Prevalence and Histopathological Studies of Hydatid Cyst in camels slaughtered at Al-Muthanna Province

Hussein Jabar Jasim
College of Veterinary medicine/ Al-Muthanna University/ Iraq,
husseinjasem2014@mu.edu.iq

Mohammed Mijbas mohammed alomari
College of Veterinary medicine/ Al-Muthanna University/ Iraq

Saif M. Abed
Faculty of Medical and Health Technique / Sawa University, Iraq

Abstract

The goal of this research was to evaluate the frequency and incidence of cystic echinococcosis among the camels slaughtered. Also, our study includes investigating the viability of protoscoleces and histopathological change evaluation. The result of the current study recorded only 29 of the 432 slaughtered camels were infected with hydatid cyst (6.71%). Occurrence of Hydatidosis was connected to climatic conditions, with a highest (14.03%) and lower (2.7%) proportion of infection in February and May respectively. In addition, the highest (9.35%) and the lowest (3.37%) proportions of infection were found in 6-9 years, and 1-3 years respectively. Infection rates were 10.69% for females and 4.39% for males, respectively, based on sex. Besides, out of 73 cysts examined, 23 (31.5%) were sterile, 28 (38.3%) calcified, and 22(30.1%) fertile out of which 8 (36.3.4%, 8/22) were viable cysts. Furthermore, the histopathological examination was revealed alterations in the lungs, including infiltration of plasma cells and lymphocytes, also alveolar edema, mild congestion, slight spot hemorrhage. while, hyperplasia of the bile ducts and leucocyte infiltration, as well as dilatation in the sinusoids, were seen as histological changes in liver. Also, these changes included atrophy and mild hepatocellular degeneration in liver around the capsule.

Keywords: *Prevalence, Histopathological, Hydatid Cyst in Camels.*

INTRODUCTION

Camels, like other domestic animals, are susceptible to a variety of pathogenic, infectious agents, such as parasites, which limit camel herd development and production (Borji et al., 2010). Echinococcus granulosus is a cestode that causes Hydatidosis in domestic animals (buffalo, cattle, sheep and camels), which serve as intermediate hosts. While, dog serves as the final host, passing the infection to human and domestic animals (Sadjjadi., 2006). In many parts of the world, Echinococcosis is a serious endemic disease produced by the larval stages of the genus Echinococcus,that poses serious health and economic challenges (Larrieu et al., 1999). There are five identified strains of E. granulosus, each with a large degree of genetic diversity These strains differ in development, morphology, host variety , pathogenesis, and geographic spreading (Thompson et al., 1995). The most prevalent strain of E. granulosus is the sheep strain genotype 1 (G1), and human infections are most frequently related to it (Addy et al., 2012). Moreover, E. multilocularis appears to have relatively little genetic variation, while, there

is no evidence to support the variability of E.oligarthus (McManus and Thompson, 2003). Furthermore, Echinococcosis is a significant public health problem and is classified as a neglected zoonotic disease, necessitating immediate attention to reduce human morbidity by removing the parasite in domestic animals (Brown, 2004). Because of its capacity to adapt to a variety of hosts and inhabit a large geographic region, the disease may be found all over the world. Beside, E. granulosus infection is frequently associated with rural grazing settings where dogs might swallow organs from infected wild and domestic animals (Craig et al., 2007). Intermediate hosts become infected by consuming free eggs discharged into the environment from the carnivore's intestinal tract or proglottids containing eggs, following which a larval stage developed in internal organs. On the other side, the Infection of the canid host with the parasite's adult stage is asymptomatic and non-pathogenic. Whereas, Cysts pressure on organs near slow-growing tumors filled with hydatid fluid in human and animal hosts, causing tissue damage (Eckert and Deplazes, 2004). The goal of this research was to evaluate the prevalence rate and the effect of some risk factors such as age, sex, and months on the infection rate. Furthermore, the current study investigated the viability of protoscolices in camels and histopathological changes in cystic echinococcosis among slaughtered camels.

Methodology

Area of study and animals

This research was conducted on 432 slaughtered camels in the Samawah abattoirs in Al-Muthanna province, Iraq. The sample collection time was extended from the 18th of November 2019 to the 14th of June 2020. Three times a week, the abattoirs were visited, and the number of camels slaughtered ranged from 2 to 5 every day. The examined camels were arranged into three age groups; 1-3, 3-6, and 6-9 years old, and sampled collected from both sexes about 273 male and 159 female. Visceral organs infected with hydatidosis have been placed into a box and conveyed to the college of Veterinary Medicine's parasitology lab at the University of Al-Muthanna for analysis.

