Cystic Echinococcosis in Algeria: the Role of Cattle as Reservoirs in the Dynamics of Transmission of *Echinococcus granulosus* to Humans via Dogs

Échinococcose kystique en Algérie : le rôle des bovins comme réservoirs dans la dynamique de transmission d’*Echinococcus granulosus* à l’homme via les chiens

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**Abstract** In North Africa, the parasite *Echinococcus granulosus* is transmitted in a synanthropic cycle evolving mainly between dogs (DH) and sheep (IH), but other animals like cattle are most often found to be more infested with hydatid cysts but their potential role in human contamination via dogs is unknown. The purpose of this study is to assess the prevalence and fertility rates of hydatid cysts in ruminants (cattle and sheep) in two slaughterhouses in central and eastern Algeria. Determining the frequency and fertility of cysts in cattle will assess the degree of involvement of this species, alongside sheep, in the epidemiological cycle of *E. granulosus* in Algeria. In the present study, prevalence rates were estimated at 4.9% and 10% in slaughtered ruminants, all species combined at the slaughterhouses of El Harrach and Souk Ahras, respectively. The distribution of the prevalence by species indicates higher infestation rates in cattle compared to sheep: 6% vs 3.9% and 37% vs 4.7% in the slaughterhouses of El Harrach and Souk Ahras, respectively. The survey results showed relatively low cyst fertility rates in cattle compared to sheep: 13.8% vs 43.7% and 33.3% vs 71.4% in the two slaughterhouses, El Harrach and Souk Ahras, respectively. The survey results showed relatively low cyst fertility rates in cattle compared to sheep: 13.8% vs 43.7% and 33.3% vs 71.4% in the two slaughterhouses, El Harrach and Souk Ahras, respectively. The low fertility rate of cysts in cattle can be explained by a poor adaptation of the species, *E. granulosus* sensu stricto, previously identified by molecular analysis in all samples of hydatid cysts collected from cattle in Algeria. In conclusion, cattle infested with *E. granulosus* sensu stricto, with low fertility rates, play a minor role in the epidemiology of cystic echinococcosis in Algeria. It is rather an indicator of the persistence of cystic echinococcosis infection in endemic regions.

**Keywords** *Echinococcus granulosus* · Hydatid cyst · Frequency · Fertility · Cattle · Sheep · El Harrach · Souk Ahras · Algeria · Maghreb · Northern Africa

**Résumé** En Afrique du Nord, le parasite *Echinococcus granulosus* est transmis dans un cycle synanthropique évoluant principalement entre les chiens (HD) et les moutons (HI). Mais d’autres animaux comme les bovins se révèlent le plus souvent très infestés par les kystes hydatiques : leur rôle potentiel dans la contamination humaine via des chiens est inconnu. Le but de cette étude est d’évaluer la prévalence et les taux de fertilité des kystes hydatiques chez les ruminants (bovins et ovins) dans deux abattoirs du centre et de l’est de l’Algérie. La détermination de la fréquence et de la fertilité des kystes chez les bovins permettra d’évaluer le degré d’implication de cette espèce, aux côtés des ovins, dans le cycle épidémiologique d’*E. granulosus* en Algérie. Dans la présente étude, les taux de prévalence ont été estimés à 4,9 et 10 % chez les ruminants abattus, toutes espèces confondues dans les abattoirs d’El Harrach et de Souk Ahras respectivement. La répartition de la prévalence par espèce indique des taux d’infestation plus élevés chez les bovins que chez les ovins : 6 vs 3,9 % et 37 vs 4,7 % dans les abattoirs d’El Harrach et de Souk Ahras respectivement. Les résultats de l’enquête ont montré des taux de fertilité des kystes relativement bas chez les bovins par rapport aux ovins : 13,8 vs 43,7 % et 33,3 vs 71,4 % dans les deux abattoirs, El Harrach et Souk Ahras respectivement. Le faible taux de fertilité des kystes chez les bovins peut s’expliquer par une mauvaise adaptation de l’espèce *E. granulosus* sensu stricto, précédemment identifiée par analyse moléculaire dans tous les échantillons de kystes.

