Basrah Journal of Veterinary Research 2025; 24(3):82-97.

BASJVETRES

Print ISSN: 1813-8497
Online ISSN: 2410-8456
https://bjvr.uobasrah.edu.iq/

Prevalence, Histopathological Diagnosis, and Molecular Identification of Cystic Echinococcosis in Slaughtered Sheep and Goats of Duhok, Iraq

Abstract

Cystic echinococcosis (CE) is a significant cyclo-zoonotic parasitic disease with worldwide distribution caused by larval stages (metacestodes) of *Echinococcus granulosus* tapeworm. The present study was conducted to determine the current prevalence, histopathology, and molecular identification of CE in sheep and goats of Duhok province, Iraq. Out of 4059 slaughtered sheep and 357 slaughtered goats, the total prevalence of hydatidosis was 9.98% and 7.56%, respectively. The liver was determined as the primary site for infection (91.44%) in both of the hosts, followed by lung (75.0%), kidney (0.69%), and spleen (0.46%). The examination of infected organs showed a moderate to severe buildup of certain immune cells around the cysts, which were either sterile, fertile, or calcified. Additional pathological findings, including fibrous tissue proliferation, necrosis, oedema, and structural collapse of tissues adjacent to the cysts were also recorded. Furthermore, molecular characterization based on PCR amplification encoding the mitochondrial cytochrome c oxidase subunit 1 (cox1) gene confirmed the presence of *Echinococcus granulosus sensu stricto* (*s.s*) genotype (G1 and G3 strains) in isolates obtained from organs of sheep and goats. Sequencing of the obtained nucleotides revealed a high level of similarity, reaching 99.45% to 100% in compare with other GenBank retrived-sequences of G1 and G3 strains published globally. Alignment and phylogenetic analysis clustered all our sequences with G1 strain, except for a single nucleotide polymorphism in isolate PV642913 clustered with G3 strain. To the authors knowledge, this is the first molecular study to identifiy G1 and G3 strains of *E. granulosus* in sheep and goats in Duhok province, Iraq.

Keywords: Sheep and Goats, Histopathology, Molecular characterization, *E. granulosus* G1 and G3 strains

Article Info.

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Article History
Received: 11 June 2025
Accepted: 17 July 2025
e Published: 30 September 2025

Article type: **Research Article**

https://doi.org/10.23975/bjvr.2025.161282.1228

Publisher: University of Basrah,
College of Veterinary Medicine, Basrah, Iraq

Introduction

Cystic echinococcosis (CE) is considered one of the most prevalent food-borne parasitic diseases with stable endemicity in the Middle East and Mediterranean regions, associated with significant public health impact and severe economic losses (1). . Dogs and wild canids are the main hosts where adult cestodes grow in their small intestine, producing eggs that contain infectious oncospheres. In contrast, herbivorous and omnivorous mammals, including sheep, goats, cattle, and humans, serve as intermediate hosts the larval stage (metacestodes) grows to fluid-filled cysts in the visceral organs, primarily in the liver and lungs (2). The parasitic cestode is found to harbour several organs such as liver, lung, kidney, heart, spleen, brain, and spinal cord of domestic and wild animals and humans (1,3).

The clinical signs and symptoms of the disease are usually varied according to the location, size, and condition of the cysts, and when the cysts rupture cause life-threatening complications such as anaphylactic shock or secondary infections (4). Globally, the lowest infection rate of CE was reported in Sudan, 0.01% and the highest infection rate was found in Italy, 69.86% (5). In Iraq, the prevalence rate of hydatidosis among livestock animals ranged from 2% to 25% (6-8). Furthermore, in a study by Joanny *et al.* (9) conducted in Lebanon, the hydatid cyst prevalence rate in sheep was 62.9% and in goats was 20.9%. Cystic echinococcosis can lead to considerable economic losses in farm animals due to substantial losses of edible organs, primarily livers and lungs, during meat inspection at abattoirs (10,11). The economic burden of hydatidosis in the livestock industry has globally been estimated at over US$2 billion per annum (12).

