Chapter

Incrimination of Dog Vector of Cystic Echinococcosis and Impact of the Appropriate Dogs' Treatment

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Abstract

Dogs are involved in the transmission of several parasitic zoonosis. Among these, hydatidosis is very endemic in many countries of the world. Dog populations are very variable from one region to another, which increases the infestation risks across human populations especially in the developing countries such as in Morocco. Moreover, the risk of exposure is higher in dogs with access to rural slaughterhouses than in owned dogs. As for preventive measures, this calls for effective implementation of the appropriate dogs' treatment against hydatidosis. Thus, the following chapter updates the most relevant information on the impact of hydatidosis upon human populations and livestock animals, as to stretch understanding on the vector contribution of dogs.

Keywords: Dogs, Morocco, hydatidosis, zoonotic diseases, echinococcus granulosus

1. Introduction

Dog-borne zoonotic diseases include all the infectious diseases targeting dogs that can be transmitted to humans. Though they present major zoonosis causing a heavy burden upon the human population worldwide, these diseases are mostly neglected as few insufficient scientific research efforts are realized to face it (WHO, 2007b). Several examples of zoonosis are present with high prevalence up to time, such as bovine tuberculosis, brucellosis, cystic echinococcosis, visceral leishmaniosis, rabies [1], especially in the developing and North African countries in the poorest and most marginalized regions, in rural areas. Some of these diseases share the same definitive host represented by the dog. Especially hydatid cyst disease, which is endemic to hyper-endemic in agricultural countries in Europe, North, East and South Africa, South and North America, the Middle East and Asia [2–6]. Morocco is one of these highly endemic countries [7, 8].

The hydatid cyst, or *Cystic echinococcosis*, is caused by a small tapeworm parasite of canids, *Echinococcus granulosus*, which is then transmitted to humans via dogs. It has been reported in numerous reports that the incidence of the disease has increased in various parts of the world [9]. In Morocco for example, the annual incidence is 5.2 cases/100,000 inhabitants [10]. For this reason, several studies have been carried out in the world and in Morocco to evaluate chemoprevention in dogs in order to truncate the parasite cycle and reduce the incidence of the disease.

Hence, the purpose of this chapter is to compile recent data regarding the identification of the main source of infestation in dogs and the determination of the prevalence of infestation. As the canine population varies considerably from one region to another, like everywhere else in the world, in Morocco there are approximately 18,000 owned dogs and 3,000 stray dogs in endemic areas. A high prevalence of *E. granulosus* infestation in dogs has been recorded in these regions, estimated at 3.6% in Oulmes, 19.6% in Sidi Kacem and 23.7% in the Middle Atlas. This makes it possible to put the spotlight on the dog as the main reservoir and vector of this disease. Therefore, the risk of exposure is higher in stray dogs with access to rural slaughterhouses than in owned dogs, which is complicated to control. Hence, it is urgent the need for a very appropriate and regular chemoprevention program in dogs [7, 11].

2. Dogs vector of the major zoonotic diseases: an overview on *Echinococcus granulosus*

The dog has a high importance in the social life of the human population. These multiple and diverse functions make it an indispensable domestic animal, particularly for households in rural areas where the relationship between dogs and humans is very close. Unfortunately, the risk of transmission of pathogenic agents from dogs to other animals, mainly mammals, is an issue of major concern. Dogs indeed can act as reservoirs of pathogens as they may transmit *Leishmania spp*. (leishmaniasis), *Leptospira interrogans* (leptospirosis), *Toxoplasma gondii* (toxoplasmosis), *Neospora caninum* (neosporosis), *Dirofilaria immitis* (dirofilaria/heartworm disease), *Brucella canis* (brucellosis), *Sarcoptes scabiei* (scabies), *Echinococcus spp.* (echinococcosis), *Rickettsia rickettsii* (Brazilian spotted fever). Various canine viruses (e.g. distemper virus, adenovirus, coronavirus, herpes virus, parvovirus), rabies virus, among other pathogens for both humans and wildlife [12, 13]. Especially, *Echinococcus granulosus,* is up to now one of the zoonosis with a considerable endemic situation upon human populations and livestock animals.

Echinococcosis, the *Echinococcus granulosus* induced disease, is asymptomatic in dogs. Even with a high parasite load (from 1500 to 6000 worms per dog), this parasitosis may progress unperceived with no clinical signs. Moreover, due to the small size of the eliminated segments, no external signs can be seen. Nevertheless, anal pruritus can be induced following the penetration of gravid segments into the anal glands [14]. As the eggs are not visible by the human eye, there are no external signs of the infestation, explaining the danger of this parasite, which can easily spread and contaminate the environment, especially when dogs move from one place to another.