Mots clés Echinococcus granulosus · Kyste hydatique · Fréquence · Fertilité · Bovins · Ovins · El Harrach · Souk Ahras · Algérie · Maghreb · Afrique du Nord

Introduction

Cystic echinococcosis is one of the most common anthropozoones in the world [7]. Echinococcus granulosus sensu stricto is generally considered to be the most widespread species in the E. granulosus sensu lato complex worldwide and involved in the majority of cases of human echinococcosis [1].

In North Africa, the parasite is transmitted in a synanthropic cycle evolving mainly between domestic dogs acting as definitive hosts and sheep, intermediate hosts [21,25], but other animals are often found to be very infested by the hydatid cyst. However their potential role in human contamination via the dog is not known. The purpose of this study is to assess the prevalence and fertility rates of hydatid cysts in domestic ruminants (cattle and sheep) in two slaughterhouses in central and eastern Algeria. Determining the frequency and fertility of cysts in cattle will assess the degree of involvement of this species, alongside sheep, in the epidemiological cycle of E. granulosus in Algeria.

Material and Methods

Study Areas

The present study was carried out in the center (Algiers Province) and in the east (Souk Ahras Province) of Algeria (Fig. 1). Algiers Province, limited by the Mediterranean Sea, at the foot of the Sahel Hills and at the outlet of a fertile plain, the Mitidja, occupies an area of 1,190 km². This province has a Mediterranean climate characterized by hot dry summers and mild, humid winters. The annual rainfall varies from 400 to 1,000 mm per year. In terms of livestock production, cattle, sheep and goats are estimated at 13,940, 23,000 and 1,000 heads, respectively. Together with forage crops and market gardeners, cereals are the main agricultural products in the Algiers region [8].

Souk Ahras Province, located in the extreme east of Algeria near the Tunisian border at 640 km from Algiers, occupies an area of 4,360 km² thus constituting one of the main province border with Tunisia along a strip of 88 km. This province is located on the semi-humid bioclimatic zone, with hot dry summers and cold humid winters. The average annual rainfall is 800 mm per year. The agricultural sector plays a very important role in the economic development of the region based on dairy milk production with 50,137 cows, 442,347 sheep and 122,361 goats [9].

Animals

The study focused on animals of different ages, races, sexes and origins. The majority of the slaughtered animals belong to the bovine and sheep species from the Algiers and Souk Ahras regions.

Methods

The surveys were carried out from December 2007 to June 2008 and from March to May 2017 at the communal slaughterhouses in Algiers and Souk Ahras, respectively. The slaughtered animals were counted and identified throughout the survey periods. The investigation of hydatid cysts was carried out mainly on the liver and lungs, and subsequently on other organs after slaughter, by visual inspection and palpation. Previously, the age of the animals was estimated by examining teeth. All hydatid cysts found were counted. To determine the fertility, a sample of cysts, collected from each of the two ruminant species slaughtered and more than 5 years old (Table 1), were punctured, incised and their content (hydatid fluid and germinal layer) were collected. Presence of protoscolices in hydatids content using light microscopy was the criteria for defining a fertile cyst [14].

Statistical analyzes

The statistical analysis was carried out using the Pearson $X^2$-test, with a 95% safety threshold and therefore a risk of 5%, in order to determine whether there is a significant difference in the results relating to the influence of animal characteristics (species, sex, age) on the prevalence and fertility of hydatid cysts in the case of cystic echinococcosis.

