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A comprehensive analysis of fasciolosis prevalence and risk factors in humans and animals: First report in Algeria

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Review Article

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Abstract

This systematic review and meta-analysis examined 27 studies published between 2003 and 2024 to assess the prevalence of *Fasciola hepatica* infestation in various animal species in Algeria. Diagnostic methods included liver inspection (16 studies), ELISA (7 studies), coproscopy (4 studies), bile microscopy (1 study), and abattoir data analysis (1 study). For humans, coproscopy and immunoelectrophoresis (IEP) were used in one study in Algiers. Among the 1,006,751 animals examined, 15,868 tested positive, resulting in an overall prevalence of 1.57% (CI 1.55–1.59). Prevalence was higher in the northeastern regions of Algeria (El Tarf, Annaba, and Jijel) at 15.95%, compared to other regions (0.9%–2.95%) (p<0.0001). Cattle showed the highest prevalence (3.91%; CI 3.84–3.98) (p<0.001), followed by sheep (0.42%; CI 0.40–0.44) and goats (0.12%; CI 0.10–0.14). Camels had a prevalence rate of 4%. Trend analysis over 20 years indicated a progressive decrease in prevalence, from 13.29% (2004–2009) to 1.79% (2010–2019) and 1.12% (2020–2024) (p<0.0001). The ELISA method was found to be the most sensitive, revealing a prevalence of 16.40% (CI 15.23–17.57) (true adjusted prevalence is 12.38%) (p<0.0001), significantly higher than liver inspection (1.83%), coproscopy (1.04%), and abattoir data analysis (1.10%). Prevalence increased with animal age across all species. This study clearly shows that fasciolosis in Algeria is most prevalent in the northeast region and that cattle are the high-risk group of animals. As a result, control strategies are urgently needed, targeting cattle in particular in northeast Algeria, to prevent and control this disease and thus reduce Fasciola infection.

Introduction

Fascioliasis is a zoonotic parasitic disease caused by the liver flukes *Fasciola hepatica* and *Fasciola gigantica* that parasite the liver and bile ducts of ruminant animals (Mas-Coma *et al.* 2022; Vázquez *et al.* 2022). Recognized as a neglected tropical disease, fascioliasis has become a growing global concern. Fascioliasis is the most prevalent trematode infection, affecting humans and animals in over 81 countries around the globe (Lan *et al.* 2024; Rosas-Hostos Infantes *et al.* 2023). Fascioliasis is a major threat to veterinary public health. Globally, around 2.4 million people are infected, with millions more at risk, especially in areas with sheep and cattle farming (WHO 2021). In livestock, the disease causes estimated annual losses of $3.2 billion worldwide (Mehmood *et al.* 2017).

F. hepatica has two hosts: a definitive host (e.g., ruminants and humans) and an intermediate host, the snail *Lymnaea*. In the definitive host, adult flukes produce eggs that are excreted with bile into the feces. In the external environment, under favorable conditions, the eggs develop into miracidium, which infect the intermediate host, *Lymnaea*. Inside the snail, the parasite undergoes several stages after miracidium penetration, leading to the formation of cercariae. These cercariae leave the snail, swim in the water, and transform into the highly resistant metacercariae. Definitive hosts are infected by consuming these metacercariae, which can cause significant health problems (Houang Quang *et al.* 2024; Mas-Coma *et al.* 2019).

Humans typically acquire the infection by ingesting contaminated water or vegetables. Symptoms in humans can range from fever and abdominal pain to diarrhea and nausea, particularly during the acute and chronic stages (Mehmood *et al.* 2017). Additionally, fascioliasis is associated with anemia and weight loss, particularly in children, who are especially vulnerable to devastating long-term complications, such as delayed growth and poor neurocognitive development (Caravedo and Cabada 2020). The global prevalence of human fascioliasis was estimated between 4.5% and 5%, representing a significant disease burden (Lan *et al.* 2024; Rosas-Hostos Infantes *et al.* 2023).

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Livestock, particularly sheep and cattle, along with goats, equines, and camels, have played a significant role in the worldwide dissemination of this disease (Mehmood *et al.* 2017). In animals, fascioliasis leads to reduced growth rates, decreased fertility, lower meat and milk production, and increased mortality. Affected animals often exhibit prolonged fever, hepatomegaly, eosinophilia, anorexia, weight loss, anemia, liver damage, and even death (Taghipour *et al.* 2019). Post-mortem examinations reveal characteristic pathology, such as pale, firm liver tissue, fibrosis, calcified and thickened bile ducts, and the presence of both adult and immature flukes (Howell *et al.* 2015).

The disease also impacts livestock productivity, resulting in reduced growth rates, decreased fertility, lower meat and milk production, and increased mortality. Additionally, the livestock industry incurs substantial economic losses due to the costs of anti-helmintic treatments, labor, and liver condemnation during meat inspections (Taghipour *et al.* 2019). Globally, the pooled prevalence of ruminant fascioliasis ranged between 13% and 17% (Lan *et al.* 2024).

Several risk factors contribute to the prevalence of fascioliasis in ruminants, including host and parasite biology, flock management, and the availability of the intermediate host snail (El-Tahawy *et al.* 2017; Zhang *et al.* 2017). Also, environmental factors such as temperature, moisture, and seasonal changes, as well as animal health and grazing practices, influence the spread of the disease (Chakraborty and Prodhan 2015).

Fascioliasis represents a significant threat to livestock productivity, human health, and the global livestock industry. This systematic review and meta-analysis aim to assess the prevalence of fascioliasis and identify associated risk factors in Algeria. To the best of our knowledge, this is the first study of its kind in the country. Its findings are expected to guide targeted research efforts and support the development of effective prevention and control strategies.

