Preventive Veterinary Medicine 172 (2019) 104788

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

Contamination of Italian parks with canine helminth eggs and health risk perception of the public

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ARTICLE INFO

Keywords:
Canine faecal pollution
Geo-helminths
Interviews
Public health
Risk awareness

ABSTRACT

The contamination of public areas by dog faeces is a social behaviour and public health problem. In fact, the most frequently isolated intestinal helminths in dogs are distributed worldwide, and most of them have zoonotic potential (i.e., ascarids and ancylostomatids).

The aims of this survey were to evaluate citizen awareness of health risks for animals and humans related to canine faecal pollution and to estimate the presence and prevalence of intestinal helminths in dog faeces collected in green public areas in three municipalities of Italy (Padua, Rome and Teramo). The awareness of citizens about the health risks related to faecal pollution was evaluated using questionnaires submitted to 313 dog owners and 159 non-dog owners in Padua (n = 341) and Rome (n = 131). Most dog owners (85.4%) declared they picked up their dog's faeces every time, and these data were confirmed by operators secretly observing dog owners. Moreover, 84.3% participants were aware of the existence of a municipal regulation concerning the correct management of animals in public areas with no significant differences between dog owners and non-dog owners, whereas Rome citizens were significantly more aware than Padua citizens. Nonetheless, only 10.9% (51/469) of responders knew the health risks related to canine faecal pollution, with no significant differences between dog and non-dog owners.

A total of 677 dog stool samples were collected and copromicroscopically analysed. Forty-eight (7.1%) samples were positive for at least one parasite species, with significantly lower prevalence values in Padua (2.2%) than in Rome (11.9%) and Teramo (8.6%). The highest prevalence was detected for *Trichuris vulpis* (4.4%), followed by *Toxocara canis* (1.9%); *T. vulpis* presented significantly lower prevalence in Padua than in the other cities. Other helminths were found with values under 0.5% in the investigated cities.

This survey shows that most citizens are unaware of the health risk related to abandoned canine faeces on public soils. Nevertheless, laboratory results suggest a limited risk for dog and human health, but the zoonotic risk due to the high vitality of infective helminths eggs in the soil should always be considered.

1. Introduction

Different parasites affecting the intestines of dogs have zoonotic potential, e.g., roundworms (*Toxocara canis*), hookworms (*Ancylostoma* spp.), tapeworms (e.g., *Echinococcus granulosus* and *Dipylidium caninum*) and protozoa (e.g., *Giardia* spp. and *Cryptosporidium* spp.) (Robertson and Thompson, 2002). Infected animals shed parasitic elements *via* their faeces and contaminate the environment, which is the most important source of infections for both dogs and humans.

Studies from various continents have shown that there is a considerable rate of soil and grass contamination in a plethora of recreational, public and urban areas (rev. in Traversa et al., 2014). The origins of this contamination are both owned dogs and stray animals that defecate in public areas (e.g., gardens, children's playgrounds, parks), contaminate the environment and promote the risk of zoonotic transmission and (re-) infections for other animals. Notably, privately owned

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https://doi.org/10.1016/j.prevetmed.2019.104788
Received 4 July 2019; Received in revised form 1 October 2019; Accepted 1 October 2019

dogs may be more frequently involved in polluting urban areas in the absence of large populations of stray dogs, specifically when they are not appropriately dewormed and owners do not collect their faeces from the ground (Morgan et al., 2013).

The interest in canine faecal pollution and linked sanitary problems is globally growing, and many authors in the last few years have described this public health problem (rev. in Traversa et al., 2014). Moreover, the evaluation of people's awareness of the health risk related to pet-borne zoonoses is another topic that has recently stimulated the interest of the scientific community. Indeed, surveys collecting information about dog owners' perception of potential health risks related to close contact with their pets were conducted all over the world (McGlade et al., 2003; Katagiri and Oliveira-Sequeira, 2008; Bingham et al., 2010; Palmer et al., 2010; Stull et al., 2012; Beraldo et al., 2014; Zanzani et al., 2014; Matos et al., 2015).