Results

Assessing the prevalence of cystic echinococcosis

Of a total of 3,154 carcasses examined (1,528 cattle and 1,626 sheep) at the El Harrach slaughterhouse (Algiers Province) between December 2007 and June 2008 (7 months), 156 animals (4.9%) of all species were infested with hydatid...
cysts. The prevalence by species was 6% in cattle and 3.9% in sheep. A total of 1,483 cysts were found in 156 parasitic animal carcasses, representing an average of 9.5 cystic/animal lesions. The average number of cysts per infected animal was 10.4 and 8.2 for cattle and sheep, respectively (Table 1). The prevalence of infestation varies within a given species by sex and age (Figs. 2, 3).

Of a total of 3,630 carcasses examined (590 cattle and 3,040 sheep) at the Souk Ahras slaughterhouse during the period March to May 2017 (3 months, 10 years later), 362

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**Table 1** Cystic echinococcosis in ruminants (cattle and sheep) prevalence and fertility rate / Échinococcose kystique chez les ruminants (bovins et ovins) prévalence et taux de fertilité

<table>
<thead>
<tr>
<th>Species</th>
<th>Province</th>
<th>Animals examined</th>
<th>Animals infected (frequency %)</th>
<th>Cysts collected</th>
<th>Fertility cysts (frequency %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Algiers</td>
<td>1,528</td>
<td>92 (6)</td>
<td>116</td>
<td>16 (13.8)</td>
</tr>
<tr>
<td></td>
<td>Souk Ahras</td>
<td>590</td>
<td>218 (37)</td>
<td>63</td>
<td>21 (33.3)</td>
</tr>
<tr>
<td>Sheep</td>
<td>Algiers</td>
<td>1,626</td>
<td>64 (3.9)</td>
<td>103</td>
<td>45 (43.3)</td>
</tr>
<tr>
<td></td>
<td>Souk Ahras</td>
<td>3,040</td>
<td>144 (4.7)</td>
<td>14</td>
<td>10 (71.4)</td>
</tr>
</tbody>
</table>

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**Fig. 1** Geographical location of El Harrach, Algiers province and Souk Ahras province, Algeria / Situation géographique d’El Harrach, province d’Alger et province de Souk Ahras, Algérie
(10%) animals of all species were infested with hydatid cysts. The prevalence by species was 37% in cattle and 4.7% in sheep (Table 1). A total of 972 cysts were found from 362 parasitic animal carcasses, or an average of 2.7 cystic/animal lesions. The average number of cysts found for each infected animal was 3.3 and 1.3 for cattle and sheep, respectively. The prevalence of infestation varies within a given species by sex and age (Figs. 4, 5).

Assessing the fertility of hydatid cysts

The fertility rates of cysts collected from both cattle and sheep species were 13.8% and 43.7%, respectively at the El Harrach slaughterhouse and 33.3% and 71.4%, respectively at the Souk Ahras slaughterhouse (Table 1).

The statistical interpretation of the relative results on the influence of animal characteristics on the prevalence rate of hydatid cysts showed that the differences are significant ($P < 0.05$) for the animal species or even very significant ($P < 0.001$) for the other parameters like sex and age. Similarly, the statistical analysis revealed a very significant difference in the influence of animal species on the fertility rate of the cysts ($P < 0.001$).

Discussion

The control program against cystic echinococcosis is essentially based on epidemiological surveillance. Assessing the prevalence of the hydatid cyst in slaughtered animals (intermediate hosts) is essential. The regularly collected epidemiological data serve as a reference for measuring the progress of the control against this major zoonosis in Algeria.

In this study, prevalence rates were estimated at 4.9% and 10% in slaughtered ruminants, all species combined at the slaughterhouses of El Harrach (Algiers Province) and Souk Ahras, respectively. The aim of our study is not to compare data separated by 600 km and obtained at different periods but to highlight the endemic nature of cystic echinococcosis in Algeria regardless of the region of the country. The distribution of prevalence by species indicates higher rates of...
infestation in cattle compared to sheep in both slaughterhouses. High prevalence rates of hydatid cysts were also reported in cattle in surveys conducted in Algeria: El Khroub and Constantine: 21.9% and 6%, 14.5% and 2% in cattle and sheep, respectively [18], 25.6% vs 3.8% for sheep [16]. This trend was also observed in surveys conducted in many slaughterhouses around the world: 23% cattle vs 10.6% sheep in Morocco [2], 19.4% cattle vs 3.6% sheep in Kenya [20], 11.6% cattle vs 3.5% sheep in Greece [11].