To date, ten genotypes (G1–G10) of the genus *Echinococcus granulosus* have been reported globally based on molecular investigation of mitochondrial cytochrome c oxidase subunit I (cox1) gene sequences (6). The *E. granulosus sensu stricto* complex (G1-G3) is commonly referred to as the sheep, goat, and cattle species. At the same time, *Echinococcus equinus* (G4) is known as the horse strain, and *Echinococcus ortleppi* (G5) as the cattle strain. Meanwhile, *Echinococcus canadensis* has been found to include several genotypes such asG6 (camel strain), G7 (pig strain), G8 (cervid strain), G9 (human/elk strain), and G10 (Fennoscandian cervid strain) (13,14).

Moreover, cystic echinococcosis remains endemic in Iraq, particularly in rural and livestock-rearing areas where close contact between domestic ruminants and dogs facilitates the transmission. The implementation of effective control strategies and enhancement of preventive measures supported by policy enforcement are essential for reducing the prevalence of the disease. This study aimed to find out how common cystic echinococcosis is and to identify its characteristics in sheep and goats that were slaughtered in Duhok province, Iraq.

Materials and Methods

Collection of samples

During a period of six months, from September 2024 to February 2025, a total of 4416 slaughtered animals, including 4059 sheep (3673 male and 386 female) and 357 goats (325 male and 32 female), were macroscopically examined at Duhok slaughterhouses to determine the presence of hydatid cysts. The age of the animals assessed depending on the eruption of the permanent incisor teeth before slaughter. After slaughtering, the carcasses were carefully examined for hydatid cysts through visual inspection, palpation, and cutting with deep incisions. The data included age, sex, and species of animals; in addition, the number of organs affected was recorded (15). The organs harbouring cysts were sealed in plastic bags and put in an ice box, then transported to the laboratory of parasitology and molecular biology centre at College of Veterinary Medicine, University of Duhok, Iraq, for further analysis.

Histopathologic examination

The infected organs marked with hydatid cysts involving fertile, sterile, and calcified cysts were examined for histopathology. A total of 30 hydatid cyst samples (13 liver, 13 lung, 2 kidney, and 2 spleen) from infected sheep and goats were dissected along with their surrounding tissues and put in 10% neutral buffered-formalin for 48 hr. The fixed specimens were trimmed, dehydrated in ascending grades by using different concentrations of ethyle-alcohol, then embedded in paraffin wax, sectioned at a thickness of 4-5 microtones (µm), and eventually stained with Haematoxylin and Eosin (H & E) for pathological and morphological investigation under an optical microscope at 400× magnification power (16).

Molecular study

The germinal layers from hydatid cysts (100 cysts) of sheep and goats preserved in 70% of ethyle-alcohol were subjected to extract their genomic DNA by using a DNA extraction kit (Macrogen Korian, Germany). The samples were collected from different cysts in the lung, liver, kidney, and spleen of both sheep (24 cysts from liver, 24 from lung, 2 from kidney, and 1 from spleen) and goats (24 cysts from liver, 23 cysts from lung, I cyst from kidney, and 1 cyst from spleen). PCR amplification of fragments 450 bp in length of mitochondrial cytochrome c oxidase subunit (cox1) gene, which is specific to *E. granulosus* was applied for each sample by using forward and reverse primer pairs, JB3: 5′-TTTTTTGGG CATCCTGAGGTTTAT-3′ and JB4.5: 5′-TAAAGAAAG AACATAATGAAAATG-3, respectively (17). The amplification reaction was accomplished in 25 µl of reaction mixture composed of 12 µl PCR Master Mix (Jena-bioscience, Germany), 1 µl (10 pmol) of both reverse and forward primers (Macrogen Korean Company), 4 µl of DNA template, and 7 µl of nuclease-free water. The thermal cycling condition is composed of an initial denaturation at 94 °C for 5 min, then 40 cycles of denaturation at 94 °C for 45 s, annealing at 55 °C for 40 s, elongation at 72 °C for 45 s, and final extension at 72 °C for 5 min. To validate the

result, the amplified PCR products were electrophoresed in 1% agarose gel after staining with safe dye and then visualized under UV-transilluminator. In this study, a good quality of PCR product (~ 150 ng/ µl) of hydatid cyst isolated from the liver of infected sheep in a previous work was used as control positive, and PCR nuclease-free water (PCR grade water) was used as control negative.

