



## Original Article

# *Echinococcus granulosus* in human and cattle: an epidemiology and economic losses of condemned organs

Mohammed Yahia Ali Al-Dhurani<sup>1\*</sup>, Mohammed Ali Mousad Tayba<sup>2</sup>, Abdullah Abdulwahab Motaher Al\_Houthi<sup>2</sup>

<sup>1</sup>Directorate General of Animal Health & Veterinary Quarantine, Department of epidemiology, Ministry of Agricultural and Irrigation, Yemen

<sup>2</sup>Faculty of Veterinary Medicine, Tamar University, Yemen

\*For correspondence: [dorany Mohammed@gmail.com](mailto:dorany Mohammed@gmail.com)

### KEYWORDS

Cattle,  
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### ABSTRACT

The study was conducted between 2016 and 2019, on epidemiology of *E. granulosus* infection (cystic echinococcosis) in humans and cattle and its economics' losses on condemned organs at Dhamar city. In human, a retrospective study was conducted by reviewing the records of patients hospitalized in government and private hospitals, out of 323 records reviewed, 46 (14.24. %) cases were found positive. The higher infection rate of *Echinococcosis granulosus* infection was recorded in liver (13.93%); whereas, the lower in lung (0.31%). The infection was more among female patients (8.05%) compared to male (6.19%) and age group of 30-35 years old (5.88%). The higher prevalence rates recorded were 9.91%, 2.17%, 6.5% and 9.29% in rural, month of January, Dhamar General Hospital Authority (DGHA) and Ultrasound technique respectively. Significant differences ( $P < 0.05$ ) were observed between the infection rate and age and diagnostic techniques used; whereas none with other factors investigated. In animals, using prospective study. Out of the 323 cattle examined by postmortem inspection and serodiagnosis tests, 40 (12.38%) were found positive for *E. granulosus* infection. The distribution of different cysts in different organs were 4.64%, 4.04% and 3.72 in liver, lungs and mixed infection respectively. Significant differences ( $P < 0.05$ ) were observed in distribution of hydatid cysts in different organs of animal. Fertility and viability tests revealed that, 63 (44.68%) were fertile, 64 (45.39%) sterile, and 14 (9.93%) calcified cysts. There were significant differences ( $P < 0.05$ ) in fertility of cysts of different organs ( $P < 0.05$ ). The cysts of lung origin were highly fertile. The higher prevalence rates were recorded in age groups of  $5 \geq$  years old (16%), Females (9.29%), Month of January (1.55%) and Post mortem examination (8.98%). Significant differences ( $P < 0.05$ ) were observed between prevalence rate of infection and all variables investigated with exception sex variable. The total economic losses due to organ condemnation and meat production in cattle slaughtered at Dhamar municipal abattoir is estimated as 2727387.52 YR (\$ US 7.312.03). In conclusion, *E. granulosus* infection is prevalent in study areas and represent an important health problem for human and cattle, which requires appropriate strategies for its control.

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## INTRODUCTION

*E. granulosus* infection or Cystic echinococcosis (CE) is a severe zoonosis caused by the cyclophyllidean cestode *Echinococcus*

*granulosus*. The disease has a worldwide distribution, with endemic regions in many countries of the Mediterranean basin, North and

East Africa, Western and Central Asia, China, South America, and Australia (Jenkins, 2005). Although the distribution of *E. granulosus* is considered worldwide, it is higher in developing countries in tropics and subtropics, especially in rural communities where there is close contact between dogs and various domestic animals (Regassa et al., 2010; Arif et al., 2013; Mwangi, 2019; Khan et al., 2021; Tekeste et al., 2023).

The adult parasites are found in the small intestine of the carnivores particularly dogs and hydatid cysts in ungulates and humans. Eggs are released from the digestive tract of the carnivore into the environment (Regassa et al., 2010; Rashikj et al., 2022). After oral uptake of eggs by the intermediate host, a larva stage penetrates the intestinal wall and reach visceral organs such as liver, lung, heart and kidney of animals and humans. In these internal organs the larva grow and develop to hydatid cysts ( Hui et al., 2012; Wang et al., 2014; Biniamin and Anwar, 2018). In animals, *E. granulosus* infections disease not apparent to farmers, but causes consider economic and public health impacts, in their animals (Moro and Schantz, 2009; Ahmadi, 2011).

The economic importance of echinococcosis in livestock, besides to its public health importance, infection has severe economic implications in ruminants' industry (Nigo et al., 2022) due to the condemnation of the Partial or whole edible carcasses and offal such as liver, lung, heart and other organs (Torgerson et al., 2000). In severe infection, the parasite may cause retarded performance and growth, reduced quality, yield of meat and milk. In addition, the costs of treatment and control which have been estimated to be over USD 3 billion annually worldwide (Getaw et al., 2010; Efrem et al., 2015; Belmamoun et al., 2017; Nigo et al., 2022).

Human is infected with *E. granulosus* during natural transmission of the disease from carnivores to domestic animals by inadvertently consuming eggs of *E. granulosus* through contaminated food, water and soil, or through direct contact with dogs (Wang et al., 2014). The clinical manifestations of cystic echinococcosis (CE) are variable and are determined by the site, size and condition of cysts (Moro and Schantz, 2009). In general, the cysts can cause life-threatening illness associated with liver failure, pulmonary edema (Brehm et al., 1999), rupture of the cyst, which may cause fatal anaphylactic shock in human (Regassa et al., 2010).

Overall economic losses in human in world due to this disease are estimated as two billion US\$ annually and CE is believed to affect more than one million people worldwide (Dakkak, 2010; Joanny et al., 2022).

