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IMPACTS OF SOCIOECONOMIC CONDITION AND SEASON ON SOIL CONTAMINATION WITH ZOONOTIC PARASITES FROM DOGS' FECES, UMUARAMA-PR, BRAZIL

(IMPACTOS DA CONDIÇÃO SOCIOECONÔMICA E DA ESTAÇÃO NA CONTAMINAÇÃO DO SOLO COM PARASITAS ZOONÓTICOS DE FEZES DE CÃES, UMUARAMA-PR, BRASIL)

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RESUMO

As doenças parasitárias intestinais de cães compreendem um grupo de doenças globalmente distribuídas e de rápida disseminação, causadas por uma ampla gama de helmintos e protozoários. A falta de cuidados veterinários aos cães errantes os torna a principal fonte de contaminação do solo por muitas zoonoses. Assim, o objetivo deste estudo foi avaliar a frequência de parasitas intestinais em fezes coletadas em áreas públicas de Umuarama – PR, bem como a influência das condições socioeconômicas e da estação do ano. Foram coletadas 100 amostras de fezes (verão:n=53; inverno:n=47) de 6 bairros de Umuarama – PR. As amostras foram processadas por três métodos coproparasitológicos: Faust; Willis; Hoffman, Pons e Janer. Seis gêneros de parasitas pertencentes a helmintos e protozoários foram encontrados nas amostras coletadas. Das 100 amostras analisadas, 47% foram positivas para um ou mais parasitas. *Ancylostoma* spp foi o gênero mais frequente (43%), seguido por *Trichuris vulpis* (10%) e *Giardia* spp. (10%). Das 47 amostras positivas, 64% estavam monoparasitadas e 36% apresentaram poliparasitismo, sendo que a associação mais frequente foi de *Ancylostoma spp* e *Giardia* spp. A estação do ano impactou na frequência de *Ancylostoma* spp, *Cystoisospora* spp, *Spirocerca lupi* e *Balandium coli*. As regiões menos favorecidas economicamente apresentaram maior diversidade e frequência de parasitas, bem como mais casos de poliparasitismo. Os resultados obtidos demonstram a necessidade de implementar políticas públicas eficientes para conscientização da população, bem como de um controle ambiental, a fim de diminuir a frequência de parasitas potencialmente zoonóticos, principalmente em locais que possuem status socioeconômico mais baixo.

Palavras-chave: co-parasitismo, flutuação espontânea; centrífugo-flutuação; sedimentação-espontânea; *Toxocara canis.*

ABSTRACT

Intestinal parasitic diseases of dogs comprise a group of globally distributed and rapidly spreading illnesses that are caused by a wide range of helminths and protozoa. The lack of veterinary care of stray dogs makes them a main source of soil contamination from many zoonoses. Thus, the aim of this study was to evaluate the frequency of intestinal parasites in feces collected in public areas of Umuarama – PR, as well as the influence of socioeconomic conditions and season. One hundred fecal samples were collected (summer: n=53; winter: n=47) from 6 neighborhoods of Umuarama – PR. The samples were processed by three coproparasitological techniques: Faust; Willis; Hoffman, Pons and Janer. Six genera of parasites belonging to helminths and protozoa were found in the collected samples. Of the 100 samples analyzed, 47% were positive for one or more parasites. *Ancylostoma* spp was the most frequent genus found (frequency of 43%), followed by *Trichuris vulpis* (10%) and *Giardia* spp. (10%). Of the 47 positive samples, 63% presented monoparasitism, and 36% presented polyparasitism, with the most frequent association being *Ancylostoma spp* and *Giardia* spp. The season impacted the frequency of *Ancylostoma* spp, *Cystoisospora* spp, *Spirocerca lupi* and *Balantidium coli*. The economically less favored regions showed greater diversity and frequency of parasites, as well as more cases of polyparasitism. The results obtained demonstrate the necessity of efficient public policy implementation to raise awareness of the population, as well as environmental control, in order to reduce the frequency of potentially zoonotic parasites, especially in places that have lower socioeconomic status.