For DNA sequencing, a total of 8 PCR products (450 bp) consisting of two samples each of liver, lung, spleen, and kidneys from both sheep and goats were used in this study. The amplicons were purified by using a column-based purification kit and subsequently subjected to Sanger sequencing by utilizing an automated sequencer of *Macrogen Korean Company*. The obtained sequences targeting mitochondrial cytochrome C oxidase subunit I (CO1) gene regions were analysed using the Basic Local Alignment Search Tool (BLAST) to determine the respective genotypes of the isolates. All partial sequences generated from the sheep and goats' isolates were deposited in the National Centre for Biotechnology Information (NCBI) database under specific accession-numbers to be compared with other DNA sequence references of the parasite existing in the GenBank to determine the genetic similarity and assign species-level identities. Phylogenetic analysis was conducted using Molecular Evolutionary Genetics Analysis (MEGA, Version 12) software to assess the genetic similarity and determine nucleotide variations of our genotypes in comparison to other globally reported sequences of *E. granulossus* strains.

Data analysis

The collected data were analysed by statistical software, namely SPSS (version 20). To determine the prevalence rate of CE among ages, sexes, and organs of infected sheep and goats, chi chi-square (X^2) test was performed. $P< 0.05$ used to indicate the significance value.

Results

Out of 4,416 slaughtered sheep and goats, the overall prevalence of echinococcosis was 9.78%. The total infection rate in males and females of sheep and goats was 9.98% and 7.56%, respectively (Table 1). Furthermore, the parasitic infection rate in animal age groups older than 2 years was higher than in animal age groups less than 1 year and between 1 and 2 years (Table 2). Statistically, the prevalence rate of infection between sexes of both hosts was found to be significant ($p> 0.05$); meanwhile, the infestation among age groups was significant ($P< 0.05$).

In this study, hydatid cysts were detected in the liver, lung, spleen, and kidney of both sheep and goats (Figure 1). The liver was identified as the primary and predominant site for the infection in both intermediate hosts, 91.44%, followed by the lungs 75%, kidneys, 0.69%, and then spleen 0.46%, (Table 3)

Table 1: The total prevalence rate of CE in male and female sheep and goats.

Species	Age groups of examined animals									Total
	Less than 1 year			1-2 years			More than 2 years			
	Male	Female	Total	Male	Female	Total	Male	Female	Total	
Sheep	2/465	3/37	5/502 (1.00%)	88/1232	28/101	116/1333 (8.70%)	232/1976	52/248	284/2224 (12.77%)	405/4059 (9.98%)
Goats	1/48	0/2	1/50 (2.00%)	5/98	2/11	7/109 (6.42%)	15/179	4/19	19/198 (9.60%)	27/357 (7.56%)
Total	3/513	3/39	6/552 (1.09)	93/1330	30/112	123/1433 (8.58%)	247/2155	56/267	303/2422 (12.51%)	432/4416 (9.78%)
X^2/ *p Value*	0.0433 S*			0.0354 S*			0.0271 S*			

NS*= Non Significant differences (*p*> 0.05)

Table 2: The infection rate of CE in different age groups of sheep and goats.

Species	No. of infected animals	Infected Organs							
		Liver		Lung		Kidney		Spleen	
		No	%	No	%	No	%	No	%
Sheep	405	372	91.85%	306	75.55%	2	0.49%	1	0.25%
Goats	27	23	85.18%	18	66.70%	1	3.70%	1	3.80%
Total	432	395	91.44%	324	75%	3	0.69%	2	0.46%

S*=Signifcant differences ($p < 0.05$)

The histopathological investigation of organs marked with CE showed diffuse moderate to severe inflammatory cells infiltrating around the outer layer of sterile, fertile, and calcified cysts. The sections in the infected organs with CE observed three layers of cysts, including fibrous (outer) layer, laminated (mid) layer, and germinal (inner) layer. In liver sections, there were thick spots of granulation tissue with moderate to severe necrosis leading to fibrosis (fibrous tissue reaction) and inflammatory reactions consisting of mononuclear cells and fibroblasts around the cyst's wall.