Cystic Echinococcosis is one of the major parasitic disease in humans and livestock, various studies have been reported the exist and prevalence of the disease in Yemen and other countries of world (Lahmar et al., 1999; Bardonnnet et al., 2003; M'rad et al., 2005; Bhattacharya et al., 2008; Zanini et al., 2008; Acosta-Jamett et al., 2010; Muqbil et al., 2012; Al-shebani et al., 2012; Singh et al., 2013; Al-Shaibani et al., 2021).

Despite the above studies, the *E. granulosus* infections has not been investigated sufficiently, and information related to its prevalence and economic impact is still limited especially in Dhamar city areas; Therefore, the aim of this study was to study an epidemiology of *E. granulosus* infection in humans and cattle and it's economics' losses on condemned organs at Dhamar city, Dhamar governorate, Yemen.

## MATERIALS AND METHODS

### Study areas

The study was conducted in Dhamar city, Dhamar governorate, Yemen with main objective to epidemiology of *E. granulosus* infections in humans in some medical centers at Dhamar. Similarly, Study on cattle was carried out at slaughterhouse of Dhamar city. Dhamar is located approximately 100 km south to Sana'a, the capital of the country. Its lies between 14° 58 'N latitude, 44° 43'E longitude and at altitude of 2330 meter above sea level (NIC, 2021). The area receives average rainfall ranging from 64.2 to 68.8 mm. The mean temperature and relative humidity are 16.5°C and 59.7% respectively. Majority of population are working in Agriculture and related field.

### Study on human

#### Study subjects, size and collection of samples and data processing

A retrospective study was conducted by reviewing the records of patients in Dhamar hospitals to study epidemiology of *E. granulosus* infections (cystic hydatid; echinococcosis) among 323 patients hospitalized in government and private hospitals including: Dhamar G.H, Queen Arwa , Dar AlShifa and Alnada hospitals and Alawlagi

laboratory in Dhamar city between March 2016 and February 2019. All medical records of patients treated surgically to remove the cysts were reviewed and collected. The general information regarded of each patient as follows: Age, sex, residency, the anatomic location of cysts and diagnostic used where obtained. Records were brought to Department of Veterinary parasitology, Faculty of Agriculture & Veterinary Medicine, Thamar University for further processing and analysis according to the guidance of Saida and Nouraddin (2012).

The sample size for both human and cattle studies was calculated according to keys given by Thrufield (2007) by considering 30% expected prevalence and 5% accepted error at 95% confidence interval using this formula:  $N = 1.962 * P_{exp}(1 - P_{exp}) / d^2$ ; where,  $N = \text{required sample}$ ;  $P_{exp} = \text{expected prevalence}$ ;  $d = \text{desired absolute precision}$ . Accordingly, a total of 323 cattle were sampled by simple random sampling method. Three hundred twenty-three records of patients were Reviewed and analyzed in this study.

### Study on animals

A cross sectional observational study method was carried out on cattle between period of 2016 -2017 to study epidemiology and economic losses of *E. granulosus* infection in slaughtered cattle in Dhamar municipal slaughterhouse, Dhamar city.

### Study animals

The study animals were indigenous and non-indigenous cattle brought to the abattoir for slaughter from districts around the Dhamar city. slaughtered animals were with different age and sex.

### Sample Size and Sampling Method

Similarly, the sample size was calculated according to keys given by Thrufield (2007) by considering 30% expected prevalence and 5% accepted error at 95% confidence interval using this formula:  $N = 1.962 * P_{exp}(1 - P_{exp}) / d^2$ ; where,  $N = \text{required sample}$ ;  $P_{exp} = \text{expected prevalence}$ ;  $d = \text{desired absolute precision}$ . Accordingly, a total of 323 cattle were sampled by simple random sampling method.

## Study methodology

### Ante-mortem examination

Regular visits were made to conduct ante mortem examination of animals brought for slaughtering to slaughterhouse. The animals arrive early morning on the day of slaughtering or the day before to make the ante mortem, during this time, individual animals were identified with regard to sex and body condition score and the results were recorded accordingly. The animals were divided into five-age categories (1 year  $\leq$ , 2yrs, 3yrs, 4yrs and 5 $\geq$  years). Estimation of age was carried out by examination of the teeth eruption using the approach forwarded by De Lahunta and Habel (1986). All the animals were identified based on enumerated marks on their body surface using ink.

### Post-mortem examination

The slaughtering of animals was carried out according to Islamic method of ritual slaughter then post-mortem inspection of offal's and carcasses was performed under the responsibility of veterinary inspectors and researcher. Postmortem examinations were thoroughly carried out by visual inspection, palpation, and systematic incision of each visceral organ particularly the lung, liver, spleen, kidney, and heart carried out according to procedures recommended by Parija (2004), Regassa et al. (2010) and Haftu & Kebede (2014). Infected organ was kept in aseptic and clean container with properly labeled information necessary for analysis and brought to Department of Veterinary Parasitology laboratory, Faculty of Agriculture and Veterinary Medicine, Thamar University, for processing and examination.

### Laboratory examination

In the laboratory, the size (diameter in centimeters) of each and individual cysts randomly selected was measured, and the number of cysts per organ was counted and recorded. The cysts randomly selected and collected from different organs were subjected to fertility tests. All organs harboring hydatid cysts were partially or totally condemned and judged according to guidelines on meat inspection for developing countries Herenda et al., (1994). According to their size, hydatid cysts were then classified as small classified as small (1-2cm, medium (3-4 cm), and large (above 5 cm) in diameter; according to Oostburg et al. (2000)

Azordegan and Pour Liakbar (2007) and Fakhar et al. (2007).

