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Incidence and Economic Impact of Fasciolosis in Ruminants from Slaughterhouses in Bejaia Province (Northern Algeria): A Retrospective Survey (2017-2023)

Bejaia Kenti (Kuzey Cezayir) Kesimhanelerindeki Ruminantlarda Fasciolozis İnsidansı ve Ekonomik Etkisi: Retrospektif Bir Araştırma (2017-2023)

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ABSTRACT

Objective: Fasciolosis is considered an important parasitic disease, and also a primary source of morbidity and mortality in ruminants with significant economic losses and public health. The objective of the present study was to determine the prevalence and the economic losses due to fasciolosis in ruminants from different local slaughterhouses in Bejaia province during 7-years.

Methods: Data were obtained from different municipal slaughterhouses, supervised by the Provincial Veterinary Inspection of Bejaia, from January 2017 to December 2023. A veterinary inspected routine animal carcasses at each stage of the slaughtering process in the slaughtering units on a regular and systematic basis.

Results: The overall prevalence of fasciolosis detected by post-mortem examination in cattle, sheep, and goats slaughtered during the study period was 1.58%, 0.04% and 0.02%, respectively. The desired absolute precision (d) of cattle, sheep and goats is 0.011%, 0.63% and 0.51%, respectively. In cattle, fasciolosis was significantly high in January, February, and March; and gradually decreased from April to September, then increased in October, November and December. On the other hand, the monthly cumulative prevalence rates of sheep and goats fasciolosis cases recorded was constant throughout the year. The high recorded prevalence was in autumn and winter was 1.92% and 1.78% in cattle, respectively ($p \leq 0.05$). An overall direct economic loss of 5,904,031€ was incurred during the period in this study from a totality of 12,321.2 kg of liver condemned. The indirect economic loss is due to carcass weight reduction as a result of fasciolosis infection was 44,746,454€.

Conclusion: Our study revealed that the prevalence of cattle fasciolosis was generally high compared to sheep and goats in the abattoir of Bejaia province associated with significant financial losses for butchers in the study area. Furthermore, livestock farmers should be made aware of the importance of this parasitose in order to reduce economic losses.

Keywords: Fasciolosis, economic loss, Algeria

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Türkiye PARAZİTOLOJİ Dergisi

ÖZ

Amaç: Fasciolozis, önemli bir paraziter hastalık olarak kabul edilmektedir. Geviş getiren hayvanlarda morbidite ve mortalitenin birincil kaynağı olarak önemli derecede ekonomik kayıplara ve halk sağlığına yol açmaktadır. Bu çalışmanın amacı, Bejaia şehrindeki farklı yerel mezbahalardan gelen geviş getiren hayvanlarda 7 yıl boyunca fasciolozis prevalansını ve ekonomik kayıpları belirlemektir.

Yöntemler: Veriler, Ocak 2017'den Aralık 2023'e kadar Bejaia İl Veterinerlik Denetim Kurumu'nun denetimindeki farklı belediye mezbahalarından elde edilmiştir. Bir veteriner, mezbaha birimlerinde kesim sürecinin her aşamasında rutin olarak ve sistematik bir şekilde hayvan karkaslarını denetlemiştir.

Bulgular: Çalışma süresince kesilen sığır, koyun ve keçilerde postmortem muayene ile tespit edilen fasciolozis prevalansı sırasıyla %1,58, %0,04 ve %0,02 idi. Sığır, koyun ve keçiler için istenen mutlak kesinlik (d) sırasıyla %0,011, %0,63 ve %0,51'di. Sığırlarda fasciolozis, Ocak, Şubat ve Mart aylarında önemli ölçüde yüksekti; Nisan'dan Eylül'e kadar kademeli olarak azaldı, ardından Ekim, Kasım ve Aralık aylarında arttı. Öte yandan, kaydedilen koyun ve keçilerdeki fasciolozis vakalarının aylık kümülatif prevalans oranları yıl boyunca sabit kaldı. Yüksek prevalans sonbahar ve kış aylarında sırasıyla sığırlarda %1,92 ve %1,78 olarak kaydedildi ($p \leq 0,05$). Bu çalışmada, toplam 12.321,2 kg karaciğerin imha edilmesi nedeniyle, söz konusu dönemde €5.904.031 tutarında doğrudan ekonomik kayıp meydana gelmiştir. Fasciolozis enfeksiyonu sonucu karkas ağırlığındaki azalma nedeniyle meydana gelen dolaylı ekonomik kayıp ise €44.746.454 olmuştur.

Sonuç: Çalışmamız, Bejaia ilindeki mezbahada sığırlarda fasciolosis prevalansının koyun ve keçilere kıyasla genel olarak yüksek olduğunu ve bu durumun çalışma alanındaki kasaplar için önemli mali kayıplara yol açtığını ortaya koymuştur. Ayrıca, ekonomik kayıpları azaltmak için hayvancılıkla uğraşan çiftçilerin bu parazitozun öneminin farkında olmaları gerekmektedir.

