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Original Article

Prevalence, risk factors and zoonotic potential of intestinal parasites in dogs from four locations in Morocco

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ABSTRACT

Dogs can harbor various intestinal parasites that have serious clinical, economic, and zoonotic impact. In Morocco, the epidemiological status of those parasites is largely unknown.

This study aimed to obtain data on the prevalence of intestinal parasites in various Moroccan dog populations, to identify associated risk factors, to evaluate people's knowledge regarding zoonotic parasites and to estimate the risk of human infection.

A total of 291 fecal samples were analyzed using a 33% Zinc Sulphate (ZnSO4) centrifugal flotation and a sheather's sugar simple flotation techniques. In addition, 100 dog owners were asked to fill out a questionnaire about their knowledge regarding canine zoonotic intestinal parasites.

Overall, 58% of sampled dogs were positive for at least one parasite species. *Ancylostoma/Uncinaria* spp. (31.9%), *Toxascaris leonina* (27.4%), *Toxocara canis* (27.1%), *Cystoisospora* spp. (13.4%) and *Giardia* spp. (7.2%) were the most frequently isolated parasites. The overall prevalence was associated with the dogs' activity, and feces consistency. More specifically, the prevalence of *Ancylostoma/Uncinaria* spp., *Toxascaris leonina* and *Cystoisospora* spp. was associated with dogs' activity and feces consistency and, additionally with age for *Cystoisospora* spp. *Toxocara canis* prevalence was associated with age and feces consistency, while *Giardia* spp. prevalence was associated with dogs' activity.

A weak awareness among dog owners regarding the zoonotic potential of canine intestinal parasites was noticed (33%) especially when their knowledge was compared to another endemic zoonotic disease, i.e. rabies (85%). Furthermore, the rate of respecting the vaccination protocol (82%) was significantly higher than the rate of respecting the deworming protocol (47%).

We conclude that intestinal parasites, including the zoonotic ones, were highly prevalent in the dogs sampled in this study whereas people's knowledge about those parasites was very limited. These findings suggest that the risk of human infection is very likely, which highlights the need for effective control programs and health education.

1. Introduction

Dogs may harbor a wide range of intestinal parasites (Traversa, 2012). These parasites, whether helminths or protozoa, usually cause growth retardation, decreased performance, increased sensitivity to acquire other infectious diseases (Yacob et al., 2007; Raza et al., 2018), and some of them can lead to severe clinical symptoms (Traversa, 2012; Riggio et al., 2013). Heaviest infections and highest morbidity rates are seen in neonates and puppies, where intestinal parasites can be fatal (Traversa, 2012; Perera et al., 2013; Baneth et al., 2016), especially

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when associated as a co-morbidity with other infectious diseases such as viral gastro-enteritis due to parvovirus (Mazzaferro, 2020). In addition, some canine intestinal parasites, such as *Taenia* spp. and *Sarcocystis* spp., can be transmitted to farm animals leading to important economic losses (Kohansal et al., 2017; Pennelegion et al., 2020).

These parasites may also represent a significant risk due to their zoonotic potential, since many of them, such as *Toxocara canis*, *Ancylostoma* spp., *Taenia* spp., *Echinococcus* spp., *Giardia* spp., *Dipylidium caninum*, and *Cryptosporidium* spp., can be transmitted to humans either directly via contact with infected dogs or indirectly via contaminated water, foods or soil (Perera et al., 2013; Gharekhani, 2014; Traversa et al., 2014; Kohansal et al., 2017). Overall, children, pregnant women, and immunocompromised people are usually at higher risk for these zoonoses and their outcomes (Robertson and Thompson, 2002; Kohansal et al., 2017).

T. canis, *Ancylostoma caninum*, *Echinococcus granulosus* and *Giardia intestinalis* (assemblages A and B) are among the most important canine zoonotic intestinal parasites. The clinical outcome of human infection with *T. canis* ranges from an asymptomatic form to a severe organ injury, depending on the host's immune response, the invaded tissues and the number of migrating larvae. Visceral and ocular larva migrans are the major clinical syndromes of toxocariasis with the first one considered more severe, especially in children (Traversa, 2012; Raza et al., 2018). Ocular larva migrans can also cause serious ocular damages ranging from impaired vision up to a total loss of sight in severe cases (Pinelli et al., 2011; Traversa, 2012; Raza et al., 2018). According to a survey conducted between 2009 and 2010, published in the 'Morbidity and Mortality Weekly Report' journal (MMWR), at least 68 cases of blindness and eye damages due to *T. canis,* were estimated to occur yearly in the USA (Lum et al., 2011). Other syndromes such as neurotoxocariasis and covert toxocariasis are also reported (Pinelli et al., 2011; Traversa, 2012; Adeel, 2020). Cutaneous infection by *A. caninum* may lead to a cutaneous larva migrans while oral infection may result in an eosinophilic enteritis. Both forms represent a serious threat to human health (Robertson and Thompson, 2002; Raza et al., 2018). The severity of human giardiasis is variable with many cases remaining asymptomatic (Raza et al., 2018). Finally, *E. granulosus* causes a severe and potentially life-threatening disease in humans called cystic echinococcosis (Pennelegion et al., 2020) which is considered a major zoonosis in Morocco (Azlaf et al., 2007). In 2012, the Moroccan Ministry of health reported 1627 surgical cases of cystic echinococcosis with a mortality rate of 3% (El Berbri et al., 2015).

In spite of their significant health impact, little interest is attributed to dog's intestinal parasites. There is currently limited data published on this topic in Morocco and other countries within the Mediterranean basin, including France, Israel, Malta, Slovenia and Lebanon. Currently, studies exclusively on *Echinococcus* spp. (Pandey et al., 1988; Azlaf et al., 2007; Dakkak, 2010; Dakkak et al., 2017; Amarir et al., 2020) were previously published in Morocco and, to the author's knowledge, only one survey conducted in 1987, reported the prevalence of intestinal parasites in a small number ($n = 57$) of dogs from Rabat region (Pandey et al., 1987). However, these previous studies involved exclusively stray dogs (Pandey et al., 1988; Azlaf et al., 2007; Dakkak, 2010). Yet, in order to develop efficient and adapted control strategies, it is crucial to understand the epidemiology of these parasites in various canine populations (Dubná et al., 2007; Gharekhani, 2014), such as owned dogs, considering their close relationship with their owners and the increasing tendency of canine ownership in Morocco these last years (Bouaddi et al., 2018); working dogs because of their close contact with their trainers; and shelter/breeding dogs because of their close relationship with their care-givers and with the visitors of these centers.

To the best of our knowledge, this is the first study in Morocco reporting the prevalence of intestinal parasites, with particular attention to the zoonotic ones, in owned, shelter, breeding and service dogs with the identification of risk factors and an evaluation of people's knowledge regarding those parasites and their zoonotic potential.