3. Impact of hydatidosis disease upon human's population and livestock animals production

Eggs of the *E. granulosus* parasite are disseminated in the environment by dogs. Thus, they are transmitted to a wide range of intermediate hosts, including sheep and humans, causing an infestation with the hydatid cyst (larval stage of the parasite) [7].

The abundance of stray dogs and slaughter practices that allow dogs' access to condemned offal, particularly in rural areas, contribute to the persistence of hydatidosis. Hydatidosis is a serious public health problem and has a significant socio-economic impact. The *Echinococcus granulosus* infestation is a major financial burden derived from human health costs and losses in livestock production. The economic burden of cystic echinococcosis on the global livestock industry has been estimated at over $2 billion per year. Despite the substantial socio-economic impact, hydatidosis is still a neglected zoonosis [15].

In humans, hydatid cyst is the cause of significant morbidity and mortality worldwide and is responsible for a significant economic loss in the public health sector [16, 17]. Hydatid cyst has several consequences, including the direct costs of diagnosis, hospitalization, surgical treatment, post-surgical care, for the patient and family members, without forgetting the indirect losses of mortality, pain and social consequences of lost working days and the cessation of agricultural activities by those affected or at risk [16–18]. People with hydatid cysts never restore a perfect health condition even after they have recovered [4].

At the livestock animal level, it involves losses in production, and their importance varies according to the breed and type of production concerned [19]:

- Organs not usable and seized at the slaughterhouse, especially liver and lung;
- Cost of destruction of infected viscera and dead animals;
- Possible restriction on the export of animals and their products;
- Parasitic hydatid cachexia associated with poly-parasitism in animals, which is a reason for reforming adult sheep whose productive life is reduced;
- Brutal mortality following the rupture of a hydatid cyst.

In sheep farming, it is estimated that 7–10% of milk losses, 5–20% of meat or whole carcass weight losses, and 10–40% of wool losses occurred (**Table 1**) [18]. In 1980, an assessment carried out in Italy [6] showed a 10% reduction in the commercial value of an infected sheep, a percentage which takes into account the cost of destroying viscera. It should be noted that the economic impact of infected viscera depends on the country's regulations and the number of animals slaughtered under veterinary control, as well as the cost of the equipment used [19]. According

Parameter	Reduction rate (%)	Reference
Cattle		[4]
Meat	2,5–10	
Milk	2,5–5	
Fertility	9,9 – 12,1	
Sheep		[4, 18]
Meat	5–10	
Wool	10–40	
Fertility	9,9 – 12,1	
Goat		[18]
Meat	5–20	
Fertility	9,9 – 12,1	
Camelin		[20]
Meat	2,5–10	

Table 1.
Reduction rate of animal products caused by hydatidosis [18].

to a recent study by Saadi et al., the economic impact of hydatidosis on animal production in Morocco is very significant [17].

4. Incrimination of dogs in transmissions of hydatidosis

4.1 Dogs infestation

In canids, particularly in dogs, infestation occurs by ingestion of intermediate host organs harboring the parasite at the larval stage (hydatid cyst). The protoscolexes released from the hydatid cyst grow into adult worms and live in the small intestine, particularly in the duodenum. The eggs are eliminated in the external environment by detaching the last proglottis from the mature worm and excreting it in the feces. In passage, some proglottis, which have been ruptured, release eggs at the marginal part of the anus. Anal pruritus provokes a licking reflex in the dog, which allows the dog to recover numerous eggs that will be found in the lingual papillae and the oral cavity and then, by licking, in the dog's pelage.

