Cystic echinococcosis among livestock in Arabia Peninsula: A systemic Review and Meta-Analysis

ABSTRACT

Cystic echinococcosis/cystic hydatidosis is a zoonotic disease caused by the larval stages of taeniid cestodes of the genus *Echinococcus*. The aim of this study is to estimate the prevalence of echinococcosis among the livestock in Arabia Peninsula countries including Yemen, Saudi Arabia, United Arab Emirate (UAE), Oman, Kuwait, Bahrain and Qatar. Literature searches were performed on PubMed, Science Direct, Scopus and Google scholar for English language articles from June 2000 to June 2021. The prevalence of cystic echinococcosis was estimated using the random effects meta-analysis. Of the 4477 records identified in the electronic databases, 713 articles met eligibility criteria. Out of 713, 19 studies addressed a total number of 1132538 individuals from the whole livestock were subjected to meta-analysis. The results revealed that, the pooled prevalence of cystic echinococcosis in livestock at Arabia peninsula countries was 13.4% (95% CI 10.8 –16.0) with high level of heterogeneity (I^2 = 100%, P < 0.001). Based on countries, subgroup meta-analysis demonstrated that, the pooled prevalence rates were 10.5 %(95% Cl 6.9-14), 9.3% (95% Cl 5.-13.5) and 34.1% (95% Cl 9.9-58.1) in S. Arabia, Yemen and Oman respectively. No publications on prevalence of cystic echinococcosis in livestock in UAE, Kuwait, Bahrain and Qatar were found. The Cattle had the highest prevalence rate 74.1(95% Cl, 0 -15-1.096) of infection; while, goats had the lowest prevalence rate 4.7% (95% Cl, 4.2-13.6). Significant differences have been observed (P < 0.001) among different animals' species. In the term of diagnostic tool, the prevalence rates were 9.7% (95% Cl: 6.9-12.4), 14.7% (95%Cl: 13.5.-16.0) and 79.0% (95% Cl: 74.084.0) for post mortem inspection, serological and Haemagglutination & Molecular assays respectively. Significant differences were observed (P < 0.001) among prevalence rates of different diagnostic techniques used. In conclusion, the results showed that, cystic echinococcosis is prevalent among livestock in Arabia Peninsula countries. Given to the importance of cystic echinococcosis on health of domestic animals industry, the results of this study could be valuable in developing strategies for prevention and control of the cystic echinococcosis in livestock.

Keywords: Arabia Peninsula, Cystic echinococcosis, Livestock, Systematic review, Meta-analysis

1. INTRODUCTION

Livestock play a critical role in human nutrition and socio-economic development. Animal products such as meat, milk, eggs and offal are sources of protein, energy, calcium and micronutrients, however, these products contributing around 13% calories and 28% protein of human nutrient worldwide [1]. In lower-income countries, livestock do not only provide a regular supply of nutrients, but also serve as a direct source of income and employment, contribute to crop production through the provision of manure

and traction power. In addition, they act as capital assets usable as future investment revenue [2].

Cystic echinococcosis (CE), caused by the metacestode of the tapeworm *Echinococcus granulosus,* is one of the most common animal infections and most widespread parasitic zoonosis in many countries of the world [3-12]. *Echinococcus* genus includes 10 main genotypes (G1-G10) viz: Sheep strain (G1), Tasmanian sheep strain (G2), Buffalo strain (G3), Horse strain (G4), Cattle strain (G5), Camel strain (G6), Pig strain (G7) and Cervid strain (G8), Human polish strain (G9), and Fennoscanadian cervid strains G10 [13-15].

The parasite has an indirect life cycle that requires two mammalian hosts. The adult cestode, which inhabits the small intestine of dogs and other canids (definitive hosts), lays eggs that are voided with the faeces of the infected canid animal, thus contaminating the environment [11]. Domestic or wild ungulates which act as intermediate hosts acquire the infection through accidental ingestion of the eggs during grazing, which in turn develop into the parasite's larval stage (metacestode/ hydatid cysts) in internal organs(liver, lung and heart) and ultimately cause the pathology associated with cystic echinococcosis [11,16, 17].

The epidemiology of CE infection in different animals depending on the *Echinococcus* species/genotype involved the number and size of hydatid cysts and the organ affected, host-associated factors such as immune status, age, and presence of concomitant infections [18]. Economic losses arise from hydatid infection in livestock not only from the condemnation of infected viscera, but also from decreases in yield and quality of meat, milk and wool, reduced hide value, reduced birth rate and fecundity, and delayed performance and growth [19, 20].

Livestock CE is widespread through many regions of Asia including Arabia Peninsula countries such as Yemen, S. Arabia and Oman [21-23]. CE in Arabia Peninsula is mainly transmitted through dogs acting as definitive host and a variety of intermediate hosts species including sheep, goats, cattle, and camels. Wild carnivores including jackals, wolves and probably red foxes have not been reported to be infected with *Echinococcus* adult worms, no demonstrating the co-existence of a sylvatic cycle [22].

Preventive measures that have been used to control *Echinococcus* infections in animals include avoidance of contact with dog faeces, hand washing, improved sanitation, reducing dog populations, treatment of infected dogs with anthelmintics, incineration of infected organs, and health education [24, 25].

It is so difficult to estimate a precise prevalence status of hydatidosis in intermediate hosts in any continent. This may be explained by poor accuracy and costly diagnostic tests. Currently, most of the prevalence status studies have been based on slaughter data [26]. In Yemen and neighboring country, where home slaughtering of cattle, sheep, goats and camels is still practiced and uncooked offal and carcass wastes are normally fed to dogs and cats, cystic hydatidosis has become an endemic disease and poses public health problems. Several studies have been conducted on the

prevalence of CE in Arabia Peninsula and reported the prevalence rate ranging between 0.2-100% [23, 27-29]. However, there is no study has systematically analyzed these information. Therefore, the aim of this systematic review and meta-analysis is to provide a summary of the available data on CE in animals obtained from countries of Arabia peninsula.

