



Clinical, pathological, and molecular characterization of *Coenurus cerebralis* infection in sheep from Salah Aldeen province, Iraq

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Abstract

Coenurosis is a neurological ailment caused by the larval stages (*Coenurus cerebralis*) of *Taenia multiceps*, a parasite that significantly affects sheep production worldwide. This study aimed to determine the prevalence of *C. cerebralis* infection and to characterize it clinically, pathologically, and molecularly in infected sheep from 15 districts of Salah Aldeen Province, Iraq. A cross-sectional study extending from March 2024 to February 2025 was conducted, involving the clinical examination of 450 sheep. Sheep exhibiting clinical signs of coenurus infection were further subjected to postmortem for confirmation of the suspected disease. Molecular identification of coenurus was done by PCR amplification of the mitochondrial cytochrome c oxidase subunit 1 (cox1) gene and the internal transcribed spacer 1 (ITS1) region. A total of 39 sheep were confirmed for coenurosis, resulting in an overall prevalence of 8.67% (95% CI: 6.28-11.67%). There was a wide spatial variation among the districts, with prevalence ranging from 3.33% in Fares district to 16.67% in Tikrit district. The most common clinical signs associated with infected sheep included circling behaviour (76.9%), head tilt (64.1%), blindness (43.6%), and ataxia (38.5%). The highest number of cases was recorded during winter months (December-February) with 14 cases (35.9%) followed by spring (March-May) with 11 cases (28.2%). Summer months (June-August) showed the lowest occurrence (6; 15.4%) followed by Autumn (September-November) with 8 cases (20.5%). Postmortem examination revealed that coenurus cysts were predominantly located in the cerebral cortex (48.7%) and cerebellum (35.9%) of infected sheep. In most confirmed cases, PCR successfully amplified fragments of the cox1 and ITS1 genes, confirming the morphological diagnosis. This study demonstrates that *C. cerebralis* infection represents a significant health concern for the sheep of Salah Aldeen province, which could potentially hinder the economic sheep production in the study area. The study highlights the importance of integrated clinical, pathological, and molecular approaches for accurate diagnosis of the disease and the data generated provides a valuable baseline epidemiological information for the development of effective and strategic prevention and control programs for coenurosis in the region.

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1. Introduction

Coenurosis, also called gid or staggers, is a global parasitic infection affecting all kinds of small ruminants, primarily sheep and goats, with significant veterinary and economic ramifications (Casulli et al. 2022). The disease is caused by the larval form (*Coenurus cerebralis*) of the cestode *Taenia multiceps*, which develops typically in central nervous system (CNS) of intermediate hosts through ingestion of infective egg (Varcasia et al. 2022). Adult *Taenia multiceps* lives in the small intestine of definitive hosts, particularly domestic dogs and other wild canids (Yusuf 2022). Coenurosis has a worldwide distribution and with considerable presence in Africa, Asia, Europe, with sporadic incidences in the Americas (Kozhayeva et al. 2025). In the Middle East, coenurosis has resulted in severe economic losses as a result of adverse effects on animal health, productivity, and product quality. The incidence/prevalence rate for coenurosis shows geographic variations depending on several factors, including climate, grazing practices, animal density, population size of definitive hosts, livestock management systems, and effectiveness of available control measures (Tavassoli et al. 2011).

The life cycle of *T. multiceps* consists of at least two hosts: canids as definitive host and herbivores, particularly sheep and goat, as intermediate host (Ježková et al. 2025). The adult tapeworms in the small intestines of definitive hosts release gravid proglottids containing thousands of eggs with hexacanth embryos that contaminate the environment through feces (Widdicombe et al. 2022). Intermediate hosts can ingest the fertilized tapeworm embryos while grazing on contaminated pastures. After ingestion of infected eggs from the contaminated pastures, the embryos is released which penetrate the intestinal wall, gains access to the circulatory system and migrates to various organs through blood stream, primarily the brain and spinal cord. In the CNS, they develop into fluid-filled coenurus cysts with many protoscoleces (Christodouloupoulos 2007). Their size may reach up to 5-10 cm in diameter, and their number, size, and location in the CNS determine the clinical signs and the severity of the disease in the affected animals (Abbas et al. 2021). The development of mature coenurus typically takes 6-8 months, during which the continuous cyst enlargement causes increased intracranial pressure and damages surrounding brain tissue (Kibona et al. 2022).