### Examination of Cysts and Viability of Protoscoleces

In fertility test, the cyst wall was carefully opened with scalpel blade and the contents were poured into a clean glass Petri dish or using syringe and examined under a microscope (×40) for the presence of hydatid protoscolices. If the protoscolices were present, seen as white dots on the germinal epithelium or brood capsule or hydatid sands within the suspension, the cyst was categorized as fertile according to technique described by Haftu and Kebede (2014). Furthermore, infertile cysts were further classified a sterile or calcified. Sterile hydatid cysts were characterized by their smooth inner lining usually with slightly turbid fluid in its content. Typical calcified cysts produce a gritty sound feeling up on incision.

### Serological study

Blood samples were collected from cattle in a septic manner and brought to parasitology laboratory, Department of Veterinary Parasitology, Faculty of Agriculture and Veterinary Medicine, Tamar University and private laboratory. In laboratory, serum was separated and stored at 20 Celsius. ELISA assay was used to detected the presence of antibody against *E. granulosus* in serum according to the manufactures instructions and guidance of Hui et al. (2012).

### Economic analysis

The economic losses due to *E. granulosus* in cattle, both direct and indirect losses were estimated following the guidance given by Endrias et al., (2010). and Haftu et al. (2014). The calculation of the direct losses is based on condemned organs (lung and liver,) and the indirect losses were assessed based on live weight reduction due to hydatidosis. In calculating cost of condemned edible organs and carcass weight loss, six Different meat sellers were interrogated randomly to establish the price per unit organ and the collective price of lung and liver was determined. Average price was drawn out from that data and this price index was later used to calculate the meat loss in terms of Yemeni Rial (YR). Average annual slaughter rate of cattle in Dhamar municipal slaughterhouse was estimated based on retrospective analysis of data recorded one year

(2017). A 5% estimated carcass weight loss due to bovine hydatidosis was taken into account to determine the carcass weight loss. Average carcass weight of an indigenous and non-indigenous was taken as 126 kg. using the following formula:

**Direct loss from organ condemnation Annual economic loss**=(PI1x TkxC1) + (PI2xTkxC2) + (PI3xTkxC3).

Where PI1=Percent involvement of lung out of the total examined, PI2=Percent involvement of liver out of the total examined, PI3 Percent involvement of Liver and lung out of the total examined, C1=Average market price of liver, C2=Average market price of lung, C3=Average market price of liver and lung, TK=Average annual kill of bovines.

**Indirect loss from carcass weight loss Annual economic losses due to carcass weight loss**=Ns × Ci × Pa

Where Ns=Total number of animals slaughtered and positive for hydatidosis; Ci=Carcass weight lost in individual animals; Pa=Average market price of a kg of beef in Dhamar. Annual economic losses were calculated by adding both direct and in direct losses.

### Statistical Analysis

The categorical data for each respective analysis were organized in contingency tables and were analyzed with Pearson's Chi-square Test for Independence. Values were presented as percentage from the total specimen count in the corresponding groups. The significance level was set at p<0. 05..

## RESULTS AND DISCUSSION

In human study, 323 patients recorded were selected and examined from different public and private hospitals and diagnostic laboratory of Dhamar city, 46 patients were found positive and 277 negatives for *E. granulosus* infections. The overall prevalence rate recorded is 14.24% (46/323).

The higher infection rate of *E. granulosus* infection was recorded in liver (13.93%); whereas, the lower in lung (0.31%). No cases infections were detected on other organs of subjects examined. Significant differences (P<0.05) were observed in prevalence rate of infection between the affected organs (Table 1).

The distribution of *E. granulosus* infection according to age, sex, residence, month variation, Medical centers and diagnostic techniques are presented in Tables 1&2. Accordingly, the higher rate of infection was recorded in age group of 30-35 years old (5.88%); whereas, the lower rate in age group of 40-45 years old (1.86%). Significant differences ( $P < 0.05$ ) were observed between prevalence rate and age groups. Infections were more among females (8.05%); compared to males (6.19%). Significant differences ( $P < 0.05$ ) were not observed between prevalence rate and sex groups of patients.

On the basis of residence, Medical centers (Hospitals or Laboratory) and diagnostic techniques, the higher prevalence rates were recorded in Rural, DGHA. and Ultrasound technique as 9.91%, 6.5% and 9.29% respectively; whereas, the lower prevalence rate in Urban, Tiba hospital and diagnostic technique used as 4.33%, 0.0% and 1.86% respectively. Statistically, significant differences ( $P < 0.05$ ) were observed between prevalence rate and residence and diagnostic technique used; whereas, none with medical centers subjected to investigation (Table 1). The distribution of *E. granulosus* infection in human according to month variation or season (Table 2). As shown, the prevalence rate was recorded in month of January (2.17%) and the lower in months of November (0.62%). Significant differences were not observed between prevalence rate and month variable.

### Results of animal's study

Out of 323 cattle slaughtered and examined, 40 (12.38%) were found harbored hydatid cysts of *E. granulosus* either in single or in multiple number. The result of distribution of *E. granulosus* infection in cattle according to breed, age, sex, organ and diagnostic technique used are presented in Table 3. The higher prevalence rate of *E. granulosus* infections was recorded in indigenous breeds (10.84%) compared to Non-indigenous (imported) breeds (1.55%).

The higher prevalence rate (5.6%) of infection was recorded in animal group of 3 years old; whereas, the lower rate (0.3%) in 2 years' age group. Sex-wise data indicated that the higher infection was recorded in females (9.29%) compared to males (3.10%). The higher rate of infection was recorded in liver (4.64%) compared to lung (4.02). Mixed infection was observed in this study with infection rate researched to 3.72%.

Two types of diagnostic techniques were used for diagnosis of *E. granulosus* infection including: Post mortem examination and serological techniques both techniques detected 29 cases (8.98%) and 11(3.11%) respectively. Statistically, significant differences were observed ( $P < 0.05$ ) between the prevalence rates of infection and breed, age, sex, organ and diagnostic technique used.