MATERIALS AND METHODS

1.2. Study area

The Arabian Peninsula, also known as Arabia, is the largest Peninsula in the world. At 1.250.005 square miles (3. 237.500 square kilometers), the Arabian Peninsula is located in western Asia to the northeast of Africa. The Peninsula is home to over 77.9 million people in seven countries. The Peninsula consists of a range of deserts, mountains, marshy coastlines, oases, and a central plateau called the Najd, which has fertile valleys [30]. The climate of Peninsula Arabian is semi-arid to arid, with high annual temperatures and low precipitation different seasons, observed temperature ranges from 8.57 to 28.32 °C in the northern Peninsula; whereas, temperature ranges from 26.68 to 33.97 °C in the southern Peninsula [31]. During summertime, the maximum temperature may exceed 50 °C at some locations over the region. The annual mean precipitation varies from 25 mm in the northwest region and 230 mm in the southwest region [32].

2.2. Data sources and Search strategy

Four international databases including PubMed, Science Direct, Scopus and Google scholar were searched on line for articles published between June 2000 and June 2021. The languages of the literature were restricted to English language only. Search terms used for this review were as following, “cystic echinococcosis,” “*Echinococcus granulosus*,” “hydatid cyst,” “hydatid disease”, “hydatidosis,”, “Animals”, “Livestock” “ Yemen,”, "S. Arabia”, “ United Arab Emirate” , "Oman", "Kuwait” , "Bahrain” and "Qatar” either alone or in combination. A study was included if it fulfilled the following criteria: cross-sectional studies that focused on the prevalence of CE published in English, studies that have the sufficient information to establish the prevalence of echinococcosis in livestock in Arabia Peninsula. Other observational as review studies, grey literature, intervention and clinical trial studies were excluded. A current systemic review and meta-analysis was performed according to Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines [33].

3.2. Data extraction

The selected articles were independently assessed by two authors. All duplicate and irrelevant articles were excluded after evaluating their titles, abstracts, and full texts. Any disagreements between the two authors were resolved by consultation with another author. From each article, the following information were extracted: the first author, year of publication, study location, number of total collected samples, and number of positive samples for cystic echinococcosis, animal species and diagnostic technique used. The relevant data were extracted using Microsoft Office Excel.

4.2. Statistical analysis

The meta-analysis procedure was performed as described previously [34]. Briefly, relevant data were exported to Open Meta Analyst version10.10 software for analysis. Meta-analysis of pooled prevalence with 95% Confidence Interval was carried out using a random effects model, and results were displayed in a forest plot. Heterogeneity among studies was estimated using the Cochran's Q and I^2 statistic.

3. RESULTS

The literature search identified 4477 potentially relevant studies/articles. On an initial screening 321 articles were excluded as duplicates. After second screening of the titles and abstracts, an additional 3424 studies were excluded. After reading the full text of the remaining articles, 713 other papers were eliminated. Finally, a total of 19 studies published from June 2000 to June 2021 representing 1132538 animals of different species which fulfilled the eligibility criteria were included in this systemic review and meta-analysis (Fig 1).

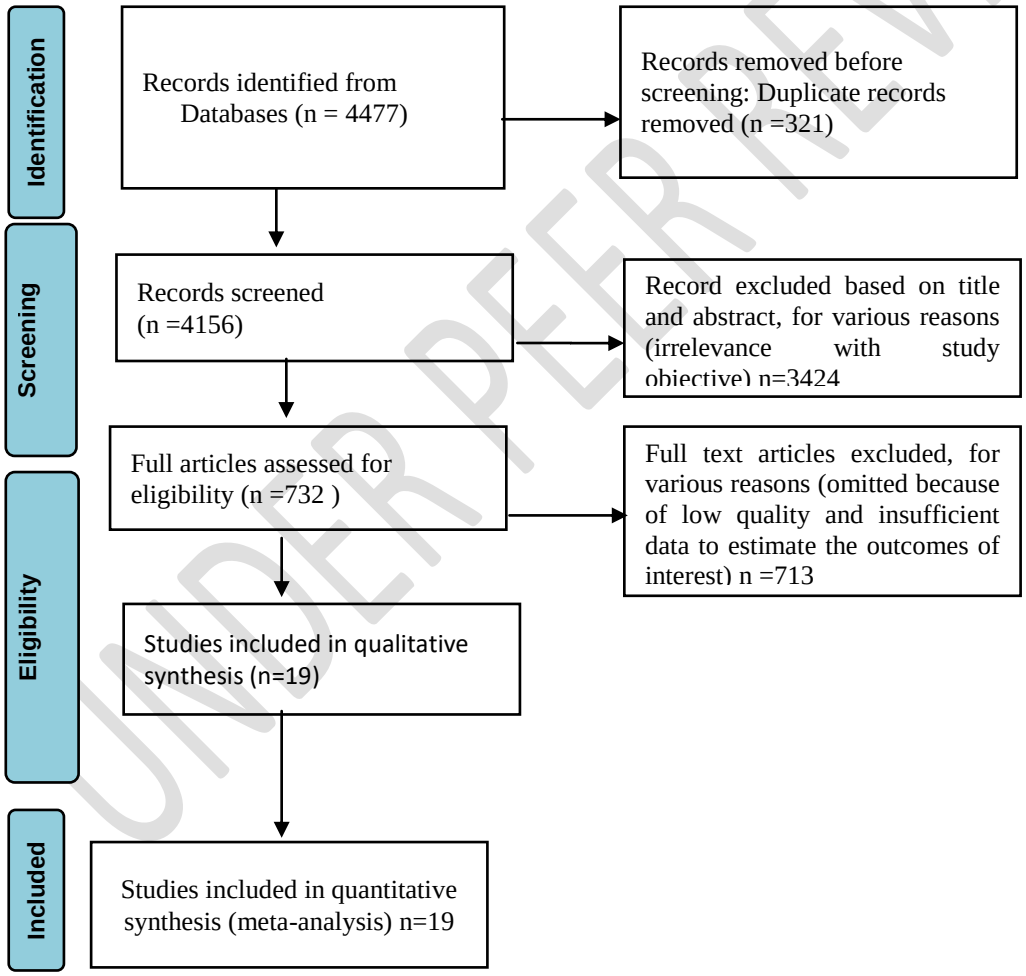

Figure 1: PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis protocol) Flowchart describing the study design process,

Echinococcosis among livestock in Arabia Peninsula: a systemic Review and Meta Analysis. Downloaded From Page et al. [35]

Data were extracted from nineteen eligible articles of cross sectional studies only. Out of 19 cross-sectional studies, sixteen studies used Post mortem inspection as the reference techniques for CE detection; whereas, three studies used serological and molecular techniques. Based on the origin of study, 10, 6 and 3 studies from S. Arabia, Yemen and Oman respectively were included. No studies or publications reporting the prevalence of cystic echinococcosis in livestock in United Arab Emirates, Kuwait, Qatar and Bahrain were found during out study period. Based on the publication years, the number of studies were, 1 (2007), 1 (2008), 2 (2009),1 (2012), 2 (2013), 3 (2014), 2 (2015), 3 (2017), 1 (2018) and 3 (2019) as presented in Table 1.