The histopathology of the lung showed thick fibrous tissue, cellular reaction, and collapsed tissue around the cyst's wall. The germinal (inner) layer of the parasite is found separating from the laminated (outer) layer, and brood capsules with scoleces of the parasite are found in certain histopathological sections. The pulmonary alveoli around the cysts were found collapsed, and some emphysemas were noticed. Furthermore, protoscoleces were detected in the alveoli and mono-nuclear inflammatory cells with multinucleated giant cell aggregations were found to be infiltration adjacent to the cysts. Moreover, oedema, and congestion of the lung were also observed. Spleen and kidney sections with hydatid cysts were histologically revealed atrophy, congestion, necrosis, fibrous tissue reaction, mononuclear cells infiltrations, and collapse of tissue adjacent to cysts (Figure 2).

Table 3: The percentage rate of CE among different organs of sheep and goats.

Species	No. of infected animals	Infected Organs							
		Liver		Lung		Kidney		Spleen	
		No	%	No	%	No	%	No	%
Sheep	405	372	91.85%	306	75.55%	2	0.49%	1	0.25%
Goats	27	23	85.18%	18	66.70%	1	3.70%	1	3.80%
Total	432	395	91.44%	324	75%	3	0.69%	2	0.46%

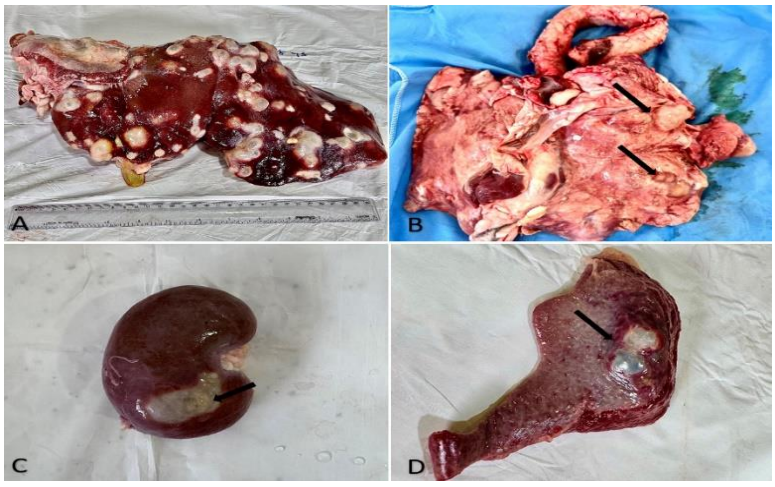

Figure 1: Gross lesions of hydatid cysts in organs of infected sheep and goats. A) Infested livers with different sizes and shapes (Bulged and embedded) of cysts. B) Infected lung with multiple cysts. C) Infected kidney with a single irregular shaped cyst. D) Infected spleen with large cyst contains protoscoleces.