4.2 Relationship between dogs, human and livestock animals infestation

In Morocco, current evidence indicates that the transmission cycle of *E. granulosus* is mainly based on a domestic cycle involving dogs and livestock species (sheep, cattle, camels, goats and horses) [21]. According to a preliminary study carried out in the Middle Atlas, the prevalence of infestation in animals (all ages) is 29.82% in cattle (N = 102), 13.29% in sheep (N = 107) and 2.36% in goats (N = 16) (unpublished study). These regions of the Middle Atlas represent a hotspot of hydatid infestation with a prevalence of infestation of 91.7% in adult sheep (age > 4 years), and a prevalence of 1.9% in humans [22]. A large population of canids is present in these areas, which include owned dogs, stray dogs, jackals and foxes [23]. In 2019, the prevalence of *E. granulosus* reached 23–39% in owned dogs and 51–68% in stray dogs, while the risk of monthly incidence was 2–8% and 19–41% in owned and stray dogs, respectively [7]. In addition, the study conducted by Azlaf & Dakkak in various regions of Morocco revealed prevalence rates of 10.58% in sheep, 1.88% in goats, 22.98% in cattle, 12.03% in camels and 17.8% in horses [21]. The study conducted by El Berbri et al. in the region of Sidi Kacem revealed a prevalence of 42.9% in cattle, 11% in sheep and 1.5% in goats [24].

However, the abundance of dogs, especially stray dogs that eat infested offal in slaughterhouses and clandestine slaughter practices but also on farms that allow owned and sometimes stray dogs to feed on condemned offal, especially in rural areas, contribute to the persistence of hydatidosis. This represents a serious public health problem and has a significant socio-economic impact. The *Echinococcus granulosus* infestation is a major financial burden derived from human health costs and losses in livestock production.

Thus, one of the interesting models that reveals great relevance on the burden of *Echinococcus granulosus* on humans is the example of Morocco, of which the studies helped lot to extend the understanding of its various aspects. In the following section, we therefore put the focus on the most pertinent finding on the prevalence within the various categories of dog's populations in Morocco.

5. Categories of dogs' population in Morocco

In Morocco, the dog population is very diversified by the presence of different types of dogs: owned dogs and stray dogs or semi stray dogs. A study carried out in

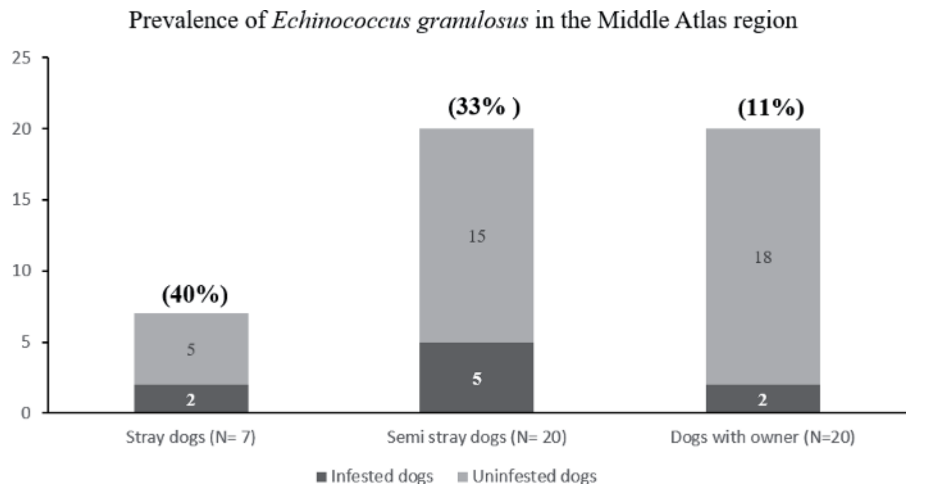

Figure 1.
Prevalence of Echinococcus granulosus *in three categories of dogs in the middle atlas region.*

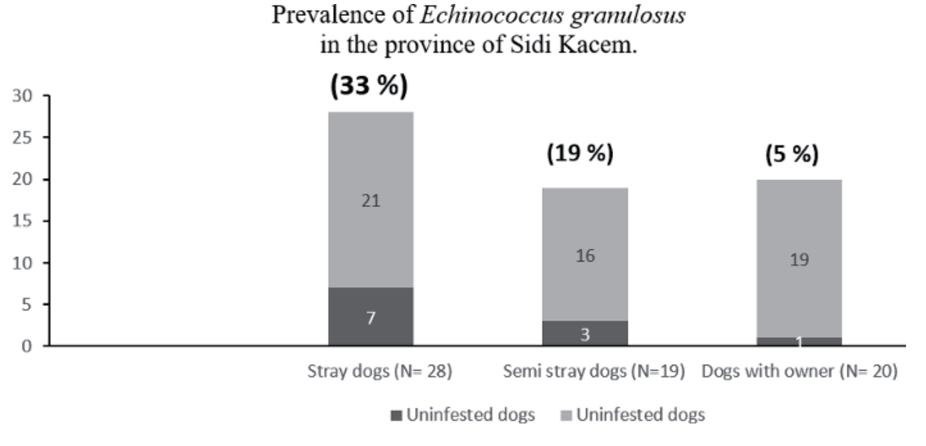

Figure 2.
Prevalence of Echinococcus granulosus *in three categories of dogs in the Sidi Kacem region.*