The clinical signs of coenurosis are mostly neurological, reflecting the involvement of CNS, and they vary based on the location, size, and number of cysts in the CNS (Varcasia et al. 2012). Commonly observed neurological signs include circling, head-tilting, ataxia, blindness, seizures, and changes in behavior (Stigger et al. 2025). In severe cases, when cysts get lodged in crucial areas of the brain, sudden death may occur with no obvious clinical signs (Hou et al. 2023). The chronic form of the disease leads to progressive loss of neurological function and eventual death if not treated (Malhotra et al. 2024).

Traditionally, diagnosis of coenurosis depended on the observed clinical signs and postmortem examination (Wandra et al. 2000). The antemortem diagnosis is difficult because the non-specific nature of clinical signs, which potentially overlap with other neurological disorders in sheep, such as listeriosis, polioencephalomalacia, and pregnancy toxemia (Varcasia et al. 2022). Advanced techniques such as computed tomography and magnetic resonance imaging have been used experimentally, but have less application for routine field diagnosis in endemic regions (Kibona et al. 2022). For improved diagnosis and characterization of specific parasitic diseases, new molecular techniques have been introduced. Molecular techniques, such as polymerase chain reaction (PCR) allows for the amplification of target genes for better genetic characterization of *T. multiceps* and its larval form - *C. cerebralis*. Molecular techniques facilitate the species differentiation of *T. multiceps* from closely related cestodes and provide better understanding of parasitic geographic distribution and population structure (Gasser et al. 1999). Phylogenetic analyses revealed significant genetic diversity among *T. multiceps* isolates from various geographic locations, which indicates geographically structured populations with potential independent evolutions along with their hosts (Hoberg et al 2006; Lavikainen et al. 2011). Very similar molecular patterns were observed in Middle Eastern countries, supporting the notion that *T. multiceps* populations developed unique regional genetic signatures, which likely came into existence independently or were introduced from outside (Kaethner et al. 2023).

Livestock is one of the most important contributors to the agricultural economy of Iraq, with the sheep farming as an important source of income and nutritional security (Jawhar et al. 2024). Due to the various climate zones and traditional pastoral production systems, Iraq provides a conducive environment for the transmission of various parasitic diseases, including coenurosis (Qasim 2024). Despite the economic significance of livestock production and the importance of the sheep farming industry, there is a dearth of information about the prevalence of coenurosis and its molecular characteristics in Iraqi sheep populations (Albayati et al. 2024). Salah Aldeen province, located in north-central Iraq, is characterized by semi-arid climate with distinct wet and dry seasons and sizeable sheep populations mostly reared under traditional extensive grazing systems (Muslih and Abbas 2024; Al-Ansari et al. 2021). The presence of sizable dog populations, and close interaction with domestic livestock facilitate the spread of *T. multiceps* (Hansh 2024). Though, there are reports of prevalence rates of coenurosis as high as high 15% in neighboring regions, data specific to Salah Aldeen province is limiting to implement evidence-based control strategy (Abbas et al. 2022; Younis et al. 2024). Environmental factors play a significant role in the epidemiology of coenurosis, with temperature and humidity affecting the survival and development of *T. multiceps* eggs in the environment and their transmission (Badwaik et al. 2024; Adamo et al. 2018). In addition to mortality, coenurosis incurs

significant economic losses in terms of reduced growth rates, poor wool quality, and increased susceptibility to secondary bacterial infections (Widdicombe et al. 2022). In endemic areas, cumulative annual economic losses due to decreased productivity and market value is significant (Tadesse and Negash 2022).

Given the sparse evidence on coenurosis in Iraq and the potential economic impact on sheep production in Salah Aldeen province, it is imperative to pursue further studies to understand the disease prevalence, clinical presentation, and study the molecular epidemiology. Such studies will provide important baseline data to assess the burden of disease and investigate the degree of local transmission dynamics to inform management interventions specific to the region. Therefore, the purpose of this study was to provide an accurate estimate of the prevalence of coenurosis in sheep populations in Salah Aldeen province through the use of clinical, pathological, and molecular techniques, and to provide baseline data that could guide future surveillance and control initiatives in Iraq and the larger Middle East.