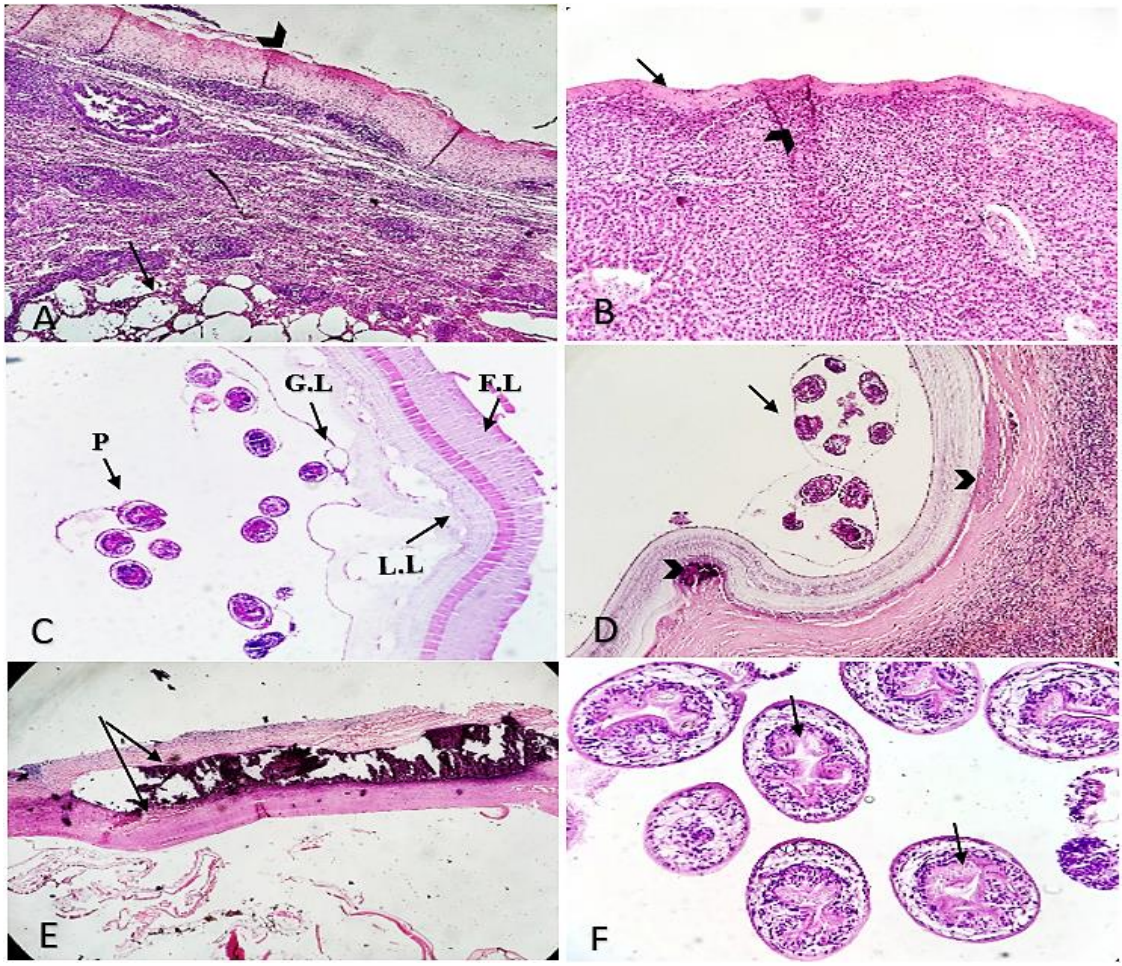

Figure 2: Histopathological sections of hydatid cysts in different organs of sheep and goats. A) Thickened fibrous layer and severe necrosis (arrowhead), edema, and degeneration of alveoli (arrow) in lung of sheep (100x). B) Thick fibrous layer (arrow) and severe necrosis (arrowhead) with inflammatory cells in liver of goats (100x). C) Fertile cyst in the kidney shows three layers of cyst's wall, including; fibrous (F.L), laminar (L.L) and germinal (G.L) layer, with protpscloceses (P), (100x). D) Fertile cyst shows daughter vesicles or brood capsules (arrow) containing protoscoleces and sever necrosis with inflammatory cells (arrowhead), (100x). E) A calcified cyst portion in lung of sheep revealed sever calcification and necrosis (arrows), (100x). F) protoscoleces with infractile hooklets inside (spines) in the middle of the protoscolex (arrows), (400x).

The genomic DNA was successfully extracted from 94 out of 100 cyst's samples from sheep and goats. PCR amplification products subjected to gel electrophoresis showed specific bands at approximately 450 base pairs, as indication for the presence of hydatid cyst-forming species (*Echinococcus granulossus*) in different organs of both hosts (Figure 3).