Keywords: co-parasitism, spontaneous-flotation; centrifugal-flotation; spontaneous-sedimentation; *Toxocara canis.*

INTRODUCTION

In modern times, demand for dogs as pet animals is increasing and demonstrate the strong bond formed between these animals and humans (FERREIRA *et al.*, 2017). The global population of dogs is estimated at more than 500 million and these animals are associated with more than 60 different zoonotic diseases (SZWABE and BŁASZKOWSKA, 2017). According to the Brazilian Association of the Pet Products Industry, Brazil has one of the highest numbers of pet population (about 149,6 million) in the world, and a dog population of 58.1 million animals (ABINPET, 2022). In addition, there is also a large growth in the stray dogs' population in urban areas, which contributes with the dissemination of several zoonotic parasites and is frequently responsible for soil

contamination of popular areas, including public squares and children's playgrounds (CASSENOTE *et al.*, 2011; FERREIRA *et al.*, 2017).

Parasitic diseases can cause serious clinical conditions in domestic animals, and it can present from asymptomatic to severe and lethal manifestations, depending on the specie and zoonotic potential of the parasite and animal characteristics. Of all dog and cat parasites, gastrointestinal species are considered the most important epidemiologically (SZWABE and BŁASZKOWSKA, 2017). Once parasitized, the animal can become a source of diseases to humans. Although both stray dogs and domiciled dogs can be hosts of zoonotic parasites, the domiciled have a greater control due to the frequent use of wormers in a preventive way. Therefore, the lack of governmental actions, such as the implementation of strategies for the control of stray dogs and the awareness of the population, favors the occurrence of zoonoses in people who frequent these public places (ARRUDA *et al.*, 2021; KATAGIRI and OLIVEIRA-SEQUEIRA, 2008; PEREIRA *et al.*, 2016).

The places contaminated by feces of parasitized animals, under favorable conditions, can be a source of infective forms of parasites for months (CAPUANO and ROCHA, 2006; PETENUSSE, 2017). In general, the main forms of contamination are through contaminated water or food by ingesting eggs, cysts or oocysts, or by penetrating the larvae through the skin (KHAN *et al.*, 2020).

In addition, the occurrence and spread of parasites is also influenced by the socioeconomic condition of the region, which influences both the care offered to domiciled dogs and the number of stray dogs in the area. People living in precarious conditions have a higher risk of exposure to parasites, and children are also more susceptible to contamination due to the habit of playing in contact with the contaminated ground (CAPUANO and ROCHA, 2006; PETENUSSE, 2017; ALBANO *et al.*, 2016).

The most frequent intestinal parasites of dogs with zoonotic potential, especially protozoa and helminths, belong to genera: *Giardia, Ancylostoma, Toxocara* and *Trichuris* (SZWABE and BŁASZKOWSKA, 2017; ALBANO *et al.*, 2016). The most important zoonoses diseases are cutaneous larva migrans (CLM) and visceral larva migrans (VLM), caused respectively by *Ancylostoma* spp. and *Toxocara* spp. (BREMM, 2007). In general, when the agent is parasitizing the host, it can cause several problems such as inflammatory reactions, tissue damage, disturbances in mechanical functions, nutritional imbalance and, in some cases, can also lead to death (SPÓSITO and VIOL, 2012).

For an effective parasite control program, it must be based on active monitoring of parasite distributions and the identification of specific risk factors (SZWABE and BŁASZKOWSKA, 2017). In this way, the objective of this study was to evaluate the frequency of intestinal parasites with zoonotic potential in fecal samples of dogs present in public places of Umuarama city (Paraná state,

Brazil), as well as the parasitic co-occurrence and influence of season and the region's socioeconomic conditions of each neighborhood.

MATERIALS AND METHOD

Study area

The study was performed in Umuarama city, located in the northwest of Paraná State (latitude 23°45'59" South, longitude 53°19'30" West), which presents a humid subtropical mesothermal climate, with hot summers reaching mean temperatures between 25,1 ºC and 26,0 ºC and rainfall from 400 to 500 mm, and winters with unusual frost with temperatures varying between 18,1 ºC and 19,0 ºC and rainfall from 200 to 300 mm (CELLIGOI and DUARTE, 2000; NITSCHE *et al.*, 2019).