Material and methods

Study design

This systematic review was carried out to explore the prevalence and risk factors associated with fasciolosis in Algeria. It was carried out in accordance with the recommendations of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guideline (Moher *et al.* 2009). Relevant studies were identified by consulting nine literary databases, including PubMed, ScienceDirect, Scopus, ASJP, Taylor and Francis, ClinicalKey, SpringerLink, ResearchGate, and Google Scholar.

The search criteria were defined in advance, and the search was carried out on March 3, 2024, with a last update on July 17, 2024.

The search string used was 'fasiolosis' or '*Fasciola*' and 'epidemiology' or 'prevalence' and 'sheep', 'goat', 'cattle', 'ruminants', 'human', 'camel', 'horse', 'rabbit", 'dogs', 'cats' or 'donkeys', and 'Algeria' (Figure 1).

Data collection and eligibility criteria

For this review, two investigators studied titles and the abstracts of all the articles and retrieved data. We inclusively searched all databases.

The aim of the study was to examine the prevalence of fasciolosis in Algeria. We adopted the following inclusion criteria:

1. The selected study should evaluate the prevalence of fasciolosis in a definitive host, excluding the intermediate host from the analysis;
2. The selected study should include the total number of individuals tested and the infection positivity rate.
3. The selected study should present a clear detection method (coproscopy, liver inspection, ELISA, grinding method, snail dissection, multiplex PCR, bile test under microscope, IEP, and data collected from abattoirs).
4. The selected study must be located in Algeria, mentioning the precise sampling area.
5. The selected studies must have been carried out between 2003 and 2024.

Articles not meeting these criteria were excluded.

The bibliographic references collected were carefully examined to eliminate duplicates, studies conducted outside Algeria, and those outside the study period.

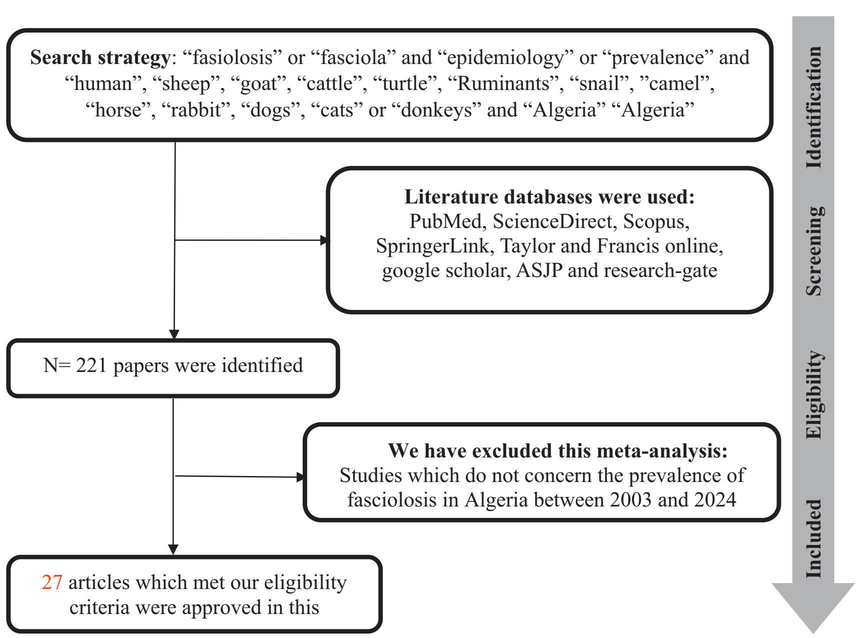

Figure 1. Flowchart describing the study design process.

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Articles presenting epidemiological parameters of interest and reporting the prevalence of fasciolosis were included in the study (Table 1).

The following data were extracted from the literature: first author, year of publication, animal species, prevalence rate, geographical study area, sample size, number of positive cases, diagnostic tests, risk factors, and study period (Tables 1 and 2). References to published data were also noted to extend the study and avoid missing valuable information.

Data analysis

Data were recorded in a Microsoft Excel spreadsheet and analysed by MetaXL version 4.0 software (EpiGear Int Pty Ltd., Wilston) for the meta-analyses and graphed as a forest plot and linear regression. Random-effect model analysis was used to estimate the overall prevalence of fasciolosis, and a forest plot was generated to visually assess the presence of heterogeneity, which occurred at a high level (Borenstein *et al.* 2010). Subgroup analysis was performed

Table 1. Prevalence (CI 95%) of *Fasciola hepatica* infestation according to regions, hosts, and detection methods