Analyses of Viability of Protoscoleces

Cysts were carefully incised and inspected to identify the protoscoleces, while, cysts containing protoscoleces were recognized as fertile cysts. The vitality of protoscoleces was investigated by pouring cyst fluid into a petri dish and adding 4 drops of aqueous eosin solution (0.1%) to the sediment, and then waiting for one minute. After that, a drop of the dyed sediment have been examined for revealed amoeboid-like peristaltic motions protoscoleces under a microscope at 40 magnification (Smyth and Barrett, 1980). Normally, live protoscoleces typically don't pick up the stain for 10 min, but dead do (Daryani et al., 2007).

Histopathological analysis

Samples of the infected camels' liver and lung were collected and fixed with 10% formalin after the gross changes were recorded. The histopathological analysis was performed according to (Bancroft and Gamble, 2002).

Results

Based on post-mortem examinations conducted at the abattoir, the results of the current study showed that only 29 of the 432 slaughtered camels tested positive for hydatid cyst infection between November 18, 2019, and June 14, 2020, at an infection rate of (6.71%).The current study also revealed that February had the greatest percentage of hydatid

cyst infections (14.03%). While May has the lowest infection rate at 2.7%, as seen in the table (1).

Table(1) displays the prevalence rate of hydatid cyst infections in camels depending on the months of year

Months	No.of camels inspected	No.of infected camels	proportion of infection
November 2019	**60**	**4**	**6.66%**
December	**49**	**2**	**4.08%**
January 2020	**42**	**5**	**11.9%**
February	**57**	**8**	**14.03%**
March	**61**	**3**	**4.91%**
April	**67**	**3**	**4.47%**
May	**37**	**1**	**2.7%**
June	**59**	**3**	**5.08%**
Total	**432**	**29**	**6.71%**

In addition, table (2) displayed the incidence rate and variations between the various sexes and age groups. The highest rate of infection with hydatid cyst in females was 10.69 %. While, the lower proportion of infection recorded in the males 4.39%. Moreover, this study found that the age group between 6-9 years old has the highest rate of hydatid cyst infection (9.35%), followed by the age group between 3-6 years (7.07%).In contrast, the findings revealed that camels aged 1-3 years had a lower percentage of infection 3.37%.

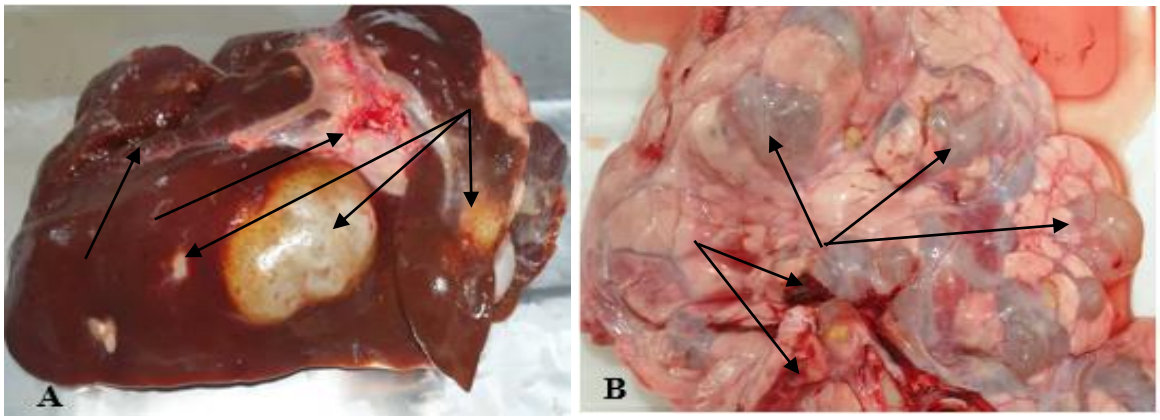
Table(3) displays the prevalence rate of hydatid cyst infections in camels depending on age and sex

Age				male			female		
	Examined	Infected	%	Examined	Infected	%	Examined	Infected	%
1-3 years	**148**	**5**	**3.37**	**94**	**2**	**2.12**	**54**	**3**	**5.55**
3-6 years	**113**	**8**	**7.07**	**65**	**3**	**4.61**	**48**	**5**	**10.41**
6-9 years	**171**	**16**	**9.35**	**114**	**7**	**6.14**	**57**	**9**	**15.78**
Total	**432**	**29**	**6.71**	**273**	**12**	**4.39**	**159**	**17**	**10.69**

On the other side, the current study found gross pathological alterations in the carcasses of camels infected with hydatid cyst, that including overall emaciation, buildup of pale-