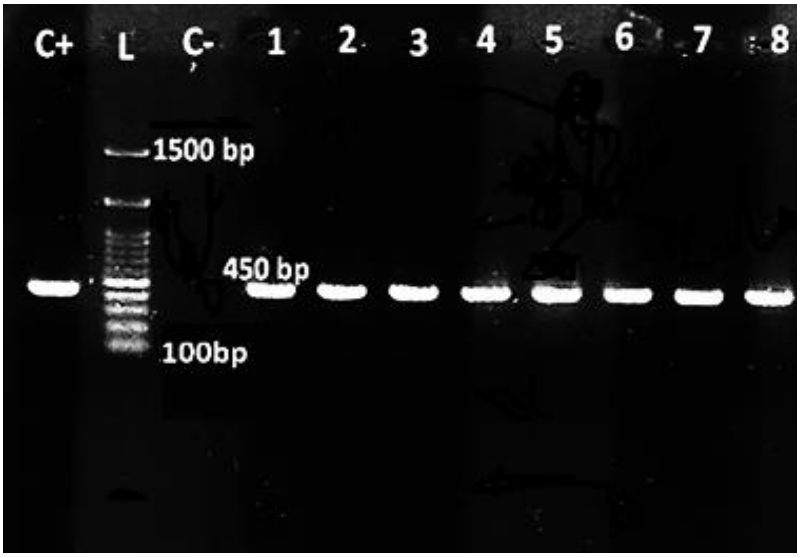

Figure 3: PCR analysis of CE from different organs of sheep and goats encoding the cox-1 gene sequence on 1% agarose gel electrophoresis showed specific bands at 450 bp. (Lane C+: Positive control, lane C-: Negative control, lanes 1-4: Positive samples of liver, lung, kidney and spleen sheep, lanes 4-8: Positive samples of liver, lung, kidney and spleen of goats, lane L: 50 bp DNA marker).

In this study, the overall molecular detection rate of CE in sheep and goats was 94%. In sheep, the organ-specific infection rates were 100% in the liver, 95.83% in lungs, 66.66% in the kidneys, and 100% in the spleen. While in goats, the infection rates were estimated at 91.30% in both liver and the lungs, and 100% in kidneys and spleen. Sequencing analysis revealed isolates; PV642624, PV642757, and PV642762 from the liver, lung, and kidney of sheep, respectively, and isolates; PV643020, PV643022, PV643024, and PV642764 from the liver, lung, kidney, and spleen of goats, respectively, genetically belonged to *Echinococcus granulosus sensu stricto* (G1 strain). In contrast, isolate PV642913 from the spleen of a sheep belonged to G3 strain. Furthermore, the identified genotypes showed 99.45% to 100% nucleotide homology with *E. granulosus* reference sequences available in GenBank, indicating strong genetic similarity (sibling sequences) to strains reported globally. Phylogenetic analysis showed our sequences genetically within the same group of *E. granulosus s.s* (G1 strains) genotype, except for a single nucleotide polymorphisms in an isolate (Accession No. PV642913), from the spleen of a sheep clustered with the G3 strain of *E. granulosus* (Table 4).

Table 4: Genotypes of *E. granulosus* from different organs of sheep and goats encoding cox1 gene regions compared with other related sequences in NCBI-BLAST alignment tool

Isolate	Host	Organ	Accession No.	Identity	Genotype	Accession No.	Country
1	Sheep	Liver	PV642624	100%	G1	KU925410	Italy
2	Sheep	Lung	PV642757	100%	G1	HF947556	Portugal
3	Sheep	Kidney	PV642762	100%	G1	OL587896	Iran
4	Sheep	Spleen	PV642913	99.47%	G3-SNPs*	MW022156	Turkey
5	Goats	Liver	PV643020	100%	G1	MF544126	Turkey
6	Goats	Lung	PV643022	100%	G1	KM014642	Tunisia
7	Goats	Kidney	PV643024	100%	G1	MN807908	Iran
8	Goats	Spleen	PV642764	100%	G1	OP412333	Turkey

G3-SNPs* = Single nucleotide polymorphism at posion 74 nucleotide (C to T).