Region	Host	Detection method	Total samples	N° positive samples	Prevalence (%)	IC 95%	References
Jijel	Cattle	Liver inspection	2139	578	27.02	[25.21–28.89]	(Mekroud *et al.* 2004)
Jijel	Cattle	ELISA	161	43	26.71	[20.00–34.41]	(Mekroud *et al.* 2004)
Jijel	Sheep	Liver inspection	890	162	18.20	[15.65–20.98]	(Mekroud *et al.* 2004)
Jijel	Sheep	ELISA	84	20	23.81	[15.50–33.66]	(Mekroud *et al.* 2004)
Constantine	Cattle	Liver inspection	1459	133	9.12	[7.65–10.75]	(Mekroud *et al.* 2004)
Constantine	Cattle	ELISA	507	3	0.59	[0.12–1.72]	(Mekroud *et al.* 2004)
Constantine	Sheep	Liver inspection	2651	226	8.53	[7.46–9.68]	(Mekroud *et al.* 2004)
Constantine	Sheep	ELISA	379	24	6.33	[4.11–9.27]	(Mekroud *et al.* 2004)
Algiers	Human	Coproscopy	-	2	-	-	(Zait and Hamrioui 2005)
Algiers	Human	IEP	-	2	-	-	(Zait and Hamrioui 2005)
Jijel	Cattle	ELISA	175	41	23.43	[17.45–30.12]	(Mekroud *et al.* 2006)
Jijel	Cattle	Liver inspection	175	55	31.43	[24.68–38.87]	(Mekroud *et al.* 2006)
Mitidja	Cattle	ELISA	1870	346	18.54	[16.83–20.34]	(Aissi *et al.* 2009)
Mitidja	Cattle	Coproscopy	1870	0	0.00	[0.00–0.20]	(Aissi *et al.* 2009)
Annaba	Cattle	Liver inspection	5985	1562	26.10	[25.07–27.16]	(Ferhati *et al.* 2014)
Bejaia	Cattle	Coproscopy	143	18	12.59	[7.67–19.17]	(Moussouni *et al.* 2018)
Ouargla	Cattle	Liver inspection	2151	37	1.72	[1.20–2.37]	(Ouchene-Khelifi *et al.* 2018)
El Tarf	Cattle	Liver inspection	3457	926	26.79	[25.32–28.30]	(Ouchene-Khelifi *et al.* 2018)
El Tarf	Sheep	Liver inspection	6161	401	6.51	[5.91–7.16]	(Ouchene-Khelifi *et al.* 2018)
Bejaia	Cattle	Data collected	157690	4 462	2.83	**[2.75–2.91]**	(Ayad *et al.* 2019.)
Bejaia	Sheep	Data collected	148713	190	0.13	**[0.11–0.15]**	(Ayad *et al.* 2019.)
Bejaia	Goats	Data collected	126903	149	0.12	[0.10–0.14]	(Ayad *et al.* 2019.)
Mitidja	Cattle	Liver inspection	1400	40	2.86	[2.05–3.89]	(Chaouadi *et al.* 2019)
Mitidja	Cattle	Microscopic bile	1400	77	5.50	[4.37–6.84]	(Chaouadi *et al.* 2019)
Mitidja	Cattle	Liver or microscopic bile examination.	1400	85	6.07	[4.87–7.49]	(Chaouadi *et al.* 2019)
Mitidja	Cattle	ELISA	206	59	28.64	[22.41–35.51]	(Chaouadi *et al.* 2019)
Bejaia	Cattle	Liver inspection	1091	64	5.87	[4.58–7.42]	(Chougar *et al.* 2019)
Ain–Temouchent	Cattle	Liver inspection	113	5	4.42	[1.44–10.05]	(Chougar *et al.* 2019)
Batna	Cattle	Liver inspection	30	2	6.67	[0.82–22.10]	(Chougar *et al.* 2019)
Tlemcen	Cattle	Liver inspection	111	3	2.70	[0.56–7.69]	(Chougar *et al.* 2019)
Tiaret	Cattle	Liver inspection	122	3	2.46	[0.51–7.04]	(Chougar *et al.* 2019)
Medea	Cattle	Liver inspection	88	3	3.41	[0.70–9.68]	(Chougar *et al.* 2019)
Souk–Ahras	Cattle	Liver inspection	18	4	22.22	[6.36–48.54]	(Chougar *et al.* 2019)

(*Continued*)

Table 1. (*Continued*)

Region	Host	Detection method	Total samples	N° positive samples	Prevalence (%)	IC 95%	References
Tissemsilt	Cattle	Liver inspection	128	3	2.34	[0.48–6.71]	(Chougar *et al.* 2019)
Jijel	Ruminants	Liver inspection	625	77	12.32	[9.88–15.12]	(Hamiroune *et al.* 2019)
Northeastern Algeria	Cattle	ELISA	143	32	22.38	[15.94–30.18]	(Taibi *et al.* 2019)
El–oued	Cattle	Liver inspection	89	6	6.74	[2.51–14.11]	(Amor *et al.* 2020)
El–oued	Cattle	Liver inspection	75	2	2.67	[0.00–6.31]	(Amor *et al.* 2020)
El–oued	Cattle	Liver inspection	36	3	8.33	[0.00–17.36]	(Amor *et al.* 2020)
Bordj Badji Mokhtar	Sheep	Liver inspection	3900	3	0.08	[0.00–0.16]	(Chougar *et al.* 2020)
Jijel	Cattle	Liver inspection	5587	447	8.00	[7.29–8.71]	(Hamiroune *et al.* 2020)
Jijel	Sheep	Liver inspection	554	3	0.54	[0.00–1.15]	(Hamiroune *et al.* 2020)
Jijel	Goats	Liver inspection	379	1	0.26	[0.00–0.78]	(Hamiroune *et al.* 2020)
Laghouat	Turtle	Coproscopy	24	3	12.50	[0.00–25.73]	(Lakehal *et al.* 2020)
Constantine	Cattle	Liver inspection	145919	4005	2.74	[2.66–2.83]	(Gherroucha *et al.* 2021)
Constantine	Sheep	Liver inspection	345282	817	0.24	[0.22–0.25]	(Gherroucha *et al.* 2021)
SouAhras	Cattle	Liver inspection	530	65	12.26	[9.47–15.06]	(Meguini *et al.* 2021)
Laghouat	Camel	Coproscopy	100	4	4.00	[0.16–7.84]	(Saidi *et al.* 2021)
Constantine	Cattle	Liver inspection	1036	20	1.93	[1.09–2.77]	(Gherroucha *et al.* 2022)
Constantine	Sheep	Liver inspection	2574	1	0.04	[–0.04–0.11]	(Gherroucha *et al.* 2022)
Jijel	Cattle	Liver inspection	1756	67	3.82	[2.92–4.71]	(Mimoune *et al.* 2022)
Djelfa	Sheep	ELISA	217	1	0.46	[–0.44–1.36]	(Hebali *et al.* 2023)
M'Sila	Cattle	Liver inspection	1781	26	1.46	[0.90–2.02]	(Adili *et al.* 2024)
M'Sila	Sheep	Liver inspection	22590	393	1.74	[1.57–1.91]	(Adili *et al.* 2024)
M'Sila	Goats	Liver inspection	3306	13	0.39	[0.18–0.61]	(Adili *et al.* 2024)
Jijel	Cattle	Liver inspection	113	69	61.06	[52.07–70.05]	(Djemai *et al.* 2024)
Jijel	Cattle	ELISA	113	63	55.75	[46.59–64.91]	(Djemai *et al.* 2024)
Tizi ouzou	Cattle	Liver inspection	376	26	6.91	[4.35–9.48]	(Mezali *et al.* 2024)

ELISA: Enzyme-linked immunosorbent assay. IEP: immunoelectrophoresis

according to region, publication year, sampling method, and sample size to identify potential sources of heterogeneity.