Six neighborhoods of Umuarama were selected for this study. The socioeconomic condition of each location was established by the Location Factor (LF) provided by the municipal government. LF expresses a relationship between the base value of the city and the value of the square meter of the land (UMUARAMA, 2014). Thus, the regions that have a lower value, have worse socio-economic status. The neighborhoods studied and its LF are Parque das Jabuticabeiras (LF=7.5), Jardim Kennedy (LF=10.5), Jardim Beira Rio (LF=10.5), Parque do lago (LF=27.7), Jardim dos Príncipes (LF=77.3) and Zona 3 (LF=140.2).

Sample collection and laboratory procedures

A total of 100 samples were collected according to the abundance of feces in each location. Samples of dog feces with fresh appearance were collected during the months of February (summer; n=53), and July (winter; n=47) from the environment. The samples were allocated in plastic bags, numerically identified, stored in an isothermal box with recyclable ice and sent to the Parasitology Laboratory of the Department of Veterinary Medicine, Universidade Estadual de Maringá (UEM), Regional Campus of Umuarama at the same day.

The samples were processed and analyzed using three complementary coproparasitological techniques: spontaneous-flotation using saturated sodium chloride solution (WILLIS, 1921); centrifugal-flotation in a saturated solution of zinc sulfate (FAUST *et al.*, 1938); and spontaneous-sedimentation (HOFFMAN *et al.*, 1934).

Statistical analysis

The occurrence of intestinal parasites was calculated. The data were submitted to the Shapiro-Wilk test, and due to no normal distribution, a non-parametric Kruskal–Wallis test was used. This test was applied to compare the values of each helminth and protozoan found in different

neighborhoods, and in winter and summer. All statistical analyses were performed using SAS software (SAS Institute, Inc.). Values of $p < 0.05$ were taken as significant.

RESULTS

Of the total samples collected, 47% (47/100) presented one or more parasites, with *Ancylostoma* spp being the most frequently parasite (43%), followed by *Trichuris vulpis* (10%) and *Giardia* spp. (10%), *Spirocerca lupi* (3%), *Toxocara canis* (2%) and *Cystoisospora* spp (2%) and *Balantidium coli* (1%). The cases of monoparasitism represent 63% (30/47) of the positives, while polyparasitism cases represent 36% (17/47) (Table 1, Table 2). In monoparasitism cases, the frequency in decreasing order was *Ancylostoma* spp., followed by *Giardia* spp., *Balantidum coli* and *Spirocerca lupi* (Table 1). Regarding polyparasitism cases, 6% of samples presented more than two different parasites (Table 2).

Table 1. Parasites in monoparasitized samples of dogs' feces collected in Umuarama-PR

Parasites	**(%) Frequency ***	**(%) Positive****
Ancylostoma spp.	26%	55%
Giardia spp.	2%	4%
Balantidium coli	1%	2%
Spirocerca lupi	1%	2%
Total	**30%**	**63%**

* Percentage calculated based on total of samples evaluated (n=100).
** Percentage calculated based on the total number of positive samples (n=47).

Table 2. Associations of parasites involved in cases of polyparasitism in dog's feces samples collected in Umuarama-PR

Parasites	**(%) Frequency ***	**(%) Positive****
Ancylostoma spp + *Giardia* spp.	6%	13%
Ancylostoma spp + *Trichuris vulpis*	4%	9%
Ancylostoma spp + *Toxocara canis*	1%	2%
Ancylostoma spp + *Trichuris vulpis* + *Spirocerca lupi*	2%	4%
Ancylostoma spp + *Trichuris vulpis* + *Giardia* spp.	1%	2%
Ancylostoma spp + *Trichuris vulpis* + *Toxocara canis*	1%	2%
Ancylostoma spp + *Trichuris vulpis* + *Cystoisospora* spp.	1%	2%
Ancylostoma spp + *Trichuris vulpis* + *Giardia* spp. + *Cystoisospora* spp.	1%	2%
Total	**17%**	**36%**

* Percentage calculated based on total of samples evaluated (n=100).
** Percentage calculated based on the total number of positive samples (n=47).

In summer (February), 43% (23/53) of samples collected in the public streets of Umuarama-PR were positive for one or more parasites, while in winter (July), the positivity was 51% (24/47). According to the season, frequency of *S. lupi* and *Balantidium coli* were significantly higher ($p<0,05$)

in the summer, while to *Ancylostoma* spp. and *Cystoisospora* were higher ($p<0,05$) in the winter (Table 3).