The results of reviewed studies are presented in Table 2 and Fig. 2. As shown, the prevalence rate of cystic echinococcosis among animal population from the reviewed studies was ranged from 2.0 to 79.0 %; while, the meta-analysis for the reviewed studies showed that, pooled prevalence of CE was 13.4% (95% CI 10.8 – 16.0%). Heterogeneity test showed a high level of heterogeneity (I^2 = 100%, P < 0.001) among the studies included in this review.

Based on subgroup analysis by countries, the pooled prevalence rates of cystic echinococcosis among countries were 10.5 % (95% CI 6.9-14), 9.3% (95% CI 5.-13.5) and 34.1% (95% CI 9.9-58.1) in S. Arabia, Yemen and Oman respectively (Table 3 & Fig. 3).

The prevalence rate of CE infections among different animal species investigated in this meta-analysis are presented in Table 4 & Fig. 4. As shown, the subgroup meta-analysis demonstrated that, cattle had the highest prevalence rate of infection 74.1(95% CI, 0 -15-1.096), while goats had the lowest prevalence rate 4.7% (95% CI, 4.2-13.6). Significant differences have been observed (P < 0.001) among different animal species studied in this review.

Considering the type of diagnostic tool, three types of diagnostic techniques were used for diagnosis of CE in animals including: Post mortem inspection in16 cases (9.7%, 95% CI: 6.9-12.4), serological techniques (14.7%, 95%CI: 13.5.-16.0) in two cases and indirect haemagglutination assay (IHA) & Molecular assay (79.0%. 95% CI: 74.084.0) in one case as depicted in Table 5 & Fig. 5. Significant differences were observed (P < 0.001) among the prevalence rates of different diagnostic techniques used.

Table 1. Summary of 19 studies on prevalence of cystic echinococcosis in Arabian Peninsula countries

Authors & Reference	Year	Country	Sample Size	Positive samples	Prevalence	Animal species	Diagnostic technique
Abdel-Baki eta l. [36]	2018	S. Arabia	2785	65	2.3	S	PM
AlKitani et al. [37]	2014	Oman	682	63	9.2	G	PM
AlKitani et al. [23]	2017	Oman	2802	410	14.6	S, G, C, Ca	ELISA
AlKitani etal. [38]	2015	Oman	257	203	79.0	C	PM & PCR
ALMalki&Degheidy [39]	2013	S. Arabia	85201	10957	12.9	**S**	PM
AlSalami et al. [40]	2009	Yemen	139	11	7.9	Ca	PM
AlShaibani et al. [22]	2014	Yemen	323	49	15.2	C	PM
AlShaibani et al. [28]	2015	Yemen	385	88	22.9	S, G, C, Ca	PM
Alsulami [29]	2019	S. Arabia	38302	90	0.2	G	PM
Baswaid [41]	2007	Yemen	640	14	2.2	S, G	PM
ElGhareeb et al. [42]	2017	S. Arabia	1485	98	6.6	S	PM
Fdaladdin et al. [21]	2013	S. Arabia	790778	96628	12.2	S, G, C,Ca	PM
Haroun et al. [43]	2008	S. Arabia	200	32	16.0	Ca	IHA
Hayajneh et al. [44]	2014	S. Arabia	1494	180	12.0	S, G	PM
Hezam et al. [45]	2019	Yemen	1006	94	9.3	G, c	PM
Ibrahim[46]	2009	S. Arabia	12911	4500	34.9	S, G, C,Ca	PM
Muqbil et al.[27]	2012	Yemen	7507	54	0.7	S, G, C	PM
Toulah & Albalawi [47]	2019	S. Arabia	52783	4248	8.0	S	PM
Toulah et al. [26]	2017	S. Arabia	132858	563	0.4	S, G, C, Ca	PM

S=Sheep, Ca=Camel, G=Goat, C=Cattle, PM=Post mortem inspection, IHA= Indirect haemagglutination assay, PCR= polymerase reaction

Table 2. Over all pooled prevalence of cystic echinococcosis among livestock in Arabia peninsula

Model	No. of studies	Sample size	No. of infected animals	Pooled prevalence	95% Cl	I^2	P *value*
Random	19	1132538	118347	13.4%	10.8-16.0	100%	.001

Table 3. Prevalence of echinococcosis among livestock in Arabia peninsula according to country geographic

Country	No. of studies	Prevalence(95% Cl)	Heterogeneity		
			I^2	Q	P
S. Arabia	10	10.5%(6.9-14)	100%	107606.310	< 0.001
Yemen	6	9.3% (5.-13.5)	98%	258.636	< 0.001
Oman	3	34.1%(9.9-58.1)	100%	655.327	< 0.001
Over all	19	13.4(10.9-16.0)	100%	109338.375	< 0.001

Table 4. Prevalence of cystic echinococcosis among livestock in Arabia Peninsula according to animal species investigated

Animal species	No. of studies	Prevalence(95% Cl)	Heterogeneity		
			I^2	Q	P
Sheep	4	7.5%(3.4-11.6)	100		0.000
Goats	2	4.7% (4.2-13.6)	98		0.000
Cattle	2	74.1(0 -15-1.10)	100		0.000
Camels	2	11.9%(3.9-19.9)	82		0.019
Sheep, Goats, Cattle	1	7.0 (0.005, 0.01)	NA		NA
Sheep, Goats, Cattle, Camels	5	16.9%(3.9-24.9)	NA		NA
Sheep, Goats	2	7.1%(−2.6- 16.8)	99		0.000
Goats, Cattle	1	9.3% (7.5-11.1)	NA		NA
Over all	19	13.4(10.9-16.0)	100%	109338.375	< 0.001

Table 5. Prevalence of echinococcosis among livestock in Arabia Peninsula according to diagnostic techniques used

Diagnostic techniques	No. of studies	Prevalence(95% Cl)	Heterogeneity		
			I^2	Q	P
PM inspection	16	9.7%(6.9-12.4)	100%	108048.979	< 0.001
Serological	2	14.7% (13.5.-16.0)	98%	0.261	< 0.609
PM& Molecular	1	79.0%(74.084.0)	NA	NA	NA
Over all	19	13.4(10.9-16.0)	100%	109338.375	< 0.001