To correct for biases related to the imperfect specificity of the ELISA test, we estimated the true prevalence by adjusting the observed test results. This compensates for the false positives and false negatives generated by the limitations of the ELISA test. This calculation was performed based on a sensitivity of 90% and a specificity of 94% for ELISA, according to Rapsch *et al.* (2006).

The formula to estimate the adjusted true prevalence is as follows:

$$\text{True Adjusted Prevalence} = \frac{\text{Observed prevalence} + \text{Specificity} - 1}{\text{Sensibility} + \text{Specificity} - 1}$$

Data mapping

The website (http://gadm.org/) was used to upload the map of Algeria and to map the spatial distribution of *F. hepatica* prevalence; ArcGIS 10.3 software (http://www.esri.com) was used.

Results

During a search of nine databases between 2003 and 2024, 27 articles were deemed eligible for inclusion in this systematic review and meta-analysis (Figure 1).

The selected studies investigated the prevalence of *Fasciola* infestation in various animal species in different regions of Algeria. Diagnostic methods used included liver inspection in 16 studies, enzyme-linked immunosorbent assay (ELISA) in 7 studies, coproscopy in 4 studies, microscopic examination of bile in 1 study, and analysis of slaughterhouse data in 1 study. Immuno-electrophoresis (IEP) and coproscopy were used for human diagnosis in 1 study at Algiers (Table 1).

Data on the prevalence of fasciolosis in cattle were collected from 20 separate studies of which 16 used liver inspection for diagnosis, 6 used ELISA, 2 used coproscopy, 1 used abattoir data, and 1 used bile microscopy (Table 1).

Eight studies concerning fasciolosis in sheep were identified. Seven of them were based on liver inspection; two used ELISA testing, and one collected data from abattoirs (Table 1).

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Four studies involving goats were identified using two diagnostic methods: liver inspection and data collection (Table 1).

One study examined the prevalence of fasciolosis in camels using coproscopy as a diagnostic method (Table 1).

A study carried out in Algiers identified only four cases of human fasciolosis between 1996 and 2005 with two diagnostic methods used: coproscopy and immunoelectrophoresis (IEP) (Table 1).

Overall, a number of 1,006,751 animals species were investigated, of which 15,868 were identified as positive cases, representing a prevalence of 1.57% (95% CI: 1.55–1.59)) Table 2).

Geographical distribution and a forest plot of *F. hepatica* prevalence in animals in Algeria were presented in Figure 2 and Figure 3, respectively.

Fasciolosis was observed more frequently in the northeastern regions of Algeria (El Tarf, Annaba, Jijel) (prevalence of 15.95%) compared to other regions (northwest, north-central, inland regions, and southern Algeria) (prevalence between 0.86% and 2.95%) (p<0.0001) (Table 2, FSigure 4).

Species breakdown shows 13383/341443 cases in cattle, 2241/533995 in sheep, 163/130588 in goats, and 4/100 in camels, which gives a prevalence 3.91% (95% CI: 3.84–3.98), 0.42% (95% CI: 0.40–0.44), 0.12% (95% CI: 0.10-0.14), and 4% (95% CI: 0.16–7.84), respectively (Table 2). Among ruminants, cattle and camel have been the most prevalent (p<0.001) (Table 2, Figure 4).

The prevalence of *Fasciola* infestation ranges between 0.59% and 61.06% in cattle, 0.04% and 23.81% in sheep, and 0.12% and 0.39% in goats (Table 1). All studies have indicated that prevalence increases with age.

Over the years, a clear decrease in prevalence was observed. The highest prevalence was recorded between 2004 and 2009 (13.29%; 95% CI: 12.69–13.89), followed by a gradual decline during the periods of 2010–2019 (1.79%; 95% CI: 1.75–1.83) and 2020–2024 (1.12%; 95% CI: 1.09–1.15) (p<0.0001) (Table 2, Figure 4).

Table 3 compares the observed and true adjusted prevalence of a disease in cattle and sheep, accounting for biases in the ELISA diagnostic test, which has imperfect specificity. The observed prevalence in cattle ranges from 0.59% to 55.75%, with the true adjusted prevalence consistently lower due to corrections for false positives and negatives. For example, in Chaouadi *et al.* (2019), the observed prevalence of 28.64% dropped to 26.90% after adjustment. Similarly, Djemai *et al.* (2024) reported an observed prevalence of 55.75%, which was slightly adjusted to 54.46%. In sheep, observed prevalence values range from 0.46% to 23.81%, with the adjusted prevalence showing a similar reduction. For instance, Mekroud *et al.* (2004) observed a prevalence of 23.81%, which adjusted to 21.98%. When combining cattle and sheep, the overall true adjusted prevalence decreases from 16.40% (observed) to 12.38% (adjusted). These values had no impact on the significant differences reported above.

The ELISA technique proved to be the most sensitive method for detecting infestations by *F. hepatica.* Indeed, the overall prevalence revealed using ELISA was the highest (16.40%; 95% CI: 15.23–17.57) (true adjusted prevalence is 12.38%) compared to other diagnostic methods, such as liver inspection at slaughterhouses (1.83%; 95% CI: 1.80–1.86), coproscopy (1.04%; 95% CI: 0.58–1.50), or data analysis (1.10%; 95% CI: 1.07–1.13) (p<0.0001) (Table 2, Figure 4).