Despite the availability of scientific data from several studies, the general public has limited knowledge of the presence and distribution of parasitoses that commonly affect pets (Palmer et al., 2010; Beraldo et al., 2014; Zanzani et al., 2014; Matos et al., 2015). Moreover, people may be scarcely informed or not informed at all on pet-borne zoonoses and on their routes of transmission (McGlade et al., 2003; Katagiri and Oliveira-Sequeira, 2008; Bingham et al., 2010; Palmer et al., 2010). In fact, this finding was confirmed by several surveys that evaluated the crucial role of veterinarians in informing and educating owners about pet-borne zoonoses. Their results have shown an existing gap of information between vets and owners, e.g., misunderstanding, misinformation received from media, and lack of information by veterinarians (Overgaauw, 1996; Katagiri and Oliveira-Sequeira, 2008; Bingham et al., 2010; Matos et al., 2015).

Given that canine parasites are globally present, keeping our guard up on their occurrence and spread in areas where they may infect both dogs and humans is essential. The present study aimed to improve knowledge on existing health hazards in public, potentially contaminated green areas. In addition, the real pollution of urban areas in three selected cities of Italy *via* the evaluation of the presence of parasitic elements in canine faeces contaminating the environment was evaluated.

2. Materials and methods

2.1. Interviews and faecal sample collection

Interviews and sample collection were performed in green public areas (i.e., historic gardens, children's playgrounds or green places for physical activities or fitness) in three Italian municipalities, i.e., Padua (northeastern Italy), Rome and Teramo (central Italy) (Fig. 1). Each green area was checked at least twice a day (time frame: 7.00–11.00 a.m. and 4.00–8.00 p.m.), when it was more frequently utilized by dogs and their owners. Questionnaires were administered to dog owners to collect information on their pet (breed, age, sex) and to evaluate dog management in a public context, i.e., the dog faeces collection, the awareness of municipal regulations concerning the management of animals in public and private contexts (e.g., use of leash and muzzle in public areas, collection of faeces with appropriate tools, obligations and responsibilities of owner, requirements of boxes/fences for keeping dogs) and the perception of the health risks linked to canine faecal pollution in urban environments. At the same time, the operators observed the dog owners to verify whether they collected the faeces of their pet. Furthermore, the same questions regarding pet management in the public context were randomly asked to citizens (non-dog owners) who were passing by. The profession of each respondent (both dog owners and non-dog owners) was ascertained before the interview to exclude any tourists or veterinarians. In addition, fresh stools were removed from the soil and placed in clean plastic containers, labelled and stored at refrigerated conditions (+4 °C) until examination within 2 days.

2.2. Copromicroscopic examinations

Faecal samples were grossly checked for visible parasitic elements, and then approximately 5 g was subjected to a copromicroscopic examination using a centrifugation-flotation technique (Dryden et al., 2005) using a sodium-nitrate solution (specific gravity 1.30). Parasitic elements were morphometrically identified according to existing keys (Sloss et al., 2004; Di Cesare et al., 2012) under a light microscope at 100x and 200x magnification.

2.3. Statistical analyses

The difference in proportions of citizens aware of the health risk related to canine faecal pollution in an urban environment between two groups of people (i.e., dog owners vs non-dog owners; Padua vs Rome citizens) was statistically evaluated with Fisher's exact test, keeping a significance level of $p < 0.05$ and using SPSS Statistics software, version 22.0.0 (IBM®, New York, USA). The chi-square test was used to compare differences in parasite prevalences in relation to the three areas of individual sampling.