2. Materials and methods

2.1. Study population and location

Between January, 2019 and March 2020, 291 fecal samples were collected from various Moroccan dog populations including owned ($n = 96$), shelter ($n = 129$), breeding ($n = 10$) and working dogs ($n = 56$). Owned dogs were all collected at the Small Animal Clinic of the Hassan II Agronomy and Veterinary Institute (IAV Hassan II), Rabat, Morocco. Shelter dogs were collected at refuges from the cities of Rabat ($n = 70$), Marrakech ($n = 24$) and Casablanca ($n = 35$). Breeding dogs were exclusively sampled from the city of Rabat while working dogs were recruited from a kennel located in Benslimane city.

Data regarding the age, sex, vaccination and deworming status of dogs were collected by interviewing the owners (owned dogs), breeding and shelters supervisors (shelter and breeding dogs) and dog trainers (working dogs). Because of logistical issues, sex of 84 shelter dogs was not recorded. Additionally, age of three dogs were not determined.

2.2. Samples collection and fecal analysis

Fresh fecal samples were collected from each dog into a clean sterile plastic bottle and stored at 4 °C until processing. The fecal analysis was performed within two days after collection, after which samples were preserved in a 10% formalin solution.

All the samples were first screened macroscopically to detect the presence of nematodes and proglottids and to record feces consistency. The macroscopic aspect of the feces was classified from 1 to 4 ascending levels depending on the consistency (1 = liquid stools, 2 = very soft, 3 = soft and 4 = formed stools). Then, samples were examined microscopically using a 33% zinc sulphate (ZnSO4) centrifugal flotation and a sheather's sugar simple flotation techniques, allowing the identification of eggs and oocysts, in most cases to genus level (Zajac and Conboy, 2013). Parasites were identified according to a key of identification (Zajac and Conboy, 2013; CAPC guideline, 2019, 2020a, 2020b).

2.2.1. Centrifugal flotation with 33% Zinc Sulphate (ZnSO4) (specific gravity 1.18)

Five grams of feces were mixed with 33% zinc sulphate solution (Zajac and Conboy, 2013). Then, 14 ml of the suspension were poured through a sieve into a 15 ml centrifuge tube and centrifuged at 1500 RPM for 5 min. Zinc sulfate solution was then filled to the rim of the centrifuge tube, forming a positive meniscus, and a coverslip was placed on top. After 10 min, the coverslip was removed and placed onto a microscope slide. The entire slide was examined under a light microscope at 100× and 400× magnifications.

2.2.2. Sheather's sugar simple flotation (specific gravity 1.25)

Five grams of feces were mixed with sheather's sugar solution (Zajac and Conboy, 2013). The suspension was poured through a sieve into a 15 ml centrifuge tube until forming a positive meniscus, and a coverslip was placed on top. After 10 min, the coverslip was removed and placed onto a microscope slide. The entire slide was examined under a light microscope at 100× and 400× magnifications.

2.3. Questionnaires

After obtaining an informed consent, one hundred dog owners were interviewed about their knowledge regarding canine zoonotic intestinal parasites and other zoonoses, such as rabies, and prevention measures including deworming and vaccination. They were also asked whether they respected their dog's vaccination protocol and whether they regularly dewormed their pet dogs. Finally, they were questioned about their perception regarding canine zoonotic intestinal parasitosis.

2.4. Statistical analysis

The prevalence of the presence of a parasite (any of the reported parasites) and specific parasites as a function of different risk factors was analyzed by a logistic regression model. Risk factor groups were compared pairwise by the likelihood ratio test in order to test whether the odds ratio differs significantly from zero. All analyses were performed using SAS Version 9.4 (Copyright (c) 2020 by SAS Institute Inc., Cary, NC, USA) at a global significance level of 5% and using the Bonferroni technique to adjust for multiple comparisons. The answers recorded in the questionnaire are binary and thus are also analyzed by logistic regression.

3. Results

The study population comprised 60.8% males ($n = 126$) and 39.1% females ($n = 81$). Dogs were distributed in four age categories including puppies (<6 months) (24.3%, $n = 70$), young adults (6–12 months) (10.7%, $n = 31$), adults (1–6 years) (56.9%, $n = 164$) and seniors (>6 years) (7.9%, $n = 23$).

The overall prevalence of intestinal parasites in the 291 studied dogs was 58% (95% CI 52.1–63.8). *Ancylostoma/Uncinaria* spp. (31.9%, 95% CI 26.6–37.6) (Fig. 1), *Toxascaris leonina* (27.4%, 95% CI 22.4–33) (Fig. 2), *T. canis* (27.1%, 95% CI 22.1–32.6) (Fig. 3), *Cystoisospora* spp. (13.4%, 95% CI 9.7–17.8) (Fig. 4) and *Giardia* spp. (7.2%, 95% CI 4.5–10.8) (Fig. 5) were the most isolated parasites (Table 1). Among positive dogs, 47.3% (80/169 dogs) were infected with a single parasite genus, while 29.5% (50/169 dogs) and 23.0% (39/169 dogs) harbored two and 3 to 5 different genera, respectively.

The prevalence of any of the parasites was the lowest in owned dogs and significantly lower than the prevalence in shelter and working dogs. For *Ancylostoma/Uncinaria* spp., *T. leonina* and *Cystoisospora* spp. the highest prevalence levels were found in shelter dogs, with significant differences from the other categories, except from the breeding category for *Cystoisospora* spp. (Table 2). However, for *Giardia* spp., breeding dogs had by far the largest and significantly different prevalence from each of the three other categories (Table 2).

The prevalence of any of the parasites did not differ significantly between the age groups. For *T. canis* and *Cystoisospora* spp., the highest prevalence levels were found in the puppy group, which differed significantly from the other age groups except from the senior group for *Cystoisospora* spp. (Table 3).

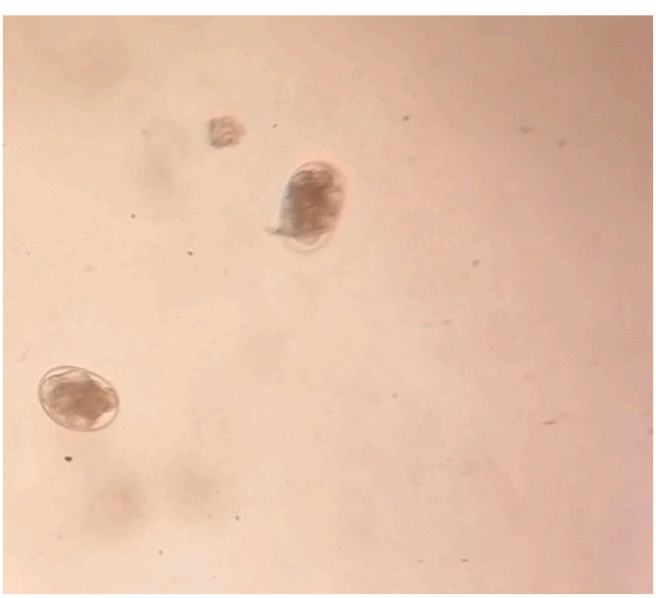

Fig. 1. Hookworm eggs. Fecal flotation, magnification x100.