Discussion

To the best of our knowledge, this study is the first meta-analysis conducted in Algeria on fascioliasis, both in animals and humans,

Table 2. Variation in the prevalence of *F. hepatica* infestation and the Odds Ratio (OR) based on different risk factors

Variables	Characteristics	Sample size	N° Positive samples	Prevalence % (CI 95%)	OR	p-value
Region	Northeastern	28497	4547	15.95 (15.52–16.38)	Ref	0.0001
	Northwestern	474	14	2.95 (1.43–4.47)	0.16	
	North-center	443062	5516	1.24 (1.21–1.27)	0.066	
	Interne regions	528367	5736	1.08 (1.05–1.11)	0.058	
	South	635175	558	0.90 86 (0.6763–1.1309)	0.048044	
Host	Turtle	24	3	12.5 (–0.73–25.73)	-	0.0001
	Cattle	341443	13383	3.91 (3.84–3.98)	Ref	0.001
	Sheep	533995	2241	0.42 (0.40–0.44)	0.10	
	Goats	130588	163	0.12 (0.10–0.14)	0.031	
	Camel	100	4	4 (0.16–7.84)	1.02	0.001
	Ruminants	625	77	12.32 (9.74–14.90)	-	
Publication year	2004–2009	12360	1631	13.29 (12.69–13.89)	Ref	0.0001
	2010–2019	458078	8202	1.79 (1.75–1.83)	0.12	
	2020–2024	536337536313	60386035	1.12 (1.09–1.15)	0.075	
Detection methods	ELISA	3855	632	16.40 (15.23–17.57)	Ref	0.0001
	Liver inspection	567477	10413	1.83 (1.80–1.86)	0.11	
	Coproscopy	21372113	2522	1.17 04 (0.7158–1.6350)	0.071075	
	Data analysis	433306	4801	1.10 (1.07–1.13)	0.067	
Overall		100675175	1586871	1.57 (1.55–1.59)	-	

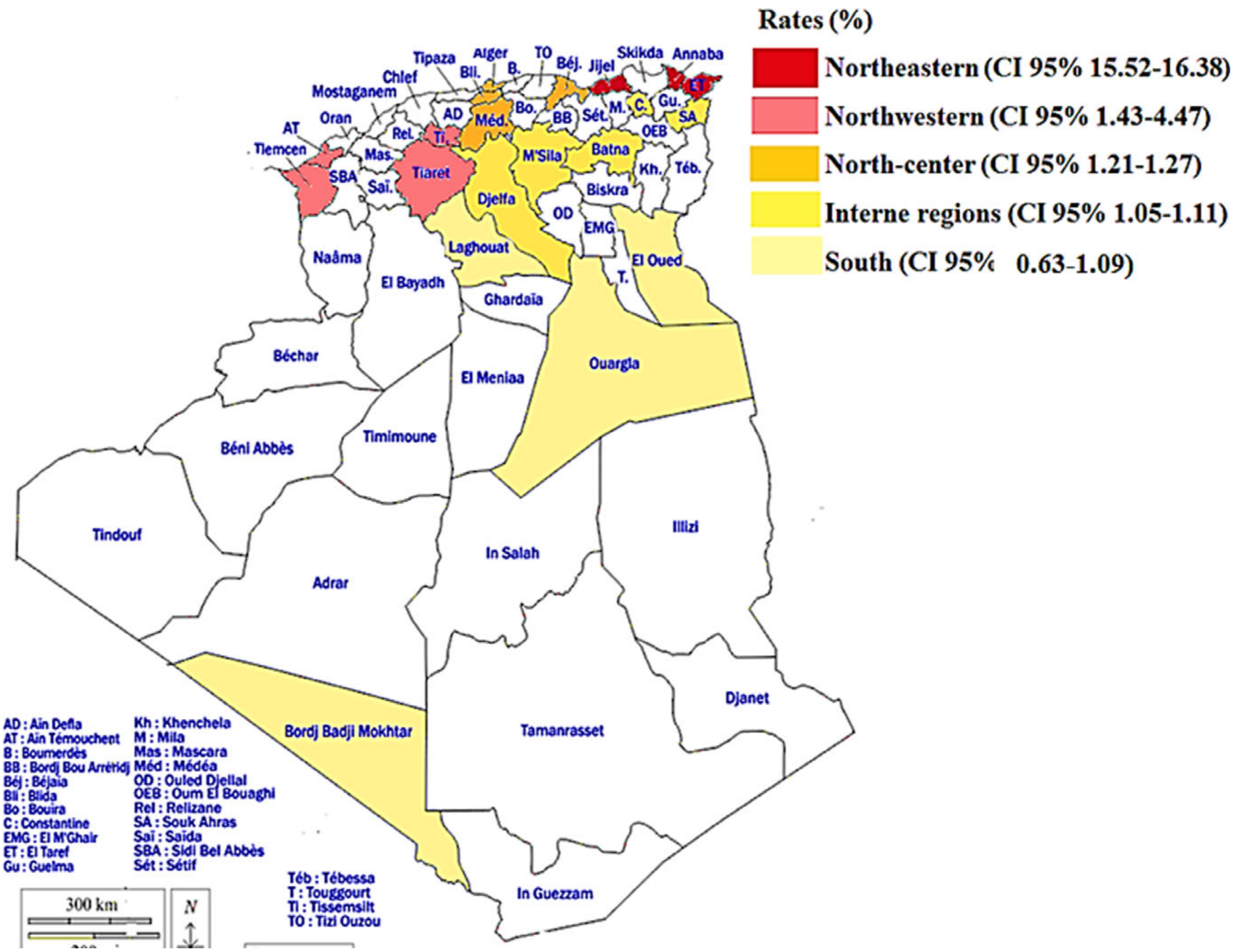

Figure 2. Geographical distribution of *Fasciola hepatica* prevalence in animals in Algeria. Areas of low and high prevalence are represented by different gradient colors; the light color indicates the least affected region, and the dark color represents the most affected region.

covering a 20-year period. By analyzing the available epidemiological data from the past two decades, this research aims to provide a comprehensive overview of the prevalence, risk factors, and trends of *F. hepatica* infection in Algeria. Through this exhaustive analysis, we hope not only to fill a significant gap in the Algerian scientific literature but also to contribute to a better understanding of the impact of this zoonosis in the local context.