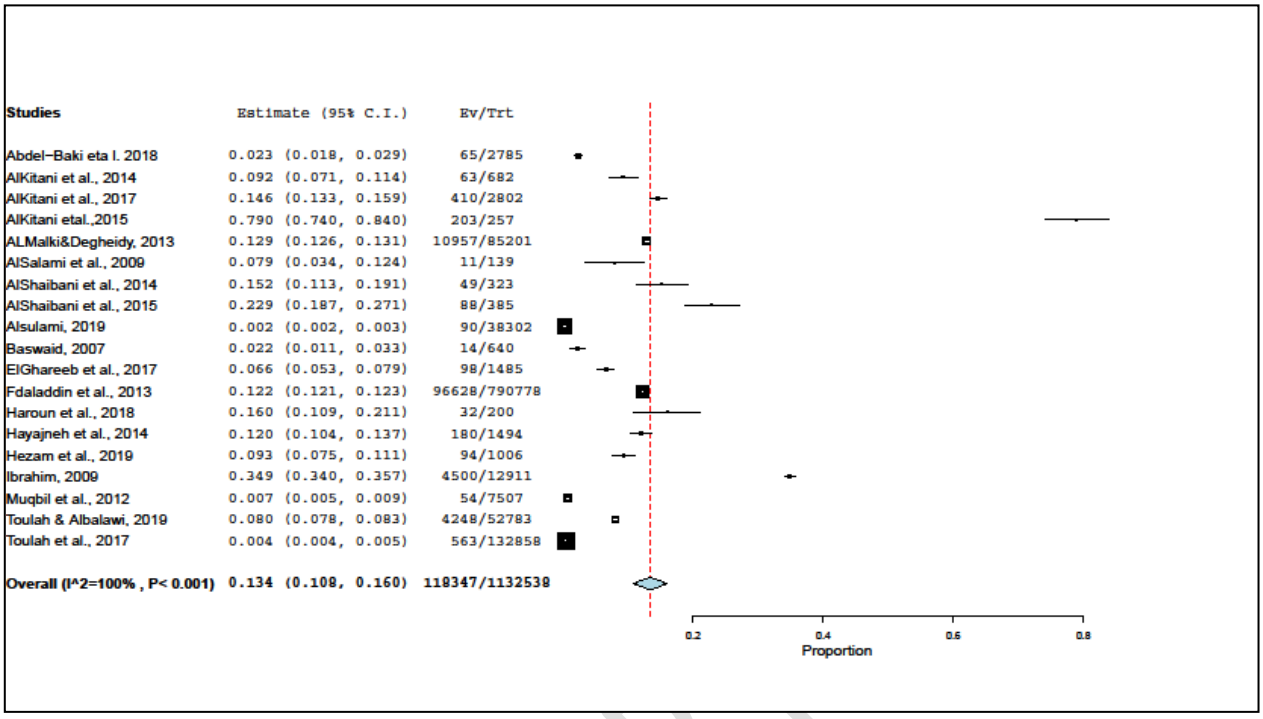

Fig. 2. Pooled prevalence of cystic echinococcosis in livestock in Arabia Peninsula countries

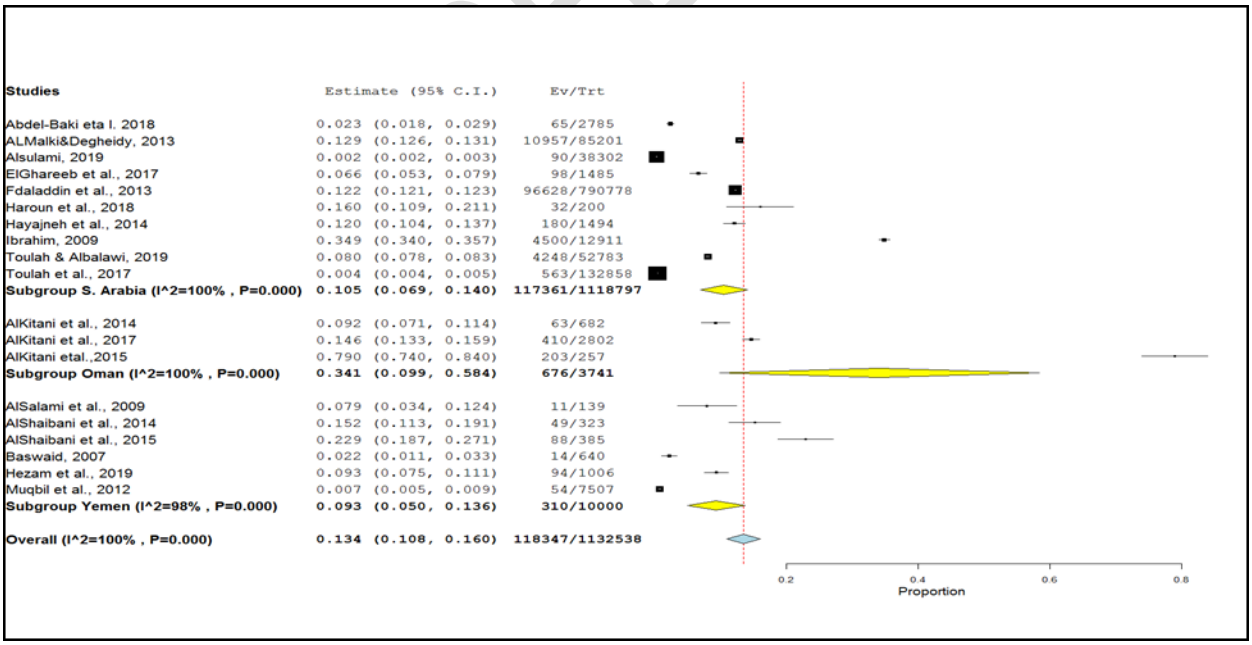

Fig. 3. Prevalence distribution of cystic echinococcosis among livestock in Arabia Peninsula countries