Fig. 2. *Toxascaris leonina* egg. Fecal flotation, magnification x100.

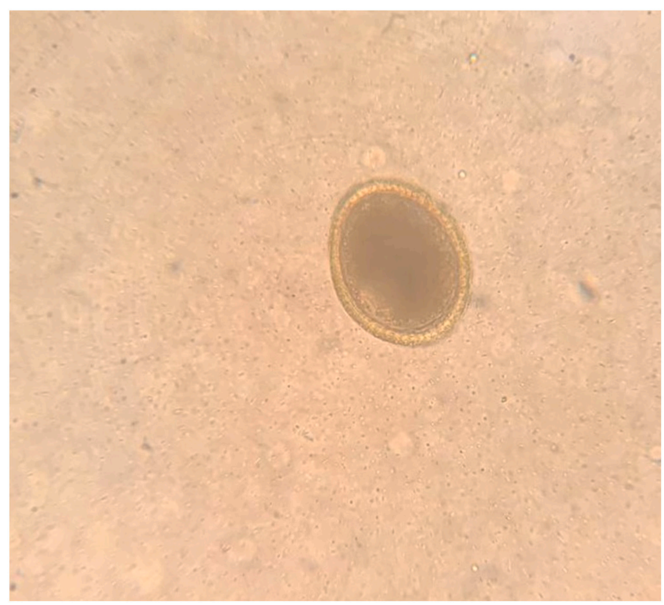

Fig. 3. *Toxocara canis* egg. Fecal flotation, magnification x100.

Significantly more parasites were detected in liquid stools compared to other fecal consistency levels. We observed a significant decrease of parasite prevalence in more consistent feces for the overall prevalence, *Ancylostoma/Uncinaria* spp., *T. leonina, T. canis*, and *Cystoisospora* spp. (Table 4).

The results of the questionnaires showed that owners respected their dogs' vaccination protocol (82%) significantly more ($p < 0.001$) than they did so for the deworming protocol (47%). Also, significantly ($p < 0.001$) more owners (85%) knew about rabies and its zoonotic potential than about canine zoonotic intestinal parasites (33%). When questioned about their perception of zoonotic intestinal parasites, 43% of owners responded that these zoonoses can cause serious diseases in humans.

Fig. 4. *Cystoisospora* spp. cyst. Fecal flotation, magnification x100.

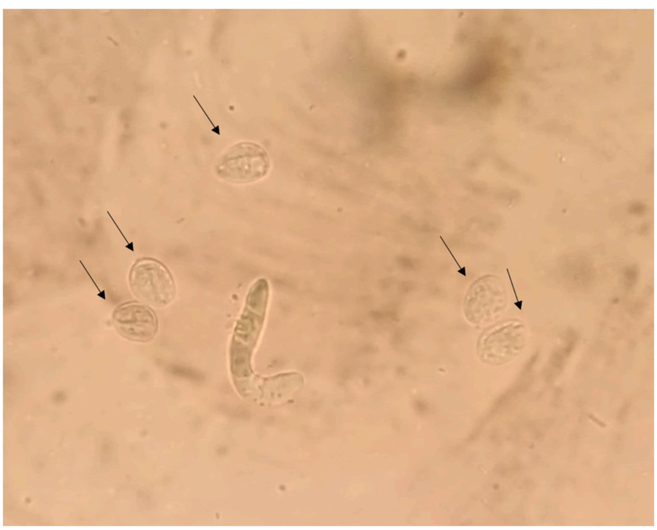

Fig. 5. *Giardia* spp. cysts (arrows). Fecal flotation, magnification x100.

Table 1
Prevalence of intestinal parasites detected in the feces of 291 dogs.

Parasite	Positive	Prevalence % (CI)
Ancylostoma/Uncinaria spp.	93	31.9 (26.6–37.6)
Toxascaris leonina	80	27.4 (22.4–33)
Toxocara canis	79	27.1 (22.1–32.6)
Cystoisospora spp.	39	13.4 (9.7–17.8)
Giardia spp.	21	7.2 (4.5–10.8)
Dipylidium caninum	2	0.6
Trichuris vulpis	1	0.3
Taenia spp.	1	0.3

Table 2
Prevalence of intestinal parasites according to activity level. Prevalences in the same row not sharing a letter differ statistically significantly from each other.

Parasite	Owned dogs (n = 96)	Shelter dogs (n = 129)	Breeding dogs (n = 10)	Working dogs (n = 56)
Overall (%)	32.2[b]	75.1 [a]	70 [ab]	60.7 [a]
Ancylostoma/ Uncinaria spp. (%)	9.3[b]	59.6[a]	0 [b]	12.5[b]
Toxascaris leonina (%)	2 [c]	49.6 [a]	0 [bc]	25 [b]
Toxocara canis (%)	20.8 [a]	32.5 [a]	10 [a]	28.5 [a]
Cystoisospora spp. (%)	7.2 [b]	23.2 [a]	20 [ab]	0 [b]
Giardia spp. (%)	5.2 [b]	6.9 [b]	50 [a]	3.5 [b]
Dipylidium caninum (%)	1 [a]	0.7 [a]	0 [a]	0 [a]
Trichuris vulpis (%)	0 [a]	0 [a]	0 [a]	1.7 [a]
Taenia spp. (%)	0 [a]	0.7 [a]	0 [a]	0 [a]

Table 3
Prevalence of intestinal parasites by age group. Prevalences in the same row not sharing a letter differ significantly from each other.

Parasite	<6 months (*n* = 70)	6–12 months (*n* = 31)	1–6 years (*n* = 164)	>6 years (*n* = 23)
Overall (%)	57.1 [a]	67.7 [a]	58.5 [a]	43.4 [a]
Ancylostoma/ Uncinaria spp. (%)	22.8 [a]	19.3 [a]	39.6 [a]	26 [a]
Toxascaris leonina (%)	21.4 [a]	35.4 [a]	31.7 [a]	8.6 [a]
Toxocara canis (%)	45.7 [a]	16.1 [b]	22.5 [b]	13 [b]
Cystoisospora spp. (%)	28.5 [a]	3.2 [b]	9.7 [b]	8.6 [ab]
Giardia spp. (%)	5.7 [a]	6.4 [a]	7.9 [a]	8.6 [a]
Dipylidium caninum (%)	1.4 [a]	0 [a]	0.6 [a]	0 [a]
Trichuris vulpis (%)	0 [a]	0 [a]	0.6 [a]	0 [a]
Taenia spp. (%)	0 [a]	0 [a]	0.6 [a]	0 [a]

Table 4
Prevalence of intestinal parasites depending on the feces consistency. Prevalences in the same row not sharing a letter differ statistically significantly from each other.