3. Results

3.1. Questionnaires

A total of 472 interviews were administered to Padua (n = 341) and Rome (n = 131) citizens divided into 313 dog owners and 159 non-dog owners (Table 1). The most relevant data of the interviews were summarized in key points as follows. The majority of dog owners said they collected the faeces of their dog from the ground every time (264/309, 85.4%) or often (36/309, 11.7%), and 9/309 (2.9%) admitted they never did it; indeed, the operators secretly observing dog owners confirmed that 84.4% (119/141) of them collected the faeces of their pet (Table 2). Moreover, 84.3% (396/470) answered that they were aware of the existence of a municipal regulation on the correct management of animals in public and private contexts, with no significant differences between dog owners and non-dog owners, whereas Rome citizens were significantly more aware ($p = 0.003$) than Padua citizens (Table 3).

The 10.9% (51/469) of responders were aware of health risks related to canine faecal pollution in urban environments, with no significant differences between dog owners (30/311, 9.6%) and non-dog owners (21/158, 13.3%), while significant differences ($p < 0.001$) were recorded between Padua (47/339, 13.8%) and Rome citizens (4/130, 3.1%), as reported in Table 4.

3.2. Copromicroscopic examinations

A total of 677 canine faecal samples were collected in green public areas, with 270, 209 and 198 in Padua, Rome and Teramo, respectively. None of the samples contained macroscopically visible parasitic elements. The copromicroscopic analysis identified 48/677 (7.1%) positive samples for at least one parasite, 6/270 (2.2%), 25/209 (11.9%) and 17/198 (8.6%) from Padua, Rome and Teramo, respectively. Overall, the highest prevalence was detected for *Trichuris vulpis* (4.4%), followed by *Toxocara canis* (1.9%); other parasites showed prevalences below 0.5% (Table 5). Furthermore, the highest prevalence values of *T. vulpis* (7.7%) and *T. canis* (3.6%) were detected in Rome and Teramo, respectively. In addition, statistical analysis showed differences in *T. vulpis* prevalence in the three municipalities, with significantly lower prevalence in Padua than in Rome and Teramo (Table 5). A similar trend was observed for *T. canis*, but the difference was not significant.

Ancylostoma caninum (3/209, 1.4%) was detected only in Rome as were taeniid cestodes (1/209, 0.5%), while *Eucoleus aerophilus* was isolated twice, once in Rome and once in Teramo. Due to the scarce prevalences detected for these parasites, statistical analysis was not performed.