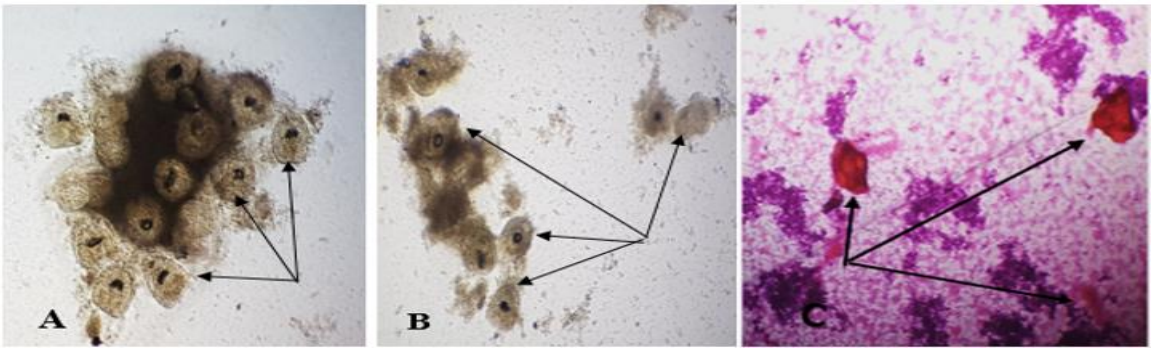
yellowish edematous fluid in body cavities and areas of petechial hemorrhages in various parts of the liver and lung. Furthermore, during the present study's gross pathological examination, single to numerous cysts of varied sizes were found to be entirely entrenched in the lung parenchyma or partially implanted. Besides, the cysts were doughy and soft to the touch and contained clear to slightly turbid fluid, although other cysts seemed hard and had condensate contents, as seen in figure (1). In addition, the lungs were enlarging and congested with petechial hemorrhage and full of edematous fluid as seen in figure (1). Also, the liver was enlarged and congested, with severe ulcer area distribution in different parts of the liver and bleeding as shown in figure (1).

Figure (1): Identification of hydatid cysts in infected camels' A-liver and B-lung



On the other hand, twenty nine from 432 slaughtered camels that had been examined had hydatid cysts, with an infection rate of (6.71%), based on post-mortem examination. Out of 73 cysts examined, 23 (31.5%) were sterile, 28 (38.3%) calcified and 22(30.1%) fertile out of which 8 (36.3%, 8/22) were viable cysts as seen in figure (2). In addition, the results were displayed that the cyst in liver was found to be 8 (28.5%) sterile, 9 (32.1%) fertile of which 3 (10.7 %) were viable, and 11 (39.2%) were calcified in the liver. While, the cysts in lung were recoded 15 (33.3%) sterile, 13 (28.8 %) fertile of which 5 (11.1%) were viable, and 17 (37.7 %) were calcified as shows in table (3).

Figure(2) Shows the result of the viability examination, A- Viable protoscolices without staining, B- Viable protoscolices after staining with eosin, and C- Dead protoscolices after staining with eosin.



Table(3): Show the fertility rates of hydatid cysts and viability of protoscolices of fertile cysts in different organs.

Organs	Fertile cysts						Sterile		Calcified		Total	
	Viable		Non-viable		Total							
	N	%	N	%	N	%	N	%	N	%	N	%
Liver	3	10.7	6	21.4	9	32.1	8	28.5	11	39.2	28	38.3
Lung	5	11.1	8	17.7	13	28.8	15	33.3	17	37.7	45	61.6
Total	8	10.9	14	19.17	22	30.1	23	31.5	28	38.3	73	

On the other hand, a histopathological study of the lungs and liver of infected camels with hydatidosis indicated varying degrees of degenerative alterations, including destruction and sloughing of the mucosal epithelial layer in severe infections. The cysts were composed of an outer fibrous layer that was surrounded by inflammatory cells such eosinophils, mononuclear cells, and a few fibroblasts, and an inner thin germinal layer that was enclosed by a laminated layer , as shown in figure (3). Also, the liver has modest hepatocellular degeneration, leukocyte infiltration, and slight spot hemorrhage as seen in figure (4). Furthermore, due to the cysts' pressure, the nearby hepatic parenchyma showed signs of atrophy, degeneration, and lymphoid-mononuclear infiltration. There were numerous small hemorrhage patches and significant congestion in the parenchyma surrounding the cysts. Furthermore, in chronic cases, fibroplasia was more obvious near cysts, where damaged hepatocytes could be observed between the proliferating fibrous tissue. In some cases, fibroplasia was even identified in the portal triads, as seen in figure (5).

In certain cases, the identification of biliary hyperplasia, degenerative changes in the biliary epithelium, and infiltration of inflammatory cells in livers affected by hydatidosis as seen in figure (6). On the other hand, the lung hydatid cyst's histological alteration resembled that of the liver. There was an increase in fibrous connective tissue and an infiltration of mononuclear cells as shown in figure (7). The lung parenchyma affected with hydatidosis showed central necrosis and there are vacuolated mesenchymal cells as shown in figure (8). In addition, results of the current study revealed that the lung parenchyma adjoining the cysts was emphysematous, congestion, and hemorrhage area as shown in figure (9), and often the damage extends into the adjacent terminal and small bronchioles as shown in figure (10).