This systematic review and meta-analysis, conducted on studies published between 2004 and 2024, concerned 27 eligible studies, including data on over one million animals, which offer valuable insights into the epidemiology of fasciolosis in Algeria.

The overall prevalence of fasciolosis in animals was found to be 1.57% (95% CI: 1.55–1.59), which is relatively low but significant enough to warrant attention, particularly in certain regions. Notably, the highest prevalence was observed in the northeastern regions of Algeria, such as El Tarf, Annaba, and Jijel, where the prevalence reached 15.95%. This gradient can be attributed to environmental and climatic factors that favor the transmission of *F. hepatica*, including a humid climate, abundant vegetation, and the presence of clayey soils that are conducive to the development of intermediate host mollusks of *F. hepatica.* These observations align with the findings of Medeiros *et al.* (2014), Howell *et al.* (2015), and Mas-Coma *et al.* (2005), who showed that wetlands, grazing in marshy areas, and clayey soils are major hotspots for the transmission of fasciolosis due to the presence of intermediate hosts such as mollusks.

In contrast, southern and inland regions showed much lower prevalence rates, ranging between 0.9% and 2.95%. The variation in prevalence between regions highlights the importance of localized interventions and targeted control measures.

Livestock – particularly sheep, cattle, goats, and camels – play a significant role in the global spread of fasciolosis (Mehmood *et al.* 2017). This disease is prevalent in ruminant farming regions worldwide and is associated with considerable morbidity and mortality rates (Fürst *et al.* 2012). Moreover, fasciolosis negatively impacts the quality of products derived from infected animals, leading to reduced yields of meat, milk, and other animal-based products (Lan *et al.* 2024). In this study, the prevalence of *Fasciola* infestation in cattle varies widely, ranging from 0.59% to 61.06%. Similar patterns have been reported in African countries, with prevalence rates between 4.9% and 74.9% (Abunna *et al.* 2010; Elelu *et al.* 2016), and in Malaysia, where rates range from 7.5% (Fazly-Ann *et al.* 2015) to 78.0% (Khadijah *et al.* 2017). On a global scale, the average prevalence worldwide in cattle spans from 12.02% to 96.67% (Lan *et al.* 2024). Regional variability in the occurrence of bovine fasciolosis is influenced by a range of factors, including

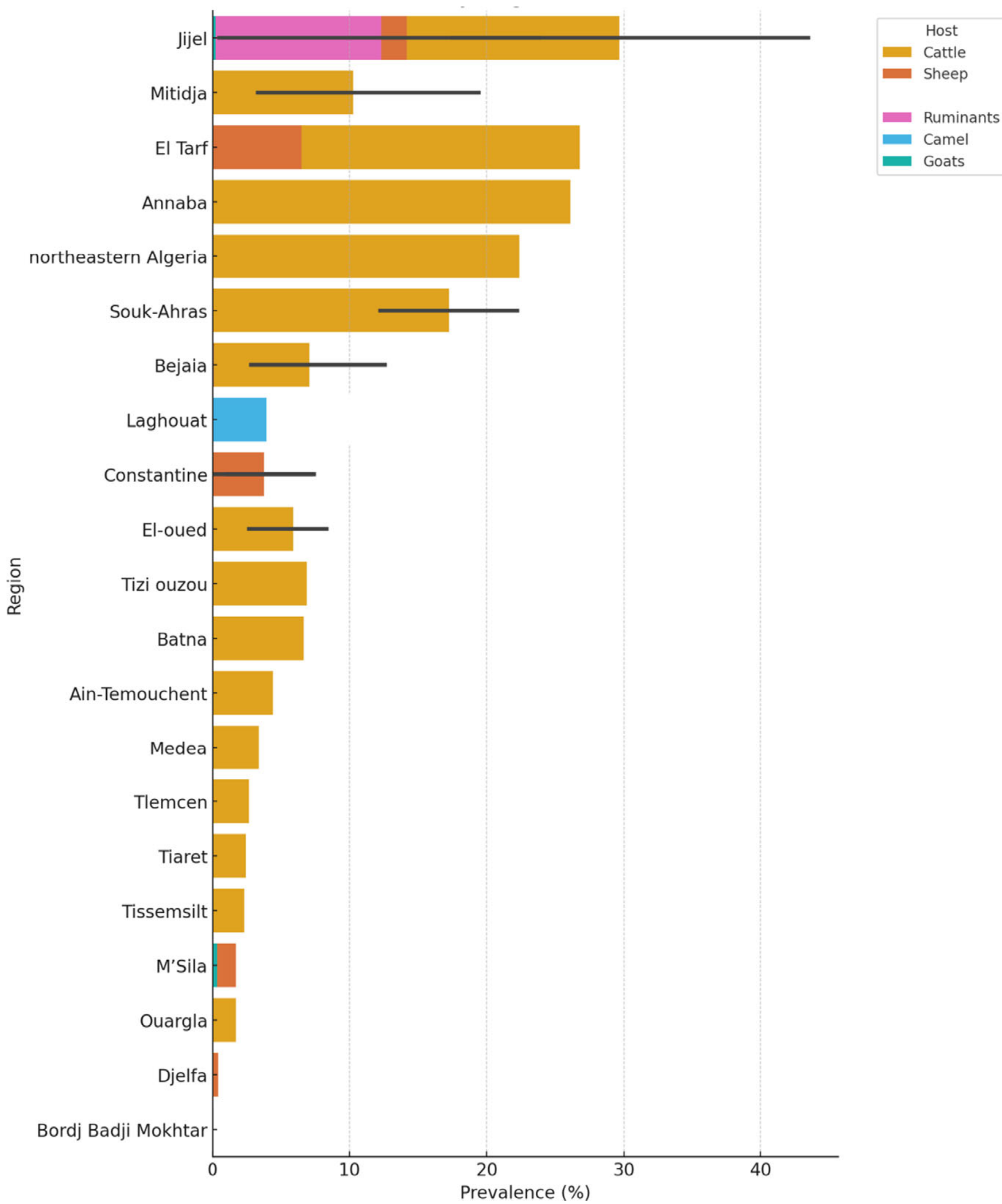

Figure 3. Forest plot of *Fasciola hepatica* prevalence by region and hosts.

climate, environmental conditions, diagnostic techniques, and the diversity of final hosts (Che-Kamaruddin *et al.* 2024).