Parasite	Liquid (*n* = 46)	Very soft (*n* = 98)	Soft (*n* = 63)	Formed (*n* = 84)
Overall (%)	86.9 [a]	69.3 [a]	50.7 [ab]	34.5 [b]
Ancylostoma/Uncinaria spp. (%)	45.6 [a]	41.8 [a]	26.9 [ab]	16.6 [b]
Toxascaris leonina (%)	41.3 [a]	39.7 [a]	22.2 [ab]	9.5 [b]
Toxocara canis (%)	52.1 [a]	27.5 [b]	22.2 [b]	16.6 [b]
Cystoisospora spp. (%)	32.6 [a]	10.2 [b]	12.6 [ab]	7.1 [b]
Giardia spp. (%)	6.5 [a]	11.2 [a]	9.5 [a]	1.1 [a]
Dipylidium caninum (%)	0 [a]	1 [a]	0 [a]	1.1 [a]
Trichuris vulpis (%)	0 [a]	0 [a]	1.5 [a]	0 [a]
Taenia spp. (%)	0 [a]	0 [a]	1.5 [a]	0 [a]

4. Discussion

Our study aimed at reporting prevalence of intestinal parasites in a large dog population from various Moroccan locations. Such studies were needed because of lack of large and recent data on this topic.

This study revealed a high overall prevalence of intestinal parasites (58%) in the sampled dogs. A study from 1987 conducted in Morocco by Pandey et al. (1987), showed an even higher prevalence (100%). This can be explained by the fact that the aforementioned study was conducted exclusively on stray dogs, and parasites were screened by necropsy, probably allowing a better sensitivity comparing to the microscopic fecal examination alone (Lahmar et al., 2017). Prevalence rates reported in other regions from the Mediterranean Basin were widely different and ranged from 22% in France to 71.3% in Spain (Franc et al., 1997; Awadallah and Salem, 2015; Gurler et al., 2015; Kostopoulou et al., 2017; Matallah et al., 2018; Scaramozzino et al., 2018; Sanchez-Thevenet et al., 2019). This variation can be attributed to several factors including the study area, the diagnostic techniques used for the detection of parasites, the studied populations and their living conditions, their ownership status, the anthelmintics used, hygienic conditions and, their proximity to other animals (Mundim et al., 2007; Katagiri and Oliveira-Sequeira, 2008; Bahrami et al., 2011).

Ancylostoma/Uncinaria spp., *T. leonina*, *T. canis*, *Cystoisospora* spp. and *Giardia* spp. were the most frequently detected parasites in our study, which is in agreement with other reports from several Mediterranean countries (Pandey et al., 1987; Martínez-Moreno et al., 2007; Riggio et al., 2013; Awadallah and Salem, 2015; Kostopoulou et al., 2017; Scaramozzino et al., 2018). The prevalence rates of *Trichuris vulpis* (Fig. 6) and cestodes, such as *D. caninum* and *Taenia* spp. (Fig. 7), were very low in the current study, which is in line with the findings of some other surveys (Awadallah and Salem, 2015; Kostopoulou et al., 2017) but contradicts others (Pandey et al., 1987; Martínez-Moreno et al., 2007). However, it is worth mentioning that the diagnostic technique used in our study (centrifugal flotation) is more specific for nematodes than for cestodes (CAPC guideline, 2016; Adolph et al., 2017), which can at least partially explain the very low prevalence rate of cestodes in our study. Also, most of sampled dogs were under controlled diet, with no access to raw meat or carcasses, which reduces the risk of contamination by Taeniid tapeworms (Pennelegion et al., 2020).

A large proportion of shelter dogs (76.9%) harbored at least one species of intestinal parasite, and showed a significantly higher prevalence of *Ancylostoma/Uncinaria* spp., *T. leonina* and *Cystoisospora* spp. This is in agreement with previous studies revealing a high level of parasitism in this dogs' category (Palmer et al., 2008; Gharekhani, 2014; Simonato et al., 2015; Kostopoulou et al., 2017; Raza et al., 2018). These findings can easily be explained by the lifestyle of these animals, characterized by a lack of health control measures and anthelmintics use, poor hygienic conditions, direct contact with other dogs and their stools, and stressful conditions such as overcrowding, loud noises, poor diet and frequent dietary changes, causing an immunosuppressive effect (Palmer et al., 2008; Pesavento and Murphy, 2014; Kostopoulou et al., 2017; Raza et al., 2018). Although breeding and service dogs are usually well-cared for and receive more veterinary care compared to shelter dogs, they were highly infected in this study. The results obtained from previous surveys are comparable to ours, indicating that service and working dogs frequently harbor intestinal parasites (Senlik et al., 2006; Ahmed et al., 2014), since these dogs go to exercise daily and the feces are not removed from training area, which increases the risk of soil contamination and infection of other dogs (Senlik et al., 2006). Additionally, working dogs enrolled in this study received anthelmintic treatment twice a year which may be insufficient according to the European Scientific Counsel Companion Animal Parasites (ESCCAP) guidelines (ESCCAP, 2021). Breeding dogs showed significantly higher prevalence of *Giardia* spp. compared to the three other categories. This could be due to the inefficacy of the anthelmintic administrated against protozoa or perhaps the lack of compliance of the owners. Moreover, the high stocking density may lead to horizontal spread of protozoan parasites (Gharekhani, 2014). Even if owned dogs showed a noteworthy prevalence of intestinal parasites (32.2%), this rate was significantly lower than that of shelter and working dogs, confirming previous results (Awoke et al., 2011; Perera et al., 2013; Gharekhani, 2014; Kostopoulou et al., 2017). Domestic dogs are usually well cared for by their owners, live in better hygienic conditions in low density, have limited contact with other animals and have a better veterinary follow-up, which explains their lowest frequency of infection (Awoke et al., 2011; Hinney et al., 2017).

Fig. 6. *Trichuris vulpis* egg. Fecal flotation, magnification x100.

Fig. 7. *Taenia* spp. egg. Fecal flotation, magnification x100.

In this study, 52.6% of infections were mixed, and among them, 79.7% occurred in shelter dogs. This can be attributed to increased exposure of shelter dogs to various parasites, due to high environmental contamination with infectious parasitic developmental stages, and exacerbated by the lack of veterinary care and inappropriate anthelmintic use (Pesavento and Murphy, 2014; Raza et al., 2018).