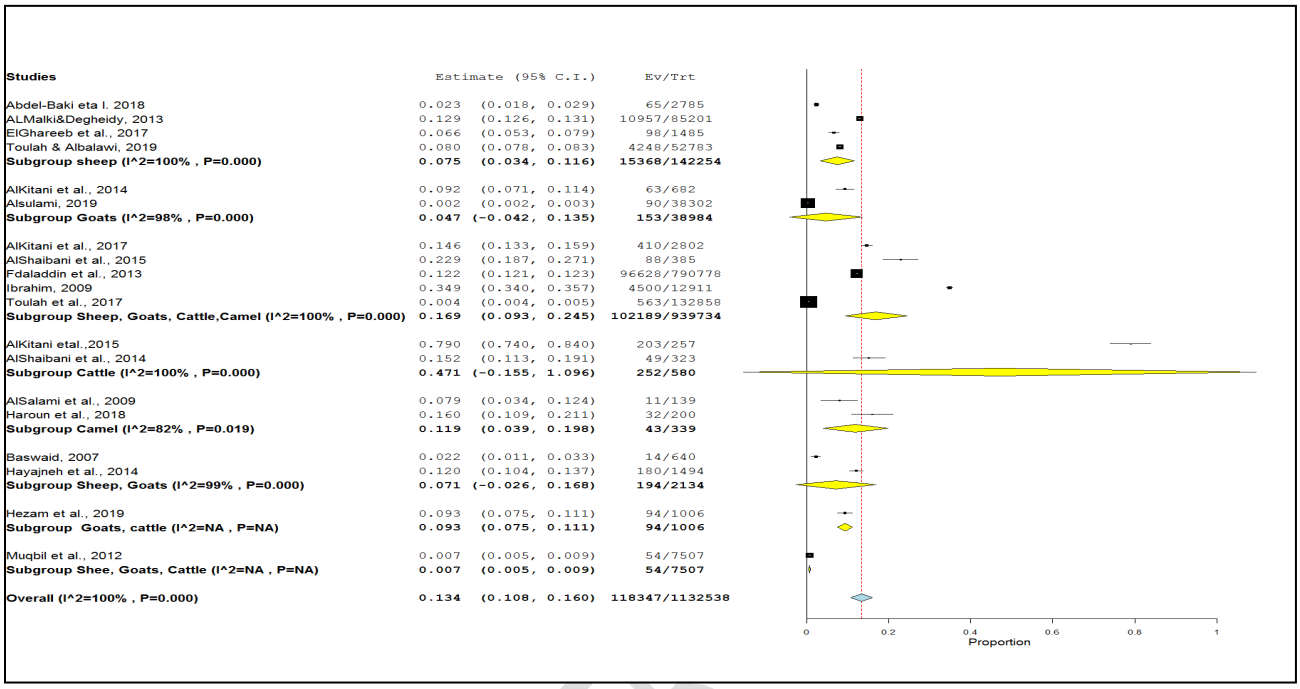

Fig. 4. Prevalence distribution of cystic echinococcosis among animals` species in Arabia Peninsula countries

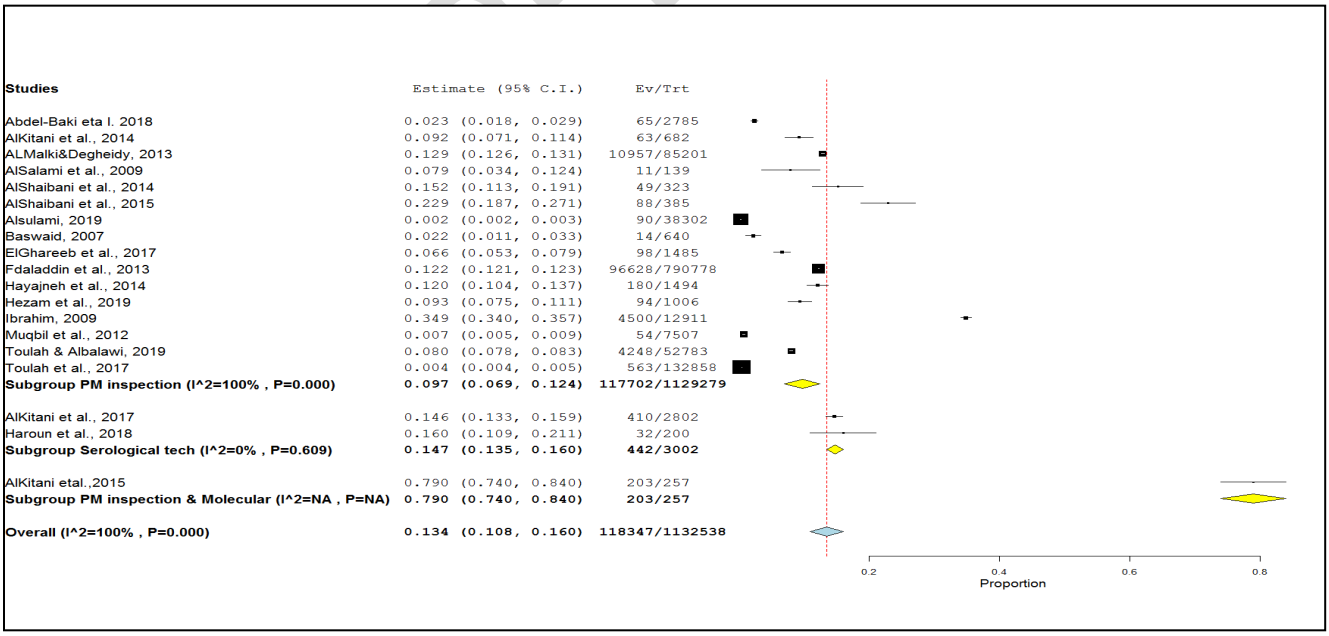

Fig. 5. Prevalence distribution of cystic echinococcosis among Livestock in Arabia Peninsula according diagnostic tools used

4. DISCUSSION

The scarcity of data on animal cystic echinococcosis in the Arabia Peninsula countries prompted us to summarize existing knowledge regarding this disease. CE infection constitutes a significant challenger constraint derived from animals' health costs and production losses. The economic burden of CE on the global livestock industry has been estimated at over $2 billion per annum [48]. Despite the substantial impact, CE remains neglected disease [49]. A sound understanding of the epidemiology of infection in animals is a key factor in limiting the transmission to humans. Controlling the parasitic infection in animals is crucial to reduce the prevalence of human disease [50].

In the present systemic review and meta-analysis, all studies performed on the prevalence of CE among slaughtered livestock in Arabia Peninsula countries were examined systematically based on the PRISMA guidelines [33]. In the initial search, 4477 studies were identified, from which 19 studies published between June 2000 to June 2021 were included in this review.