2. Materials and Methods

2.1 Study area and design

A cross-sectional study was carried out in Salah Aldeen Province, located in the north-central Iraq, covering an area measuring 24,751 km². The province is characterized by a semi-arid climate with an average annual precipitation of 200-400 mm, primarily occurring from November to April. This study area was selected based on the presence of significant number of sheep farms and constant influx of large number of cases with neurological disorders to College of Veterinary Medicine, University of Tikrit.

2.2 Sample size calculation and sampling strategy

The minimum sample size was calculated for a cross-sectional study as follows:

$$n = Z^2 \times P(1-P) / d^2$$

where n is the sample size, Z is the standard normal value at a 95% confidence level (1.96), P is the expected prevalence (10%), and d is the desired precision (3%). Though the minimum sample size needed was calculated as 384, the sample size was increased to 450 to increase statistical power and to account for potential losses.

The stratified random sampling method was utilized and the study Province was divided into 15 administrative districts based on administrative boundaries and livestock density. From each administrative district, considered as a stratum, 30 sheep were randomly selected. The age of selected animals ranged from 6 months to 5 years and had not received any form of neurological treatment in the preceding three months. Pregnant ewes in the last trimester, animals with obvious signs of any systemic diseases, and those which received anti-parasitic treatment in past three month were excluded from the study.

2.3 Clinical examination and case definition

An extensive standard clinical assessment of all animals was conducted by qualified veterinarians following standardized protocols. The clinical examination consisted of assessment of general condition, behavior, neurological function, cranial nerve function, gait, posture, and visual response (de Lahunta 1977).

A suspected case for coenurosis was designated as a sheep with one or more neurological signs, such as consistent circling in one direction, head tilt, loss of vision without obvious ocular pathology, ataxia, or abnormal behavior, indicating CNS involvement. Furthermore, disease was classified as mild having a single clinical sign with minimal functional impairment, moderate having multiple clinical signs with moderate functional impairment, and severe having multiple clinical signs with major functional impairments or recumbency.

2.4 Postmortem examination and cyst collection

All animals exhibiting severe clinical signs of coenurosis as well as dead animals were subjected to thorough postmortem examinations. Euthanasia was performed humanely using barbiturate overdose following accepted animal welfare guidelines and with animal owner consent. The skull was opened carefully and examined systematically for the presence, size, location, and number of coenurus cysts along with the associated tissue changes. To facilitate molecular analysis, coenurus cysts and protoscoleces were collected aseptically and stored at -20°C. Multiple coenurus cysts were collected from each infected animal, wherever possible.

2.5 DNA extraction

Genomic DNA was extracted from cysts and protoscoleces using the QIAamp DNA Mini Kit (Qiagen, Germany) according to the manufacturer's directions with minor modification. Specifically, the cyst fluid and the protoscoleces were centrifuged at 12,000 × g to obtain a clean pellet of protoscoleces without inhibitory cyst fluid and pellets were re-suspended in phosphate buffer saline. Following centrifugation, the samples were subjected to three freeze-thaw cycles to enhance cell lysis. About 20 µL Proteinase K solution (20 mg/ml) was added at the thawing stage, followed by three hours of incubation at 56 °C with periodic mixing. After digestion of the proteins, DNA was extracted using the DNA extraction kit protocol. The purity and concentration of the DNA were measured using a NanoDrop Spectrophotometer, and extracted DNA samples were stored at -20 °C until PCR amplification.

2.6 PCR amplification

Molecular identification of *T. multiceps* was done by targeting the amplification of two genes – cytochrome c oxidase subunit 1 (cox1) and the internal transcribed spacer 1 (ITS1) (Jeon et al. 2007) using previously described primers. The cox1 primers were F (5' - TTTTGTGGGCATCCTGAGGTTTAT - 3') and R (5' - TAAAGAAAGAACATAATGAAAATG - 3'), producing an amplicon size of 400 bp and ITS1 primers were F (5' - GTCGTAACAAGGTTTCCGTA - 3') and R (5' - GCTGCGTTCCTCATCGAT - 3'), producing an amplicon size of 460 bp (Nakao et al. 2000). All PCR reactions were carried in 25 µL final volumes, containing 2.5 µL of 10 × PCR buffer, 2.0 µL of 25 mM MgCl₂, 2.0 µL of a 10 mM dNTP mix, 1.0 µL of each of the forward and reverse primers at a concentration of 10 pmol/µL, 0.2 µL of Taq DNA polymerase (5 U/µL), 2.0 µL of template DNA, and nuclease-free water to obtain a final volume of 25 µL. The PCR conditions used for amplification of cox1 included an initial denaturation at 94°C for five minutes, then 35 cycles of denaturation at 94°C for 30 seconds, annealing at 52°C for 30 seconds, and extension at 72°C for 45 seconds, and a final extension at 72°C for seven minutes. The annealing temperature for ITS1 amplification was adjusted to 55°C and the remaining PCR conditions were the same. PCR positive control