Figure (3).Section of the camels liver affected with hydatidosis revealing laminated cyst wall (C) surrounded by macrophage cell followed by a layer of infiltrating cells of eosinophil and fibroblastic cell layer (I).10 X. H&E.

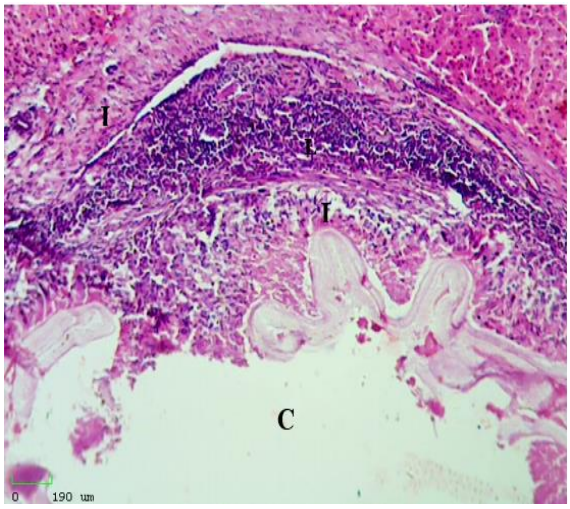


Figure (4). Section of the Camels liver showing hydatid cyst (C) with massive inflammatory cells (lymphocytes) and mild hepatocellular degeneration (L). 10 X. H&E.

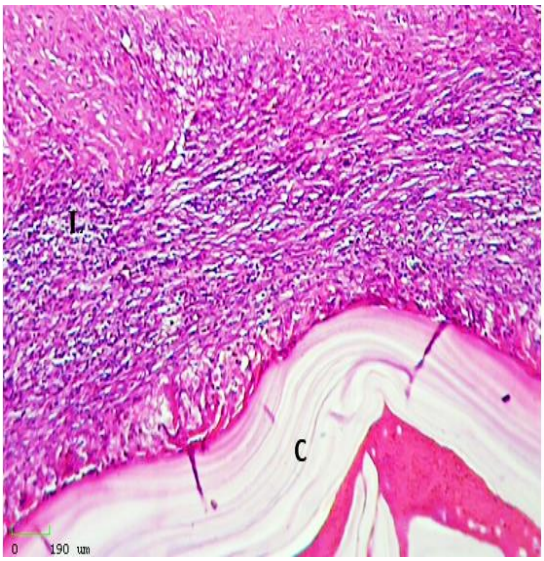


Figure (5). Section of the Camels liver affected with hydatidosis showing fibrosis (F) and congestion (C).H&E. 10X.

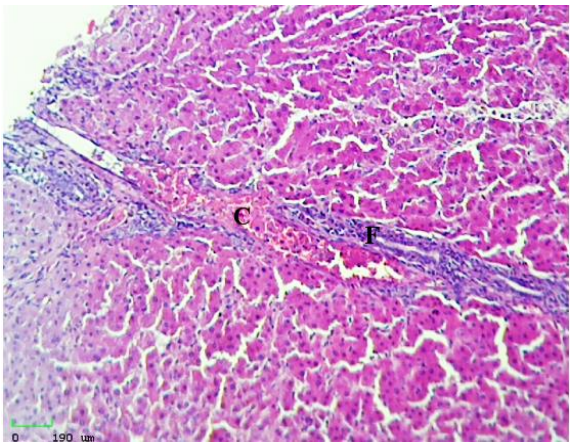


Figure (6). Section of the Camels liver affected with hydatidosis showing fibrosis obviously in adjacent to periportal region, bile duct proliferation (B).and congested portal vein(C).10 X. H&E.

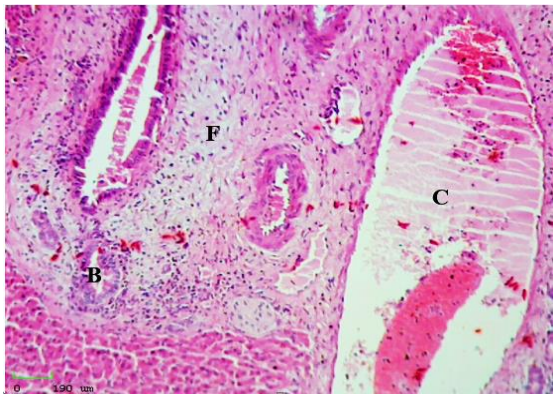


Figure (7). Section of Camels lung showing hydatid cyst with laminated wall and with area of inflammatory cells (I) .10 X. H&E.