Considering Umuarama regions, the number of positive samples was inversely related to the LF of the neighborhood. The three neighborhoods with the lowest LF represent 67% and 88% of the mono and polyparasite cases, respectively (Table 4). The occurrence of Ancylostoma spp, T. vulpis, T. canis and total of positives are also impacted by LF. Table 5 shows the results considering season and neighborhood. In summer, the positive samples in polyparasitism cases presented differences between the regions. The same happens in the winter.

Table 3. Frequency of parasites found in dogs feces samples collected on the streets of Umuarama-PR by season

Season	**n**	***Ancylostoma* spp**	***Trichuris vulpis***	***Toxocara canis***	***Giardia* spp**	***Balantidium coli***	***Cystoisospora* spp**	***Spirocerca lupi***	**Parasitism**	
									Mono	**Poly**
Summer (February)	**53**	38%*	11%	2%	9%	2% *	0% *	6% *	26%	17%
Winter (July)	**47**	49%*	9%	2%	11%	0% *	4% *	0% *	34%	17%
P-value		0.0007	0.161	0.7968	0.548	0.0045	< 0.001	< 0.001	0.4085	0.9872

* Values from the same column with statistically different values (P <0,05).

Table 4. Frequency of parasites and polyparasitism cases by neighborhood in Umuarama-PR

Region	**LF**	**n**	***Ancylostoma* spp**	***Trichuris vulpis***	***Toxocara canis***	***Giardia* spp**	***Balantidium coli***	***Cystoisospora* spp**	***Spirocerca lupi***	**Parasitism**	
										Mono	**Poly**
Zona 3	140.2	13	8% [a]	0% [a]	0% [a]	0% [a]	0% [a]	0% [a]	0% [a]	8%	0% [a]
Jardim dos príncipes	77.3	18	17% [a]	0% [a]	0% [a]	6% [ab]	6% [b]	0% [a]	0% [a]	17%	6% [a]
Parque do Lago	27.7	16	37% [b]	0% [a]	0% [a]	12% [bc]	0% [a]	0% [a]	0% [a]	37%	6% [a]
Jardim Kennedy	10.5	17	41% [b]	11% [b]	0% [a]	12% [bc]	0% [a]	0% [a]	18 [b]	35%	17% [b]
Jardim Beira Rio	10.5	18	78% [c]	17% [bc]	6% [b]	22% [c]	0% [a]	6% [b]	0% [a]	50%	28% [bc]
Parque das Jaboticabeiras	7.5	18	67% [c]	28% [c]	6% [b]	6% [ab]	0% [a]	6% [b]	0% [a]	28%	39% [c]
P-value			< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.124	< 0.001

LF: Location factor.

a, b, c Values in the same column with different superscripts are significantly different (P <0,05).

Table 5. Frequency of parasites and polyparasitism cases by neighborhood per season in Umuarama-PR