(reference target gene instead of DNA template) and negative control (without DNA template) were included in each run.

2.7 Agarose gel electrophoresis and purification

The products of the PCR were separated by electrophoresis on 1.5% agarose gel stained with ethidium bromide, which was viewed under ultraviolet illumination. A 100 bp DNA ladder served as a molecular weight standard. The expected sized amplicons were removed from the gel and purified by using commercially available gel extraction kit (QIAquick Gel Extraction Kit, Qiagen, Germany) following the manufacturer's recommendations.

2.8 Statistical analysis

The data were entered in Microsoft Excel and analyzed by SPSS version 28.0 (IBP Corp., USA) to determine the prevalence. The associations between infection status and categorical variables were assessed chi-square test of Fisher's exact test as applicable. At 95% confidence interval (CI) Odds Ratio (OR) were calculated to quantify associations. Seasonal variation in prevalence was determined by chi-square test analysis. P 0.05 was considered statistically significant for all of the variables assessed.

3. Results

3.1 Overall prevalence and spatial distribution

In a 12-month study, 450 sheep from 15 districts of Salah Aldeen province were examined for coenurosis. A total of 39 animals were confirmed as infected with *Coenurus cerebralis*, resulting in an overall prevalence of 8.67% (95% CI: 6.28-11.67%). There was a wide spatial variation among the districts, with prevalence ranging from 3.33% in Fares district to 16.67% in Tikrit district (Table 1).

3.2 Clinical manifestations

All thirty-nine confirmed cases revealed nervous signs characterizing coenurosis and most of the cases presented multiple clinical signs (Table 2). Circling movement was the most commonly observed sign (30, 76.9%), followed by head tilt (25, 64.1%), visual impairment (17, 43.6%), and ataxia (15, 38.5%). The least observed clinical presentation was recumbency (4, 10.3%).

3.3 Seasonal distribution

The seasonal analysis revealed significant variation in case detection throughout the year (Table 3). The highest number of cases was recorded during winter months (December-February) with 14 cases (35.9%), followed by spring (March-May) with 11 cases (28.2%). Summer months (June-August) showed the lowest occurrence (6; 15.4%) followed by Autumn (September-November) with 8 cases (20.5%). The average monthly case count was lowest in the summer (2.00 cases/month) and highest in the winter (4.67 cases/month).

3.4 Pathological findings

Postmortem examination was performed on all 39 confirmed cases. Coenurus cysts were most commonly located in the cerebral cortex (19 cases, 48.7%), followed by the cerebellum (14 cases, 35.9%) (Table 4). Multiple cyst locations were observed in 8 animals (20.5%). Less commonly affected locations were brainstem (10.3%) and the ventricular system (5.1%). The average cyst diameter was 4.2 cm (range: 1.5-8.5 cm), with larger cysts generally associated with more severe clinical manifestations (Fig. 1A, 1B).

Table 1. District-wise prevalence of coenurosis in sheep in Salah Aldeen province

District	No. of animals examined	No. of positive cases	Prevalence (%)	95% CI
Tikrit	30	5	16.67 ^a	5.64-34.72
Samarra	30	4	13.33 ^{ab}	3.76-30.72
Balad	30	3	10.00 ^{bc}	2.11-26.53
Tuz Khurmatu	30	3	10.00 ^{bc}	2.11-26.53
Tooz	30	3	10.00 ^{bc}	2.11-26.53
Al-Shirqat	30	3	10.00 ^{bc}	2.11-26.53
Baiji	30	2	6.67 ^c	0.82-22.07
Al-Daur	30	2	6.67 ^c	0.82-22.07
Yathrib	30	2	6.67 ^c	0.82-22.07
Al-Alam	30	2	6.67 ^c	0.82-22.07
Sulaiyah	30	2	6.67 ^c	0.82-22.07
Makshifah	30	2	6.67 ^c	0.82-22.07
Al-Ishaqi	30	2	6.67 ^c	0.82-22.07
Dhuluiya	30	2	6.67 ^c	0.82-22.07
Fares	30	1	3.33 ^{cd}	0.08-17.22
Total	450	39	8.67	6.28-11.67