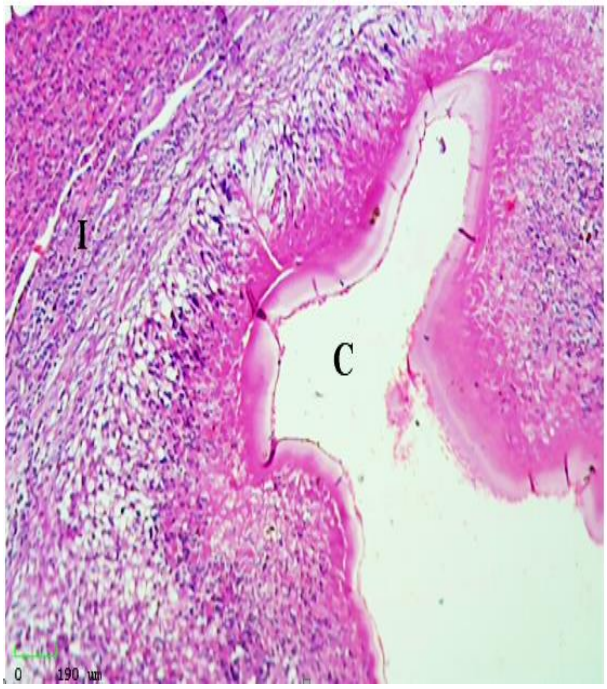


Figure (8). Section of Camels lung showing hydatid cyst with central necrosis (N) and there is vacuolated mesenchymal cells under it (V). 40 X. H&E.

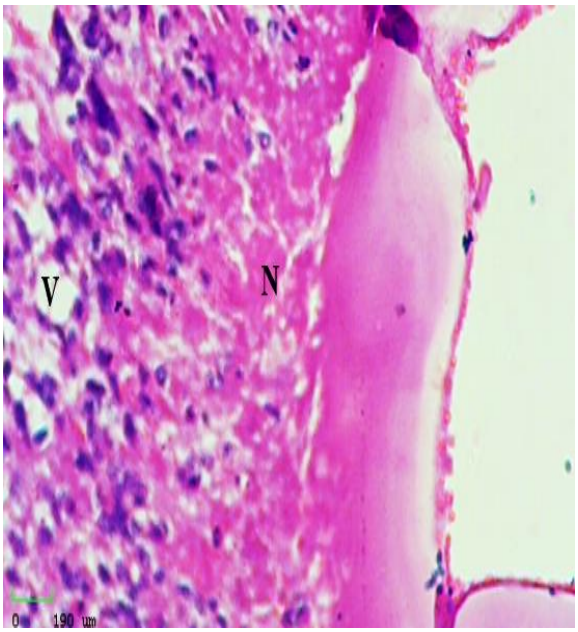


Figure (9). Section of Camels lung show markedly dilatation of bronchiole and proliferation of bronchiolar parenchyma (P) .10 X. H&E.

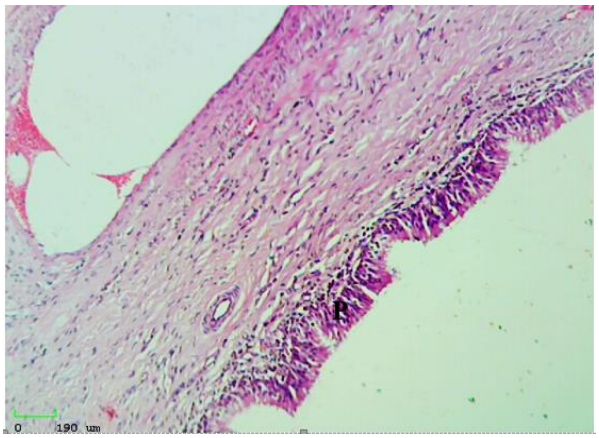
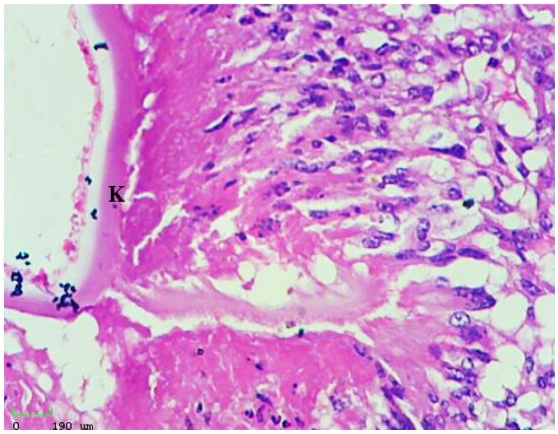


Figure (10). Section of Camels lung show markedly Keratinization of lamina properia of bronchiole (K) .40 X. H&E.