Period/ Region	LF	n	*Ancylostoma* spp	*Trichuris vulpis*	*Toxocara canis*	*Giardia* spp	*Balantidium coli*	*Cystoisospora* spp	*Spirocerca lupi*	Parasitism	
										Mono	Poly
Summer (February)											
Zona 3	140.2	8	0% [a]	0% [a]	0% [a]	0% [a]	0% [a]	0%	0% [a]	0%	0% [a]
Jardim dos príncipes	77.3	10	20% [b]	0% [a]	0% [a]	0% [a]	10% [b]	0%	0% [a]	30%	0% [a]
Parque do Lago	27.7	9	44% [c]	0% [a]	0% [a]	0% [a]	0% [a]	0%	0% [a]	44%	0% [a]
Jardim Kennedy	10.5	9	22% [b]	22% [b]	0% [a]	11% [b]	0% [a]	0%	33% [b]	22%	22% [b]
Jardim Beira Rio	10.5	9	78% [d]	22% [b]	11% [b]	33% [c]	0% [a]	0%	0% [a]	33%	44% [c]
Parque das Jaboticabeiras	7.5	8	55% [cd]	25% [b]	0,0% [a]	12% [b]	0% [a]	0%	0% [a]	25%	37% [bc]
P-value			< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	1.000	< 0.001	0.4582	< 0.001
Winter (July)											
Zona 3	140.2	5	20% [a]	0% [a]	0% [a]	0% [a]	0%	0% [a]	0%	20%	0% [a]
Jardim dos príncipes	77.3	8	12% [a]	0% [a]	0% [a]	12% [ab]	0%	0% [a]	0%	0%	12% [a]
Parque do Lago	27.7	7	29% [a]	0% [a]	0% [a]	29% [b]	0%	0% [a]	0%	29%	14% [a]
Jardim Kennedy	10.5	8	62% [b]	0% [a]	0% [a]	12% [ab]	0%	0% [a]	0%	50%	12% [a]
Jardim Beira Rio	10.5	9	78% [b]	11% [b]	0% [a]	11 %[ab]	0%	11% [b]	0%	67%	11% [a]
Parque das Jaboticabeiras	7.5	10	70% [b]	30% [c]	10% [b]	0% [a]	0%	10% [b]	0%	30%	40% [b]
P-value			< 0.001	< 0.001	< 0.001	< 0.001	1.000	< 0.001	1.000	<0.001	< 0.001

LF: Location factor.

[a, b, c] Values in the same column with different superscripts are significantly different (P <0,05).

DISCUSSION

The use of different coproparasitological techniques, isolated or combined, as well as the origin of the evaluated animals (domiciled or stray dog) directly interferes in the results. In this study, the combination of centrifugal flotation technique in association with simple flotation and centrifugal sedimentation improves the diagnostic of helminths and protozoa in dogs' samples. The 43% of positivity for at least one parasite in this study, resembles the results found by other authors in Southern of Brazil, as 41% of positivity by Antunes *et al.* (2020), 44% by Prates *et al.* (2009) and 45% by Leite *et al.* (2004).

Ancylostoma spp. was the most frequently genus in the present study, which is similar to that reported by several authors (SCAINI *et al.*, 2003; LEITE *et al.*, 2004; TESSEROLLI *et al.*, 2005; CAPUANO and ROCHA, 2006; MARTINS *et al.*, 2012; CHAGAS *et al.*, 2019; SNAK *et al.*, 2019, ANTUNES *et al.*, 2020). These endoparasites live and reproduce in the small intestine and their eggs, once in the soil, give rise to larvae. Under ideal conditions of heat and humidity, the larvae remain viable in the soil for several weeks, which contributes to high transmission of these parasites in several regions of the world. At this moment, these endoparasites have great zoonotic potential and can cause the Cutaneous Larva Migrans (CLM). The higher frequency of this parasite in dogs may be related to the different possible routes of infection, such as transmammary and transplacental, feco-oral and percutaneous (ANTUNES *et al.*, 2020). Humans, by direct contact with soil or sand, can be infected through the feces of parasitized animals, becoming an accidental host (SOARES *et al.*, 2018; FILHO *et al.*, 2008).

Studies related to seasonal influence on the occurrence of endoparasites in dogs in Brazil are scarce, especially in the southern region. Seasonal variation in the transmission of intestinal parasites is often observed in regions with a temperate climate and is related to the variation of temperature and humidity, which affect mainly the stages of free life of the parasites. In tropical regions, variations in temperature and humidity appear not to be sufficient to determine a significant reduction in the transmission rate of most canine gastrointestinal parasites (OLIVEIRA-SEQUEIRA *et al.*, 2002).

The rainy season is related to a higher incidence of cutaneous larva migrans (HEUKELBACH *et al.*, 2013). Studies in São Paulo and Pindamonhangaba (both in southeastern of Brazil) reported a peak in the shedding of *Ancylostoma* eggs in dog feces during summer and autumn (OLIVEIRA-SEQUEIRA 2002, ALVES *et al.*, 2014). However, in a study carried out with soil samples from public places in Maringá (a city close to Umuarama-PR), the positivity for eggs and/or hookworm larvae was higher during the winter, which corroborates

the present work (TIYO *et al.*, 2008). Additionally, in Porto Alegre – RS, Lorenzini *et al*. (2007) also reported a higher value of Ancylostoma spp in dog feces in winter compared to summer, although the season with the highest frequency was autumn in their study.

