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Evaluation of Fascioliasis, Hydatidosis, and Tuberculosis in Domestic Animals during Post-Mortem Inspection at Jijel Slaughterhouse (Algeria)

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HIGHLIGHTS

- Prevalence of fascioliasis (6.9%) was higher than that of hydatidosis (4.8%) and tuberculosis (1.0%) in animals at Jijel.
- Prevalence rate of all three studied diseases in cattle was higher than sheep and goats.
- Three significant negative correlations of precipitation with fascioliasis, hydatidosis, and tuberculosis were observed.

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Acronyms and abbreviations
DJU=unified degree day
UCDD=Unified-Climaticien Day Degree
UHEDD=Unified-Heating Engineer Day Degree

ABSTRACT

Background: Some animal infectious diseases such as tuberculosis, hydatidosis, and fascioliasis cause public health concerns and also significant economic losses. The goal of this study was to assess the rate of fascioliasis, hydatidosis, and tuberculosis in domestic animals during post-mortem inspection at Jijel slaughterhouse, North-Eastern Algeria.
Methods: The present study was carried out from March 2017 to February 2018, on 6 520 animals slaughtered at Jijel slaughterhouse. It was based on post-mortem inspection of livers and lungs by visual inspection, palpation, and incision. The statistical analysis was performed using open source software R 2017 and Microsoft Office Excel software.
Results: The prevalence rate of fascioliasis (6.9%) was significantly (p<0.001) higher than that of hydatidosis (4.8%) and tuberculosis (1.0%). Regarding all three studied diseases in the slathered animal, the prevalence rate of the diseases in cattle was significantly higher than one in sheep and goats. Three peaks in the rate of studied diseases were recorded during March to May 2017, which corresponds to spring.
Conclusion: Considerable prevalence rate of fascioliasis, tuberculosis, and hydatidosis in domestic animals slaughtered at the Jijel slaughterhouse seems to be an important indicator of lack of inspection, preventive, and curative treatments of animals in this region.

Introduction

Fresh meats and its derivatives are essential food sources for the human health, due to their richness in good quality proteins and other important micronutrients (De Smet and Vossen, 2016). At the same time, contami-

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nated meat may enter food chain when hygienic rules are not considered during slaughter, transport, storage, and sale. Some animal infectious diseases such as tuberculosis, hydatidosis, and fascioliasis cause public health concerns and also significant economic losses (Collins and Huey, 2015).

Fascioliasis is a parasitic disease characterized by the development of a parasite of the genus *Fasciola hepatica* or *F. gigantica* in the bile ducts of the liver. Their diagnosis is based on the search for adult forms of pathogen in the bile ducts after incision of the livers. These two species have an evolutionary cycle that includes an intermediate host, an amphibious gastropod of the genus *Galba* (Chauvin et al., 2007; Cwiklinski et al., 2016). Hydatidosis or hydatid cyst is another parasitic infection caused by *Echinococcus granulosus*. It is characterized by a parasitic life cycle where carnivores are predicted as the definitive host, while several domestic ruminants act as intermediate host in which the infesting forms (metacestodes) develop (Cardona and Carmena, 2013; Moro and Schantz, 2009). Tuberculosis is caused by various bacterial species belonging to the genus *Mycobacterium*, including *M. tuberculosis*, *M. bovis*, *M. africanum*, *M. avium*, etc. On the lesion level, it causes inflammatory lesions like tuberculous tubercles or granulomas (Collins and Huey, 2015; Devine and Dikeman, 2014).

Previously, we have designed a primarily study to evaluate general pathologic legions in carcass and offal of animals slaughtered at Jijel slaughterhouse in Algeria (Hamiroune et al., 2019). In the present survey, we additionally focused on economic losses resulted from condemnation of infected offal's slaughtered animals. Since liver and lung are the most expensive consumed edible offals in Algeria, we decided to assess prevalence of three infectious diseases (tuberculosis, hydatidosis, and fascioliasis) involving liver and lung of animals at Jijel Slaughterhouse, Algeria.

Materials and methods

Study zone

The Jijel region is located in the North-East of Algeria between the meridians 5 ° 25 and 6 ° 30 East of Greenwich, and between the parallels 36 ° 10 and 36 ° 50, Northern hemisphere (Official website of the Wilaya of Jijel, 2018). It is considered among the rainiest regions of Algeria. It is characterized by a Mediterranean climate, rainy and cold in winter, hot and humid in summer. Temperatures vary between 20 and 35 °C in summer to 5 to 15 °C in winter. The rainy season lasts around 6 months. The prevailing winds usually blow from the sea towards the mainland (National Investment Development Agency of Algeria, 2013). Overall, the Jijel region is characterized by a warm temperate climate especially during summer and rainfall is higher in winter than in summer.