High frequency of infestation in cattle must be due to advanced age of the slaughtered animals, most often corresponding to cows culled at the end of their economic life and who have had numerous opportunities to infest and develop hydatid cysts.

Do cattle, with often high prevalence rates really constitute potential reservoirs of *E. granulosus* for humans via dogs (definitive hosts)? In this study, the fertility rates of cysts collected from cattle are relatively low compared to sheep: 13.8% vs 43.7% at the El Harrach slaughterhouse and, 33.3% vs 71.4% at the Souk Ahras slaughterhouse, respectively. Although in a previous study, Bardonnet et al. [3] reported high rates in Algeria, cysts of *E. granulosus* sensu striceto observed on the liver and lungs of cattle are rarely fertile [24]. Low fertility rates in cattle compared to sheep have been reported by many authors around the world, Algeria: 7% vs 72.4% [16], Tunisia: 0.9% vs 30.2% [17], Saudi Arabia: 13.1% vs 47.7% [12], Iraq: 0% vs 83.3% [13], France: 5% vs 42% [26] and Iran: 6.8% vs 69.3% [22].

Low cyst fertility in cattle may be due to the poor adaptation of the species *E. granulosus* sensu stricto observed on the liver and lungs of cattle but produces a low level of fertile cysts in this species. The cattle may be infested with another species more adapted, specific, genotype G5 corresponding to *Echinococcus ortleppi* which differs from *E. granulosus* sensu stricto by a predilection for the lungs, a high fertility rate (90%) cysts and a short prepatence (33–35 days) in dogs [6,10,23,27]. This species has not been identified in Algeria until now.

**Conclusion**

In conclusion, cattle infected with *E. granulosus* sensu stricto, with low fertility rates, play a minor role in the epidemiology of cystic echinococcosis. It has in fact an indicator role in the persistence of cystic echinococcosis infection in endemic areas. They are considered as accidental hosts, sentinels of the presence in the environment of the species *E. granulosus* sensu stricto. Cattle play an insignificant role in the transmission dynamics of *E. granulosus* s.s. in Algeria.

On the other hand, sheep with high cyst fertility are and remain the main reservoirs of hydatid cysts and a major source of contamination for humans via dogs (definitive hosts) in Algeria.

The existence, currently, of favorable factors (illegal slaughter, lack of incinerators, absence of fencing in many slaughterhouses and killing places combined with the presence of stray dogs in the neighborhood, feeding dogs with raw organ meats) largely contributes to the persistence of cystic echinococcosis transmission in intermediate and final hosts and to the increase in parasite biomass.

In a previous study, it was shown that in 42% of slaughterhouses, dogs could easily access to potentially parasitized offal [5]. Control measures must take into account the main transmission factors, such as the feeding of dogs with parasitic offal, the access of dogs to slaughterhouses, the non-destruction and the absence of burial of viscera infested with hydatid cysts, and the lack of pest control treatment for dogs.

Control measures should also address the eradication of stray dogs, and the anthelmintic treatment under regular control of owner dogs.

Health education is imperative and must target above all people exposed to contamination (breeders, butchers, children, etc.) in order to make them aware of the parasite’s life cycle and the risks it presents for people and animals. Humans play an important role in the transmission of *E. granulosus*. Also, awareness campaigns carried out in the field in rural and urban areas must encourage humans to change their habits and behavior towards animals.

**Conflict of interest**: The authors declare that they have no conflict of interest.

**References**