Anahtar Kelimeler: Fasciolozis, ekonomik kayıp, Cezayir

INTRODUCTION

Algeria is known for its diverse livestock population. According to the National Statistics Office, the local livestock is estimated at thirty-eight million of heads, including cattle, sheep, goats, camels, and equines. In addition, an average of five million tons of red meat is recorded per year. However, animal diseases of parasitic origin have a significant impact on animal productivity as well as human health. Furthermore, the Algerian authorities have adopted a policy aimed at increasing animal production through surveillance and animal health control in order to safeguard the animal herd and ensure food security.

Fasciolosis is considered an important parasitic disease, and also a primary source of morbidity and mortality in ruminants, with significant economic losses and public health consequences (1,2). It is brought on by two genuses of *Fasciola*: *F. gantica*, which is restricted to Africa and Asia, and *F. hepatica*, which is found all over the world (3). The route of fasciolosis transmission is ingestion of metacercaria-infested plants or water contaminated with floating metacercariae in animals and humans (4). Fasciolosis is defined by chronic, acute, or subacute inflammation of the liver and bile ducts, as well as submandibular oedema, anemia, general intoxication, or even death of the animal (5). Significant economic losses are huge caused by fasciolosis such as decreased weight gain, poor carcass quality, decreased milk yield, high treatment and control costs, mortality, and as well as the condemnation of infested livers at abattoirs (6-9).

It is reported that fasciolosis affects about 700 million herbivorous domestic animals worldwide and causes three billion US$ or more is the annual loss in farm animals as a sequence of productivity losses (10,11). In Algeria, numerous studies have been conducted on post-mortem fasciolosis disease in ruminants (12-15); however, there is very little investigation regarding the economic impact of fasciolosis in animals slaughtered (16). There is a need to continually evaluate the fasciolosis incidence and to estimate the economic losses of the liver condemnations caused by fasciolosis parasites in order to management of this pathology. Thus, the objective of the present study was to determine the prevalence and the economic losses due to fasciolosis in ruminants from different local slaughterhouses in Bejaia province from 2017 to 2023.

METHODS

Study Area

The investigation was conducted in the Province of Bejaia (36°43'N, 5°04'E), which is located in northern Algeria and has a land area of 326,826 square kilometer (km^2) (Figure 1). The study area is composed mainly of several species of trees and natural or cultivated herbs, with the climate in the Mediterranean Region. Meteorological data presented in the present study were obtained from the website https://fr.tutiempo.net/climat/ws-604020.html (Table 1) (17).

Slaughterhouse Postmortem Inspection Procedure

Data were obtained from different municipal slaughterhouses, supervised by the Provincial Veterinary Inspection of Bejaia, from January 2017 to December 2023. A veterinary inspector inspected animal carcasses at each stage of the slaughtering process in the slaughtering units on a regular and systematic basis. The routine slaughterhouse inspection as previously described by Bensid (18). The diagnosis of fasciolosis was done by visual examination and palpation of the liver's entire surface. Two incisions (long and shallow; short and deep) on the visceral surface of the liver (right, left, and the base of the caudate lobes) to inspect the bile ducts for cholangitis lesions related to the presence of flukes (Figure 2).

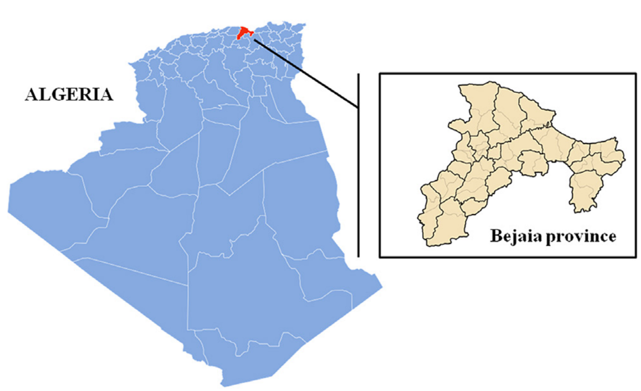

Figure 1. Map of Bejaia province, Algeria

Sample Size Determination

The sample size of the study was determined using the formula given by Thrusfield and Christley (19) with an expected prevalence of 0.6%, since there was no study conducted in the area, a confidence level of 95% and a required absolute precision of 5%.

$N = 1.96^2 * P*(1 - P)/d^2$

Where N = required sample size. P = observed prevalence, d = desired absolute precision at 5%.

Prevalence Determination

The overall fasciolosis prevalence of the three animal species (cattle, sheep, and goats) was calculated from the collected data over the period from 2017 to 2023. The number of slaughtered animals infected with *Fasciola* was reported monthly and annually. The annual fasciolosis prevalence (%) rate was calculated as the number of animals with *Fasciola* parasite divided by the number of animals examined postmortem. The seasonal prevalence (%) was also determined by calculating the total number of animals with the *Fasciola* infection, recorded during all four seasons (spring, summer, autumn, and winter), divided by the total number of animals slaughtered, and examined for each season.