The effect of month variation (season) in distribution of *E. granulosus* infection in cattle during different months of year is presented in Table 4. As shown, the higher infection rate was recorded in the month of January (1.55%); whereas, the lower rate was in the month March (0.62%). No significant differences ( $P < 0.05$ ) were observed in prevalence of *E. granulosus* infections and month variation.

The correlation between the prevalence rate *E. granulosus* infection in cattle and meteorological data including Monthly mean of temperature, relative humidity and rainfall during the year of study period are presented in Fig. 1. As shown, there are slightly increased in prevalence rate of infection in the month of January compared to other month of the year. Statistically, significant differences were not observed ( $P < 0.05$ ) between the prevalence rates of meteorological data.

The systematic size measurement of the cysts revealed that majority of large, medium and small sized cysts were found in lungs while, the low number of small and medium sized cyst were found in liver. The size of cysts was categorized as 1-2cm, 3-4 cm and 5 and above cm for small, medium and large cysts respectively. There were significant differences ( $P < 0.05$ ) among size of cysts of different organs as presented in Table 5.

The fertility and sterility rates of *E. granulosus* cysts are presented in Table 6. As shown, the results of fertility and sterility, reveals, in general, 44.68%, 45.39% and 9.93% were fertile, sterile and calcified respectively. There were significant differences ( $P < 0.05$ ) between fertility and sterility rate of cysts in different organs.

### Economic losses study:

The data of economic losses study due to *E. granulosus* infection in cattle slaughtered at slaughterhouse of Dhamar city annually are presented in Table 7. The annual economic loss due to organs condemnation was estimated as follows:

- I. **Annual economic loss due to organ condemnation**=(PI1xTkxC1)+(PI2xTkxC2) + (PI3xTkxC3)= (0.0404 × 13528 × 200) + (0.0464 × 13528 × 3200) +(0.0372 × 13528 × 1700=2724106.3YR.
- II. **Annual economic losses due to carcass weight loss**=Ns × Ci × Pa = =0.1238 × 0.05 × 146.23 × 3625 = 3281.3 YR.
- III. **Annual economic loss**=Annual economic losses due to organ condemnation + Annual economic losses due to carcass

weight loss. Annual economic loss= 2724106.3 + 3281.3= 2727387.52 YR. Hence, the total loss from organ condemnation and meat production loss in cattle slaughtered at Dhamar municipal abattoir is estimated at 2727387.52 YR, considering the \$US one Dollar equivalents 373YR in 2017; thus, The annual economic loss due to organs condemnation estimated in Dollar is \$ US 7.312.03

**Table 1. Distribution of *E. granulosus* infection in human according sociodemographic characteristics, anatomical site and Diagnostic techniques (n=323)**

| Characteristics      | Categories       | No. of Subject Infected | Prevalence % | P value |
|----------------------|------------------|-------------------------|--------------|---------|
| Organ                | Liver            | 45                      | 13.93        | 0.00    |
|                      | Lung             | 1                       | 0.31         |         |
| Age group            | 20 ≤             | 10                      | 3.10         | 0.01    |
|                      | 30-35 Yrs        | 19                      | 5.88         |         |
|                      | 40-45 Yrs        | 6                       | 1.86         |         |
|                      | 50≥              | 11                      | 3.41         |         |
| Sex                  | Female           | 26                      | 8.05         | 0.135   |
|                      | Male             | 20                      | 6.19         |         |
| Residence            | Rural            | 32                      | 9.91         | 0.039   |
|                      | Urban            | 14                      | 4.33         |         |
| Medical centers      | Dhamar G.H.      | 21                      | 6.50         | 0.516   |
|                      | Alawlagi         | 13                      | 4.02         |         |
|                      | Almaleka         | 6                       | 1.86         |         |
|                      | Dar AlShifa      | 3                       | 0.93         |         |
|                      | Alnada           | 3                       | 0.93         |         |
|                      | Taiba            | 0                       | 0.00         |         |
| Diagnostic Technique | Ultrasound       | 30                      | 9.29         | 0.000   |
|                      | Serological test | 10                      | 3.10         |         |
|                      | Clinical signs   | 6                       | 1.86         |         |

**Table 2. Distribution of *E. granulosus* in human according to month variation(n=323)**

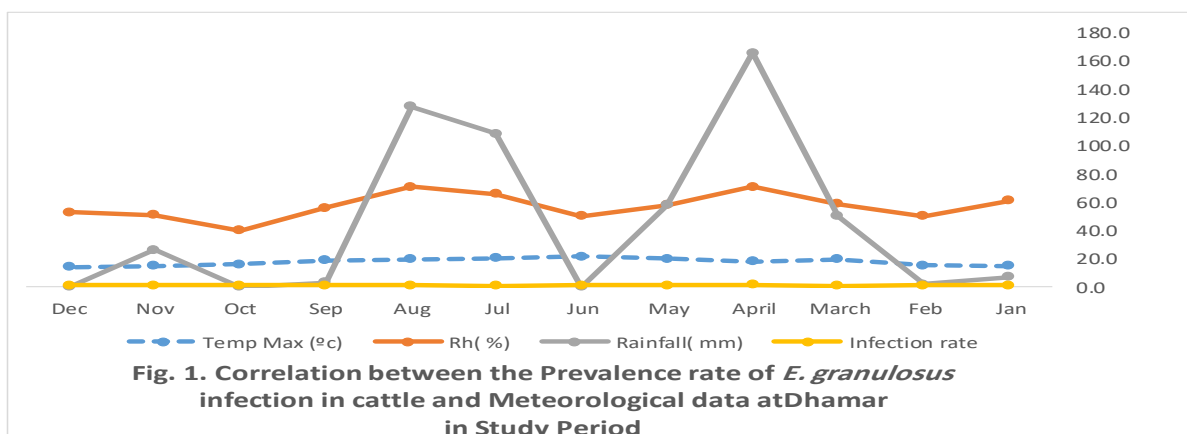
| Month   | No. of Subjects infected | Prevalence % | P value |
|---------|--------------------------|--------------|---------|
| Dec     | 3                        | 0.93         | 0.675   |
| Oct     | 3                        | 0.93         |         |
| Apr     | 4                        | 1.24         |         |
| January | 7                        | 2.17         |         |
| Nov     | 2                        | 0.62         |         |
| Feb     | 4                        | 1.24         |         |
| Mar     | 4                        | 1.24         |         |
| Jun     | 3                        | 0.93         |         |
| Jul     | 4                        | 1.24         |         |
| Aug     | 6                        | 1.86         |         |
| May     | 4                        | 1.24         |         |
| Sep     | 2                        | 0.62         |         |