Discussion

Due to the difficulty of working with the camels' breeders, as well as the fact that camels are transported from one location to another in the desert, studying them is difficult. The current study discovered that the animals were slaughtered due to weight loss and sterility, hence medical history data provided by the owner should be taken into consideration. The present study's post-mortem abattoir examination found that just 29 of the 432 camels examined were infected with Hydatidosis, with an overall rate of infection was (6.71%). These findings were very close to those of previous investigations (Kassem and Gdoura, 2006; Mirzaei, et al., 2016), and in disagreement with (Mohammed and El-Malik, 2000; Ahmadi, 2005), who recorded that the percentage of infection with Hydatidosis was 79.5% and 35.2% respectively. Variances in infection rates may be as a result of environmental factors including temperature, humidity and the way camels are raised and grazed, or they could be due to difficulties in controlling stray dogs and a lack of comprehension of the disease's life cycle and preventative methods among shepherds (Al-Khalidi, 1998; El-Dakhla et al., 2019). In

addition, the variations might be related to the camel's owner having a dog, which is E.granulosus final host, thus increasing the risk of exposure to E. granulosus eggs from the dog, which may be helpful in the spread of the disease (Gusbi, 1987; Ahmadi, 2005). Besides, the current study revealed that February (Winter) had the highest rate of hydatidosis infection (14.03%), while, a lower rate of hydatidosis infection 2.7% was reported in May (summer). These results agree with a number of other investigations that indicated climate had a major impact on the incidence of hydatidosis in camels (Elmajdoub and Rahman, 2015; Ahmed et al., 2021), and conflict (Kadir and Rasheed, 2008; Dyab et al., 2018). the interaction between camels and dogs in pastures throughout the winter during rainy and humid seasons may contribute to the spread of parasites, resulting in differences in prevalence between studies. E. granulosus infects dogs in large numbers (Eslami and Hosseini, 1998). Furthermore, the differences might be linked to the origins and ages of camels (Daryani et al., 2007; Ibrahim 2010). Furthermore, the current study found that females have a higher rate of infection with hydatidosis (10.69%) than males (4.39%). These results agreed with several studies' findings that gender has a significant impact on the incidence of hydatidosis infection (Debela et al., 2015; Dyab et al., 2018), but not with others (Anwar and Khan, 1998). Because the majority of females are employed for reproduction, female resistance may be reduced (Parija 2004; Dyab et al., 2018). Whereas, in many countries, the majority of males were utilized for racing and hard work (Bekele, 2001). In addition, the results of the current study showed that the proportion of hydatidosis infection that recorded in the age group between 6-9 years old is 9.35%. But, a lower proportion of infections were reported in camels in age group between 1-3 years at 3.37 %. These results were consistent with many previous studies (Elham et al., 2014). Moreover, there are several studies revealed that age has the effect of a significant factor in the prevalence of infection with hydatidosis (Ibrahim et al., 2011; Debela et al., 2015). Variation in the distribution of hydatidosis infection between age groups in the current research is attributed to continuous exposure of older camels to the disease during the course of their prolong life. Furthermore, the discrepancy could be explain by the slaughter of camels when they get exhausted in milk and production or have lower ability for work, which always occurs at an older age (Urquhart et al., 1996; Debela et al., 2015). Otherwise, the distribution of hydatidosis between the infected organs in the current study was demonstrated that the lung the most usually infected organ with a proportion of infection of 61.6% followed by the liver at 38.3 %. These findings agreed with a number of previous research by (Dyab et al., 2018) and our results contrast with the findings by (Haemaei et al., 2017). This predilection may be due to the lung tissue being smooth and soft in consistency allowing the cyst's more rapid development. Since, camel liver tissue is solid and hard, this makes it challenging for oncospheres to grow regularly when present . Furthermore, the great number of cysts in the camel's lung is attributed to as, camels lack bile ducts, the oncosphere passes through the blood, streams to the lungs, and deposits there (Elmajdoub and Rahman, 2015). In addition, Information on the percentage of fertile (viable), sterile and calcified cysts in camels is provide a reliable indicator of the significance of a species as a potential source of infection in dogs. The present study revealed that the fertility rates of hepatic cysts were higher (32.1%) than that of pulmonary cysts (28.8 %). The results were in agreement with many

previous studies (Elham et al., 2014) and conflict with (Amer et al., 2007). These variations can be attributed to the diversity of protoscolices origins, or to environmental and incubation temperature factors, time passed between when the sample was acquired and when it was processed, and the criteria used to determine reproductive viability. Furthermore, the result of the histopathological examination was observed the changes in the lungs which include cellular infiltration of lymphocytes and plasma cells, alveolar edema, atelectasis mild congestion, and slight spot hemorrhage and compression of bronchioles adjacent to the cyst wall. In addition, the lung parenchyma adjoining the cysts was emphysematous, congestion and often the damage extends into the adjacent terminal and small bronchioles. In the liver, the histopathological changes were observed atrophy and mild hepatocellular degeneration in the liver tissue around the capsule, leucocyte infiltration and hyperplasia of the bile ducts, and dilatation in the sinusoids. The parenchyma adjacent to cysts was markedly congested and had multiple small hemorrhagic areas. Moreover, in chronic cases fibroplasia was more evident adjacent to the cysts. These results were consistent with several previous studies by (Adam, 1997; Singh et al., 2014).