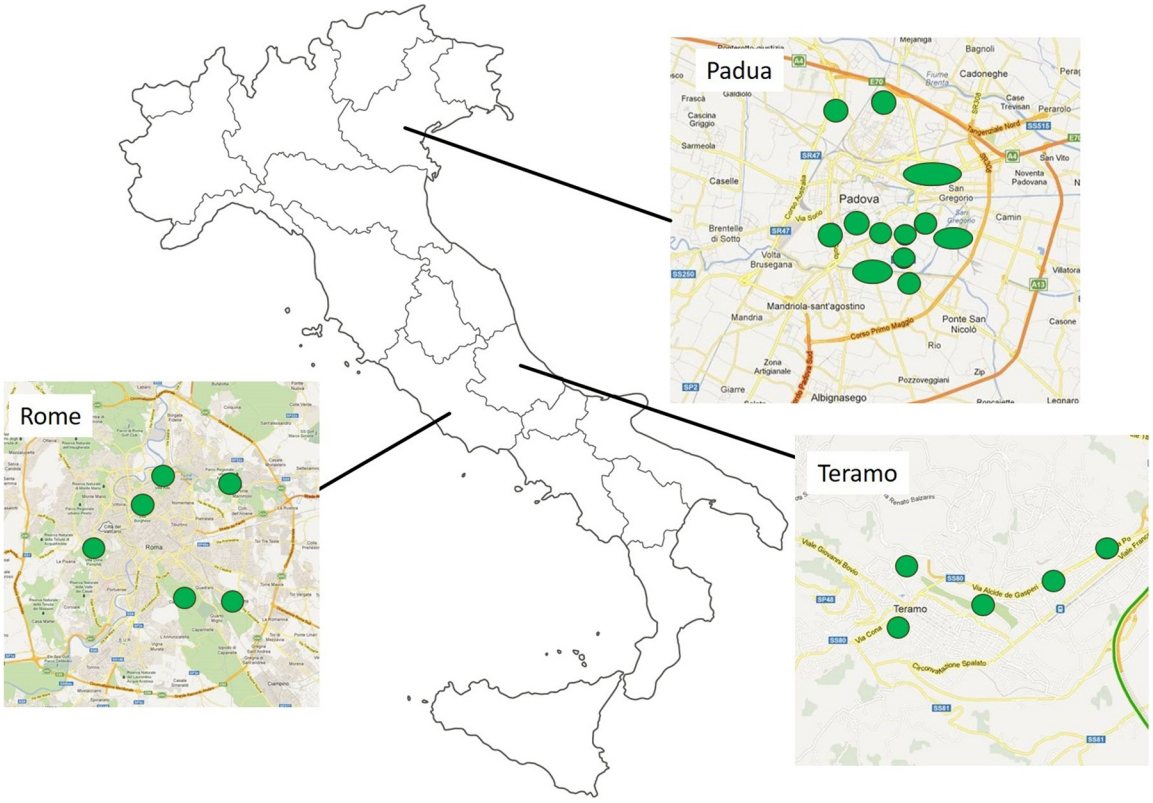

Fig. 1. Map representing the investigated green areas (circled areas) in the three Italian cities.

Table 1
Number of questionnaires administered in Padua and Rome to dog owners and non-dog owners.

	Dog owners	Non-dog owners	Total
Padua	230	111	341
Rome	83	48	131
Total	313	159	472

Out of 48 positive samples, 41 (85.4%) showed only one parasite species, 6 (12.5%) showed two species, represented by *T. canis/T. vulpis* co-infection isolated in Padua and in Teramo, and 1 (2.1%) three species found in Rome, i.e., *A. caninum*, *E. aerophilus* and *T. vulpis*.

4. Discussion

The contamination of public areas by dog faeces is a social behaviour and public health problem worldwide, and many researchers have addressed this issue in the last few years (rev. in Traversa et al., 2014). In this study, the questionnaires submitted to people, both dog owners and non-dog owners, aimed to evaluate their awareness of health risks related to the abandoned dog faeces on public soil.

In Italy, a ministerial ordinance (published in Official Gazette of the Italian Republic, August 22nd 2019) regulates the management of dogs in public settings, and additionally, the investigated municipalities issued a municipal regulation that specifically describes the correct behaviour of dog owners in public areas and obligates them to collect the faeces of their dogs. Since most citizens stated that they knew the municipal regulations in effect in their own city and operators confirmed that they picked up the faeces of their dogs, the public education by municipalities was effective, even if the contamination by dog faeces is yet substantially present.

Although most citizens collected the faeces of their dogs, they seriously ignored the potential health risks related to environmental faecalization.

This is surprising in comparison to previous studies carried out in Italy, where most dog owners were aware of faecal-transmitted zoonoses, including routes of transmission (Beraldo et al., 2014; Zanzani et al., 2014). Similar data were described in Australia: dog and cat owners were aware of the potential risk of parasitic zoonoses originating from pets, even if the routes of transmission were not clear (McGlade et al., 2003; Palmer et al., 2010). Nonetheless, a USA study provided similar results to those presented here: most of the people interviewed were unaware of dog-originating zoonoses (Bingham et al., 2010). In another study, the dog owners' knowledge of pet-borne zoonoses was scarce and incorrect, even if most of them carried out

Table 2
Canine faeces collection: dog owner (OWs) statements (n. answers/n. total responders, %) and evaluation of their behaviour by operators (OPs) (n. of owners collecting or not the faeces of their dog/ n. of observed owners).