Economic Losses Estimation

The following elements were used to estimate economic losses: average weight of liver, monthly fasciolosis prevalence, and monthly liver price per kg. The economic analysis was conducted by taking the average cost of the monthly selling price of liver in the area study. Financial losses were calculated in Algerian Dinar (DZD) and then converted into Euro (€). The exchange rate considered was different depending on the year. Direct economic losses due to liver condemnation caused by ruminant fasciolosis were assessed by considering the overall prevalence of the disease in the abattoir and the retail market price of an average liver. Indirect economic losses were assessed by estimating

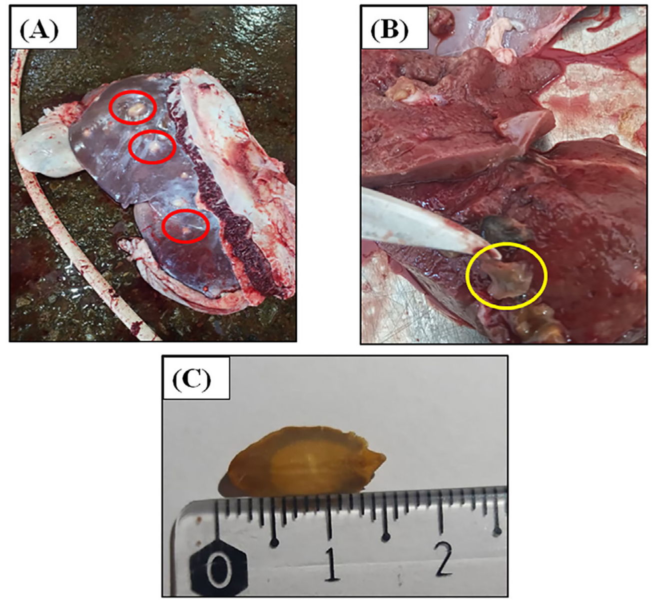

Figure 2. Dorsal side of diseased liver with fluke lesions (A); ventral side of diseased liver with flukes in the bile ducts (B); liver fluke specimen collected in slaughterhouse from infected ruminants of Bejaia province (Algeria) (C)
Yellow circle: Liver with fluke lesions, Red circle: Flukes in the bile ducts

Table 1. Data of temperature, relative humidity and precipitation of different seasons (2017-2023) in Bejaia province, Algeria

Years	2017	2018	2019	2020	2021	2022	2023	All
Winter								
T° min (T °C)	8.27	6.5	7.4	9.1	8.03	7.67	9	**8.00**
T° max (T °C)	17.17	14.8	15.97	18.73	17.7	16.33	18.67	**17.05**
Rainfall (mm)	54.13	78	125.33	81	130.3	111.33	91.87	**95.99**
Humidity (%)	76.17	76.03	77.30	72.40	67.30	72.13	67.10	**72.63**
Spring								
T° min (T °C)	11.1	11.87	13.23	12.63	11.67	11	12	**11.93**
T° max (T °C)	19.8	20.63	22.5	21.13	21.33	21	21	**21.06**
Rainfall (mm)	106.4	74.33	67.67	69.33	79.3	52.6	31.23	**68.69**
Humidity (%)	74.47	77.23	79.73	75.87	74.00	72.60	70.20	**74.87**
Summer								
T° min (T °C)	19.9	19.93	19.83	20.53	20.67	20.67	19.33	**20.12**
T° max (T °C)	29	29.1	29.23	28.87	28.67	30.33	28.67	**29.12**
Rainfall (mm)	6.4	4.67	6.67	15	27.57	22.93	4.2	**12.49**
Humidity (%)	73.53	75.97	74.30	70.20	70.00	70.67	68.77	**71.92**
Autumn								
T° min (T °C)	15.83	15.47	16.4	15.43	16	15.33	15.67	**15.73**
T° max (T °C)	25.53	24.87	26.8	23.73	24	25.33	24.33	**24.94**
Rainfall (mm)	129.13	112	119.67	112	41.7	29.77	29.4	**81.95**
Humidity (%)	72.87	73.23	72.60	70.30	70.63	62.47	64.03	**69.45**

the reduction in carcass yield of animals. Economic losses were calculated using the procedure described by Ogurinade and Ogunrinade (20), explained below:

Direct economic losses due to liver condemnation

LC = CSR * LCo * P

Where: LC = losses due to liver condemnation; CSR = average number of animals slaughtered at abattoir during the study period; LCo = average cost of one liver in Bejaia province, Algeria; P = prevalence of the fasciolosis at the study abattoir.