The results of this systemic review demonstrated that the cystic echinococcosis is prevalent among livestock in Arabia Peninsula countries with varying rates. These results are in line with findings of previous studies carried out in many countries of the world [51-61]. Meta-analysis revealed that, the estimated pooled prevalence of CE among livestock in countries of Arabia Peninsula during a period of 21 years, from June 2000 to June 2021, was 13.4%(95% CI:10.9-16.0). These results are in agreement with findings reported by Vaisi-Raygani et al. [15] in Iran, who reported the pooled prevalence rate as 13.9% (95% CI: 10.7–17.7%), and lower than prevalence rate (53.5%) reported by Ibrahem et al. [62] in Libya. The differences in the prevalence rate of CE among various studies could be due to climatic conditions, which could affect the viability of parasite's eggs, infected final hosts and livestock farming system in region and level of contact with dogs.

Based on subgroup Meta-analyses of countries, the pooled prevalence of CE in Arabia peninsula were 10.5 %(95% CI 6.9-14), 9.3% (95% CI 5.-13.5) and 34.1% (95% CI 9.9-58.1) in S. Arabia, Yemen and Oman respectively. The varying in percentages among livestock in the countries of Arabia Peninsula could be attributed to the animals' management system, abundance of definitive hosts, stock population and slaughtering process. In addition, in S. Arabia during religious gatherings, such as the annual Hajj pilgrimage to Mecca, where thousands of live animals, including cattle, sheep and goats are imported from various neighboring countries, slaughtered, and prepared for consumption in which the CE is epidemic in those countries and act source of disease.

Regarding animals` species, subgroup Meta-analysis results revealed that there were significant differences in CE pooled prevalence among animal's species. The higher prevalence of infection was recorded in cattle compared to other animal farm species investigated in this review. These results are in line with suggestions and findings of Azlaf and Dakkak [52] in Morocco, Cringoli et al. [63] in Italy and Fromsa and Jobre [64] in Ethiopia. However, the goats showed the lower rate of CE infection. These

results are in agreement with findings of Hassan et al. [65] and in contrast with finding of Getahun et al. [66]). The lower prevalence rate of CE in goats may be attributed to that, goats are browsers and eat the most distal parts of plants where there are fewer eggs of *E. granulosus* and other helminthes. Moreover, these eggs commonly have a greater exposure to hostile environmental conditions, and thus show a reduced infective capacity [10]. The results of this review also reported that sheep and camels as the domestic intermediate host infected with different range of infection. The difference in prevalence among animals` species could be a result of the existence of different strains of *E. granulosus* morphologically and biochemically adapted to each animal species and size sample examined [64].

Several techniques have frequently have been used for diagnosis of CE in farm animals, but post mortem inspection is still, the gold standard technique for detection the disease. In this review, the higher rate of CE were detected by post mortem inspection & Molecular technique, followed by serological and post mortem inspection techniques. The differences in efficacy of diagnostic tools may be due to human error or the limitations of these techniques.

Conclusion

It could be concluded that cystic echinococcosis is prevalent in livestock in Arabia Peninsula countries. Studies on the prevalence of cystic echinococcosis in livestock could provide critical information to support health policy makers to take effective decisions for the prevention and control of this zoonotic disease in animals and human.

Limitations

This systemic review presents some limitations concerning missing and bias publications. It is highly possible that relevant articles, which did not contain in their titles or abstracts the key words used in our search, will have been overlooked. Articles in non-indexed journals and non-published papers were not searched, which might make publication bias. Inclusion of studies published only in English may cause language bias.

REFERENCES

1. FAO. World Livestock in food security. Food and Agriculture Organization, Rome. 2011.
2. Randolph, TF, Schelling E, Grace D, Nicholson CF Leroy JL, Cole, DC. Demment, MW, Omore A, Zinsstag J and Ruel M. Role of livestock in human nutrition and health for poverty reduction in developing countries, J. Anim. Sci. 2007, 85, 2788–2800.
3. Torgerson, PR and Heath DD. Transmission dynamics and control options for *Echinococcus granulosus*. Parasitology. 2003, 127: 143–158.
4. Jenkins, DJ. Hydatid control in Australia: where it began, what we have achieved and where to from here. International Journal for Parasitology. 2005, 35:733–740

5. Jenkins, DJ. *Echinococcus granulosus* in Australia, widespread and doing well! Parasitology International. 2006. 55 (Suppl): S203–S206.
6. Sadjjadi, SM. Present situation of echinococcosis in the Middle East and Arabic North Africa. Parasitology International. 55 (Suppl). 2006, S197–S202.
7. Wang, Z, Wang, X and Liu X. Echinococcosis in China, a review of the epidemiology of *Echinococcus spp*. Ecohealth. 2008, 5: 115–126.
8. Torgerson, PR, Keller K, Magnotta M and Ragland N. The Global Burden of Alveolar Echinococcosis. PloS Neglected Tropical Diseases. 2010, 4(6): e722.
9. Romig, T, Omer RA, Zeyhle E, Huttner M, Dinkel A, Siefert L, Elmahdie IE, Magambo J, Ocaido M, Menezes CN, Ahmed ME, Mbae C, Grobusch MP and Kern P. Echinococcosis in sub-Saharan Africa: emerging complexity. Veterinary. Parasitolology. 2011, 181:43–47.
10. Torgerson, PR, Williams DH and Abo-Shehada MN. Modelling the prevalence of *Echinococcus* and *Taenia* species in small ruminants of different ages in northern Jordan. Veterinary Parasitology. 1998, 79: 35–51.
11. Negash, K, Beyen D and Kumsa B. Cystic echinococcosis in cattle slaughtered at Shashemanne Municipal Abattoir, south central Oromia, Ethiopia: prevalence, cyst distribution and fertility. 2013. Transactions of the Royal Society of Tropical Medicine and Hygiene. doi:10.1093 /trstmh/ trt003.
12. Li, B, Quzhen G, Xue2 C, Han S, Chen W, Yan XL et al. Epidemiological survey of echinococcosis in Tibet Autonomous Region of China. Infectious Diseases of Poverty. 2019, 8:29. https://doi.org/ 10.1186/s 40249-019-0537-5.
13. Grosso, G, Gruttadauria S, Biondi A, Marventano S, Mistretta. Worldwide epidemiology of liver hydatidosis including the Mediterranean area. World Journal of Gastroenterology 2012, 18 (13):1425 –37. Https: //doi. Org/10. 3748 / wjg. v18.i13.1425.
14. Hosseini-Safa, A, Mohaghegh MA, Pestechian N, Ganji M, Mohammadi R, Lamouki M, et al. First report of Tasmanian sheep strain (G2) genotype isolated from Iranian goat using the high-resolution melting (HRM) analysis. Gastroenterol Hepatol Bed Bench. 2016, 6(9):S70–4.
15. Vaisi-Raygani, A, Mohammadi M, Jalali R, Salari N and Hosseinian-Far M. Prevalence of cystic echinococcosis in slaughtered livestock in Iran: a systematic review and meta-analysis. BMC Infectious Diseases. 2021, 21:429.
16. Dakkak, A. Echinococcosis/hydatidosis: a severe threat in Mediterranean countries. Veterinary Parsitology. 2010, 174: 2–11.
17. Romig, T, Dinkel A and Mackenstedt U. The present situation of echinococcosis in Europe. Parasitology International, 55 (Suppl. 2006, S187–S191.
18. Eckert, J and Deplazes, P. Biological, epidemiological, and clinical aspects of echinococcosis, a zoonosis of increasing concern. Clinical Microbiology Reviews 2004, 17:107–135.
19. Torgerson, PR. Economic effects of echinococcosis. Acta Tropica. 2003, 85: 113–118.
20. Azami, M, Anvarinejad M, Ezatpour B, AlirezaeiM. Prevalence of Hydatidosis in Slaughtered Animals in Iran. Turkiye Parazitol Derg. 2013, 3(37): 102-6. doi:10.5152/tpd.2013.24.