The prevalence in sheep revealed herein varied between 0.04% and 23.81% and seems in line with other African countries (0.19%–16.78%) (Hammami *et al.* 2024; Mbaya *et al.* 2011; Mohamed 2013; Mungube *et al.* 2006). The overall prevalences in Western Europe did not exceed 16% (Rinaldi *et al.* 2015). In Asia and America, however, infection rates were higher, reaching 40% (Acici *et al.* 2017; Aghayan *et al.* 2019; Arbabi *et al.* 2018; Carmona and Tort 2017). These differences in *F. hepatica* prevalence rates can be

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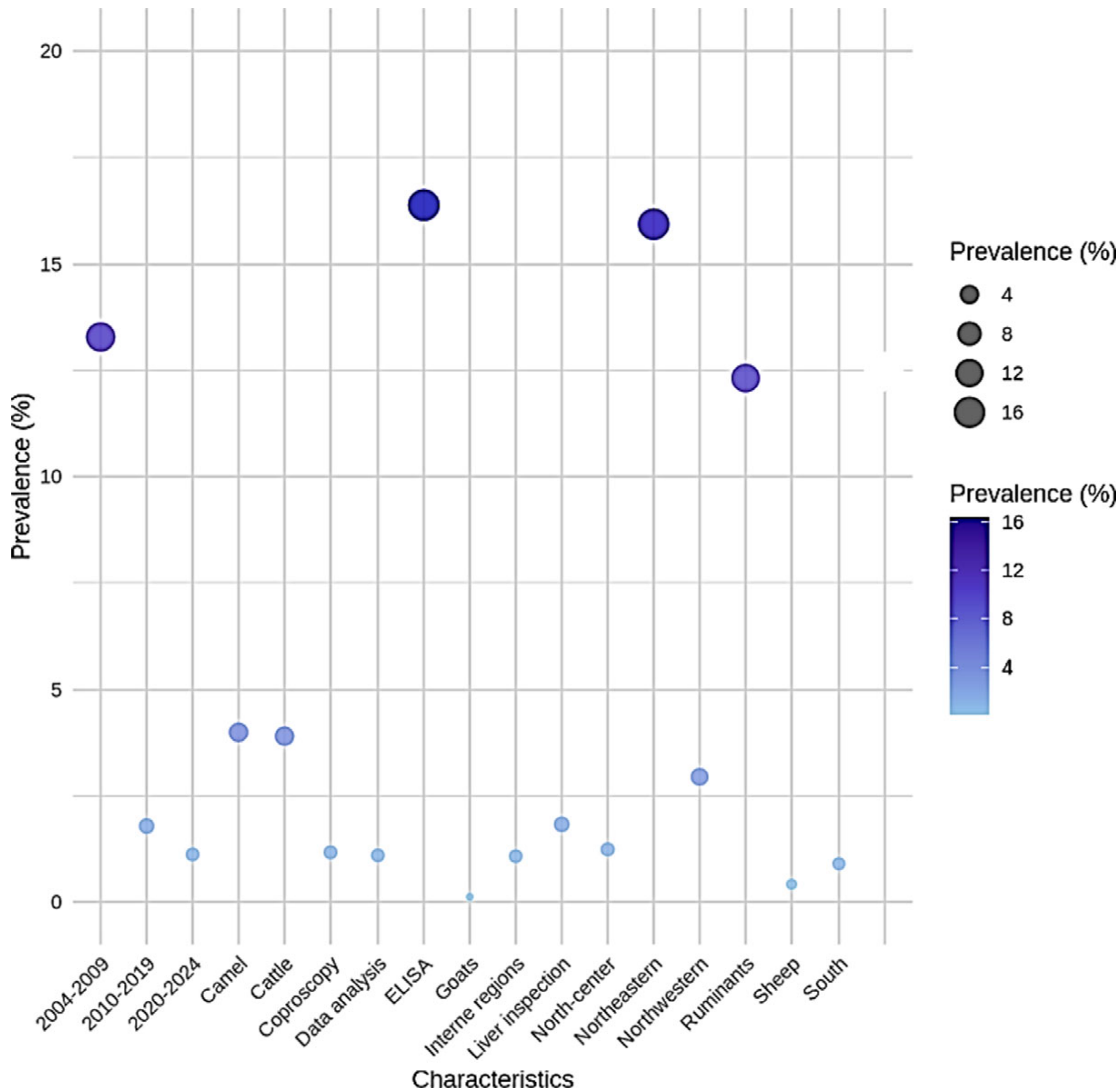

Figure 4. Bubble diagram showing the variation in *Fasciola hepatica* prevalence according to different risk factors. The size of the bubble indicates the incidence.