This study showed that the prevalence of *T. canis* and *Cystoisospora* spp. were age-dependent, with the highest infection rates in puppies (<6 months). This is in agreement with data reported in numerous previous studies (Pandey et al., 1987; Fontanarrosa et al., 2006; Martínez-Moreno et al., 2007; Gates and Nolan, 2010; Barutzki and Schaper, 2013; Riggio et al., 2013; Gharekhani, 2014; Hinney et al., 2017; Stafford et al., 2020) and could be due to the immature immune system of young animals. Indeed, parasite-specific immunity is usually acquired with age, probably as a consequence of single or repeated exposures (Fontanarrosa et al., 2006; Palmer et al., 2008; Gharekhani, 2014). Furthermore, the transplacental and transmammary routes of transmission of *T. canis* promote its occurrence in puppies (Palmer et al., 2008; Gharekhani, 2014).

Parasite's prevalence, especially *Ancylostoma/Uncinaria* spp., *T. leonina, T. canis* and *Cystoisospora* spp. significantly increased in less consistent feces. *T. leonina* and some hookworms (e.g. *Uncinaria stenocephala*) are known to mainly cause asymptomatic infections (ESCCAP, 2021) but it should be considered that in this study, these species were mainly detected in shelter dogs and most of them were polyinfected, therefore they were more susceptible to have less consistent feces probably due to coinfections with other parasites such as *T. canis*, *Cystoisospora* spp. and *Giardia* spp. or possibly other agents such as viruses and bacteria. *T. canis* and *Cystoisospora* spp. are found in puppies (<6 months), which are known to be more sensitive to these two parasites and hence more susceptible to have diarrhea when infected (Barutzki and Schaper, 2013; Kostopoulou et al., 2017; ESCCAP, 2021).

The zoonotic helminth, *T. canis*, was significantly prevalent in our study and was detected in the four canine populations, including owned dogs (20.8%). Noteworthy, 29% of detected hookworms were suspected to be from the zoonotic species *A. caninum*, according to the eggs length and width measurements (Lucio-Forster et al., 2012; Zajac and Conboy, 2013). In Morocco, published data on human infection with *T. canis* and *A. caninum* are sporadic and limited to case reports (Laghmari et al., 2003; Guamri et al., 2009; Daoudi et al., 2014; Benbella et al., 2016; Elyadari et al., 2018; Adeel, 2020; Gakosso et al., 2020; Kaibi et al., 2020). However, when taking in consideration the significant prevalence of *T. canis* among dogs of this study and the suspected cases of *A. caninum*, in addition to the Moroccan investigations that have revealed vegetable and wastewater contamination with these parasites (Hajjami et al., 2012, 2013; Hajjami, 2013; Adeel, 2020), the risk of human infection seems to be very likely and thus, human cases may be under-diagnosed or under reported in Morocco. *Giardia* spp. was also commonly found in dogs, but molecular-based tests and genotyping of the parasite are needed to determine the species and assemblages implicated and, to estimate their zoonotic potential (El Fatni et al., 2014; Pallant et al., 2015).

The evaluation of owners' knowledge through the questioners allowed us to highlight a weak level of knowledge regarding zoonotic intestinal parasites, their severity and the prevention measures. In contrast, the majority of the interviewed dog owners had great knowledge about rabies. Also, most of them respected their dogs' vaccination protocol. Our results showed poor owner awareness and high prevalence of intestinal parasites, this together with the close proximity between humans and their pet dogs, emphasizes the major human health threat.

Veterinarians have a crucial role in education of pet owners, veterinary staff and people interacting with dogs about canine zoonotic intestinal parasites and prevention measures (Traversa, 2012; Kostopoulou et al., 2017). More widely, veterinarians are considered a more congruous source of knowledge on zoonoses than physicians (Traversa, 2012).

People in regular contact with dogs should be clearly informed about transmission routes of zoonotic intestinal parasites, to both dogs and humans, and about the prevention practices and behaviors to adopt to reduce the risk of contamination (Palmer et al., 2008; Traversa, 2012; Traversa et al., 2014).

According to the European Scientific Counsel Companion Animal Parasites (ESCCAP, 2021) and the North American Companion Animal Parasite Council (CAPC) guidelines, deworming 1–3 times a year does not provide sufficient protection and does not necessarily eliminate patent infections. Thus, it is recommended to deworm pets at intervals not exceeding 3 months, or even monthly, depending on their individual risk and the risk for their owners (Traversa, 2012; Pennelegion et al., 2020; ESCCAP, 2021).

Regular fecal examinations, at least four times in the first year of life and at least two times per year in adulthood, should be considered when, for whatever reason, a year-round-control is not possible to detect any parasitic stage and monitor the efficacy of the preventive treatment used (Traversa, 2012; Traversa et al., 2014; CAPC guideline, 2020a, 2020b; ESCCAP, 2021; von Samson-Himmelstjerna et al., 2021).

Epidemiological studies on human infections with zoonotic ascarids, hookworms and *Giardia* species are also strongly needed in order to investigate the real impact of these zoonotic parasites on human health and to guide preventive measures following the One Health approach (Adeel, 2020). The collaboration of physicians and veterinarians following the One Health approach is essential to address zoonotic diseases in both humans and animals and hence contribute to a more effective control/prevention.

5. Conclusion

To our knowledge, this is the first report of intestinal parasites in owned, shelters, breeding and working dogs from Morocco. Our results revealed that intestinal parasites were highly prevalent in all dog categories. We also highlighted a high prevalence of the zoonotic parasites *T. canis*, that can be a serious threat to public health. People's knowledge about zoonotic intestinal parasites of dogs was found very limited. These results stress the need of improved control programs against canine intestinal parasites to protect both dogs and humans and the need of increasing knowledge of dog owners and caregivers on this subject. These observations also highlight the central role of veterinarians in preventing both canine and human intestinal parasitic infections not only by prescribing anthelmintic preventive treatments but also by educating dog owners and caregivers. We also recommend investigating the situation in humans by performing epidemiological studies on human infection with canine zoonotic parasites to apply the One Health approach, compare data, and study the possibility of zoonotic transmission.

Ethical statement

The work described in the manuscript 'Prevalence, risk factors and zoonotic potential of intestinal parasites in dogs from Morocco' involved the use of non- experimental animals only (owned, shelter, breeding and service dogs) and non-invasive approaches were performed. Oral informed consent was obtained from all dog owners, shelter, breeding and kennel managers, before inclusion of dogs in the study and before the start of any procedure described in the manuscript. Dogs were subjected to a routine clinical examination following the established internationally recognized high standards ('best practice') of individual veterinary clinical patient care. Freshly passed fecal samples were collected by dog owners (owned dogs), breeding and shelters supervisors (shelter and breeding dogs) and dog trainers (working dogs), then stored at 4 °C. Fecal analysis were performed within two days after collection. No invasive or painful procedures were performed on the dogs included in this study.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Adeel, A.A., 2020. Seroepidemiology of human toxocariasis in North Africa. Adv. Parasitol. 109, 501–534. https://doi.org/10.1016/bs.apar.2020.01.023.