The Jijel region is characterized by the presence of a varied herd composed of cattle, sheep, and goats. The total number of cattle are estimated at 87 942 head. They are mainly located in the municipalities of Texenna, Kaous, Chekfa, Taher, El-Milia, and Settara. In addition, the number of sheep and goats is estimated at 109 336 and 62 292 head, respectively. Sheep are located in the communes of Jijel, Djimla, Beni Yadjis, Belhadef, El Milia, Settara, Ghebala, and Ouled Rabah; while goats are mainly located in the communes of Erraguene, Ghebala, and Ouled Rabah (Economic Directory of the Wilayas of Algeria, 2015).

Animals

A total of 5 587 head of cattle, 554 head of sheep, and 379 head of goats were subjected to Jijel slaughterhouse over a period of one year during March 2017 to February 2018.

Post-mortem examination

The livers and lungs of the slaughtered animals were inspected. The routine post-mortem examination was carried out five times a week, except on public holidays. It was performed by visual inspection, palpation, and incision of these offals. The number of contaminated organs which were condemned during inspection was noted to estimate the economic losses. At the same time, data on weather conditions in the Jijel area were collected.

Each of the three evaluated diseases (fascioliasis, hydatidosis, and tuberculosis) is characterized by macroscopic lesions compatible with the disease. Fasciolosis was manifested by cholangitis and the presence of adult fluids in the bile ducts. Double membrane water cyst with a pressurized liquid was the evidence for hydatidosis. Tuberculosis was recognized by the presence of tubercles, with lymph node reactions observed during the incision. Likewise, the biology of the parasites must be taken into account because there is a pre-patent period between the period of infestation and the expression of the lesions observed at the slaughterhouse.

Meteorological data

To establish the potential risk factors involved in the occurrence of the three diseases, the affected organs were studied according to the study period, the average temperature, the precipitation during a month, the climatician unified degree day (DJU), and the DJU heating engineer.

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It should be noted that the degree day is a value representative of the difference between the temperature of a given day and a pre-established temperature threshold. It is generally used to estimate energy expenditure for heating or air conditioning (Direction of Climatology, 2005).

The Table 1 reports the average values of four meteorological indicators at different periods. According to the recorded data, the average temperature (26.4±1.7 °C) and the Unified-Climaticien Day Degree (UCDD; 260.9±53.6) were higher for the period from June 2017 to August 2017. While the precipitation (157.0±94.9 mm) and the Unified-Heating Engineer Day Degree (UHEDD; 169.3±24.2) were higher between December 2017 and February 2018.

Statistical analysis

The statistical analysis was performed using open source software R 2017 (version 3.3.3.) and Microsoft Office Excel® 2007 software. Two-way factor analysis of variance (ANOVA) was used to compare the results between the two contaminated organs. It was also used to compare the results of contamination according to the three studied diseases. The chi-square test was used to compare the lesion prevalence rates of the three diseases and to compare the animal species affected and the three diseases. It was also used to compare the three diseases and the affected organs and to assess the quarterly progress of three diseases. The correlation coefficients (r) were calculated between the average number of cases of the three diseases and the average seasonal temperature, the average cumulative precipitation, the UCDD and the UHEDD in the Jijel region.

Results

Overall results

As shown in Table 2, it emerged that prevalence rate of fascioliasis (6.9%) was significantly (p<0.001) higher than that of hydatidosis (4.8%) and tuberculosis (1.0%).

Prevalence rate based on animal species

No cases of hydatidosis or tuberculosis were identified in goats; also, sheep were free from tuberculosis. Simultaneous cases of hydatidosis, tuberculosis, and fascioliasis were identified in cattle (Table 3).

Regarding all three studied diseases in the slathered animal, the prevalence rate of the diseases in cattle was significantly (p<0.001) higher than the one in sheep and goats. For the cattle, the most prevalence rate was belonged to fascioliasis, showing significant difference (p<0.001) with rate of hydatidosis and tuberculosis.

Prevalence rate based on condemned organ

According to the results obtained, the livers and lungs were mostly infected with fascioliasis and hydatidosis, respectively, having significant (p<0.001) differences (Figure 1).