Acknowledgments

many thanks are given to the staff of the department of parasitology at the college of veterinary medicine at Al-Muthanna University /Iraq for their assistance and provision of facilities during sample processing.

Conflict of interest

There are no stated conflicts of interest by the authors.

Reference

- Addy, F., Alakonya, A., Wamae, N., Magambo, J., Mbae, C., Mulinge, E., Zeyhle, M., Wassermann, E., Kern, P. and Romig, T. (2012). Prevalence and diversity of cystic echinococcosis in livestock in Maasailand, Kenya. Parasitol Res 111, 2289–2294

- Ahmadi, N.A. (2005) Hydatidosis in camel (C. dromedaries) and their Potential Role in the Epidemiology of Echinococcus granulosus. Iran J Helminthol. 79:119–125.

- Ahmed, A.B., Ras, R., Mahmoud, A.F. El-Ghazaly, E., Widmer, G., Dahshan, H. and Elsohaby, I. (2021). Prevalence and bacterial isolation from hydatid cysts in dromedary camels (Camelus dromedarius) slaughtered at Sharkia abattoirs, Egypt. J Parasit Dis 45, 236–243.

- Anwar, A.H. and Khan, M.N. (1998). Parasitic fauna of camel in Pakistan. Proceedings of the Third Annual Meeting for Animal Production, under Arid Conditions, Vol. 2, 69–76, United Arab Emirates University.

-Adam, A. (1997). Some Epidemiological Indicators of the Echinococcosis/ Hydatidosis Infection in Dogs, Cattle, Camels, and Man in Nyala town, Southern Darfur State. M.T.A.H. Thesis, University of Khartoum

-Al-Khalidi, N.W. (1998). Cystic Echinococcosis in Sheep, Goats, Cattle and Camels in Shahat Abattoir, Al-Jabal, Libya. Proceedings of the 3rd Annual Meeting for Animal Production under Arid Conditions, 1, 143-149.

-Amer, H.A., Nibal, A.H., Dalal, S.M.and Hassan, H.M. (2007). Pathological and serological studies on cystic

exhinococcosis in naturally infected camel calves. Vet Med J Giza; 55(1): 115-129.

-Bancroft, J. D., M. Gamble (2002): Theory and Practice of Histological Techniques. 5th ed., Harcout Publ. Ltd., London. P125-131.

- Bekele, T. (2001). Studies on Cephalopina titillator, the cause of, Sengale, in camels (Camelus dromedaries) in semi-arid areas of Somali state, Ethiopia. Trop. Anim. Hlth. Prod. 33:489-500.

- Borji, H., Razmi, G., Movassaghi, A.R., Naghibi, A.G., Maleki, M. (2010). A study on gastrointestinal helminthes of camels in Mashhad abattoir, Iran. Iran J. Vet. Res. 11:174–179.

-Brown, C. (2004). Emerging zoonoses and pathogens of public health significance – an overview. Revue Scientifique et Technique de l`Office International des Epizooties, 23: pp. 435-442.

-Craig, P.S., Budke, C.M., Schantz P.M., Li, T., Qiu, J., Yang, Y., Zeyhle, E., Rogan, M.T. and Ito, A. (2007a). Human Echinococcosis: A Neglected Disease? Tropical Medicine and Health, 35(4): pp. 283-292.

- Daryani, A., Alaei, R., Arab, R., Sharif, M., Dehghan, M.H. and Ziaei, H. (2007). The Prevalence, Intensity and Viability of Hydatid Cysts in Slaughtered Animals in the Ardabil Province of Northwest Iran. J. Helminth; 81: 13-17.

- Debela, E., Abdulahi, B., Megersa, B., Kumsa, B., Abunna, F., Sheferaw, D., Regassa, A. (2015). Hydatidosis of camel (Camelus dromedarius) at Jijiga municipal abattoir, Eastern Ethiopia: prevalence, associated risk factors and financial implication. J. Parasit. Dis. 39(4):730-5.

- Dyab, A. K., Marghany, M. E., Othman, R. A., Ahmed, M. A. and Abd-Ella, O. H. (2018). Hydatidosis of Camels and Sheep Slaughtered in Aswan Governorate, Southern Egypt. Russ. J. Parasitol. 12(3):33–41.

