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An epidemiological study of gastrointestinal parasites of dogs from Southern Greater Buenos Aires (Argentina): Age, gender, breed, mixed infections, and seasonal and spatial patterns

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Abstract

A total of 2193 fecal samples from owned dogs were collected during the 2003–2004 period in Southern Greater Buenos Aires, and were evaluated for the presence of intestinal parasites by a flotation–centrifugation method. The overall prevalence was 52.4%, and the 11 species found were: *Ancylostoma caninum* (13%), *Isospora ohioensis* complex (12%), *Toxocara canis* (11%), *Trichuris vulpis* (10%), *Sarcocystis* sp. (10%), *Giardia duodenalis* (9%), *Isospora canis* (3%), *Hammondia–Neospora* complex (3%), *Dipilydium caninum* (18 cases), *Cryptosporidium* sp. (5 cases), and *Toxascaris leonina* (1 case). There was no significant difference in the overall prevalence between genders (female = 50.4%, male = 54.6%), and breeds (pure = 52.3%, mixed = 53%), but prevalence in puppies (<1 year) was higher than in adult dogs (62.7% versus 40.8%, respectively). Only the prevalence of *A. caninum* differed between genders, with higher values for males. The prevalences of six of the parasite species showed a decreasing trend with increasing host age, and an inverse pattern was found for two other species. The prevalences of three protozoa were significantly higher in pure-breed dogs, and those of two nematodes were significantly higher in mixed-breed dogs. The prevalences of *T. canis*, *A. caninum*, and *T. vulpis* were spatially heterogeneous with a clear Southwest–Northeast gradient. Only prevalences of *Sarcocystis* sp. and *G. duodenalis* showed seasonal variation. The frequency distribution of the number of species per fecal sample did not differ from a random distribution. Results obtained throughout the world were discussed.

Keywords: Dog; Intestinal parasites; Argentina; *Toxocara*; *Ancylostoma*; *Trichuris*; *Giardia*; *Isospora*; *Sarcocystis*; Zoonoses

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1. Introduction

In recent years, numerous surveys have been conducted around the world to investigate the prevalence of intestinal parasites among dogs; e.g., Fok et al. (2001) in Hungary, Minnaar et al. (2002) in South Africa, Ramírez-Barrios et al. (2004) in Venezuela, Asano et al. (2004) in Japan, and Eguía-Aguilar et al. (2005) in Mexico. Each of these provides baseline knowledge on parasitic infections at a local scale. The most common factors used to evaluate association with parasite prevalence in dogs have been age, gender, and breed, but some authors also included seasonal variations and diversity indexes for a more comprehensive analysis (e.g., Oliveira-Sequeira et al., 2002; Eguía-Aguilar et al., 2005). These studies reveal heterogeneous results among regions for species composition, relative prevalences, and factors involved in parasite transmission. For example, when the prevalences of *Toxocara canis* infection were compared between genders, no statistical differences were found in São Paulo (Oliveira-Sequeira et al., 2002), males showed higher prevalence in Maracaibo (Ramírez-Barrios et al., 2004), and both of these outcomes were obtained in different neighborhoods of Buenos Aires (Rubel et al., 2003). Local and updated information is essential to understand the epidemiology of gastrointestinal parasitic diseases in dogs and to design rational control strategies at local, country, or regional scales.

In Argentina, data on overall prevalences of intestinal parasites among dogs derive from fecal or soil samples taken at public places; e.g., La Plata (Minvielle et al., 1993; Córdoba et al., 2002), Mar del Plata (Andresiuk et al., 2003), and the Province of Chubut (Zunino et al., 2000; Sánchez Thevenet et al., 2003). In Greater Buenos Aires, current information on this issue is limited to a study by Rubel et al. (2003) on *T. canis* in dogs from two neighborhoods of different socioeconomic and urban status.

The aim of our study was to provide baseline knowledge about intestinal parasites of dogs in Greater Buenos Aires, the most crowded urban centre of Argentina. We evaluated parasite prevalences regarding the age, gender, and breed of the host, mixed infections, and seasonal and spatial patterns.

2. Materials and methods

2.1. Study area

Greater Buenos Aires includes the Federal District (Buenos Aires City) and the surrounding belt composed of 24 municipalities (INDEC, 2003). The population of this urban agglomeration is over 11 million people. The climate is temperate humid with a mean annual RH of 76% and a mean annual temperature of 15.8 °C (Anonymous, 1992).

