. Meslin & Z. S. Pawlowski (Eds.), WHO/OIE manual on echinococcosis in humans and animals: a public health problem of global concern, World Organization for Animal Health, Paris, France, pp: 238-247.

Elmajdoub, L. O. & Rahman, W. A. (2015). Prevalence of hydatid cysts in slaughtered animals from different areas of Libya. *Open Journal of Veterinary Medicine*, 5: 1-10.

Etana Debela, Buckhary Abdulahi, Bekele Megersa, Bersissa Kumsa, Fufa Abunna, Desie Sheferaw & Alemayehu Regassa (2015). Hydatidosis of camel (*Camelus dromedarius*) at Jijiga municipal abattoir, Eastern Ethiopia: prevalence, associated risk factors and financial implication. *Journal of Parasitic Diseases,* 39: 730-735.

FAO (2000). Manual on meat inspection for developing countries. Food and Agriculture Organization of the United Nations Rome, Italy. FAO animal production and health paper, 119.

Faye, B., Bengoumi, M., Cleradin, A., Tabarani, A. & Chilliard, Y. (2001). Body condition score in dromedary camel: A tool for management of reproduction. *Emirates journal of agricultural sciences,* 13: 1-6.

Gracey, J. F. (1986). Meat hygiene, 8th ed., London: Baillere Tindall, pp: 239-289.

Ibrahem, M. M. & Craig, P. S. (1998). Prevalence of cystic echinococcosis in camels (*Camelus dromedarius*) in Libya. *Journal of Helminthology,* 72: 27-31.

Ibrahim, M. M. & Gusbi, A. M. (1997). Cystic echinococcosis in Northern Africa (excluding Morocco): Veterinary aspects. In: F. L. Anderson, H. Ouhelli & M. Kachani (Eds.), Compendium on cystic echinococcosis in African and in Middle Eastern countries with special reference to Morocco, Brigham Young University, Provo. UT 84602, USA, pp: 207.

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.

Khan, B., Iqbal, A. & Riaz, M. (2003). Production and management of camels, University of Agriculture, Faisalabad, Pakistan, pp: 152-156.

Lahmar, S., Debbek, H., Zhang, L. H., Mcmanus, D. P., Souissi, A., Chelly, S. & Torgerson, P. R. (2004). Transmission dynamics of the *Echinococcus granulosus* sheep-dog strain (G1 genotype) in camels in Tunisia. *Veterinary Parasitology,* 121: 151-6.

Macpherson, C. N. L. (1985). Epidemiology of hydatid disease in Kenya: A study of the domestic intermediate hosts in Masuil and Traan. *Royal Society of Tropical Medicine and Hygiene,* 79: 209-217.

Miheret Mulatu, Biruk Mekonnen, Habtamu Tassew & Ashwani Kumar (2013). Bovine hydatidosis in Eastern part of Ethiopia. *Momona Ethiopian Journal of Science*, 5: 107-114.

Moges Woldemeskel, Issa, A., Mersic, A. & Potgieter, L. N. D. (2001). Investigation of parasitic disease of one- humped camel (*Camelus dromedarius*) in eastern Ethiopia. *Journal of Camel Practice and Research,* 8: 77-81.

Morar, R. & Feldman, C. (2003). Pulmonary echinococcosis. *European Respiratory Journal,* 21: 1069-1077.

Muskin Salih, Hailu Degefu & Moti Yohannes (2011). Infection rates, cyst fertility and larval viability of hydatid disease in camels (*Camelus dromedarius*) from Borena, Kereyu and Harar areas of Ethiopia. *Global Veterinaria,* 7: 518–522.

Nigatu Kebede, Abebe Abuhay, Getachew Tilahun & Abebe Wossene (2009a). 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.

Nigatu Kebede, Abebe Mitiku & Getachew Tilahun (2009b). Hydatidosis of slaughtered animals in Bahir Dar abattoir, Northwestern Ethiopia. *Tropical Animal Health and Production,* 41: 43-50.

Nigatu Kebede, Habtamu Mekonnen, Abebe Wossene & Getachew Tilahun (2009c). Hydatidosis of slaughtered cattle in Wolayita Sodo abattoir, Southern Ethiopia. *Tropical Animal Health and Production,* 41: 629-633.

Njoroge, E. M., Mbithi, P. M. F., Gathuma, J. M., Wachira, T. M., Gathura, P. B., Magambo, J. K. & Zeyhle, E. (2002). A study of cystic echinococcosis in slaughter animals in three selection areas of Northern Turkana, Kenya. *Veterinary Parasitology*, 104: 85-91.

Pangui, L. J. & Ould, A. E. (1991). Incidence of camel hydatidosis in Mauritania. *Bulletin Animal Health and Production in Africa*, 39: 25-30.

Polydorou, K. (1981). Animal health and economics. Case study: echinococcosis with reference to Cyprus. *Bulletin de l'Office International des Epizooties,* 93: 981-992.

Samuel T. Bekele (2008). Gross and microscopic pulmonary lesions of camels from Eastern Ethiopia. *Tropical Animal Health and Production,* 40: 25–28.

Shapiro, B. I., Getachew Gebru, Solomon Desta, Asfaw Negassa, Kidus Nigussie, Gezahegn Aboset & Henok Mechale (2017). Ethiopia livestock sector analysis, ILRI Project Report, Nairobi, Kenya: International Livestock Research Institute (ILRI), pp: 8.

Sharrif, L., AL-Rawashdeh, O. M., Al-Qudah, K. M. & Al-Ani, F. K. (1998). Prevalence of gastrointestinal helminthes, hydatid cysts and nasal myiasis in camel in Jordan. In: The proceeding of the third annual meeting for animal production under arid conditions, United Arab Emirates University, pp: 108–114.

Smyth, J. D. & Barrett, N. J. (1980). Procedure for testing the viability of human hydatid cysts following surgical removal, especially after chemotherapy. *Royal Society of Tropical Medicine and Hygiene,* 74: 649-652.

STATA (1985-2015). Statistics/Data Analysis: Stata/SE, Version 14.0, Texas, USA.

Tadele Tolosa, Worku Tigre, Teka, G. & Dorny, P. (2009). Prevalence of bovine cysticercosis and hydatidosis in Jimma municipal abattoir, Southwest Ethiopia. *Onderstepoort Journal of Veterinary Research*, 76: 323–326.

Thrusfield, M. & Christley, R. (2018). Veterinary epidemiology, 4th ed., John Wiley & Sons Ltd., Oxford, UK, pp: 275-276.

Velasco-Tirado, V., Alonso-Sardón, M., Lopez-Bernus, A., Romero-Alegría, A., Burguillo, F. J., Muro, A., *et al.* (2018). Medical treatment of cystic echinococcosis: systematic review and meta-analysis. *BMC Infectious Diseases,* 18:306.

Vellar, I. D. (1999). The blood supply of the biliary ductal system and its relevance to vasculobiliary injuries following cholecystectomy. *The Australian and New Zealand Journal of Surgery,* 69:816-820.

Yohannes Mehari, Zeleke Mekuriaw & Getachew Gebru (2007). Potentials of camel production in Babilie and Kebribeyah *woredas* of the Jijiga Zone, Somali Region, Ethiopia. *Livestock Research for Rural Development*, 19: 58-62.