Indirect economic losses due to ruminant fasciolosis

CW = CSR * CL * MC * P * (n) kg

Where: CW = losses due to carcass weight reduction; CSR = average number of animals slaughtered at abattoirs during the study period; MC = average price for 1 kg of meat in Bejaia province, Algeria; P = prevalence of fasciolosis in the study abattoir; (n) kg = average carcass weight of animal; CL = carcass weight loss (10%) in individual animal due to fasciolosis (21). The adopted carcass weight loss in (kg) was estimated from fresh, normal and health looking, randomly selected from 20 dressed carcasses already passed for human consumption. These were weighed and the average weights of carcasses taken as the estimate weight of a particular carcass. Data on average animal carcass weight and the cost of one kilogram of meat were supplied by Department of Agricultural Statistics, Ministry of Agriculture and Rural Development, Algeria (22).

Statistical Analysis

All the data were entered, stored, and calculated in Microsoft Excel 2007. The retrospective data were analyzed using Statview (Version 4.55) and the Statistical Package for the Social Sciences (SPSS) version 21.0 (SPSS Inc., Chicago, IL, USA). The data were also presented using descriptive statistics in the form of a table. Means were compared using One-Way Analysis of Variance (ANOVA) to compare differences across multiple groups (years, months and seasons) and Tukey's HSD post-hoc test was applied to identify specific pairwise differences. The independent samples t-test was applied for the purpose of comparison in pairs of groups. Moreover, logistic regression models were additionally performed with infection status as the dependent variable, and species (cattle, sheep, and goats), season (winter, spring, summer, and autumn), year, and meteorological parameters (mean temperature, rainfall, and relative humidity) as independent predictors. In this analysis, a p-value less than 0.05 at the 95% confidence level was considered statistically significant.

RESULTS

Table 2 shows meat inspection data of the number of slaughtered animals (cattle, sheep, and goats) and of fasciolosis detection during a 7-year period (January 2017 to December 2023). A total of 131,961 cattle, 91,658 sheep, and 131,565 goats were slaughtered and inspected during the study period in Bejaia province (i.e., 37.2, 25.8 and 37%, respectively). The rate of slaughtered animals affected by fasciolosis (cattle, sheep, and goats) in the various municipal slaughterhouses in the Bejaia province was 0.6% (i.e., 2146 cases), with a desired absolute precision of 0.32%. The overall prevalence of fasciolosis detected by post-mortem examination in cattle, sheep and goats slaughtered during the study period was 1.58% [95% confidence interval (CI), 1.45-1.82%], 0.04% (95% CI, 0.01-0.08%) and 0.02% (95% CI, 0.006-0.05%), respectively. The distribution of infection by *Fasciola* sp. in slaughtered cattle shows a significant difference when compared to sheep or goats ($p \leq 0.05$). The desired absolute precision (d) of cattle, sheep and goats is 0.011%, 0.63%, and 0.51%, respectively.

A result of annual trends and monthly prevalence of infected animals by fasciolosis during the recording period (2017-2023) is illustrated in Figures 3 and 4, respectively. In cattle, the maximum rate of fasciolosis was 2.39% in the year 2020 and a minimum of 1.09% in the year 2018, as substantiated by analysis of variance followed by Tukey's test ($p \leq 0.05$). The overall annual prevalence rate of the disease showed significant fluctuation ($p \leq 0.05$) in

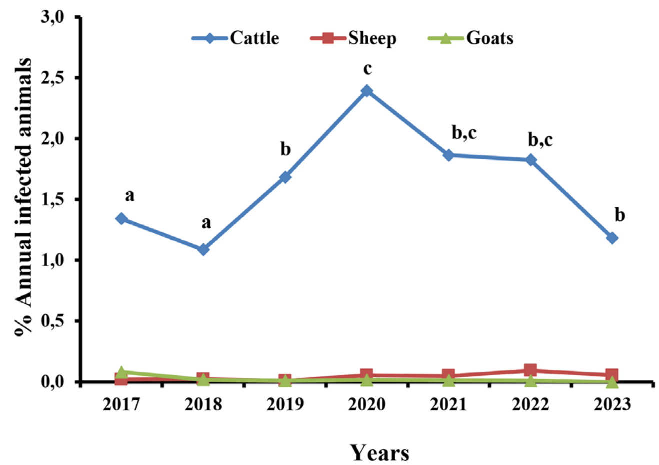

Figure 3. Annually variations in proportions of infected animals for fasciolosis in slaughterhouse during the year 2017-2023 in Bejaia province

a, b, c: Different letters on the same curve indicate a statistically significant difference (Tukey's test, p≤0.05)

Table 2. Slaughter statistics fasciolosis rates of infected animal between 2017 and 2023 in Bejaia province