Prevalence rate based on quarterly time trend

The prevalence rate of the three examined diseases varied greatly depending on the study periods of time. For fascioliasis, the highest prevalence rate (8.3%) was recorded between March and May 2017; and the lowest rate (6.5%) was found from June 2017 to August 2017, indicating no significant (p=0.51) difference.

For hydatidosis, a peak prevalence (8.6%) was revealed in the period between March 2017 and May 2017; the lowest prevalence was detected between December 2017 and February 2018 (1.7%), showing significant (p<0.001) difference.

Regarding tuberculosis, the highest prevalence rate (1.8%) was observed between March 2017 and August 2017; while the lowest prevalence rate (0.3%) was indicated between September 2017 and February 2018, showing significant (p<0.001) difference.

Overall, three peaks in the prevalence rate of the three studied diseases were recorded during the period between March 2017 and May 2017, which corresponds to spring. These peaks were 8.6±7.4, 1.8±4.2, and 8.3±7.3% for hydatidosis, tuberculosis, and fascioliasis, respectively.

Daily average condemnation

The most daily average condemnation was recorded by fascioliasis (1.8±1.5 livers), followed by hydatidosis (0.5±0.7 livers; 0.8±1.0 lungs), and tuberculosis (0.1±0.4 livers; 0.2±0.5 lungs).

Estimation of daily economic losses

The average weight of a liver and lungs of cattle are estimated 5 and 3 kg, respectively. Also, the average costs of 1 kg of liver and lungs in Algeria are 2 000 and 400 algerian dinars, respectively. This induces estimated daily losses of 18 000±15 000 algerian dinars of livers linked to the possible infection by fascioliasis; 5 000 algerian dinars of livers and 960 algerian dinars of lungs due to possible infection by hydatidosis; and 1 000 algerian dinars of livers and 240 algerian dinars of lungs related to possible tuberculosis infection.

The correlations between diseases and meteorological indicators

Table 4 shows the analysis between each disease and temperature, precipitation, the UCDD as well as the

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UHEDD. There are only three high negative correlations, the first was for hydatidosis versus precipitation (r=-0.63; R^2=0.39); the second was for tuberculosis compared to precipitation (r=-0.60; R^2=0.35); and finally, the third was for fascioliasis compared to precipitation (r=-0.58; R^2=0.33).

Table 1: Quarterly average weather conditions in the Jijel climate zone (North-East of Algeria, 2017-2018) according to the Achouat station (Infoclimat, 2018)

Period	Meteorological indicators			
	Temperature (°C)	Precipitation for 1 month (mm)	UCDD	UHEDD
March 2017-May 2017	17.0±2.9	18.7±30.6	41.7±43.4	70.3±43.5
June 2017-August 2017	26.4±1.7	13.0±22.5	260.9±53.6	0.3±0.6
September 2017-November 2017	19.6±4.0	99.3±93.9	88.3±74.3	38.1±44.3
December 2017-February 2018	12.0±0.8	157.0±94.9	2.6±0.4	169.3±24.2
Average	18.8±5.9	72.0±86.0	98.4±111.7	69.5±71.4

UCDD: Unified-Climaticien Day Degree; UHEDD: Unified-Heating Engineer Day Degree

Table 2: The overall prevalence rate of fascioliasis, hydatidosis, as well as tuberculosis in the slaughtered animals at Jijel slaughterhouse, Algeria

Disease		Number of slaughtered animals	Number of infected animals	Prevalence of infected animals (%)
Hydatidosis				
	Cattle	5587	310	5.55
	Sheep	554	1	0.18
	Goat	379	0	0.0
Tuberculosis				
	Cattle	5587	67	1.20
	Sheep	554	0	0.0
	Goat	379	0	0.0
Fasciolosis				
	Cattle	5587	447	8
	Sheep	554	3	0.54
	Goat	379	1	0.26

Table 3: Prevalence rate of fascioliasis, hydatidosis, and tuberculosis in the slaughtered animals at Jijel slaughterhouse, Algeria according to the animal species

Animal species	Number of hydatidosis cases (%)	Number of tuberculosis cases (%)	Number of fasciolosis cases (%)	Total number of infected animals (%)
Cattle	310 (99.7)	67 (100)	447 (99.1)	824 (99.4)
Sheep	1 (0.3)	0 (0.0)	3 (0.7)	4 (0.5)
Goats	0 (0.0)	0 (0.0)	1 (0.2)	1 (0.1)
Total	311	67	451	829