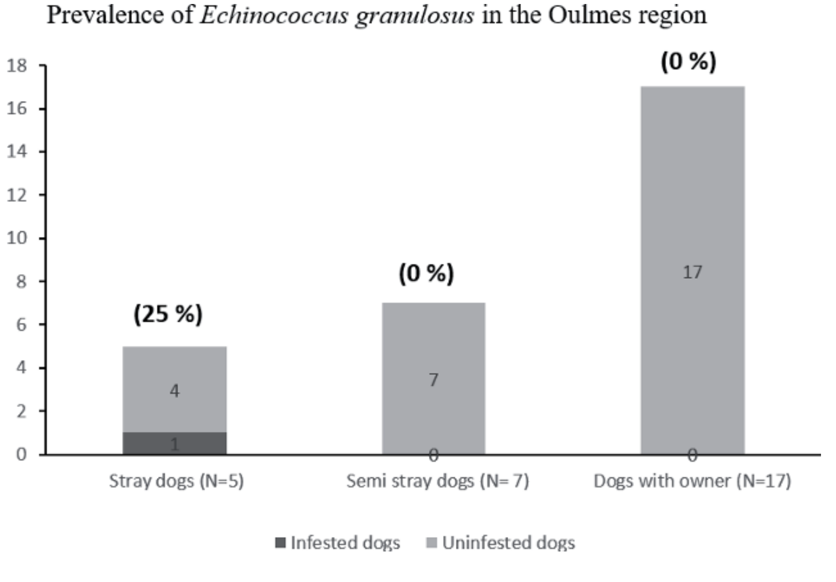

Figure 3.
Prevalence of Echinococcus granulosus *in three categories of dogs in the Oulmes region.*

three regions of Morocco revealed that stray dogs were the most infested category by *E. granulosus*, representing a prevalence of 40% in the Middle Atlas Mountains, 33% in Sidi Kacem and 25% in Oulmès, followed by semi-stray dogs and owned dogs (unpublished study) (**Figures 1**–**3**).

6. Diagnostics of echinococcosis in dogs

6.1 Clinical diagnosis

The identification of dogs infested with *E. granulosus* is extremely important for epidemiological studies and monitoring of this zoonosis in control programs [25]. Compared to other gastrointestinal infections of parasitic origin in dogs, echinococcosis is difficult to detect, even if the parasite load is high, premortem diagnosis appears to be very difficult. Recently, there has been considerable progress in research and development of immunological diagnosis for canine echinococcosis. The coproantigen test, in particular, can be considered to be of good sensitivity to reflect a common infestation and can therefore replace purging with arecoline (**Table 2**).

6.2 Parasitological diagnosis

The diagnosis of cystic echinococcosis in ante-mortem dogs can be made using several techniques:

6.2.1 Coproscopy

Coproscopy consists of looking for the eggs or proglottis of the adult worm in the feces of the final host. Eggs can be detected in fecal samples by the flotation technique or on the perianal skin by attaching a transparent adhesive paper to the skin and examining it under a magnifying glass under a microscope. However, this microscopic detection of *Echinococcus granulosus* eggs is not recommended because of the morphological nature of the egg which is similar in all taenia species. In addition, the removal of eggs is often irregular. However, proglottis from *Echinococcus granulosus* released spontaneously by dogs and detected on the surface of fecal samples can provide a good diagnosis of parasitosis in dogs [9].

6.2.2 Arecoline purging

Arecoline purging is the standard diagnostic method used for years in the detection of *Echinococcus granulosus* worms in dogs is purging the intestinal contents

Methods	Sensitivity %	Specificity %
Autopsy	> 90	100
Arecoline purging	50–70	100
Serology	35–70	> 90
The coproantigen test	75–80	> 95

Table 2.
Comparison of the sensitivity and specificity of different diagnostic methods for canine echinococcosis [12].

of the host with hydrobromide arecoline. Arecoline is a parasympathomimetic molecule which has an effect on the smooth muscles of the small intestine and at the same time paralyzes adult worms. The purgation removes the paralyzed worms with the feces, which must be inspected afterwards [9].