Species slaughtered	Cattle	Sheep	Goats	Animal total
Number slaughtered **Mean ± SD** **min-max**	131.961 1571±192 646-3685	91.658 1091±286 361-2882	131.565 1566±173 502-2434	355.184 1409±217 361-3685
Percentage slaughtered (%)	37.2	25.8	37	100
Number with fasciolosis infestation	2079	38	29	2146
Global prevalence (%), **95% confidence interval**	1.58[a] 1.45-1.82	0.04[b] 0.01-0.08	0.02[b] 0.006-0.05	0. 0.66%-0.89

a, b: Values with different superscripts in the same raw are significantly different (p≤0.05), SD: Standard deviation levels over the seven-year period of the study. The maximum annual prevalence of fasciolosis cases for sheep and goats was 0.09% and 0.08% in the years 2022 and 2017, respectively. In cattle, fasciolosis was significantly high in January, February, and March and gradually decreased from April to September, then increased in October, November and December. On the other hand, the monthly cumulative prevalence rates of sheep and goats fasciolosis cases recorded were constant throughout the year. The prevalence of fasciolosis was evaluated during four seasons and the results are shown in Table 3. The high recorded prevalence was in winter and autumn, at 1.92% and 1.78% in cattle, respectively ($p \leq 0.05$). Statistical analysis of data on the seasonal prevalence of fasciolosis of small ruminants (sheep and goats) did not show a significant difference (Tukey's test). Logistic regression further corroborated these findings, indicating that the odds of infection were significantly higher in autumn and winter compared to summer, and that cattle were far more likely to be infected than sheep or goats. These analyses provide further support for the hypothesis that there is a clear temporal and seasonal pattern in fasciolosis prevalence, with autumn and winter representing the highest risk periods.

Multivariate logistic regression analyses were used to determine the strength of the association between the occurrence of F. hepatica and its risk factors (Table 4). Cattle exhibited the highest infection risk and served as the reference group. The odds of infection were significantly lower in sheep [odds ratio (OR)=0.03, CI 95%: <0.01-0.05, $p<0.001$] and goats (OR=0.02, CI 95%: <0.01-0.04, $p<0.001$) when compared to cattle. Concerning the seasonality, autumn showed a significantly increased risk of infection (OR=1.45, CI 95%: 1.25-1.68, $p<0.001$), followed by winter (OR=1.32, CI 95%: 1.15-1.52, $p<0.001$). Spring was not significantly associated with infection risk (OR=1.01, NS). Using 2020 as the reference, infection odds were lower in 2017 (OR=0.56), 2018 (OR=0.45), and 2019 (OR=0.70), indicating a rising trend towards the 2020 peak. The post-peak period (2021, 2022, and 2023) exhibited a significantly decline in risk with ORs of 0.78, 0.76, and 0.53, respectively. Increased rainfall was associated with higher infection odds (OR=1.08 per 10 mm, $p=0.01$), while higher temperatures reduced infection risk (OR=0.91 per 1 °C, $p=0.03$). Relative humidity showed a non-significant trend.

Table 5 showed the annual variation of confiscated livers (kilograms) due to *Fasciola* infection (2017-2023) and its financial loss in slaughtered ruminants in Bejaia province abattoirs. The direct economic loss due to condemnation of liver as the result of fasciolosis was done for study animals and a 7-year slaughter rate. More livers were condemned in cattle (12,254 kg) than in sheep (45 kg) and goats (23 kg) during the period of this study. An overall direct economic loss of 5,904.031€ was incurred during the period in this study from a totality of 12,321.2 kg of liver condemned. The indirect economic loss is due to carcass weight reduction as a result of fasciolosis infection was 44,746,454€. Therefore, total annual economic loss due to fasciolosis is the summation of the losses from organ condemnation (direct loss) and carcass weight reduction (indirect loss), with a total of 50,650,484€.

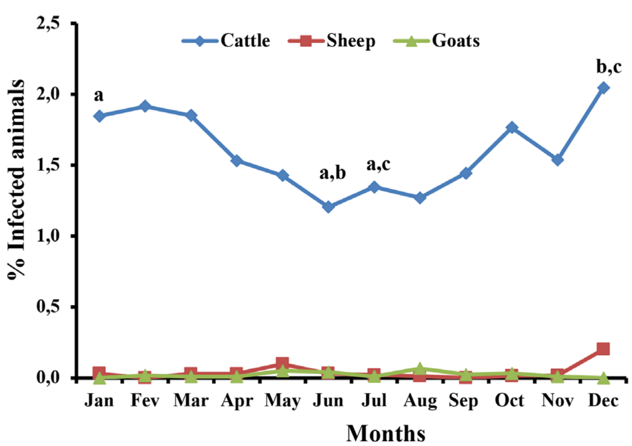

Figure 4. Monthly variations in proportions of infected animals for fasciolosis in slaughterhouse during the year 2017-2023 in Bejaia province.

a, b, c: Values with different superscripts in the same species between months are significantly different ($p \leq 0.05$)

Table 3. Prevalence of ruminant fasciolosis on the basis of different seasons in slaughterhouse during the year 2017-2023 of Bejaia province