21. Fdaladdin, YAJ, Alsaggaf AI and Wakid MH. Comparative epidemiological studies on *Echinococcosis* of local and imported livestock in Al-madina Al-munawwarah in Saudi Arabia. The Egyptian Journal of Hospital Medicine. 2013, 50:108-126.
22. AlShaibani, IRM, Ulmoghni AHA, AlRiashi BA, Al-Hodi AA. Bovine hydatidosis at central abattoir of Dhamar city, Yemen. Yemeni Journal of Agriculture & Veterinary Sciences. 2014, 1(2):1-10.
23. AlKitani, FA, Mansoor MK, Hussain MH, Al Rawahi AH, Saqib M, Al Maawali MG. Sero-epidemiology of cystic echinococcosis (*Echinococcus granulosus*) in the livestock of 2017. Oman. Veterinary Parasitology: Regional Studies and Reports. 2017, 8: 21-27.
24. McManus, DP and Thompson RC. Molecular epidemiology of cystic echinococcosis. Parasitology. 2003. 127: S37—51.
25. Moro, P, and Schantz PM. Echinococcosis: a review. International Journal of Infectious Diseases. 2009, 13: 125—133.
26. Toulah, FH, El Shafi AA, Alsolami MN, Wakid MH. Hydatidosis among Imported Animals in Jeddah, Saudi Arabia. Journal of Liver and Clinical Research; 2017, 4(1): 1031.
27. Muqbil, NA, Al-salam OM and Arab HA. Prevalence of Unilocular Hydatidosis in Slaughtered Animals in Aden Governorate-Yemen. Jordan Journal of Biological Sciences. 2012, 5(2):121 – 124.
28. AlShaibani, IRM, Saad FA, Al-Mahdi H. Cystic echinococcosis in humans and animals at Dhamar and Taiz governorates, Yemen. International Journal of Current Microbiology and Applied Sciences. 2015, 4 (2): 596-609.
29. Alsulami, M. Prevalence and histopathological study on cystic hydatidosis in heart and spleen of goat slaughtered at Makkah, Saudi Arabia. Annals of Parasitology. 2019, 65(3):225-236. doi: 10.17420/ap6503.204.
30. WPR, Arabia peninsula countries, retrieved 13.7.2021, //https:// world population review. com/country-rankings/arabian-peninsula-ountries. 2021.
31. Almazroui, M, Islam MN, Jones PD. Urbanization effects on the air temperature rise in Saudi Arabia. Climatic Change. 2013, 120 (1–2):109–122. Https: //doi.org/ 10.1007/s 10584-013-0796-2.
32. Almazroui, M. Temperature variability over Saudi Arabia and its association with global climate indices. Journal of King Abdulaziz University-Meteorology Environment and Arid Land Agriculture Sciences. 2012, 23 (1): 85 –108. https: //doi.org/10.4197/Met.23-1.6
33. Liberati, A, Altman DG, Tetzlaf J, Mulrow C, Gotzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analysis of studies that evaluate health care interventions: explanation and elaboration. Journal of Clinical Epidemiology. 2017, 62 (10):1–34.
34. Mohamed, SOO, Elkhidir IHE, Abuzied AHI, Noureddin AAHM, Ibrahim GAA and Mahmoud AAA. Prevalence of autoimmune thyroid diseases among the Turner Syndrome patients: meta-analysis of cross sectional studies. BMC Research Notes. 2018; 11:842
35. Page, MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA. statement: an updated guideline for reporting systematic reviews.