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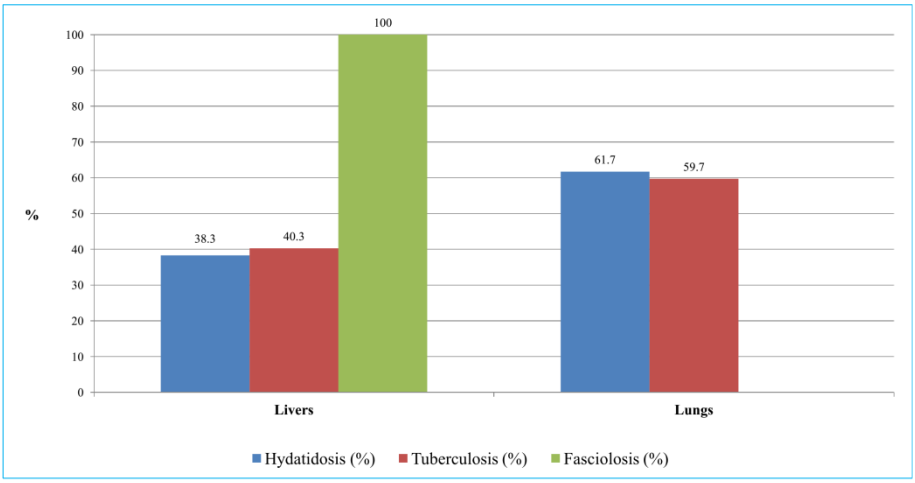

Figure 1: Prevalence rate of fascioliasis, hydatidosis, and tuberculosis in the slaughtered animals at Jijel slaughterhouse, Algeria based on condemned organ

Table 4: Correlation between the average number of the three studied diseases and the average seasonal weather indicators

Relationship between parameters	r	R^2
HD-TS	0.45	0.21
HD-PR	-0.63	0.39
HD-UCDD	0.35	0.12
HD-UHEDD	-0.54	0.29
TB-TS	0.20	0.04
TB-PR	-0.60	0.35
TB-UCDD	0.23	0.05
TB-UHEDD	-0.14	0.02
FC-TS	0.37	0.14
FC-PR	-0.58	0.33
FC-UCDD	0.38	0.14
FC-UHEDD	-0.34	0.12

FC: Fasciolosis; HD: Hydatidosis; TB: Tuberculosis; TS: Temperature
PR: Precipitation; r: correlation coefficient; R^2: Coefficient of determination
UCDD: Unified-Climaticien Day Degree; UHEDD: Unified-Heating Engineer Day Degree

Discussion

In this survey, the condemnation rates of liver and lung of slathered animals in Algeria due to fascioliasis, hydatidosis, and tuberculosis were evaluated. Also we investigated the involvement of climatic factors and economic losses. Overall, our results show that cattle are the most affected animals by these three diseases followed by sheep which are affected only by fascioliasis and hydatidosis; while in goats, only one case of fascioliasis has been reported. This finding may be related to this fact that in Algeria in spite of goats, cattle and sheep mostly feed on grasses in contact with the soil, which favors the transmission of infectious agents (Hamiroune et al., 2019).

Analysis of the findings obtained showed that 12.7% (i.e. 829 out of 6 520) of slaughtered animals presented lesions of the livers and lungs compatible with hydatidosis (4.8%), tuberculosis (1.0%), and fascioliasis (6.9%). The results of the quarterly evolution of the rates of the three diseases have enabled us to distinguish the most critical interval between March and May 2017 in

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spring season in which the prevalence rate of hydatidosis, tuberculosis, and fascioliasis were 8.6±7.4, 1.8±4.2, and 8.3±7.3%, respectively. In spring, the majority of animals are grazed outdoors which promotes transmission of pathogens and contamination of animals with infectious diseases.

The present result concerning fascioliasis is comparable to that reported by Bendiaf (2011), who found a prevalence rate of 7.5% in cattle slaughtered in the region of El Khroub in Constantine, Algeria. According to Blaise (2001), the most prevalent parasite in 1 518 cattle slaughtered at 16 major slaughterhouses in Haiti was *F. hepatica* with prevalence rate of 10.67% and the average fluke number per liver ranged from 13.83 to 61.25. However, higher prevalence rate of 27.0% was reported in cattle slaughtered in North-Eastern Algeria (Mekroud et al., 2004). These controversies can be explained by many factors, such as place of raising the animals, climate condition, season, age of animals, or lack of integrated snail (intermediate host) management program (Boucheikhchoukh et al., 2012; Merdas Ferhati, 2015). In this sense, the Jijel region is very humid and rich in water resources having five large dams, three large natural lakes and numerous streams which are all indicators of the infestation. In addition, the zoonotic risk is linked to the consumption of raw local vegetables contaminated by *Fasciola* metacercariae.