**Table 3. Distribution of *E. granulosus* infection cattle according to animal characteristics, anatomical site and diagnostic technique used (n=323)**

| Characteristics      | Categories       | No. of Subject Infected | Prevalence % | P value |
|----------------------|------------------|-------------------------|--------------|---------|
| Breed                | Local breed      | 35                      | 10.84        | 0.004   |
|                      | Imported breed   | 5                       | 1.55         |         |
| Age group            | one year≤        | 3.0                     | 1.3          | 0.002   |
|                      | 2yrs             | 1.0                     | 0.3          |         |
|                      | 3yrs             | 18.0                    | 5.6          |         |
|                      | 4yrs             | 2.0                     | 0.6          |         |
|                      | 5≥yrs            | 16.0                    | 5.0          |         |
| Sex                  | Female           | 30                      | 9.29         | 0.000   |
|                      | Male             | 10                      | 3.10         |         |
| organ                | Liver            | 15                      | 4.64         | 0.000   |
|                      | Lung             | 13                      | 4.04         |         |
|                      | Mix infection    | 12                      | 3.72         |         |
| Diagnostic Technique | Post mortem      | 29                      | 8.98         | 0.000   |
|                      | Serological test | 11                      | 3.41         |         |

**Table 4. Distribution of *E. granulosus* in cattle according to month in at Dhamar city(n=323)**

| Month | No. of animals infected | Prevalence % | value |
|-------|-------------------------|--------------|-------|
| Dec   | 4.0                     | 1.24         | 0.999 |
| Oct   | 4.0                     | 1.24         |       |
| Apr   | 2.0                     | 0.62         |       |
| Jan   | 5.0                     | 1.55         |       |
| Nov   | 3.0                     | 0.93         |       |
| Feb   | 3.0                     | 0.93         |       |
| Mar   | 2.0                     | 0.62         |       |
| Jun   | 3.0                     | 0.93         |       |
| Jul   | 4.0                     | 1.24         |       |
| Aug   | 4.0                     | 1.24         |       |
| May   | 3.0                     | 0.93         |       |
| Sep   | 3.0                     | 0.93         |       |



## DISCUSSION

### Study in Human

The epidemiology of *E. granulosus* infection in human in many countries has been investigated, but at Dhamar Yemen little data available. The results of this study revealed that cystic echinococcosis is common prevalent in humans at Dhamar city, Yemen. These results are in agreement with findings of Azazy et al. (2000), Alghoury, et al. (2010); Al-Shebani et al. (2012) who carried out studies in human's echinococcosis in Yemen and other studies in elsewhere in world (Acosta-JamettMan et al., 2010; Rahimi et al., 2011; Manfredi et al., 2011; Mandal and Mandal, 2011; Khan et al., 2013; Singh et al., 2013; Karshima et al., 2022; Hoge et al., 2024).

In this study, the overall prevalence of *E. granulosus* infection in humans in Dhamar was 14.24 %. This prevalence higher than prevalence rate reported by Kebede et al. (2000); Zanini et al. (2009); Acosta-Jamett et al. (2010); Alghoury, et al. (2010); Mandal and Mandal (2011) and Saida and Nouraddin (2011); Al-Shaibani et al. (2015); Li et al. (2019); Karshima et al.(2022). Who reported prevalence rate ranging between 0.9-10 %, and it's lower than findings of Zhenghuan et al. (2008); AlShibani et al.(2012),; Singh et al. (2013), who reported the prevalence rate up to 15.8 percent. The differences in the prevalence rate recorded in this study and above workers may be attributed to socio-economic, cultural status, standard medical services and size of the samples.

The higher rate of infection was recorded in liver compared to lung. No cases infections were detected on other organs of subjects examined. These Results are in complete agreement with findings of Djuricic et al. (20210); Saida and Nouraddin (2011); Al-Shebani et al. (2012) and Habtie (2019; Eshraghi et al., 2022). Moreover, Derfoufi (et al., 2012) Suggested that, in humans, the parasite may, in principle, infest all organs but exhibits a predilection for the liver (70%-80% of cases), followed by the lung (20%-30%). Less commonly involved are the spleen, central nervous system, and other organs. The differences in the prevalence rate recorded between liver and lung could be explained in view of Djuricic et al. (2010) who cited that Hepatic cysts were found more frequently than pulmonary cysts, at a ratio of 2:1.

Pathophysiological influences on the anatomic location of cysts are still unknown; however, likely the liver is more commonly infected because oncospheres penetrating the intestinal wall are preferentially disseminated to the liver via the portal vein.