Within the Prevalence column, values sharing a common superscript letter are not significantly different ($p > 0.05$) according to Chi-square post-hoc pairwise comparisons with Bonferroni correction
CI: Confidence interval

3.5 Molecular analysis results

Genomic DNA extraction was successful from 36 of 39 collected samples (92.3%). PCR amplification of the *cox1* gene yielded positive

results in 34 samples (94.4% of extracted samples), while ITS1 amplification was successful in 32 samples (88.9% of extracted samples), confirming molecular identification of *C. cerebralis* (Fig. 2A, 2B).

4. Discussion

The present investigation is potentially the first comprehensive study on coenurosis in sheep from Salah Aldeen province, Iraq, providing the baseline epidemiology, clinical features, and molecular characteristics of *Coenurus cerebralis* infection. The overall prevalence of 8.67% recorded in this study falls within the range reported from other countries in the Middle East and confirms that coenurosis is an important health problem for sheep production in the area (Evangelisti et al. 2016; Gasser 2001). The prevalence rates of 6.2-11.8% in Turkey (Gicik et al. 2007), 7.4-12.3% in Iran (Tavassoli et al. 2011), and 5.9-9.7% in Syria (Philipo et al. 2024) are comparable to the present study. However, compared to the present study lower prevalence of 3.2-5.8% has been reported from Egypt (El Beskawy et al. 2018). This variation in prevalence may be due to differences in study designs, study sites, density of definitive hosts, livestock management practices, climatic conditions, or the changing epidemiology of coenurosis. The observed prevalence in Salah Aldeen

Table 2. Clinical manifestations observed in sheep infected with *Coenurus cerebralis*

Clinical sign	No. of cases	Percentage (%)	95% CI
Circling movement	30	76.9 ^a	60.7-88.9
Head tilting	25	64.1 ^{ab}	47.2-78.8
Visual impairment	17	43.6 ^{bc}	27.8-60.4
Ataxia	15	38.5 ^{bc}	23.4-55.4
Behavioral changes	12	30.8 ^c	17.0-47.6
Hyperesthesia	9	23.1 ^c	11.1-39.3
Seizures	6	15.4 ^c	5.9-30.5
Recumbency	4	10.3 ^c	2.9-24.2

Within the Percentage column, values sharing a common superscript letter are not significantly different ($p > 0.05$) according to a Chi-square test of proportions with post-hoc pairwise comparisons; CI: Confidence interval

Table 3. Seasonal distribution of coenurosis cases

Season	Months	No. of cases	Percentage (%)	Cases per month
Winter	Dec-Feb	14 ^a	35.9	4.67
Spring	Mar-May	11 ^{ab}	28.2	3.67
Autumn	Sep-Nov	8 ^b	20.5	2.67
Summer	Jun-Aug	6 ^b	15.4	2.00
Total		39	100.0	3.25

Values sharing a common superscript letter within the No. of cases column are not significantly different ($p > 0.05$) according to a Chi-square test for independence with post-hoc pairwise comparisons

Table 4. Anatomical distribution and characteristics of <i>Coenurus cerebralis</i> cysts				
Cyst location	No. of. cases	Percentage (%)	Mean diameter (cm)	Range (cm)
Cerebral cortex	19	48.7	4.8	2.0-8.5
Cerebellum	14	35.9	3.9	1.5-6.2
Brainstem	4	10.3	2.8	1.8-4.1
Multiple locations	8	20.5	5.2	2.5-7.8
Ventricular system	2	5.1	3.5	3.2-3.8

Province emphasises the necessity of focused control measures and the continued transmission of *T. multiceps*.