Discussion

Cystic echynococcosis is a cosmopolitan zoonotic parasitic disease with significant medical, veterinary, and economic impact (6). Globally, the total prevalence rate of hydatid cysts in sheep and goats ranged from 1.6 - 40% and 5.6 - 70%, respectively (18). Irrespective of sex, the prevalence rate of hydatid cysts in older ages of sheep and goats is found to be higher than in younger ages, as they are exposed for a longer time to the parasitic infestation and may increase the likelihood of infection (19). In addition, the liver is considered the primary site for hydatid cysts, followed by the lungs, kidneys, and spleen. The liver's higher vascularity and role as the first filter organ for larval infestation may explain its higher infection rate. The lungs act as the second filter; therefore, the oncosphere travels through the portal vein, going through the liver's filtering system first, then the lungs, before impacting any other organs(15,20). Similarly, in a study belonging to Duhok veterinary directorate, the total prevalence rate of infection in sheep and goats was 9.49 % and 4.81%, respectively (19). Meanwhile, in a study by Salim and Ramadhan, (7), the prevalence rate in sheep was 2.19% and in goats was 3.08%, as well as the highest infection rate among organs of sheep and goats was reported in liver (60.33% and 64.10%), followed by lung (30.59% and 33.33%), then other organs (2.56% and 12.55%), respectively. Furthermore, in Erbil province, the prevalence rate in sheep was 6.54%, and in goats was 0.22% (8). In contrast, the highest infection rate among organs was reported in the lung, 1.23% compared to in the liver 0.61% with no infection recorded in the kidney and spleen of both hosts (21). In Zakho, the total infection rate in females of sheep was 29.49% and of goats was 36.38%. In regard to organs, the infection in liver, lung, and kidney of sheep was 70.5%, 25.3%, and 36%, while in goats it was 72.2%, 23.7% and 24%, respectively (22). In Sulaymaniyah, the total prevalence of hydatidosis in sheep and goats was 4.4%, and in Kalar it was 16.8%. Conversely, the infection rate in males of sheep (66.7%) was found to be higher than in females of sheep (33.3%), while in goats, the infection was

higher in females (58.6%) than in males (41.4%) (23). Low prevalence rates of cystic echinococcus in Erbil and Selemanyia provinces than in Duhok may be due to the irradiation program, such as shelters for controlling stray dogs, restriction of animal slaughtering outside of abattoirs, and hygienic improvement of slaughterhouses to avoid discarding of visceral organs in areas in contact with dogs (22). In other provinces of Iraq; in Brash, the total infection rate of CE in sheep was 7.3% (24), in Mosil, the parasitic infestation rate in sheep was 3.16% and in goats was 1.25% (25), in AL- Qadisiyia province, the prevalence rate of hydatidosis was 25.13% in goat (6), while in Kirkuk, it was 2.25% in sheep and 0.88% in goats (26).

Histopathological investigations of the liver, lungs, spleen, and kidneys of sheep and goats infected with CE revealed significant structural and inflammatory changes. These included thickened fibrous layers, tissue necrosis, and degeneration, accompanied by dense infiltration of inflammatory cells such as neutrophils, lymphocytes, macrophages, monocytes, eosinophils, and fibrocytes surrounding the sterile, fertile, and calcified cysts (16,27). In the liver, chronic inflammation was evident with hepatocyte vacuolation, Kupffer cell proliferation, and fibrous encapsulation. Lung tissue exhibited moderate to severe fibrotic and cellular reactions, with alveolar degeneration, collapse, and occasional emphysematous cysts (28). Protoscoleces were observed within the alveoli, along with multinucleated giant cells and mononuclear inflammatory infiltrates (29).

The common widespread cycle present for *E. granulosus* is between sheep, goats, and cattle as intermediate hosts with dogs as definitive hosts (12). Likewise, G1 strain was regarded as the common prevalent parasitic species reported in sheep (30), and G3 strain was found to be predominant in cattle (31), but also reported in sheep (32), and goats (33). Globally, the G1 and G3 genotypes of *Echinococcus granulosus* are the most prevalent strains associated with human infection. These genotypes exhibit higher zoonotic potential and are responsible for causing severe and potentially fatal disease in affected individuals (34). In Iraq, G1, G3, and G6 stains of cystic echynoccosis were molecularly reported in sheep, cattle, and camels based on PCR amplification encoding cox1 and NDH5 genes with 99-100% similarity (35). Correspondingly, in Saudi Arabia and Egypt, *E. granulosus* genotype G1 was reported in liver and lung of sheep based on PCR targeting COX1, NADH, and nuclear actin (ACTII) genes (36). In Iran, G1 strain of *E. granulosus* was isolated from aspirated fertile cyst of liver and lung of domestic goats (33). In Lebanon, *E. granulosus* (G1 strain) genotype was reported in the majority of isolates in sheep, and only one isolate belonged to *E. canadensis* (G7 strain), detected in goats (9). Moreover, in Turkey, *E. granulosus s.s* (G1-G3) genotype was molecularly reported in cattle and humans (4).