Adolph, C., Barnett, S., Beall, M., Drake, J., Elsemore, D., Thomas, J., Little, S., 2017. Diagnostic strategies to reveal covert infections with intestinal helminths in dogs. Vet. Parasitol. 247, 108–112. https://doi.org/10.1016/j.vetpar.2017.10.002.

Ahmed, W.M., Mousa, W.M., Aboelhadid, S.M., Tawfik, M.M., 2014. Prevalence of zoonotic and other gastrointestinal parasites in police and house dogs in Alexandria, Egypt. Vet. World 7, 275–280. https://doi.org/10.14202/vetworld.2014.275-280.

Amarir, F.E., Saadi, A., Marcotty, T., Rhalem, A., Oukessou, M., Sahibi, H., Obtel, M., Bouslikhane, M., Sadak, A., Kirschvink, N., 2020. Cystic echinococcosis in three locations in the middle atlas, Morocco: estimation of the infection rate in the dog reservoir. Vector-Borne Zoonotic Dis. 20, 436–443. https://doi.org/10.1089/vbz.2019.2538.

Awadallah, M.A.I., Salem, L.M.A., 2015. Zoonotic enteric parasites transmitted from dogs in Egypt with special concern to *Toxocara canis* infection. Vet. World 8, 946–957. https://doi.org/10.14202/vetworld.2015.946-957.
Awoke, E., Bogale, B., Chanie, M., 2011. Intestinal nematode parasites of dogs: prevalence and associated risk factors. Int. J. Anim. Vet. Adv. 3, 374–378.
Azlaf, R., Dakkak, A., Chentoufi, A., El Berrahmani, M., 2007. Modelling the transmission of *Echinococcus granulosus* in dogs in the northwest and in the southwest of Morocco. Vet. Parasitol. 145, 297–303. https://doi.org/10.1016/j.vetpar.2006.12.014.
Bahrami, A., Doosti, A., Nahravanian, H., Noorian, A.M., Asbchin, S.A., 2011. Epidemiological survey of gastro-intestinal parasites in stray dogs and cats. Aust. J. Basic Appl. Sci. 5, 1944–1948.
Baneth, G., Thamsborg, S.M., Otranto, D., Guillot, J., Blaga, R., Deplazes, P., Solano-Gallego, L., 2016. Major parasitic zoonoses associated with dogs and cats in Europe. J. Comp. Pathol. 155, S54–S74. https://doi.org/10.1016/j.jcpa.2015.10.179.
Barutzki, D., Schaper, R., 2013. Age-dependant prevalence of endoparasites in young dogs and cats up to one year of age. Parasitol. Res. 112, 119–131. https://doi.org/10.1007/s00436-013-3286-6.
Benbella, I., Khalki, H., Lahmadi, K., Kouara, S., Abbadi, A., Er-Rami, M., 2016. Cutaneous larva migrans syndrome on a malformed foot (a case report). Pan Afr. Med. J. 23, 1–4. https://doi.org/10.11604/pamj.2016.23.50.8696.
Bouaddi, K., Bitar, A., Ferssiwi, A., Bouslikhane, M., Fitani, A., Mshelbwala, P.P., Audu, S.W., 2018. Socioecology of the canine population in the province of El Jadida, Morocco. Vet. Med. Int. 2018, 1–7. https://doi.org/10.1155/2018/4234791.
CAPC guideline, 2016. Cestodes [WWW Document]. In: Companion Anim. Parasite Counc. website. https://capcvet.org/guidelines/cestodes/. accessed 7.2.21.
CAPC guideline, 2019. *Giardia*. [WWW Document]. Companion Anim. Parasite Counc. website. https://capcvet.org/guidelines/giardia/ (accessed 7.2.21).
CAPC guideline, 2020a. Ascarid. [WWW Document]. Companion Anim. Parasite Counc. website. https://capcvet.org/guidelines/ascarid/ (accessed 7.2.21).
CAPC guideline, 2020b. Hookworms. [WWW Document]. Companion Anim. Parasite Counc. website. https://capcvet.org/guidelines/hookworms/ (accessed 7.2.21).
Dakkak, A., 2010. Echinococcosis/hydatidosis: a severe threat in Mediterranean countries. Vet. Parasitol. 174, 2–11. https://doi.org/10.1016/j.vetpar.2010.08.009.
Dakkak, A., El Berbri, I., Petavy, A.F., Boué, F., Bouslikhane, M., Fassi Fihri, O., Welburn, S., Ducrotoy, M.J., 2017. *Echinococcus granulosus* infection in dogs in Sidi Kacem Province (north-West Morocco). Acta Trop. 165, 26–32. https://doi.org/10.1016/j.actatropica.2016.07.007.
Daoudi, C., Laghmari, M., Naciri, K., Handor, H., Hafidi, Z., Hajji, C., Daoudi, R., 2014. Toxocarose oculaire: À propos de deux cas et revue de la littérature. Pan Afr. Med. J. 17, 1–4. https://doi.org/10.11604/pamj.2014.17.71.3823.
Dubná, S., Langrová, I., Nápravník, J., Jankovská, I., Vadlejch, J., Pekár, S., Fechtner, J., 2007. The prevalence of intestinal parasites in dogs from Prague, rural areas, and shelters of the Czech Republic. Vet. Parasitol. 145, 120–128. https://doi.org/10.1016/j.vetpar.2006.11.006.
El Berbri, I., Petavy, A.F., Umhang, G., Bouslikhane, M., Fassi Fihri, O., Boué, F., Dakkak, A., 2015. Epidemiological investigations on cystic echinococcosis in north-west (Sidi Kacem Province) Morocco: infection in ruminants. Adv. Epidemiol. 2015, 1–9. https://doi.org/10.1155/2015/104025.
El Fatni, C., Olmo, F., El Fatni, H., Romero, D., Rosales, M.J., 2014. First genotyping of *Giardia duodenalis* and prevalence of enteroparasites in children from Tetouan (Morocco). Parasite 21. https://doi.org/10.1051/parasite/2014049.
Elyadari, M., Zarrouki, M., Elorch, H., Azennoud, S., Harchali, S., Elmerrouni, S., Bouzoubaa, T., Hajji, Z., Abdallah, E., Boulanoir, A., Berraho, A., 2018. Toxocarose oculaire. J. Fr. Ophtalmol. 41, 277–279. https://doi.org/10.1016/j.jfo.2017.06.026.
ESCCAP, 2021. Worm Control in Dogs and Cats. ESCCAP Guideline 01 Sixth Edition.
Fontanarrosa, M.F., Vezzani, D., Basabe, J., Eiras, D.F., 2006. An epidemiological study of gastrointestinal parasites of dogs from southern greater Buenos Aires (Argentina): age, gender, breed, mixed infections, and seasonal and spatial patterns. Vet. Parasitol. 136, 283–295. https://doi.org/10.1016/j.vetpar.2005.11.012.
Franc, M., Cadiergues, M.C., Marchand, A., Bourdoiseau, G., Bussieras, J., 1997. Intestinal parasitism in dogs and cats. Results of an epidemiological survey in France. Rev. Med. Vet. (Toulouse). 3, 247–250.
Gakosso, L.G.C., Baadi, F., Abakka, F.Z., Basraoui, D., Jalal, H., 2020. The visceral larva migrans caused by *Toxocara canis*: a case report. Pan Afr. Med. J. 36, 1–5. https://doi.org/10.11604/pamj.2020.36.150.24176.
Gates, M.C., Nolan, T.J., 2010. Groups of dogs and cats. Vet. Parasitol. 166, 153–158. https://doi.org/10.1016/j.vetpar.2009.07.041.Endoparasite.
Gharekhani, J., 2014. Study on gastrointestinal zoonotic parasites in pet dogs in Western Iran. Turkiye Parazitol. Derg. 38, 172–176. https://doi.org/10.5152/tpd.2014.3546.
Guamri, Y. El, Belghyti, D., Achicha, A., Tiabi, M., Aujjar, N., Barkia, A., Kharrim, K. El, Barkia, H., El-Fellaki, E., Mousahel, R., Bouachra, H., Lakhal, A., 2009. Enquête épidémiologique rétrospective sur les parasitoses intestinales au Centre hospitalier provincial El Idrissi (Kénitra, Maroc) : bilan de 10 ans (1996–2005). Ann. Biol. Clin. (Paris). 67, 191–202. https://doi.org/10.1684/abc.2009.0313.
Gurler, A.T., Bolukbas, C.S., Pekmezci, G.Z., Umur, S., Acici, M., 2015. Nematode and cestode eggs scattered with cats-dogs feces and significance of public health in Samsun, Turkey. Ankara Üniversitesi Vet. Fakültesi Derg 62, 23–26. https://doi.org/10.1501/vetfak_0000002653.