The study area comprised six contiguous municipalities in Southern Greater Buenos Aires: Avellaneda (A), Quilmes (Q), Lomas de Zamora (LZ), Lanús (L), Almirante Brown (AB), and Esteban Echeverría (EE) (Fig. 1). It has 2,651,725 inhabitants within a total area of 556 km^2 (INDEC, 2001).

2.2. Methods

A total of 2193 fecal samples from owned dogs were examined for the presence of parasite elements between January 2003 and December 2004. All samples were collected by dogs' owners and submitted by veterinary practitioners to our laboratory (DIAP, Diagnóstico en Animales Pequeños) for diagnosis. Unpreserved samples were stored in closed containers at 4 °C, and processed within 48 h. Each sample was first examined macroscopically for the detection of *Dipylidium caninum* proglottids, and then processed by the centrifugation–flotation Sheather technique (saccharose solution with a density of 1.3 g/ml) (Vignau et al., 2005). All eggs, cysts, and oocysts found were identified according to morphological characteristics under light microscopy (Soulsby, 1987; Mc Allister et al., 1998; Cordero del Campillo and Rojo Vázquez, 1999). A dog was classified as positive if at least one of these elements was present in its stool sample.

Due to the morphological similarity in the oocysts of some species, we considered *Hammondia heydorni* and *Neospora caninum* as *Hammondia–Neospora* complex. Likewise, three species of the genus *Isospora* (syn. *Cystoisospora*), namely *I. ohioensis*, *I. burrowsi*, and *I. neorivolta* were grouped as *Isospora ohioensis* complex.

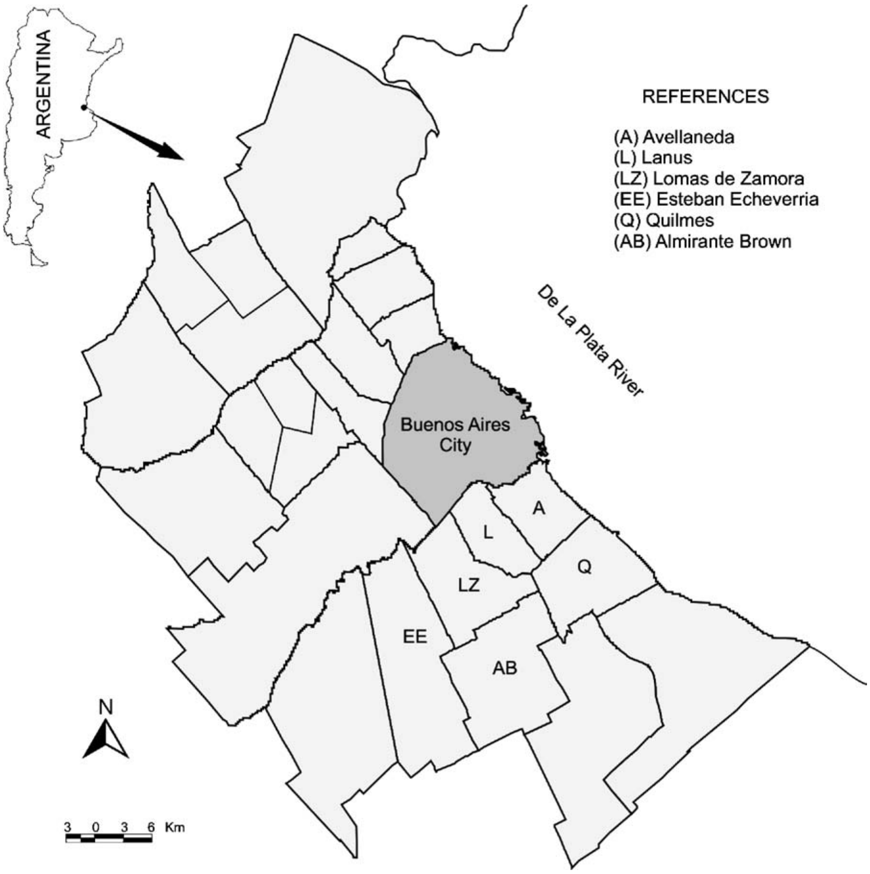

Fig. 1. Location of the six municipalities studied in Greater Buenos Aires, Argentina. Period 2003–2004.

2.3. Data analysis

We defined overall prevalence as the percentage of fecal samples positive for any parasite species, and the specific prevalence as the percentage of fecal samples positive for a given parasite species. Prevalence data from the 2193 fecal samples were regrouped according to age, breed, gender, municipality, and season. Overall prevalence by age was first compared between categories <1-year-old and ≥ 1-year-old, and then among 0–6 months, 7–11 months, 1–6 years, and 7 or more years. Breed was classified as pure-breed and mixed-breed, and gender as male and female.