Conclusion

Cystic echinococcosis remains a significant zoonotic parasitic disease affecting sheep and goats in Iraq and in neighboring regions, with notable variations in prevalence across provinces due to differences in control measures, slaughterhouse hygiene, and dog population management. The liver and lungs are the primary sites of infection, with fertile cysts being the most commonly

observed, indicating the ongoing potential for disease transmission. Histopathological findings confirm the extensive tissue damage and inflammatory responses associated with cyst development. Molecular studies affirm the predominance of *E. granulosus s.s* (G1 and G3) genotype in sheep and goats. The phylogenetic analysis regarded G1 and G3 strains of *E. granulosus* as sibling sequences exhibiting significant molecular similarity and close genetic relationships, reflecting their widespread distribution and zoonotic importance.

Acknowledgment

The authors would like to express their sincere gratitude to the University of Duhok, College of Veterinary Medicine, Head of the Department of Internal Medicine and Surgery for providing the necessary support and research facilities.

Conflicts of interest

The authors declare that there is no conflict of interest.

Ethical Clearance

This work is approved by The Research Ethical Committee.

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الانتشار، التشخيص النسيجي، و التعرف الجزيئي لداء الأكياس المائية في الأغنام والماعز المذبوحة في دهوك، العراق

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الخلاصة

يعد داء المشوكات الكيسي او ما يسمى الكيس العدري من الامراض الهامة والمشتركة بين الانسان و الحيوان ومنتشرة في جميع أنحاء العالم, اذ تسببه يرقات الديدان الشريطية من نوع المشوكة. اجريت الدراسة الحالية للتعرف على مدى انتشار الطفيلي و التعرف الشكلي والجزيئي للعامل المسبب لهذا المرض في الاغنام والماعز في مدينة دهوك، العراق. تم فحص 4416 ذبيحة من الاغنام والماعز ولوحظ ان نسبة الاصابة الكلية بالأكياس المائية بلغت 9.98% و 7.56% على التوالي. تركزت اكثر الاصابات في الكبد بنسبة 91.4% في كلا المضيفين، ثم الرئة 75%، و الكلى 0.69%, واخيرا الطحال 0.46%. عند دراسة التغيرات النسيجية للأعضاء المصابة لوحظ ارتشاح الخلايا احادية النواة بدرجات شدة متفاوتة حول الاكياس العذرية والخصبة والمتكلسة. كما لوحظ تغيرات مرضية اخرى ضمت التليف والنخر والوذمة والتكلس في الانسجة الحاوية على الاكياس. وعلى الصعيد الجزيئي، أُجري اختبار تفاعل البلمرة المتسلسل PCR لاستهداف الجين cox1 التابع للحمض النووي mitochondrial cytochrome c oxidase subunit 1 وجود الطراز الجيني *Echinococcus granulosus sensu stricto* السلالة G1 في جميع العزلات باستثناء عينة واحدة من طحال خروف على أنها السلالة G3. كما أظهرت نتائج تحليل الجيني ومحاذاة العينات درجة عالية من التشابه تراوح مابين 99.45% الى 100% عند مقارنتها بالعزلات المرجعية للسلالتين G1 وG3 عالميا. كما أظهر التحليل الوراثي أن عزلاتنا ينتمي الي نفس المجموعة مع سلالة G1، باستثناء تعدد شكلي نوكليوتيدي منفرد في العزلة PV642913 التي تُصنَّف ضمن سلالة G3. وفقًا لعلم المؤلفين, تُعد هذه الدراسة أول تحقيق جزيئي يُوثّق وجود السلالتين G1 وG3 من النوع *E. granulosus* في الأغنام والماعز في محافظة دهوك.

الكلمات المفتاحية: الاغنام و الماعز، فحص النسيجي, التعرف الجزيئي, *Echinococcus granulosus* السلالة G1 و G3