The hydatidosis rate in the current research was lower than the results obtained by Kayoueche (2009) who stated that the prevalence rate of hydatidosis in cattle, goats, and sheep in Eastern Algeria were 9.87, 7.6, and 3.98%, respectively. It is proved that easy accessibility of stray dogs with infected raw offals is the main source to the transmission of *E. granulosus* (Craig et al., 2007). The high prevalence of hydatidosis in spring is probably linked to the availability of grass and to the grazing and semi-extensive farming methods.

Our findings regarding prevalence rate of tuberculosis was lower than that described by Sahraoui et al. (2012) in two slaughterhouses (Boufarik and Hadjout) in Algeria with prevalence rates of 3.89% for goats and 4.40% for sheep. The prevalence rates of tuberculosis in slaughtered domestic animals in Haiti (Blaise, 2001) and sub-Saharan Africa (Boukary et al., 2012) were similar to results of the present survey for sheep. It seems that many developing African countries are characterized by certain specific risk factors increasing the rate of tuberculosis, such as lack of surveillance of bovine tuberculosis, reduced interactions with veterinary services, uncontrolled animal movements, etc. (Humblet et al., 2009; Oloya et al., 2006). So, there is a need to develop standardized methodologies for evaluating diagnostic methods through meat inspection and applying control measures to domestic cattle (Humblet et al., 2009). For example, it seems that the tuberculin test remains the most effective way in Algeria for the diagnosis of bovine tuberculosis in the cattle.

The results of the current study showed that in general, the average daily number of condemned organs is 0.8±1.2 of liver and 0.3±0.7 of lungs with daily average number 0.6±1.1 organs. It should be noted that the two examined edible organs, especially the liver, are widely consumed in Algeria. We estimated daily losses of 8 000 algerian dinars of livers and 360 algerian dinars of lungs only in the Jijel slaughterhouse. This constitutes great economic losses without counting the other losses (such as drop in production of meat, milk, and wool) either in the Jijel slaughterhouse or the other slaughterhouses in Algeria. Similarly, remarkable economic losses were reported at the Niamey slaughterhouse in Niger (Boukary et al., 2012).

The present investigation revealed that precipitation plays a key role on prevalence rates of fascioliasis, hydatidosis, and tuberculosis in domestic animals in the region of Jijel. The results obtained can be explained by several factors, in particular, during the fattening period, in the majority of cases, the animals (mainly the males) prepared for slaughter, are raised in an intensive system and returned to an environment closed which fed on dry foods favored their fattening like straw, hay, corn, bran and other concentrates. Moreover, according to the aptitude of the breeders and the practicing veterinarians who follow the breeding, these animals are treated with antiparasitic against parasites and with antibiotics against infectious diseases, as well as other drugs such as vitamins, which leads to a decrease in the number of cases of parasitized organs despite the presence of humidity in the external environment.

According to Valenzuela and Quintana (1998), the development time of *F. hepatica* eggs is influenced by the ambient temperature, and that no hatching occurs below an average temperature of 10 °C. Additionally, heat remains the most reliable method for killing *Echinococcus* eggs. They can also be inactivated by freezing (Craig et al., 2007). However, the practical elimination of human infection can be achieved with a control program targeting only domestic animals. In addition, better coordination of efforts between research institutions and actors in the field as well as the transfer of skills and technologies are essential.

Conclusion

The considerable prevalence rate of fascioliasis, tuberculosis, and hydatidosis in domestic animals slaughtered at the Jijel slaughterhouse seems to be an important indicator of lack of inspection, preventive, and curative treatments of animals in this region. So, intervention on

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the life cycles of pathological agents responsible for the appearance of these diseases remains mandatory to limit the responsible agents before contamination of animals. In addition, training and dissemination of information to farmers is too necessary. In addition, it will be very useful to carry out a systematic screening in all the farms of the country by general and specific laboratory examinations for confirmation.

Author contributions

M.Da., A.C., H.C., and H.F. carried out the experimental work in the slaughterhouse; K.S. did the statistical analysis; M.H. designed the study and wrote the manuscript; M.Dj. revised of the manuscript. All the authors read and approved the final revised manuscript.

Conflicts of interest

This research was conducted without any conflict of interest.

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