All statistics calculations were performed with WINPEPI software (Abramson, 2004), and only parasite species with prevalences higher than 1% were included in the analysis. The comparisons of prevalences between dichotomous categories (male versus female, pure-breed versus mixed-breed, and <1-year-old versus ≥ 1-year-old) were made using a χ^2 test for two independent proportions (Fleiss, 1981).

The comparisons among three or more prevalences (involving the four age categories and the six municipalities) were made with the χ^2 test for multiple independent proportions (Fleiss, 1981). To identify groups contributing to significant differences, new tests for multiple proportions were performed using Tukey's procedure (Zar, 1999; Abramson and Gahlinger, 2001). In addition, the increasing or decreasing trend in prevalence with age was evaluated using the Bartholomew's test (Fleiss, 1981; Abramson, 2005).

Seasonal variation in the prevalence of each parasite species was analyzed using monthly data, and values from 2003 and 2004 were combined under the assumption of no long-term trend. We used the following tests for the analysis of seasonality: (a) Freedman's test, to detect departures from uniform occurrence throughout the year; (b) ratchet circular scan test, based on the maximum number of events in two or three consecutive months; and (c) Hewitt's rank-sum test, to detect 4-, 5-, or 6-month seasonal peaks (Abramson, 2005).

In order to determine if the presence of any particular parasite species in a dog was enhanced or diminished by the presence of the others, the frequency distribution of the number of species per sample was tested for a Poisson distribution using a goodness-of-fit test. Associations between species were determined by pairwise comparisons between observed and expected frequencies of mixed infections under the null hypothesis of species independence (i.e., the prevalence of a mixed infection is the product of individual species prevalence) (Sokal and Rohlf, 1969).

3. Results

During the whole study period, 11 parasite species were found from a total of 2193 fecal samples. Among these, 52.4% (1149) included at least one of the parasite species. The overall annual prevalence was similar for both study periods (2003: 591/1079 = 54.8%, 2004: 558/1114 = 50.1%). The highest prevalences were recorded for *Ancylostoma caninum* (13.4%), *I. ohioensis* complex (11.9%), *T. canis* (10.9%), *Trichuris vulpis* (10.1%), *Sarcocystis* sp. (9.8%), and *Giardia duodenalis* (8.9%). The remaining five species found were *Isospora canis* (3.5%), *Hammondia–Neospora* complex (3%), *Dipilydium caninum* (18 cases), *Cryptosporidium* sp. (5 cases), and *Toxascaris leonina* (1 case).

The overall prevalence was significantly higher in <1-year-old dogs than in older dogs (598/953 = 62.7% versus 327/802 = 40.8%, $\chi^2 = 84.378$, $p < 0.001$). A significant decreasing trend was observed when comparing overall prevalences among the four age categories, with 0–6 months puppies showing the highest prevalence (Table 1). Except for *Sarcosystis* sp., specific prevalences differed significantly among age categories. The prevalence of most of the parasite species (*T. canis*, *I. canis*, *I. ohioensis* complex, *Hammondia–Neospora* complex, *Sarcocystis* sp., and *G. duodenalis*) showed a significant decreasing trend with increasing age. *A. caninum* and *T. vulpis* were the only species showing an inverse pattern (Table 1).

Pure- and mixed-breed dogs showed no significant difference in overall prevalence (827/1582 = 52.3% versus 210/396 = 53%; $\chi^2 = 0.072$, $p = 0.788$). However, the specific prevalences of *I. ohioensis* complex, *Hammondia–Neospora* complex, and *G. duodenalis*, were significantly higher in pure-breed dogs, whereas

Table 1
Overall and specific prevalences in dogs by age categories.