Question		Padua		Rome		Total	
		OWs	Ops	OWs	OPs	OWs	OPs
Do you pick up the faeces of your dog?	Yes	202/229 (88.2%)	74/89 (83.1%)	62/80 (77.5%)	45/52 (86.5%)	264/309 (85.4%)	119/141 (84.4%)
	No	6/229 (2.6%)	15/89 (16.9%)	3/80 (3.8%)	7/52 (13.5%)	9/309 (2.9%)	22/141 (15.6%)
	Often	21/229 (9.2%)	–	15/80 (18.7%)	–	36/309 (11.7%)	–

Table 3
Municipal regulation on management of pets in public/private context: awareness of Padua/Rome citizens and dog /non-dog owners.

Are you aware of a municipal regulation *regarding dog management in urban context?*		**Total**	**Dog owners**	**Non-dog owners**	**p-value***
	Yes	396/470 (84.3%)	256/312 (82.1%)	140/158 (88.6%)	p = 0.081
	No	74/470 (17.7%)	56/312 (17.9%)	18/158 (11.4%)	–
		Total	**Padua**	**Rome**	**p-value***
	Yes	396/470 (84.3%)	276/340 (81.2%)	120/130 (92.3%)	p = 0.003
	No	74/470 (17.7%)	64/340 (18.8%)	10/130 (7.7%)	–

* $p < 0.05$ indicates a statistically significant difference between correct (Yes) and wrong (No) answers.

preventive measures such as hygiene and anthelmintic administration (Katagiri and Oliveira-Sequeira, 2008).

An information gap similar to that found here between veterinarians and pet owners has been reported in a study from Australia where few veterinarians informed their owners about the zoonotic potential of some pet parasites, although they recommended anthelmintic treatments, and some ignored pet-borne zoonoses completely (Palmer et al., 2010). In Canada, the veterinarians recommend anthelmintic treatments to 13% and 39% of the examined puppies and kittens, respectively; in addition, in veterinary clinics, where an anthelmintic protocol is usually present, vets stated they applied it in 78% of the cases. Moreover, 66% of interviewed vets declared that they informed their clients about potential zoonotic risks related to endoparasites of dogs and cats only in particular cases or never (Stull et al., 2007).

On the other hand, 7.1% of the analysed samples in this study were positive for at least one parasite with higher prevalences in Rome (11.9%) and Teramo (8.6%) than in Padua (2.2%). The overall low prevalences for geohelminths in the three municipalities are in agreement with results already reported in Italy (rev. Traversa et al., 2014). In particular, *T. vulpis* showed a higher prevalence followed by ascarids in all study sites, probably due to egg high persistence in the environment for a long time (Traversa, 2012). The low prevalence of nematodes recorded in Padua is probably due to the usual chemoprophylaxis with macrolactones against endemic *Dirofilaria immitis* (Otranto et al., 2009; Genchi et al., 2011; Otranto et al., 2013), which is generally effective against the majority of dog intestinal nematodes. Moreover, some of these drugs (e.g., moxidectin) work efficiently against larval and immature stages of *T. vulpis*, *T. canis* and *A. caninum* (Bowman et al., 2003; Traversa, 2012), thus contributing more to the reduction in the level of infection in canine populations under protection from heartworm.

The scarce presence of ancylostomatids, isolated only in Rome, could be caused by the low tolerance of their larval stages in the environment, and the limited presence in urban settings of shaded, warm, and humid soils favouring their development and survival (Traversa, 2012).

The pulmonary nematode *E. aerophilus* is worthy of attention, especially because it is often underdiagnosed due to egg morphological similarity with those of *T. vulpis*. Moreover, even if this nematode was isolated only in two samples, its presence must not be underestimated because of its zoonotic potential, contrary to *T. vulpis* (Traversa, 2011).