The frequency of *Trichuris vulpis* corroborates the findings of Leite *et al.* (2007), which reported a positivity of 10% in samples collected from public areas of Curitiba-PR. This results also are similar to results found in the state of Rio Grande do Sul, reported by Bremm (2007) in Santa Cruz do Sul (10%), Ferraz *et al.* (2019) in Pelotas (10%) and Silva *et al.* (2007) in Santa Maria (11%). Dogs are definitive hosts of *Trichuris vulpis*, a parasite that lives in the intestine, mainly in the cecum. The eggs are shed in the feces of infected animals and are deposited in the soil. The eggs of *T. vulpis* are highly resistant in the environment. Then, they can mature into an infective form and transmission occurs through ingestion of eggs. Infected dogs may present pain, abdominal distension and diarrhea (LONGO *et al.*, 2008). Despite the high host specificity, *T. vulpis* are rarely found in humans and can cause an uncommon zoonosis. Cases of human enteric infection and Visceral Larva Migrans syndrome have already been reported (MÁRQUEZ-NAVARRO *et al*., 2012).

In the present study, all 10 samples contaminated with *T. vulpis* were always co-parasitized by *Ancylostoma* spp. In six cases, there are still one or two more agents involved in these polyparasitism cases. A study in Ribeirão Preto-SP reported that the frequency of 25% for the association between *Trichuris vulpis* and *Ancylostoma* spp (CAPUANO and ROCHA, 2006). These results were similar to the data found in this research of 21% of positive samples.

The low frequency of *Toxocara canis* (2%) found in this study is similar to other studies carried out in the state of Paraná, as reported by Prates *et al*. (2009) in Maringá (3%), Leite *et al*. (2007) in Curitiba (1%) and Santos *et al*. (2007) in Londrina (1%). *T. canis*, a nematode belonging to the *Ascaridae* family, has a worldwide distribution and is responsible for a human infection called toxocariasis. Dogs are important in the transmission of these parasites to the human, through the excretion of eggs in the feces. Humans are accidental hosts and may acquire infection by ingestion of embryonated or larvated eggs of *Toxocara canis* (and *T. cati*) present in soil. Toxocariasis is commonly an asymptomatic infection; however, larvae migration may cause a range of diseases as visceral toxocariasis, ocular toxocariasis or neurotoxocariasis (DELAI *et al*. 2021). Toxocariasis is also common in humans and is one of the most frequent zoonosis transmitted by dogs around the world being one of top five neglected zoonotic diseases targeted for public health action. A recent serological study reported that 66% of people

evaluated in the state of Parana, Brazil, were positive for *Toxocara* spp. anti-bodies. It reflects the high level of environmental contamination by *Toxocara* spp. in that region (DELAI *et al*. 2021).

Giardia spp. was the most frequently protozoa found in the present study (10%), as observed in previous studies as reported by Pegoraro *et al.* (2011) in Laboratory of Parasitology of the Veterinary Hospital of the University Center of Maringá (CESUMAR) (9%), Prates *et al.* (2009) also in Maringá (11%) and Santos *et al.* (2007) in Londrina (9%).

As well as *Ancylostoma spp* and *Toxocara canis*, *Giardia* spp. is an important zoonotic agent due to the close relationship between tutors and animals. Giardiasis is transmitted by the fecal-oral route. After ingestion, the protozoa perform binary division and reach the lumen of the small intestine, where they are free or adhered to the intestinal mucosa, by suction mechanism. The formation of the cyst occurs when the parasite transits the colon, and at this stage the cysts are found in the feces (CAVALINI and ZAPPA, 2011). The elimination of *Giardia* spp. cysts is intermittent, which may provide an underestimated occurrence of this parasite in several studies (FERREIRA *et al.*, 2016)