Hajjami, K., 2013. Wastewater reuse for irrigation in Morocco: helminth eggs contamination's level of irrigated crops and sanitary risk (a case study of Settat and Soualem regions). J. Bacteriol. Parasitol. 04, 1–5. https://doi.org/10.4172/2155-9597.1000163.
Hajjami, K., Ennaji, M.M., Fouad, S., Oubrim, N., Khallayoune, K., Cohen, N., 2012. Assessment of helminths health risk associated with reuse of raw and treated wastewater of the Settat City (Morocco). Resour. Environ. 2, 193–201. https://doi.org/10.5923/j.re.20120205.03.
Hajjami, K., Ennaji, M.M., Amdiouni, H., Fouad, S., Cohen, N., 2013. Parasistic contamination on fresh vegetable consumed in Casablanca city (Morocco) and risk for consumer. Int. J. Sci. Technol. 2, 543–549.
Hinney, B., Gottwald, M., Moser, J., Reicher, B., Schäfer, B.J., Schaper, R., Joachim, A., Künzel, F., 2017. Examination of anonymous canine faecal samples provides data on endoparasite prevalence rates in dogs for comparative studies. Vet. Parasitol. 245, 106–115. https://doi.org/10.1016/j.vetpar.2017.08.016.
Kaibi, I., Gargouri, S., Sehli, M., Zone, I., Feki, E.T.J., 2020. Adult ocular toxocariasis: case report. J.I. M. Sfax 35, 60–63.
Katagiri, S., Oliveira-Sequeira, T.C.G., 2008. Prevalence of dog intestinal parasites and risk perception of zoonotic infection by dog owners in São Paulo state, Brazil. Zoonoses Public Health 55, 406–413. https://doi.org/10.1111/j.1863-2378.2008.01163.x.
Kohansal, M.H., Fazaeli, A., Nourian, A., Haniloo, A., Kamali, K., 2017. Dogs' gastrointestinal parasites and their association with public health in Iran. J. Vet. Res. 61, 189–195. https://doi.org/10.1515/jvetres-2017-0024.
Kostopoulou, D., Claerebout, E., Arvanitis, D., Ligda, P., Voutzourakis, N., Casaert, S., Sotiraki, S., 2017. Abundance, zoonotic potential and risk factors of intestinal parasitism amongst dog and cat populations: the scenario of Crete, Greece. Parasit. Vectors 10, 1–12. https://doi.org/10.1186/s13071-017-1989-8.
Laghmari, M., Karim, A., Guedira, K., Ibrahimy, W., Dahreddine, M., Essakalli, N.H., Mohcine, Z., 2003. Les uvéites de l ' enfant À propos de 20 cas. J. Fr. Ophtalmol. 26, 609–613.
Lahmar, S., Arfa, I., Ben Othmen, S., Jguirim, W., Saïd, Y., Dhibi, A., Boufana, B., 2017. Intestinal helminths of stray dogs from Tunisia with special reference to zoonotic infections. Parasitol. Open 3, 1–9. https://doi.org/10.1017/pao.2017.21.
Lucio-Forster, A., Liotta, J.L., Yaros, J.P., Briggs, K.R., Mohammed, H.O., Bowman, D.D., 2012. Morphological differentiation of eggs of *Ancylostoma caninum*, *Ancylostoma tubaeforme* and *Ancylostoma braziliense* from dogs and cats in the United States. J. Parasitol. 98, 1041–1044. https://doi.org/10.1645/GE-2928.1.
Lum, F.C., Hoskins, H.D., Moorthy, R.S., Read, R.W., Starr, M.C., Montgomery, S.P., Jones, J.L., Woodhall, D.M., 2011. Ocular Toxocariasis — United States, 2009–2010 ocular. MMWR 60, 734–736. https://doi.org/10.1016/j.jsr.2011.07.001.
Martínez-Moreno, F.J., Hernández, S., López-Cobos, E., Becerra, C., Acosta, I., Martínez-Moreno, A., 2007. Estimation of canine intestinal parasites in Córdoba (Spain) and their risk to public health. Vet. Parasitol. 143, 7–13. https://doi.org/10.1016/j.vetpar.2006.08.004.
Matallah, F., Khelaifia, W., Lamari, S., Matallah, S., 2018. Gastrointestinal helminth parasites of dogs in rural areas of the north east of Algeria. Iraqi J. Vet. Sci. 32, 93–98. https://doi.org/10.33899/ijvs.2018.153829.
Mazzaferro, E.M., 2020. Update on canine Parvoviral enteritis. Vet. Clin. North Am. Small Anim. Pract. 50, 1307–1325. https://doi.org/10.1016/j.cvsm.2020.07.008.
Mundim, M.J.S., Rosa, L.A.G., Hortêncio, S.M., Faria, E.S.M., Rodrigues, R.M., Cury, M. C., 2007. Prevalence of *Giardia duodenalis* and *Cryptosporidium* spp. in dogs from different living conditions in Uberlândia, Brazil. Vet. Parasitol. 144, 356–359. https://doi.org/10.1016/j.vetpar.2006.09.039.
Pallant, L., Barutzki, D., Schaper, R., Thompson, R., 2015. The epidemiology of infections with *Giardia* species and genotypes in well cared for dogs and cats in Germany. Parasit. Vectors 8, 2. https://doi.org/10.1186/s13071-014-0615-2.
Palmer, C.S., Thompson, R.C.A., Traub, R.J., Rees, R., Robertson, I.D., 2008. National study of the gastrointestinal parasites of dogs and cats in Australia. Vet. Parasitol. 151, 181–190. https://doi.org/10.1016/j.vetpar.2007.10.015.
Pandey, V.S., Dakkak, A., Elmamoune, M., 1987. Parasites of stray dogs in the Rabat region, Morocco. Ann. Trop. Med. Parasitol. 81, 53–55. https://doi.org/10.1080/00034983.1987.11812090.
Pandey, V.S., Ouhelli, H., Moumen, A., 1988. Epidemiology of hydatidosis/echinococcosis in Ouarzazate, the pre-Saharian region of Morocco. Ann. Trop. Med. Parasitol. 82, 461–470. https://doi.org/10.1080/00034983.1988.11812277.
Pennelegion, C., Drake, J., Wiseman, S., Wright, I., 2020. Survey of UK pet owners quantifying internal parasite infection risk and deworming recommendation implications. Parasit. Vectors 13, 1–11. https://doi.org/10.1186/s13071-020-04086-2.
Perera, P.K., Rajapakse, R.P.V.J., Rajakaruna, R.S., 2013. Gastrointestinal parasites of dogs in Hantana area in the Kandy District. J. Natl. Sci. Found. Sri Lanka 41, 81–91. https://doi.org/10.4038/jnsfsr.v41i2.5703.
Pesavento, P.A., Murphy, B.G., 2014. Common and emerging infectious diseases in the animal shelter. Vet. Pathol. 51, 478–491. https://doi.org/10.1177/0300985813511129.
Pinelli, E., Herremans, T., Harms, M.G., Hoek, D., Kortbeek, L.M., 2011. *Toxocara* and ascaris seropositivity among patients suspected of visceral and ocular larva migrans in the Netherlands: trends from 1998 to 2009. Eur. J. Clin. Microbiol. Infect. Dis. 30, 873–879. https://doi.org/10.1007/s10096-011-1170-9.
Raza, A., Rand, J., Qamar, A.G., Jabbar, A., Kopp, S., 2018. Gastrointestinal parasites in shelter dogs: occurrence, pathology, treatment and risk to shelter workers. Animals 8, 108. https://doi.org/10.3390/ani8070108.
Riggio, F., Mannella, R., Ariti, G., Perrucci, S., 2013. Intestinal and lung parasites in owned dogs and cats from Central Italy. Vet. Parasitol. 193, 78–84. https://doi.org/10.1016/j.vetpar.2012.11.026.
Robertson, I.D., Thompson, R.C., 2002. Enteric parasitic zoonoses of domesticated dogs and cats. Microbes Infect. 4, 867–873. https://doi.org/10.1016/S1286-4579(02)01607-6.
Sanchez-Thevenet, P., Carmena, D., Adell-Aledón, M., Dacal, E., Arias, E., Saugar, J.M., Rodríguez, E., Dea-Ayuela, M.A., 2019. High prevalence and diversity of zoonotic and other intestinal parasites in dogs from eastern Spain. Vector-Borne Zoonotic Dis. 19, 915–922. https://doi.org/10.1089/vbz.2019.2468.