Taeniid eggs were isolated only in one sample in Rome. The low sensitivity for cestode detection of a single copromicroscopic test has already been described (Simonato et al., 2015), and it is probably due to the intermittent presence of proglottids in the faecal material and the uneven distribution of eggs in faeces after proglottid disruption.

In Italy, the problem of free-ranging and stray dogs is predominantly present in the southern regions and islands, and it decreases significantly in the central-northern regions, except for Lazio (LAV, 2018). Stray dogs are practically absent in the city of Padua, whereas packs of them are reported in some suburban neighbourhoods of Teramo and Rome, but quite far from the green areas investigated in this study. In conclusion, we suppose that canine faecal pollution in Italian urban areas is mainly caused by owned dogs. In fact, the low presence of intestinal helminths could be referred to a greater attention paid by owners for their dog health along with a cleaner and less stressful living context. Despite the low prevalence values found here, suggesting a limited risk for dog and human health, *T. canis*, *A. caninum* and *E. aerophilus* should not be underestimated for their zoonotic potential (Robertson et al., 2000; Heukelbach and Feldmeier, 2008; Bowman et al., 2010; Nicoletti, 2013; Veraldi et al., 2013; Holland, 2017).

The role of veterinarians in educating owners is pivotal, as shown in the present survey and in previous similar studies carried out elsewhere. Thus, it is necessary to improve this aspect towards a better health education of both vets and the general public to guarantee the "one health" concept (Paul et al., 2010). Even if a close contact between owners and dogs is not a risk factor for the transmission of intestinal helminths, as eggs need time to become infective in the environment, the zoonotic risk linked to the persistence of infective eggs in the soil should be kept in mind (Traversa, 2012). Moreover, since most citizens are unaware of the health risk related to canine faecal contamination of public areas, multidisciplinary programmes of information and education involving physicians, veterinarians, and public administration are necessary to reduce environmental pollution and educate citizens on the correct prevention of species-specific and zoonotic parasites.

Declaration of Competing Interest

During the study, FLT was an employee of Novartis Animal Health. FLT is currently employed at Zoetis Italia s.r.l.

Acknowledgements

This work was financed by the research project n. CPDA110843 of the University of Padua (2011) and supported by Novartis Animal Health (n. GTS-12-007, 2012), currently Elanco.

Table 4
Perception of the health risks linked to canine faecal pollution in urban environment: differences between dog and non-dog owners and between Padua and Rome citizens.

Do you think that dog faeces can transmit diseases?		**Total**	**Dog owners**	**Non-dog owners**	**p-value***
	Yes	51/469 (10.9%)	30/311 (9.6%)	21/158 (13.3%)	p = 0.272
	No	418/469 (89.1%)	281/311 (90.4%)	137/158 (86.7%)	–
		Total	**Padua citizens**	**Rome citizens**	**p-value***
	Yes	51/469 (10.9%)	47/339 (13.8%)	4/130 (3.1%)	p < 0.001
	No	418/469 (89.1%)	282/339 (83.2%)	126/130 (96.9%)	–

* $p < 0.05$ indicates a statistically significant difference between correct (Yes) and wrong (No) answers.

Table 5
Prevalence of helminths in canine faecal samples collected in urban green areas of Padua, Rome and Teramo.

Parasite	Padua (n = 270)		Rome (n = 209)		Teramo (n = 198)		Total (n = 677)		p-value*
	Pos	%	Pos	%	Pos	%	Pos	%	
Trichuris vulpis	4	1.5	16	7.7	10	5.1	30	4.4	p = 0.004
Toxocara canis	2	0.7	4	1.9	7	3.6	13	1.9	p = 0.094
Ancylostomatidae	0	–	3	1.4	0	–	3	0.4	–
Eucoleus aerophilus	0	–	1	0.5	1	0.6	2	0.3	–
Taeniidae**	0	–	1	0.5	0	–	1	0.1	–

* $p < 0.05$ indicates a statistically significant difference among prevalence values in the three locations.
** The sensitivity of the adopted procedure is very low.

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