The low frequency of *Cystoisospora* spp. found in the present study resembles the results reported by Leite *et al.* (2004) in Curitiba-PR (2%), Ferreira *et al.* (2016) in São Paulo-SP (2%), Prates *et al.* (2009) in Maringá-PR (4%) and Ferraz *et al.* (2019) in Pelotas-RS (1%). Some studies suggest that the occurrence of *Cystoisospora* spp. is higher in young animals due to an immature immune system (LABRUNA *et al.*, 2006; RIGGIO *et al.*, 2013; SYMEONIDOU *et al.*, 2018). The low frequency in this study might be due to the relatively small number of subadult dogs in the whole dog population (HINNEY *et al*., 2017). *Cystoisospora* spp. are protozoa capable of causing epithelial obstruction due to infestation of the intestinal wall. Transmission begins by eliminating uncultured oocysts in the animal's feces, which can contaminate soil and water and infect other domestic animals, wild animals, and humans. However, canine coccidia (represented mainly by *C. canis* and *C. ohioensis*) are not considered zoonotic agents. When sporulated, the oocyst containing sporozoites becomes infective (VASCONCELOS *et al.*, 2008; FERREIRA *et al.*, 2013).

Domestic dogs act as definitive hosts in the life cycle of *Spirocerca lupi*, a nematode that causes spirocercose. The infection of definitive hosts occurs through the ingestion of intermediate or paratenic hosts containing encapsulated third-stage larvae (L3). In the stomach, L3 larval excysts and penetrates the gastric mucosa, reaching the thoracic aorta, where it molts to a fourth-stage larva (L4) and migrates to the esophagus. The formation of esophageal

nodules with an orifice are induced, through which females release embryonated and infective eggs, containing first-stage larvae (L1). In the present study, this parasite was only observed in summer and in one neighborhood (Jardim Kennedy). Some authors suggest that spirocercosis can become endemic in certain geographical areas due to several factors, such as climate change, urbanization, and the dissemination of dung beetles (PORRAS-SILESKY *et al*., 2021). The frequency of *S. lupi* is often low, as reported by Gennari *et al*. (1990; 2001) in São Paulo-SP (0,3%; 0,2%) and Oliveira-Sequeira *et al*. (2002) in Botucatu-SP (2%).

Finally, *Balantidium coli* is an intestinal protozoan which affects many species including pigs (considered reservoir hosts), non-human primates, humans, cattle, camels, sheep, goats, horses and rarely cats and dogs, being a zoonotic agent. Ingestion of contaminated water or food and mechanical vectors are also forms of contamination of the parasite (BARBOSA, 2015). Mello (2010) reported the presence of cysts of *Balantidium coli* in 1% of the soil samples collected in public squares frequented by people and animals, results that resemble the low percentages found in the present study (1%). In Ecuador, Gonzalez-Ramirez *et al.* (2021) reported a 1% of positivity in carnivores' feces. In contrast, Albano *et al.* (2016) obtained the *Balantidium coli* as the second most frequent parasite in its research, with a frequency of 6%.

Zone 3 has the highest FL and was the most difficult region to find dog feces in public areas, being the one with the lowest number of samples collected. In addition, the low frequency of parasites found in the feces indicates that there are probably fewer stray dogs in this region, as well as more aware owners who deworm their animals and collect the feces of their dogs on the street. The opposite was observed in the Parque das Jaboticabeiras, since the region had many stray dogs, which probably contributes to the high number of polyparasited samples.

CONCLUSION

All the worms found in the present study, except *S. lupi*, are described as zoonotic parasites and offer risk of infection to humans. Human exposure to feces or soil contaminated with many parasites increases the risk of zoonoses, and the harmful effects can be potentiated due to their joint action. Socioeconomic factors also contribute to maintaining higher levels of transmission, since the occurrence of parasites is more frequent. In addition, those parasites may also be pathogenic to dogs, especially to young ones, and in cases of heavy infections.

The high incidence of positive feces samples for helminths and protozoa confirms the role of dogs, mainly stray dogs, as a source of zoonotic diseases. Special attention should be

given to the high occurrence of *Ancylostoma* spp in the city, especially in the winter, as they are agents that cause CLM.

The adoption of prophylactic and educational measures, allied to the implementation of government programs in Umuarama are necessary to control intestinal parasites in dogs and cats, and reduce environmental contamination with zoonotic parasites. In addition, strategies for population control of homeless dogs, such as setting up new shelters with adequate veterinary care are also important.

CONFLICT OF INTEREST STATEMENT

The authors report no conflict of interest.

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