Species	Season	Number slaughtered animals	Number of infected animals by *Fasciola* (%)
Cattle	Winter	29371	549 (1.92^a)
	Spring	37787	524 (1.47^b)
	Summer	34259	461 (1.46^b)
	Autumn	30544	545 (1.78^b)
Sheep	Winter	18843	4 (0.03)
	Spring	31264	17 (0.06)
	Summer	22901	3 (0.01)
	Autumn	18650	14 (0.09)
Goats	Winter	33060	5 (0.02)
	Spring	35360	12 (0.03)
	Summer	27677	9 (0.02)
	Autumn	35468	5 (0.01)

a, b: Values with different superscripts in the same species between seasons are significantly different ($p \leq 0.05$), Seasons: Winter (January-March), spring (April-June), summer (July-September), autumn (October-December)

Table 4. Multivariate logistic regression analysis of *Fasciola* spp. infection with the associated risk factors among ruminants in Bejaia province

Variable	Fasciolosis status (infected/non-infected)	Odds ratio	CI (95%)	p-value	Interpretation
Species					
Cattle	2079/129882	1.00 (Ref.)			Most affected species
Sheep	38/91620	0.03	<0.01-0.05	<0.001	Very low risk
Goats	29/131536	0.02	<0.01-0.04	<0.001	Very low risk
Season					
Summer		1.00 (Ref.)	-	-	Lowest risk season
Autumn		1.45	1.25-1.68	<0.001	Significantly increased risk
Winter		1.32	1.15-1.52	<0.001	Moderately increased risk
Spring		1.01	NS	NS	No significant difference
Year (vs. 2020)					
2017		0.56	0.48-0.65	<0.001	Lower risk vs. 2020
2028		0.45	0.38-0.54	<0.001	Very low risk
2019		0.70	0.60-0.82	<0.001	Moderate risk
2020		1.00 (Ref.)	-	-	Reference (peak)
2021		0.78	0.68-0.89	<0.001	Decline after peak
2022		0.76	0.66-0.87	<0.001	Stable post-peak
2023		0.53	0.45-0.63	<0.001	Marked decrease
Metrological variables					
Temperature (+ 1 °C)		0.91	-	0.03	Risk decreases with heat
Rainfall (+10 mm)		1.08	-	0.01	Risk increases with rainfall
Relative humidity		Slight trend	NS	>0.05	Non-significant effect

NS: Non significatif (p>0.05), OR: Odds ratio, CI: Confidence interval, Ref.: Reference method

Table 5. Annual variation of confiscated livers (kilogram) due to *Fasciola* infection (2017-2023) and its corresponding direct and indirect economic loss (Euro) in slaughterhouses of Bejaia province

Species	Season	Liver condemnation (kg)	Direct economic losses due to liver condemnation (Euro)	Indirect economic losses due to ruminant fasciolosis (Euro)
Cattle	**2017**	2052	738,485	6,400,416
	2018	1367	490,630	4,086,720
	2019	1473	562.860	5,035,296
	2020	1903	721,600	6,974,592
	2021	1816	518,408	6,728,640
	2022	2386	646,020	8,492,544
	2023	1256	621,006	5,396,328
Sheep	**2017**	4	170,101	148,156
	2018	4	162,110	140,944
	2019	1	37,974	35,303
	2020	8	255,887	244,083
	2021	10.5	165,982	269,920
	2022	9.5	539,125	584,492
	2023	7	179,971	175,473

Table 5. Continued

Species	Season	Liver condemnation (kg)	Direct economic losses due to liver condemnation (Euro)	Indirect economic losses due to ruminant fasciolosis (Euro)
Goats	**2017**	12	34,725	16,716
	2018	3.2	9,424	4,435
	2019	1.6	4,920	2,512
	2020	2.4	6,831	3,721
	2021	3	4,710	3,553
	2022	2	3,262	2,610
	2023	0	0	0
All		**12321.2**	**5,904,031**	**44,746,454**

Direct economic losses due to liver condemnation: LC = CSR * LCo * P
Where: LC = losses due to liver condemnation; CSR = average number of animals slaughtered at abattoir during the study period; LCo = average cost of one liver in Bejaia province, Algeria; P = prevalence of the fasciolosis at the study abattoir.
Indirect economic losses due to ruminant fasciolosis: CW = CSR * CL * MC * P * (n) kg
Where: CW = losses due to carcass weight reduction; CSR = average number of animals slaughtered at abattoirs during the study period; MC = average price for 1 kg of meat in Bejaia province, Algeria; P = prevalence of fasciolosis in the study abattoir; (n) kg = average carcass weight of animal; CL = carcass weight loss (10%) in individual animal due to fasciolosis

DISCUSSION

Fasciolosis is the most common helminthes infection that affects ruminants with economic losses in livestock productivity considerable. Moreover, World Health Organization reported that 2.4 million people are infected with fasciolosis and a huge risk of infection to humans (23). Sanitary surveillance by veterinary inspectors plays an important role in the parasitic infection control of livestock. The slaughterhouse is considered a crucial epidemiological point for the data collecting of fasciolosis infection and their tracking in ruminants. The authors are convinced that it is very necessary to continue the epidemiological investigations on fasciolosis infection in slaughterhouses in Bejaia province (Algeria) (12). Moreover, to the best of our knowledge, the economic loss data regarding fasciolosis in slaughterhouses have not been reported. In Algeria, veterinary health authorities have implemented awareness campaigns to control the spread of parasitose in ruminants (e.g., fasciolosis), such as regular deworming of livestock, in order to reduce the risk of human infection. However, the results obtained in the study indicate that fasciolosis is still widespread in livestock farms, and is an economically important disease in the study area (Bejaia province, Algeria).