The advantage of this technique is the high specificity, which can reach 100%. On the other hand, the sensitivity does not even reach 50% if it is only used once. This test is contraindicated in pregnant dogs, older dogs and puppies. Arecoline should be administered orally at a dose of 4 mg/kg BW. This dose should be carefully calculated since severe undesirable secondary effects may occur [7].

6.2.3 Necropsy diagnosis: Sedimentation and counting

After cutting the intestine into several sections, these must be placed in metal trays, opened with scissors and finally immersed in physiological saline solution. The worms adhering to the mucous membrane are then counted using a magnifying glass or binocular microscope. The disadvantage of this method is that small worms can escape detection [9].

6.3 Immunological diagnosis by detection of coproantigens

This technique consists of searching for one of two types of antigens, either antigens extracted raw somatically from the worm or excretory-secretory antigens from the protoscolex in the feces of the host using double sandwich ELISA kits [26].

Positive ELISA results can be collected even in the prepatent period, starting on day 5 post-infestation. The values begin to decrease to negative values 2–4 days after the elimination of *Echinococcus granulosus* worms by treatment with praziquantel. The results of studies using this technique have shown that ELISA values correlate positively with the amount of worms present in the intestine, and that antigen levels are correlated with the amount of worms present in the intestine. This technique has been shown to be important with a sensitivity of 99% and a specificity of 97% [26].

Fecal samples can be taken directly from the ground or rectum and can be kept cold (−20°C) for up to 6 months. The test can be used for the identification of infected cases in control program, including pregnant dogs, older dogs and puppies. Three ELISA kits are commercially available today [27].

6.3.1 Serum antibody detection

Specific serum antibodies (IgG, IgA and IgE) can be detected in the serum of dogs infected with *Echinococcus granulosus* using antigenic preparations from the protoscolexes in ELISA kits. These antibodies can be detected 2–3 weeks post-infestation. One study suggests that eggs released in the small intestine of the final host, after proglottis apolysis, can penetrate the intestinal barrier and cause immunological stimulation in the host [27].

The ELISA kits available have low sensitivity and highly variable specificity. However, a new kit using a newly derived recombinant antigen from the protoscolex showed 100% specificity, but the sensitivity is not comparable to that of older kits. The use of ELISA kits for the detection of serum antibodies is still questionable because of their low sensitivity, the persistence of antibodies in serum after worm removal and the lack of correlation with infestation pressure [12, 26, 27].

If a seropositive test has been detected but the result is negative for the coproantigens, this is an indication of possible recent exposure [28].

6.4 Molecular biology diagnosis

Parasite DNA can be obtained from eggs, proglottis or worm cells and can be detected in feces after PCR amplification. However, no copro-PCR is currently available for the detection of all strains of *Echinococcus granulosus*; PCR primers for G1, G5 and combined G6/7 strains have been developed. This technique, due to its high cost, is only used for confirmation on positive samples in areas where the prevalence of cystic echinococcosis is low [29].

7. Treatment of infected dogs

Praziquantel is the only drug without significant undesirable effects known to be effective against *E. granulosus*. With a dose of 5 mg/kg, it can indeed achieve 100% efficacy [30, 31]. Because of its very broad therapeutic index, praziquantel is particularly suitable for cystic echinococcosis control programs [32]. Indeed, after its introduction in 1977, it was widely used in the majority of programs that undertook the control of the disease.

8. Prevention

Regular and accentuated treatment of stray dogs is necessary. However, regular treatment of owned dogs with Praziquantel should be an obligation in highly endemic areas, as treatment of dogs remains the most effective measure of prevention [7].

Vaccination of dogs with two recombinant proteins, EgA31 isolated from the adult worm and oncosphere and EgTrop isolated from protoscolex, is a promising approach to limiting the development of the *E. granulosus* worm in the dog's intestine [33].

9. Conclusion

In the case of zoonotic diseases, preventive veterinary treatments allow the protection of the public and animal health, but also the reduction of the risk of their transmission to humans, as is the case for cystic echinococcosis. To be effective, these treatments must be applied regularly. Thus, facility of access to them must be taken into account when developing the canine population management program. However, it should be noted that it is not only the dog that needs to be controlled, but also the intermediate host, and efforts should be made to eliminate the parasite or pathogen in general from the intermediate host that represents the main source of transmission to the dog to allow the pathogen to complete its life cycle and become infectious. Therefore the need for an integrated approach (action on the different hosts involved in the life cycle of the pathogen and the involvement of the socio-economic factor in control programs including stakeholders) to control these zoonosis is strongly advised.

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