Table 3. The adjusted true prevalence of fasciolosis in ruminants

Host	Total samples	N° positive samples	Observed prevalence (%)	References	True adjusted prevalence (%)
Cattle	161	43	26.71	(Mekroud *et al.* 2004)	24.66
	507	3	0.59	(Mekroud *et al.* 2004)	0.53
	175	41	23.43	(Mekroud *et al.* 2006)	21.61
	1870	346	18.54	(Aissi *et al.* 2009)	16.71
	206	59	28.64	(Chaouadi *et al.* 2019)	26.90
	143	32	22.38	(Taibi *et al.* 2019)	20.34
	113	63	55.75	(Djemai *et al.* 2024)	54.46
Total	3175	587	18.48		14.86
Sheep	84	20	23.81	(Mekroud *et al.* 2004)	21.98
	379	24	6.33	(Mekroud *et al.* 2004)	5.35
	217	1	0.46	(Hebali *et al.* 2023)	0.41
Total	680	45	6.61		0.73
Total: cattle and sheep	3855	632	16.40		12.38

attributed to geographical and climatic factors such as temperature, humidity, rainfall, and many other factors that influence the growth of intermediate hosts (Hammami *et al.* 2024; Qin *et al.* 2016; Selemetas *et al.* 2015).

In this study, fasciolosis was infrequently detected in goats, with prevalence ranging from 0.12% to 0.39%. These results align with the findings of Mickiewicz *et al.* (2024), who observed a prevalence of 1.2% in Poland. The seroprevalence observed in our study likely provides a more accurate representation of the actual exposure of goats to *F. hepatica* in Algeria. The level of exposure to *F. hepatica* in goats is undoubtedly much lower than that seen in cattle and sheep (Mickiewicz *et al.* 2024). The risk of fasciolosis is mainly determined by the presence and abundance of infected mollusks (Roldán *et al.* 2021). However, these gastropods can only thrive in humid environments, while goats generally avoid wet and marshy pastures (Mickiewicz *et al.* 2024). Additionally, goats tend to browse rather than graze, which leads to frequent changes in feeding sites and reduces the chances of ingesting large amounts of metacercariae, even on pastures heavily contaminated with the parasite (Smith 2023).

Fasciolosis mainly affected cattle (3.91%), while sheep (0.42%) and goats (0.12%) had a lower prevalence. These differences may reflect the different feeding habits and habitats of the various species. Livestock grazing in humid areas and other factors were associated with high prevalences (Lan *et al.* 2024), which is in line with our results. In fact, cattle are concentrated mainly in northern Algeria, which has a humid climate. Sheep and goats, on the other hand, are mainly found in the steppic and southern regions of the country, where the climate is more arid. This explains the high prevalence observed herein in cattle compared with sheep and goats.

The high prevalence observed in dromedaries (4%) in our survey is due to the low number of examined animals (100) and only in one study by Saidi *et al.* (2021) in Laghouat. This result does not reflect the overall situation of camel fasciolosis in Algeria.

Humans can contract fasciolosis by consuming contaminated salads and raw vegetables. The disease has been reported in over 81 countries worldwide (Mas-Coma *et al.* 2022). The World Health Organization (WHO) has recognized fasciolosis as a neglected tropical disease (Webb and Cabada 2018). However, in this study, human fasciolosis seems very rare in Algeria, having been observed in only 4 patients (Zait and Hamrioui 2005). Lan *et al.* (2024) revealed a worldwide human prevalence of 5%.

The results of this survey showed that prevalence increases with the age of the animals, which is in agreement with the observations of Lan *et al.* (2024) worldwide, Che-Kamaruddin *et al.* (2024) in Malaysia, and Zewde *et al.* (2019) in Ethiopia. This is attributed to older animals experiencing prolonged exposure to *Fasciola*-contaminated grazing areas (Che-Kamaruddin *et al.* 2024). In addition, the immunity of older animals tends to weaken (Lan *et al.* 2024). In older animals, the parasitic burden of *Fasciola* lasts longer, facilitating continuous egg excretion and maintaining infection. Unlike younger animals, which are kept indoors and provided with specific feed that reduces exposure to *Fasciola* metacercariae, older animals have access to contaminated pastures. However, a study conducted in farms without age-based management showed no significant link between age and fascioliasis, as animals of all ages were equally exposed to the infection (Shinggu *et al.* 2019).

The ELISA technique demonstrated the highest sensitivity for detecting infestations, with a prevalence of 16.40% (95% CI: 15.23–17.57) (true adjusted prevalence of 12.38%), compared to other methods such as liver inspection (1.83%), coproscopy (1.04%), and slaughterhouse data analysis (1.10%). The higher sensitivity of ELISA may be due to its ability to detect antibodies or antigens even in the early stages of infection (Vashist and Luong 2018), which may not be identifiable through traditional methods such as liver inspection or coproscopy. These findings underscore the importance of using sensitive diagnostic tools in surveillance efforts to better capture the true extent of *Fasciola* infections in both animals and humans. These findings corroborate the study of Aftab *et al.* (2024), who emphasized the effectiveness of ELISA for early diagnosis and its ability to detect subclinical cases, particularly in environments with low prevalence.

The decrease in prevalence over two decades (13.29% in 2004–2009 to 1.12% in 2020–2024, $p<0.0001$) could be attributed to improved veterinary practices, better pasture management, and awareness campaigns in Algeria. The data also suggest an effect of climate change on the dynamics of intermediate hosts, as highlighted by the investigation of Dube *et al.* (2023) and Fox *et al.* (2011), who show a correlation between climate changes and a reduction in habitats favorable to lymnae. However, while the decline is encouraging, the persistence of the parasite at lower levels suggests that continued surveillance and control strategies remain essential, particularly in high-risk regions.

Conclusion

This study provides a comprehensive analysis of the epidemiology of *F. hepatica* in Algeria, shedding light on the regional variation in prevalence, the influence of host species, and the diagnostic methods used. Despite the decline in prevalence over the years, *Fasciola* continues to be a significant concern, particularly in high-risk regions. The findings highlight the importance of continued surveillance and the use of sensitive diagnostic tools like ELISA to monitor and control fasciolosis in both animals and humans.

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Ethical standard. This study did not require an ethical approval, as it was based on information/data retrieved from published studies already available in the veterinary public domain.

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