- Eckert. J. and Deplazes, P. (2004). Biological, Epidemiological, and Clinical Aspects of Echinococcosis, a Zoonosis of Increasing Concern. CLIN. MICROBIOL. REV. 17(1): pp.107-135.

- El-Dakhly, K.M., Arafa, W.M., El-Nahass, E.N., Shokier, K.A.M. and Noaman, A.F. (2019). The current prevalence and diversity of cystic echinococcosis in slaughtered animals in Egypt. J. Parasit. Dis.; 43:711–717.

- Elmajdoub, L.O. and Rahman, W.A. (2015). Prevalence of Hydatid Cysts in Slaughtered Animals from Different Areas of Libya. Open Journal of Veterinary Medicine, 5, 1-10.

-Elham, M., Hassan, B., Ghasem, N.A., Gholamreza, R.and Parviz, S. (2014). Epidemiological study of hydatidosis in the dromedaries (Camelus dromedarius) of different regions of Iran. Asian Pac. J. Trop. Biomed. 4: 148–151.

- Eslami, A. and Hosseini S. H. (1998): Echinococcus granulosus infection of farm dogs of Iran. Parasitol. Res. J. Vol. 84 (3), pp. 205–207.

- Gusbi, A.M., Awan, M.A. and Beesley, W.N. (1987). Echinococcosis in Libya. II. Prevalence of hydatidosis Echinococcus granulosus in sheep. Annals of Tropical Medicine and Parasitology. 81: 35-41.

- Haemaei, A.K.D., Mohamed, G.M. and Abd Ella, O.H. (2017) Seroprevalence of hydatidosis in camels of Assuit province, Egypt. Madridge J. Vaccines, 1:5–8.

- Ibrahim, K., Thomas, R., Peter, K.., Omer, R.A. (2011). A molecular survey on cystic echinococcosis in Sinnar area, Blue Nile

State (Sudan). Chinese Med. J. 124 (18): 2829-2833.

- 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 Trop. 113 (1):26–33.

- Kadir M. and Rasheed S. (2008): Prevalence of some parasitic helminthes among slaughtered ruminants in Kirkuk slaughter house, Kirkuk, Iraq. Iraqi Vet. Sci. J. Vol. 22 (2). pp. 81–85.

- Kassem, H.H. and Gdoura, N.K. (2006). Hydatidosis in camels (Camelus dromedarius) slaughtered at Sirt Abattoir, Libya. J Egypt Soc Parasitol 2006; 36: 1-10.

-Larrieu, E., Mercapide, C. and Del- Carpio, M. (1999). Evaluation of the losses produced by hydatidosis and cost-benefit analysis of different strategic interventions of control in the province of Rio Negro, Argentina. Parasitology, 33, pp. 122-128.

- McManus, D.P. and Thompson, R.C.A., (2003). Molecular epidemiology of cystic echinococcosis. Parasitology 127: pp. 37-51.

- Mirzaei, M., Rezaei, H., Nematollahi, A. and Ashrafihelan, J. (2016).Survey of hydatidosis infection in slaughtered camel (Camelus dromedarius) in Tabriz area, Northwest Iran. J Parasit Dis 40, 444–447 (2016).

- Mohammed A. A., El-Malik K. H. (2000): The Epidemiology of Cystic Echinococcosis in Nyala, Southern Darfur State, Sudan. The Sudan Vet. Res. J. Vol. 16. pp. 49–53.

- Parija, S. C. (2004): Medical Parasitologoy, Protozology and Helminthology text and Atlas. 2nd Ed. India chennia medical Books Publisher. pp. 221–229.

- Sadjjadi, S.M. (2006). Present situation of echinococcosis in the Middle East and Arabic North Africa. Parasitol Int., 55(l): 197-202.

- Singh, B.B., Sharma, R., Sharma, J.K., Mahajan, V. and Gill, J.P. (2014). Histopathological changes associated with E. granulosus echinococcosis in food producing animals in Punjab (India). J. Parasit.Dis.;40 (3):997-1000.

- Smyth, J.D. and Barrett, N.J. (1980). Procedures for testing the viability of human hydatid cysts following surgical removal, especially after chemotherapy. Trans. RSoc. Trop. Med. Hyg., 74 (5):649-52.

- Thompson, R.C.A. (1995). Biology and systematics of Echinococcus. In: Echinococcus and Hydatid Disease. ed. Thompson, R. C. A. & Lymbery, A. J. Wallingford, Oxon, UK, CAB International. pp. 1-50.

- Urquhart, G.M., Armour, J., Duncan, J.L., Dunn, A.M. and Jennings, F.W. (1996). Veterinary Parasitology, 2nd edn. Blackwell Science Ltd., London, pp 120–129.