In the present study, the higher infection rate of *E.granulosus* was recorded in age group of 30-35 years old. The results of this study are in consistent with findings of Al-Shebani et al. (2012; Eshraghi., 2022) and in contrast with findings of Zanini et al. (2009), Saida and Nouraddin (2011), who studies the epidemiology of echinococcosis in humans and animals. The Higher prevalence rate of echinococcosis infection in age group of 30-35 years old might be due to the exposure to the contaminated environment. Stray dogs mostly occupy open areas like those that parks which are preferred sites for majority of people thus are exposed to parasite eggs. Parasite eggs survive and remain infective for months under favorable conditions such as high humidity and low temperature ( Fomda et al., 2015). In addition, Al-Shebani et al. (2012) suggested that human cystic echinococcosis may be occur in the subjects/patients in between 1-75 years of age, but high prevalence rate recorded in age groups from 20-40 years old.

The higher infection rate in females compared to males found in this study are in the line with findings of previous studies( Alghoury, et al. (2010); Al\_Shebani et al. (2012); Babadjanov et al., 2021) who reported that females are more prone to infection compared to males. On other hand, these results are contrary with finding of Fomda et al. (2015) who reported that males are more influencing by the infection of echinococcosis in India. Traditionally, in Yemen, the females are more associated to animals either in the home or in field. This association may be increased the risk of infection and transmission of diseases to them (Al-Shaibani et al., 2015).

The risk factors such residence, month's variation, Medical centers (hospitals and Lab) and diagnostic techniques and their influencing in distribution of *E. granulosu* prevalence in individual investigated. The results revealed that, the higher prevalence rates were recorded in Rural, month of January, Dhamar G.H and Ultrasound technique respectively; whereas, the lower prevalence rate were recorded in Urban, November, Tiba hospital



and clinical signs diagnostic technique used respectively.

The higher prevalence rate of infection in rural areas is in agreement with findings of Djuricic et al., (2010) and Fomda et al. (2015) and in contrary with finding of Eshraghi et al. (2022) in Iran and Ullah et al., (2023) in Pakistan. The higher prevalence rate of infection in rural areas may be due to the people are closely related to animals and echinococcus biological cycle, poor economic conditions, low education levels and poor medical services, Contamination of soil by dog feces. In addition, farming is the main occupation in rural areas thus rural population is at a high risk of acquiring infection because people come in contact with contaminated soil and inhale dust containing eggs during farming activity (Siddharth et al., 2012).

In current study, the higher rate of infection recorded in January; whereas, the lower rate in November. These results are in agreement with findings of Mohamadin and Abdelgadir (2011); Al-Shaibani et al., (2015). The reason behind that could be attributed to that in January, the environmental is suitable for survival and development of parasites.

The patients who admitted either in governmental or in private medical centers for clinical examination or surgical operation due to echinococcosis during same period of study were more in Dhamar G.H comparing to other medical centers. This could be attributed to the size and source of the samples examined.

Echinococcosis lesions of the liver or other organs are detected by means of diagnostic imaging methods, such as ultrasonography, magnetic resonance imaging (MRI), or computed tomography (Stojkovic et al., 2012; Babadjanov et al., 2021). The diagnosis of Echinococcosis using serological methods remains controversial (Schweiger et al., 2012). Serological methods currently employed in the diagnosis of Echinococcosis include the enzyme-linked immunosorbent assay (ELISA), the indirect hemagglutination test (IHA), the latex agglutination tests, and immunoblots (Nunnari et al., 2012; Eshraghi., 2022). In this study Ultrasound technique detected more cases of Echinococcosis compared to other techniques used. Ultrasonography is the diagnostic method of choice recommended for the work-up of cystic liver lesions and Echinococcosis (Tabain et al., 2010). Ultrasound represents a safe and cost-efficient method that is superior to both computed tomography (CT) and magnetic

resonance imaging (MRI) in the visualization of the morphology of cystic lesions (Liang et al., 2005). In addition, ultrasound facilitates the recognition of cystic echinococcosis in asymptomatic disease stages (Kilimcioglu et al., 2006).

#### In cattle study

The current study reveals that the prevalence rate of *E. granulosus* infection in cattle was 12.38%. Previous studies carried out on *E. granulosus* infection in cattle in Yemen (Muqbil et al., 2012; Lahmar et al., (2013); AlShaibani et al., 2015; Hezam et al., 2016 ) reported the prevalence rate ranging between 7.2 -15.2%; whereas, in different countries of world reported different prevalence rates of *E. granulosus* infection either low or higher rates for example; in Turkey, Umur (2003a); in Morocco, Azlaf and Dakkak (2006); Fakhar, 2007; in Wale, Daryani et al., 2009; in Ethiopia, Regassa et al. (2010); in S. Arabia, Ibrahim (2010); in Sudan, Moamadin and Abdelgadir (2011); in Ethiopia, Fikire et al. (2012); in Iran, Azami et al. (2013); in Libya, Tamarozzi et al., (2020) in European, Mediterranean and Balkan countries, Kassem et al. (2013) in Pakistan, Khan et al., (2021), the prevalence rates reported by the above workers were ranged from 2.5- 68.73%. The contrary between the prevalence rate recorded in this study and rates reported by above workers may be attributed to size of samples, difference in strains of *E. granulosus* that exist in different geographical regions, difference in culture, social activity, and availability of dog in study area (Regassa et al., 2010). In addition, Zewdu et al., (2010) cited that *E. granulosus* is known to be important in livestock and public health in different parts of the world and its prevalence and economic significance has been reported by different workers in different geographical areas.

The prevalence rate of *E. granulosus* infections in indigenous cattle were comparatively more than non-indigenous breed. These results are in agreement with suggestion of AlShaibani et al. (2021) who cited that, the varying in infection percentages among livestock in the countries could be attributed to the animals' management system, abundance of definitive hosts, stock population, breed of animals and slaughtering process. Furthermore, Gusbi et al. (1990) reported varying ecological zones of echinococcosis in different areas of country leading to varying infection rates have

been reported in various domestic herbivores in Libya and other countries.