British Medical Journal. 2021. 372: n71. doi: 10.1136/bmj.n71. http://www.prisma-statement. org/
36. Abdel-Baki, AAS, Almalki E, Al-Quarish A. Prevalence and characterization of hydatidosis in Najdi sheep slaughtered in Riyadh city, Saudi Arabia. Saudi Journal of Biological Sciences. 2018, 25(7):1375-1379.
37. AlKitani, F, Baqir S, Hussain MH, Roberts D. Cystic hydatidosis in slaughtered goats from various municipal abattoirs in Oman. Tropical Animal Health and Production. 2014. DOI 10.1007/s11250-014-0646-x.
38. AlKitani, F, Baqir S, HussainMH and Roberts D. Prevalence and Molecular Characterization of *Echinococcus granulosus* in Cattle in Oman. Global Veterinaria. 2015, 14 (6): 883-891.
39. ALMalki, JS and Degheidy NS. Epidemiological studies of hydatidosis among slaughtered sheep and human in Taif, Saudi Arabia. Assiut Veterinary medicine journal. 2013, 59:139.
40. AlSalami, OM, Ali, M Z, Hyderah MA. Prevalence of hydatid cysts in camels in Lahej district, Yemen. University of Aden Journal of Natural and Applied Sciences. 2009;13(1):33-38.
41. Baswaid S. H. Prevalence of hydatid cysts in slaughtered sheep and goats in Hadhramout (Yemen). Assiut University Bulletin of Environmental Research. 2007;10 (2): 2007.
42. ElGhareeb, WR, Edris AM, Alfifi AEand Ibrahim AM. Prevalence and histopathological studies on hydatidosis among sheep carcasses at Al-Ahsa, Saudi Arabia. American Journal of Animal and Veterinary Sciences. 2017; 55(2): 146-153.
43. Haroun, EM, Omer OH, Mahmoud OM and Draz A. Serological studies on hydatidosis in camels in Saudi Arabia. Research Journal of Veterinary sciences. 2008; 1(1): 71-73.
44. Hayajneh, FMF, Althomali AMH, Nasr ATM. Prevalence and characterization of hydatidosis in animals slaughtered at Al Taif abattoir, Kingdom of Saudi Arabia. Open Journal of Animal Sciences. 2014; 4: 38-41.
45. Hezam, K, Morshed AF, Hassan A, Abbas AB, GhalebH, Zhang J and Qahta ASA. Prevalence of parasitic helminthes among slaughtered animals in slaughterhouses in Taiz, Yemen. International Journal of Current Microbiology and Applied Sciences. 2016; 5(8): 80-88.
46. Ibrahim, MM. Study of cystic echinococcosis in slaughtered animals in Al Baha region, Saudi Arabia: Interaction between some biotic and abiotic factors. Acta Tropica. 2009; 113(1):26-33.
47. Toulah FH, Albalawi IM. Prevalence of hydatidosis among slaughtered sheep in Makkah, Kingdom of Saudi Arabia. Journal of Bacteriology and Parasitology. 2019, 10:358.
48. Budke, CM, Deplazes P, Torgerson PR. Global socioeconomic impact of cystic echinococcosis. Emerg Infect Dis. 2006; 12: 296–303.
49. Craig, PS, Budke CM, Schantz PM, Li T, Qiu J, et al. Human Echinococcosis: A Neglected Disease? Tropical Medicine and Health. 2007; 35: 283–292.
50. Otero-Abad B and Torgerson PR. A Systematic Review of the Epidemiology of Echinococcosis in Domestic and Wild Animals. PLOS Neglected Tropical Diseases; 2013, 7(6): e2249. doi:10.1371/journal.pntd.0002249.

51. Njoroge, EM, Mbithi PMF, Gathuma JM, Wachira TM, Gathura PB et al. A study of cystic echinococcosis in slaughter animals in three selected areas of northern Turkana, Kenya. Veterinary Parasitology. 2002; 104: 85–91.
52. Azlaf, R and Dakkak L. Epidemiological study of the cystic echinococcosis in Morocco. Veterinary Parasitology. 2006, 137:83–93.
53. Battelle, G. Echinococcosis: costs, losses and social consequences of a neglected zoonosis. Veterinary Research Communications. 2009; 33 (1): 47–52.
54. Sotiraki, S and Chaligiannis I. Cystic echinococcosis in Greece. Past and present. Parasite. 2010, 17: 205-210.
55. Abiyot, J., Beyene, D., and Abunna F. Prevalence of hydatidosis in small ruminants and its economic significance in Modjo Modern Export Abattoir, Ethiopia. Journal of Public Health and Epidemiology. 2011; 3(10): 454-461.
56. Salem, OA, Schengen's F, Chollet JY and Jemli MH. Epidemiological Studies on Echinococcosis and Characterization of Human and Livestock Hydatid Cysts in Mauritania. Iranian Journal of Parasitolology. 2011; 6(1): 49-57.
57. Saida, LA and Nouraddin AS. Epidemiological study of cystic echinococcosis in Man and slaughtered Animals in Erbil province, Kurdistan Regional-Iraq. Tikrit Journal of Pure Science. 2011; 16 (4) 2011.
58. Addy, F ,Alakonya A Wamae N, Magambo J, Mbae C, Mulinge E, Zeyhle E, Wassermann M, Kern P, Romig T. Prevalence and diversity of cystic echinococcosis in livestock in Maasailand, Kenya. Parasitology Research. 2012; 111: 2289–2294. DOI 10.1007/s00436-012-3082-8.
59. Kassem, HH, Abdel-Kader, AKM and Nass SA. Prevalence of hydatid cysts in slaughtered animals in Sirte, Libya. Journal of the Egyptian Society of Parasitology. 2013, 43(1): 33– 40.
60. Ziaei, H, Fakhar M and Armat S. Epidemiological aspects of cystic echinococcosis in slaughtered herbivores in Sari abattoir, North of Iran. Journal of Parasitic Disease. 2013; 35(2):215–218. DOI 10.1007/s12639-011-0051-6.
61. Qingling, M, Guanglei W, Jun Q, Xinquan Z, Tianli L, Xuemei S, Jinsheng Z, Huisheng W, Kuojun C and Chuangfu C. Prevalence of hydatid cysts in livestock animals in Xinjiang, China. Korean Journal of Parasitololgy. 2014; 52(3): 331-334. http: //dx.doi.org/1 0.3347/ kjp.2014.52.3.331.
62. Ibrahem, MM, Ibrahem WM, Abdorrahem MM and Ibrahem KM. Livestock hydatid disease (Cystic Hydatidosis) in Libya: A Review. American Journal of Animal and Veterinary Sciences. 2016; 11 (2): 70.84.
63. Cringoli, G, Rinaldi L, Musella V, Veneziano V, Maurelli MP. et al. Geo-referencing livestock farms as tool for studying cystic echinococcosis epidemiology in cattle and water buffaloes from southern Italy. Geospatial Health. 2007; 2: 105–111.
64. Fromsa, A, Jobre Y. Infection prevalence of hydatidosis (*Echinococcus granulosus*, Batsch, 1786) in domestic animals in Ethiopia: A synthesis report of previous surveys. Ethiopian Veterinary Journal. 2011; 15: 11–33.
65. Hassan, ZI, Mero WMS, Casulli A, Interisano M, Boufana B. Epidemiological study of cystic echinococcosis in sheep, cattle and goats in erbil province. Journal University of Zakho. 2016; 4(1): 43-55.
66. Getahun, D, Henten SV, Abera A, Senkoro M, Owiti P, Lombamo F, Girma B, Ashenefe B, Deressa A, Diro E. Cysts and parasites in an abattoir in Northwest

Ethiopia, an urgent call for action on “one health”. Journal of Infection in Developing Countries. 2020;14(6.1):53S-57S. doi:10.3855/jidc.11713.