Large difference in the prevalence of coenurosis was observed among the districts in Salah Aldeen Province, with Tikrit and Samarra revealing the highest prevalence rates. This distribution pattern suggests that the transmission dynamics are significantly influenced by the local risk factors. The areas showing high infection rates might have a greater level of transmission either through the abundance of dogs, improper disposal of sheep carcasses, close association of dogs and sheep, and favourable environmental factors facilitating the survival and dispersal of *T. multiceps* eggs (Soliman et al. 2022). The clinical signs observed in the present study are the characteristics descriptions of coenurosis in sheep reported worldwide. The most common neurological signs were circling movement and head tilting, indicating the presence of space-occupying cystic lesions within the brain parenchyma (Achenef et al. 1999). The signs were predominantly unilateral, which provides a clear correlation between the location of cysts and clinical expression. Abnormalities in cortical elements within

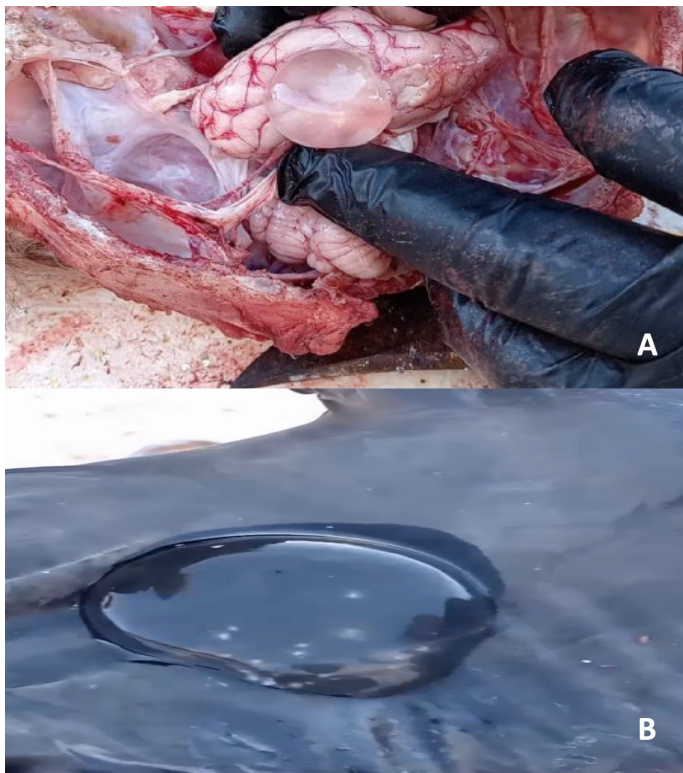


Fig. 1A. Gross appearance of coenurus cysts observed during post-mortem examination. The cysts are fluid-filled, translucent sacs attached to the affected tissue
1B. *Coenurus cerebralis*: Gross morphology of a fluid-filled, translucent coenurus cyst

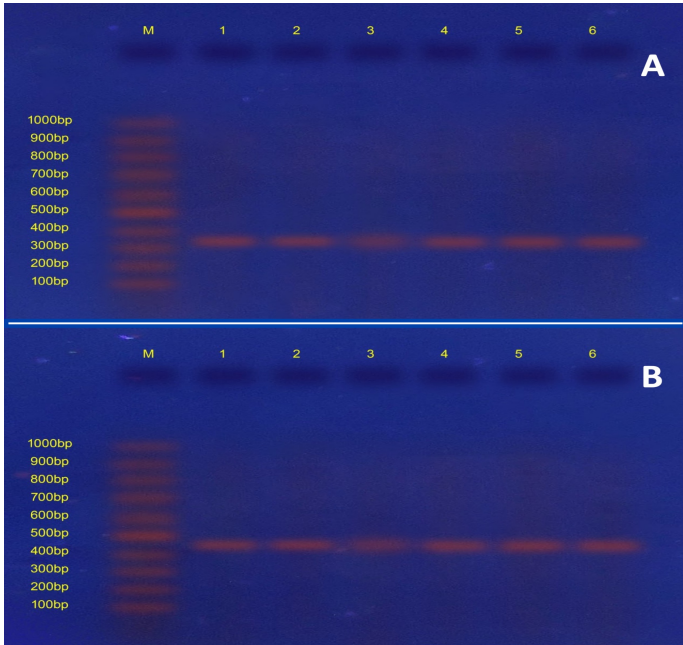


Fig. 2A. Gel electrophoresis for *col1* gene fragments 338 bp
2B. Gel electrophoresis for *ITS1* gene fragments 460 bp

the cerebral cortex are likely to result in more serious behavioral disturbance (González et al. 2000). The high frequency of visual impairment (43.6%) observed in present study indicates the involvement of visual cortical areas or compression of visual pathways by expanding cysts. This clinical sign is of particular importance from animal welfare and productivity point of view, as the affected animals may have difficulty finding feed and water and are more susceptible to secondary complications (Tavassoli et al. 2011).