In the current study, the higher rate of infection was recorded in animals of 3years old and elder animals; whereas, lower rate in younger animals age group. The results of this study are in line with findings of Kassem et al. (2013) in Libya and Saleem et al.,(2023) in Pakistan, who observed that elder animals are more infected with *E. granulosus* infection compared to younger animals. The higher infection rate recorded in elder animals group may be due to aged animals have longer exposure time to eggs of *E. granulosus* compared to younger animals.

Sex risk factor was found to be positively associated with *E. granulosus* infection, females' cattle being more likely to be positive than males. These results are in agreement with the findings of Daryani et al. (2007), who observed that the prevalence rate was higher in females than males. The higher rate of infection in female animals may be attributed to more female animals are bought to abattoir and slaughtered compared to male during study period.

The higher infection rate was recorded in the month of January (1.55%); whereas, the lower rate was in the month March (0.62%). These results are parallel with findings of Mohamadin et al. (2011) who also documented a higher prevalence rate in winter. The increase incidence\prevalence of the disease in winter may be due to the survival of the cyst in the organs for several days under colder temperatures as compared to hot summers. However, in contrast with findings of Mansoor lakooraj et al. (2011) who evaluated the month variation or seasonal effects on the condemnation of infected organs of cattle with *E. granulosus* infection. The reasons for a higher number of infections recorded during winter could be attributed to the fact that there was also a higher inflow of cattle for slaughter in winter as compared to other seasons or month or the season of winter favorable for spreading of *E. granulosus* infection (Khan et al., 2013).

The results of this study revealed that, the prevalence rate of *E. granulosus* cysts was slightly higher in liver compared to lungs organs of investigated in cattle. These results are in agreement with findings of koudri et al. (2012); Azami et al. (2012); Melaku et al. (2013); who evaluated the prevalence rate of hydatid cysts in liver of cattle and reported liver are more infected

with hydatid cysts compared to other organs examined in their studies. However; these results in contrary with findings of by Kebede et al. (2006), Getaw et al. (2010), Zewdu et al., (2010) and Banda et al., (2013) who reported that prevalence rate of infection in lung was more than liver. The differences could be due to the fact that liver possesses the first capillaries sites encountered by the migrating Echinococcus onchosphere which adopt the portal vein route and primarily hepatic filtering system sequentially before any other peripheral organ is involved (Urquhart et al., 2003; Kebede et al., 2009; Getaw et al., 2010).

In the current study, the *E. granulosus* cysts count was the highest in lung compared to liver. In addition, lung harbored a higher frequency of large, medium, and small cysts; whereas, liver found to harbor low number of cysts. This fact can be explained in view of Getaw et al. (2010) who suggested that the relative softer consistency of lung and liver allowed easier development of the pressure of cyst. Furthermore, Banda et al., (2013) suggested that, the lungs however have a larger capillary bed than any other organs and this could account for the observed higher number of cysts than seen in the other organs. The higher number of small cyst observed in both organs in this study may be indicate late infection of the animals as a result of heavy rainfall and continuous grazing in the past raining season or due to immunological response. Rainfall and moisture favor the survival of eggs of echinococcus species and at the same time eggs may get chance to be disseminated by flood (Urquhart et. al., 2003). Furthermore, suggested that, such variations in cyst abundance are mainly due to the spatial distribution and the infectivity (biotic potential) of *E. granulosus* eggs and to the susceptibility and defensive capabilities of the host.

Fertility and sterility of hydatid cysts in various organs of cattle are important indicators of potential sources of infection to perpetuate the disease in dogs (Mulatu et al., 2013). The fertility and sterility of cysts collected and tested from various infected organs of cattle in present study in general, were 63.0% and 45.39% respectively. These results are in partial agreement with findings of Zewdu et al. (2010) and these rates are less than rates reported by Muqbil et al. (2012) and Koudri et al. (2012) and higher than rates reported by Melaku et al. (2013). The contrary between the results of this study and above workers may be due to strains of *E. granulosus*. Furthermore, hepatic cysts

presented the majority of fertile cysts; however, pulmonary cyst presented all of calcified cyst in current study. These results are in agreement with findings of Bardonnnet et al.(2003) and in contrast with findings of Melaku et al., (2012). Variations in fertility and sterility within different animal species depend on the strain, geography, ecology, host, organic location and type of cysts (Thompson, 1995).

Several techniques have frequently been used for diagnosis of *E. granulosus* in farm animals, but post mortem inspection is still, the gold standard technique for detection the disease. In this study, the higher rate of *E. granulosus* infection was detected by post mortem inspection followed by serological and clinical signs techniques. The differences in the efficacy of diagnostic tools used may be due to human error or the limitations of equipment used (AlShaibani et al., 2021).

In abattoirs of various locations, researchers indicated that hydatidosis/Echinococcus is widespread in different countries of the world with great economic and public health significance (Efrem et al., 2015; Tekeste et al., 2023). It's among the major causes of organs condemnation of carcass as reported by Melaku and Bogale(2012); Alembrhan and Haylegebriel (2013); Ochi (2015); Ibrahim et al. ( 2016; Cai et al., 2023) .

In the current study, it was emphasized to carry out an assessment on annual economic loss due to bovine hydatidosis at Dhamar municipal slaughterhouses. Losses from organ condemnation and carcass weight loss (meat production loss) in infected cattle were assessed and estimated as 2727387.52 YR (\$US 7.312.03). The current estimate is approximately greater than (2.069.0) that estimated by Kebede et al., (2009) in Ethiopia and Ochi (2015) in South Sudan (US\$ 2,035.77). However, it is lower than that estimated (\$US 138.563.49) by Regassa et al. (2010) in Hawassa municipal abattoir and Belmamoun et al., 2017 (\$ US 10368.16) in Algeria. The difference in economic loss estimates in various abattoir/regions may be due to the variations in the prevalence of disease, mean annual number of cattle slaughtered in different abattoirs, and variation in the retail market price of organs (Haftu and Kebede (2014). Considering the current results, hydatidosis is an important disease of cattle in Dhamar and its surroundings, causing substantial visible and invisible losses.