The present study revealed that the rate of cattle and goats slaughtering was higher than for sheep (37.2%, 37%, and 25.8%, respectively). It should be noted that the demand for red meat in the province of Bejaia is mainly focused on beef, particularly in mountainous regions; whereas the consumption of mutton is primary for the religious festival of Eid Al-Adha. Based on detailed post-mortem inspection, the overall prevalence of fasciolosis in cattle, sheep and goats recorded in the current study (1.58%, 0.04%, and 0.02%, respectively) is widely different compared to several investigations. The fasciolosis prevalence of bovine slaughtered in the present study is slightly lower compared to the previous report (12), which reported respective prevalence of 2.83%, 0.13%, and 0.12% in abattoirs of Bejaia province during the period 2009-2016. It could be due to increased anthelmintic use, changes in climate (rainfall and humidity rates), or improved farmer awareness in the Bejaia province. The rate of fasciolosis calculated in our study was very low to those cattle (8%), sheep (0.54%) and goats (0.26%) recorded previously in the Jijel area (24). In this study, the difference of fasciolosis rate observed in slaughtered cattle, sheep and goats might be attributed to grazing area (humid and marshy area). In order to lower the rate of exposure to fluke metacercariae, it is also recommended to avoid from grazing livestock on marsh forage. In addition, the selective behavior of goats during grazing may limit their consumption of infested plants by *Fasciola* sp., i.e., goats browse the leaves and branches of bushes, shrubs, and trees (25). Also, this bovine fasciolosis rate at slaughter is similar compared to investigation in Saharan Region of Ouargla (1.7%) (16). The low rate observed in our study can be explained that the local farmers used anthelmintics routinely for prophylaxis of animal fasciolosis rather than for treatment. Likewise, when compared with the data recorded in different areas of Algeria, the prevalence of cattle fasciolosis recorded in this study was lower than 6.9% and 5.9% prevalence reported in Northern Algeria by Mezali et al. (26) and Chougar et al. (27), respectively. On the other hand, higher prevalence rates of bovine fasciolosis in slaughterhouse have been documented by Ouchene-Khelifi et al. (16) in El-Tarf and Meguini et al. (15) in Souk Ahras (26.7% and 12.3%, respectively). The disparities in prevalence in the different regions of Algeria could be influenced mainly by the climatological factors such as temperature, rainfall and humidity. In worldwide, the prevalence of *Fasciola* sp. infection in cattle is high compared to investigation in semi-arid region of Egypt (11.1%) (28) and (30.9%) (29), Ghana (10.27%) (30), Mexico (24.9%) (31), Ireland (23.68%) (32), Pakistan (42.8%) (33) and Malaysia (36.9%) (34). In another survey, the prevalence of *Fasciola* sp. in Slaughtered ruminants at Muyinga Slaughterhouse (Burundi) was 13.04% (95% CI: 5.10%-20.99%) in cattle, 3.16% (95% CI: 0.67%-5.64%) in goats and 0% in sheep (35). However, the rate of organ condemnation due to fasciolosis was 2.028% in the cattle slaughterhouse in Bavaria, southeast Germany (36). The variation in prevalence in different countries might be due to use of anthelminthic drugs properly, awareness among the farmers, proper control measures (37). Fasciolosis infection seems to be spreading throughout in animal farms of the world; this could be explained by climate factors favorable developing the intermediate host, such as temperature and humidity, as well as access to pasture, the livestock production system, and length of the grazing season (26,31). In addition, the variation in previous investigations might be attributed to age and immune status of animals (38).

Fasciolosis infection in slaughtered cattle showed annual fluctuations throughout the study period, with a detection high rate of 2.39%. The reason for this significant increase in the prevalence of fasciolosis in cattle could be due to the economic crisis, i.e., coronavirus period, which has affected the world, especially the agricultural sector. Consequently, appropriate prophylactic or therapeutic control measures, such as the use of anthelmintic drugs, are neglected. The overall monthly prevalence rate of the fasciolosis in cattle showed instability in levels over the seven years period of the study. However, rates of fasciolosis infection decreased significantly from April to August. This could be due to the to better management and husbandry practices against this parasitose, which corresponds to the grazing period (39).