A seasonal analysis of coenurosis in sheep revealed predominance of cases during winter months, which reflects a potential seasonal trend in disease occurrence. This pattern of disease phenomenon reflects the multifactorial interplay of environmental conditions on parasite transmission dynamics to produce clinical disease (Varcasia et al., 2013). The infection rate in the cooler and wetter months may be due to increased survival of *T. multiceps* eggs in the environment, a greater contact surface area between sheep and contaminated surfaces, higher animal congregation, or the potential breeding cycle in sheep, which may influence susceptibility (Varcasia et al. 2013). This study revealed a clear anatomical predilections of *C. cerebralis* cysts for the cerebral cortex and cerebellum. This anatomical predilection may be due to the blood flow pattern in the brain during the larval migration process or the tissue characteristics that favours cyst development (Miller 2016). However, the presence of multiple cysts in 20.5% of cases in the present study suggests heavy infection load, which generally produce more severe clinical signs and a poorer prognosis.

Confirmation by molecular identification of 94.4% of examined *T. multiceps* samples demonstrated the reliability of PCR-based diagnostics for confirmation of coenurosis. The high sequence similarity (96.8 to 98.5%) with sequence based reference isolates confirms the species attribution as well as the morphological diagnosis (Le et al. 2002). The molecular confirmation is highly valuable in case of coenurosis due to a significant risk of misdiagnosis, as clinical signs and gross pathological lesions can potentially overlap with other neurological conditions (Lavikainen et al. 2003; Le et al. 2002). From an economic perspective, the observed prevalence of coenurosis (8.67%) indicates a significant burden on sheep production in Salah Aldeen province. Considering the neurological nature of the disease and the greater chances of fatality in infected animals, losses constitutes direct costs of dead animals, loss of productivity, and potential veterinary costs (Budke et al. 2013). Indirect costs to the industry can also include psychological distress to farmers and potential trade restrictions in affected areas.

Controlling coenurosis requires a multi-faceted approach targeting both definitive and intermediate hosts. The higher prevalence rates identified in this study emphasize the need of dog deworming programs in sheep-producing communities along with proper carcass and offal disposal, and educating the sheep-producing farmers about the risks of disease transmission (Deplazes et al. 2017). The environmental management actions aimed at reducing the contamination of grazing areas with dog feces by restricting access of dogs to sheep pastures are equally important (Craig et al. 2017). According to the observed seasonal pattern in this study, increased preventive measures during high-risk times, especially winter, may help lower disease occurrence and break endemic transmission cycles of *T. multiceps* (Romig et al. 2017). Furthermore, possible long-term climate change may have an impact on the dynamics of egg survival and transmission, potentially changing the future conditions of disease epidemiology and morbidity, which necessitates an ongoing monitoring and flexible control measures (Hoberg et al. 2001).

5. Conclusions

This study offers the first thorough evidence of coenurosis in sheep populations in Salah Aldeen Province, Iraq, with a total prevalence of 8.67%, distinctive neurological symptoms, seasonal variation, and conclusive molecular confirmation of *Taenia multiceps*. These results demonstrate that coenurosis poses a serious risk to the region's sheep production, both economically and health-wise. The study warrants immediate need for integrated control methods that target both definitive and intermediate hosts, including routine dog deworming, offal and carcass disposal, environmental management, and better flock management techniques backed by farmer education. The molecular diagnostic method used in this investigation was effective in confirming the species and provides a useful instrument for integration into surveillance and monitoring initiatives. To lessen the impact of this significant parasitic disease on Iraqi sheep production, more research should concentrate on identifying particular risk factors, assessing the efficacy of control measures, and creating management recommendations tailored to a given region.

Declarations

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