## CONCLUSIONS

This study confirmed that *E. granulosus* infection in humans and cattle is prevalent in Dhamar city areas. *E. granulosus* was found to be highly prevalent in human compared to cattle this could be a potential threat to human health and public health. *E. granulosus* infection is associated with significant economic losses among cattle slaughtered at Dhamar slaughterhouse. Based on the findings of current study, it's recommended that a serious measure action should be undertaken to reduce the prevalence of the infection in humans and cattle. The results of this study showed the importance of this neglected infection in the study area and strongly prompt public health authorities to implement surveillance strategies and control programme for both human and animal infections. Further studies on epidemiology of cystic echinococcosis in Dhamar and other geographical zones of country are needed.

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## CONFLICTS OF INTEREST

The authors of this article declare that no conflict of interest regarding to this article.

## ETHICAL CONSIDERATIONS

The Faculty of Agriculture & Veterinary Medicine had been approved this study before commencing the research work. all information was anonymized and used for research purpose only.

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## دراسة عن المشوكة الحبيبية في الانسان والابقار: الوبائية والخسائر الاقتصادية

محمد يحيى علي الضوراني<sup>1\*</sup>، محمد علي مسعد طبية<sup>2</sup>، عبد الله عبد الوهاب مطهر الحوثي<sup>2</sup>  
<sup>1</sup>الإدارة العامة لصحة الحيوانات والحجر الصحي، قسم الوبائيات، وزارة ال زراعة  
<sup>2</sup>كلية الزراعة والطب البيطري، جامعة ذمار، اليمن  
 \*للمراسلة: doranyomohammed@gmail.com

### الملخص

جريت الدراسة في الفترة ما بين مارس 2016 وفبراير 2019، لدراسة وبائية المشوكات الحبيبية في الانسان والماشية والخسائر الاقتصادية التي تسببها في أعضاء الحيوانات المذبوحة في مدينة ذمار. ففي دراسة الإنسان، أجريت دراسة بأثر رجعي من خلال مراجعة سجلات المرضى في المستشفيات الحكومية والخاصة في ذمار، من أصل 323 سجل تمت مراجعتها، 46 (14.24%) من الحالات كانت ايجابية. كانت نسبة الإصابة بحسب اعضاء الجسم، في الكبد (13.93%)، وفي الرئة (0.31%). لم يتم تسجيل اي حالة اصابة في أعضاء أخرى في الأشخاص الذين تم فحص سجلاتهم. كانت الإصابات مرتفعة بين المرضى الإناث (8.05%) مقارنة بالذكور (6.19%)، وفي الفئة العمرية ما بين 30-35 سنة (5.88%). تأثير عوامل الخطورة على انتشار الاصابة بين المرضى مثل الإقامة، والشهور(الموسم)، والمراكز الطبية وطرق التشخيص، كانت نسبة الاصابة المسجلة هي: 65.22%، 1.86%، 6.5% و 9.29% في الريف، في شهر يناير، في هيئة مستشفى ذمار، وتقنية الموجات فوق الصوتية على التوالي. إحصائياً، لوحظت فروق ذات دلالة إحصائية ( $P > 0.05$ ) بين نسبة الإصابة والعمر وطرق التشخيص المستخدمة. في حين لم يتم ملاحظة اي فروق معنوية مع العوامل الأخرى. في دراسة الابقار، باستخدام الدراسة المستقبلية او عرضية القطاع، من بين 323 بقرة تم فحصها بعد الذبح واختبارات التشخيص المصلي، وجد ان 40 (12.38%) كانت ايجابية لعدوى المشوكة الحبيبية. كان توزيع الأكياس المختلفة في الأعضاء المختلفة 4.64% و 4.04% و 3.72% في الكبد والرئتين والعدوى المختلطة على التوالي، ولم يتم العثور على كيس في أعضاء أخرى. لوحظت فروق ذات دلالة إحصائية ( $P > 0.05$ ) في توزيع الأكياس العذرية في أعضاء مختلفة من الحيوان. أظهرت اختبارات الخصوبة والحيوية للأكياس، أن 63 (44.68%) كانت خصبة، 64 (45.39%) عقيمة، 14 (9.93%) كيسات متكسة. لوحظ فروق ذات دلالة إحصائية ( $P > 0.05$ ) في خصوبة الاكياس بين الأعضاء المختلفة ( $P > 0.05$ ). كانت الأكياس ذات الأصل الرئوي شديدة الخصوبة. وسُجلت اعلى نسبة انتشار للعدوى في الفئات العمرية في عمر 5 سنوات (16%) والإناث (9.29%) وشهر كانون الثاني (1.55%) وفحص ما بعد الوفاة (8.98%). إحصائياً، لوحظت فروق ذات دلالة إحصائية بين نسبة انتشار العدوى وجميع عوامل الخطورة تم دراستها مع استثناء عامل الجنس. يقدر إجمالي الخسائر الاقتصادية الناتجة عن إعدام الأعضاء في الأبقار المذبوحة في مسلخ بلدية ذمار بمبلغ 2727387.52 ريال يمني (7.312.03 دولار أمريكي). عدوى المشوكات الحبيبية من الامراض المشتركة والمنتشرة في منطقة الدراسة، وتشكل مشكلة صحية كبيرة، لذا يتطلب تصميم طرق فاعلة ومناسبة للمكافحة والسيطرة عليه.

الكلمات المفتاحية: المشوكة الحبيبية، الانسان، الابقار، ذمار، اليمن

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