In this retrospective survey, ruminant fasciolosis persisted throughout the year; these findings were in concordance with other previous reports by Chaouadi et al. (40). The rate of fasciolosis infection observed in slaughtered cattle showed significant autumn and winter slightly high prevalence. The seasonal prevalence of *Fasciola* sp. infection was significantly different ($p<0.001$) in the high throughput abattoirs of South Africa, i.e., 12.8%, 10.8%, 6.5%, and 7.8% during summer, autumn, winter and spring, respectively (41). This could be attributed to a variety of climatic conditions in this study region. It is noted that autumn and winter temperatures (17-24 °C), relative humidity (69-72%), and rainfall (81-95 mm) recorded during 7-year are sufficient for the development of *Fasciola* sp. larval stages and the growth of snails. However, because fluke metacercariae may persist longer in previously flooded places and on vegetation, dry pastures are not entirely safe (42,43). Moreover, it has been shown that rainfall and temperatures above 10 °C affect the hatching of *Fasciola* sp. eggs and the growth of snails (44). For this reason, it would be more judicious deworming livestock twice a year, especially before and after autumn season, as a method of controlling liver flukes (45). These findings were in concordance with previous report of Al-Jibouri et al. (46), who found that the prevalence of fasciolosis in cattle was associated with lower temperature and higher relative humidity. Indeed, Utrera-Quintana et al. (31) indicated that season was significantly associated with an increased risk of parasitic infection. Furthermore, Ahmed et al. (47) found that long rainy seasons in Ethiopia have a significant role in *Fasciola* sp. infection because of predisposing factors for snails to complete their life cycles, therefore facilitating the survival of parasites. In addition, Kuerpick et al. (48) has been reported seasonal prevalence, which the prevalence of fasciolosis is related heavy rainfall, and invasion of sheep in endemic fluke areas during seasonal grazing.

Numerous authors reported that fasciolosis infection is an important disease from an economic point of view, as it causes huge financial losses to butchers and farmers. In this study, the total economic loss caused by ruminant fasciolosis in slaughterhouses of Bejaia province was calculated based on liver seizure for abnormalities caused by *Fasciola* sp. All fasciolosis-related liver defects were considered unfit for human consumption at the slaughterhouse and were condemned. Our study revealed abattoir direct and indirect economic losses of 5.9 and 44.7 million € during the study period because of liver condemnation due to *Fasciola* sp. infection, respectively. This huge economic loss might be attributed to the fact that a 7-year survey and three animal species were considered in this study. In our study, it has also been estimated that annual economic losses due to fasciolosis in slaughterhouses of Bejaia province during a 7-years period are more than €50 million. This magnitude of economic losses indicates that ruminant fasciolosis poses an important and serious risk to the livestock sector in Algeria, especially in Bejaia province. Likewise, the losses as a result of liver condemnation valued in the Uganda abattoir are estimated at 92 US$ millions annually (49). Similar observations have been reported by Odeniran et al. (50), who revealed that a total of US$ 77,940,024/year was estimated as overall economic losses to small ruminant fasciolosis. In another study, the average cost of liver condemnation has been reported as US$ 0.2 million annually in Saudi Arabia (51). Also, Swai and Ulicky (52) reported that economic loss due to liver condemnation was approximately 1,780 US$ during 13 months in Tanzania. The variations in the amount of financial losses could be attributed to the difference in the length of carrying out the study, the rates of rejection of organs, and the number of animals slaughtered. Furthermore, our findings and previous studies suggest that fasciolosis in ruminants has a significant economic impact on the global agricultural sector. Therefore, in order to minimize these economic losses, it is essential to redouble efforts by improving control strategies to fight fasciolosis infection.

CONCLUSION

This is the first retrospective survey (2017-2023) on ruminant fasciolosis and estimation of financial loss due to *Fasciola* sp. infection in slaughterhouses in the Bejaia province. Our study revealed that the prevalence of cattle fasciolosis was generally high compared to sheep and goats in abattoir of Bejaia province (Algeria) associated with significant financial losses for butchers and livestock farmers in the study area. It is therefore necessary to reproduce this type of study in other regions of Algeria in order to generate data and calculate global economic losses because of *Fasciola* spp. infection. The management practices of animals, especially grazing habits and access to freshwater habitats could decrease Fasciola infections. Thus, molluscicide control and rotation of grazing areas are the basic control strategies. Preventive and therapeutic measures need to be further implemented in the field, including grazing management, reducing the number of intermediate hosts, as well as diagnosing and treating animals with anthelmintics. Furthermore, livestock farmers should be made aware of the importance of this parasitose in order to reduce economic losses.

*Ethics

Ethics Committee Approval: Ethical review and approval were waived for this study because the data in this study were collected from Provincial Veterinary Inspection of Bejaia (Algeria).

Informed Consent: This study was conducted solely using data collect from provincial Veterinary Inspection, no human participants subjects were involved.Informed consent was not required.

Footnotes

*Authorship Contributions

Concept: E-H.B., A.A., Design: E-H.B., A.A., Data Collection or Processing: K.R., K.M., Analysis or Interpretation: M.I., K.R., K.M., N.B.D., Literature Search: E-H.B., M.I., K.R., N.B.D., A.A., Writing: E-H.B., A.A.

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