Scaramozzino, P., Carvelli, A., Iacoponi, F., De Liberato, C., 2018. Endoparasites in household and shelter dogs from Central Italy. Int. J. Vet. Sci. Med. 6, 45–47. https://doi.org/10.1016/j.ijvsm.2018.04.003.
Senlik, B., Cirak, V.Y., Karabacak, A., 2006. Intestinal nematode infections in Turkish military dogs with special reference to *Toxocara canis*. J. Helminthol. 80, 299–303. https://doi.org/10.1079/JOH2005336.
Simonato, G., Frangipane di Regalbono, A., Cassini, R., Traversa, D., Beraldo, P., Tessarin, C., Pietrobelli, M., 2015. Copromicroscopic and molecular investigations on intestinal parasites in kenneled dogs. Parasitol. Res. 114, 1963–1970. https://doi.org/10.1007/s00436-015-4385-3.
Stafford, K., Kollasch, T.M., Duncan, K.T., Horr, S., Troy Goddu, C.H.-L., Rumschlag, A.J., Ryan, W.G., Sweet, S., Little, S.E., 2020. Detection of gastrointestinal parasitism at recreational canine sites in the USA: the DOGPARCS study. Parasit. Vectors 13, 275. https://doi.org/10.1186/s13071-020-04147-6.
Traversa, D., 2012. Pet roundworms and hookworms: a continuing need for global worming. Parasit. Vectors 5, 1–19. https://doi.org/10.1186/1756-3305-5-91.
Traversa, D., Frangipane Di Regalbono, A., Di Cesare, A., La Torre, F., Drake, J., Pietrobelli, M., 2014. Environmental contamination by canine geohelminths. Parasit. Vectors 7, 1–9. https://doi.org/10.1186/1756-3305-7-67.
Von Samson-Himmelstjerna, G., Thompson, R.A., Krücken, J., Grant, W., Bowman, D.D., Schnyder, M., Deplazes, P., 2021. Spread of anthelmintic resistance in intestinal helminths of dogs and cats is currently less pronounced than in ruminants and horses – yet it is of major concern. Int. J. Parasitol. Drugs Drug Resist. 17, 36–45. https://doi.org/10.1016/j.ijpddr.2021.07.003.
Yacob, H.T., Ayele, T., Fikru, R., Basu, A.K., 2007. Gastrointestinal nematodes in dogs from Debre Zeit, Ethiopia. Vet. Parasitol. 148, 144–148. https://doi.org/10.1016/j.vetpar.2007.06.007.
Zajac, A.M., Conboy, G.A., 2013. Veterinary Clinical Parasitology, Eighth Edi. ed. Wiley-Blackwell.