	Age categories				Multiple comparisons $\chi^2_{(\mathrm{d.f.}=3)}$	Bartholomew's test for trend χ^2
	0–6 months (*n* = 860) (%)	7–11 months (*n* = 93) (%)	1–6 years (*n* = 583) (%)	6 years (*n* = 219) (%)		
Overall prevalence	64.5 a	46.2 b	41.7 b	38.4 b	96.36***	96.31**
T. canis	18.9 a	12.9 a	3.1 b	1.83 b	109.96***	109.88**
A. caninum	8.5 a	11.8 ab	18.2 b	15.9 b	31.47***	30.76**
T. vulpis	2.4 a	22.6 b	16.1 b	18.3 b	111.57***	107.84**
I. canis	6.2 a	2.2 ab	1.4 b	0.0 b	33.45***	33.45**
I. ohioensis complex	22.8 a	4.3 b	1.9 b	0.0 c	186.07***	186.02**
Hammondia–Neospora complex	4.9 a	1.1 ab	2.1 b	0.5 b	17.05**	16.74**
Sarcosystis sp.	11.2 a	11.8 a	8.2 a	6.4 a	6.78	6.74*
G. duodenalis	16.1 a	5.4 b	3.1 b	0.0 c	98.40***	98.43**

Results of multiple comparisons tests and the Bartholomew's test for trend. Same letters in rows indicate no significant differences ($p > 0.05$) between categories according to the multiple pairwise comparison (Tukey's procedure). Southern Greater Buenos Aires, 2003–2004 period.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 2
Comparison of the specific prevalences by breed and gender of dogs

	Breed			Gender		
	Pure ($n = 1582$) (%)	Mixed ($n = 396$) (%)	χ^2	Male ($n = 1004$) (%)	Female ($n = 977$) (%)	χ^2
T. canis	10.9	9.8	0.348	11.4	10.1	0.770
A. caninum	11.9	17.2	7.860**	16.4	11.1	12.062**
T. vulpis	8.8	14.9	13.137***	10.2	11.0	0.330
I. canis	3.7	3.5	0.034	3.2	3.6	0.237
I. ohioensis complex	13.5	6.8	13.121***	10.5	12.7	2.417
Hammondia–Neospora complex	3.4	1.0	6.427*	3.0	3.0	0.001
Sarcosystis sp.	9.5	11.1	0.951	10.8	9.5	0.832
G. duodenalis	10.1	4.5	11.992**	9.2	8.5	0.274

Southern Greater Buenos Aires, 2003–2004 period.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

those of *A. caninum* and *T. vulpis* were significantly higher in mixed-breed dogs (Table 2).

In regard to gender, there was no significant difference in the overall prevalence between males and females (548/1004 = 54.6% versus 492/977 = 50.4%; $\chi^2 = 3.542$, $p = 0.060$). *A. caninum* was the only parasite showing significant differences between genders, with higher values for males (Table 2).

All species were found in the six municipalities, except for *Cryptosporidium* sp. and *T. leonina*. The overall prevalence showed significant differences among municipalities (Table 3), but further analysis revealed a significant difference only between AB and LZ ($p < 0.05$). The specific prevalences of *I. canis*, *I. ohioensis* complex, *Hammondia–Neospora* complex, and *Sarcocystis* sp. did not differ significantly among municipalities, thus indicating that these parasites were homogeneously distributed over the study area. By contrast, *T. canis*, *A. caninum*, *T. vulpis*, and *G. duodenalis* had a heterogeneous spatial distribution (Table 3). The latter did not show any spatial pattern, with a significant difference only between A and LZ

Table 3
Overall and specific prevalences in dogs by municipality, and results of multiple comparisons tests

	Municipalities						Multiple comparisons $\chi^2_{(\text{d.f.}=5)}$
	A ($n = 547$) (%)	AB ($n = 458$) (%)	EE ($n = 134$) (%)	L ($n = 262$) (%)	LZ ($n = 499$) (%)	Q ($n = 293$) (%)	
Overall prevalence	53.9	57.8	61.9	47.3	48.3	48.1	19.10**
T. canis	14.2	8.9	6.7	12.6	9.8	10.2	12.02*
A. caninum	8.9	19.0	21.6	9.1	13.0	13.6	33.62***
T. vulpis	5.4	14.1	17.9	11.0	10.2	7.5	32.79***
I. canis	3.8	4.5	3.7	1.5	3.6	2.7	5.34
I. ohioensis complex	15.1	11.7	14.1	9.1	10.0	10.9	10.05
Hammondia–Neospora complex	3.1	3.2	5.2	2.2	3.0	2.0	3.77
Sarcosystis sp.	10.4	12.2	9.7	7.2	9.8	7.5	6.92
G. duodenalis	12.4	8.0	6.7	9.5	6.4	8.5	13.52*

Southern Greater Buenos Aires, 2003–2004 period. Municipalities abbreviations: (A) Avellaneda, (AB) Almirante Brown, (EE) Esteban Echeverría, (L) Lanús, (LZ) Lomas de Zamora, (Q) Quilmes.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

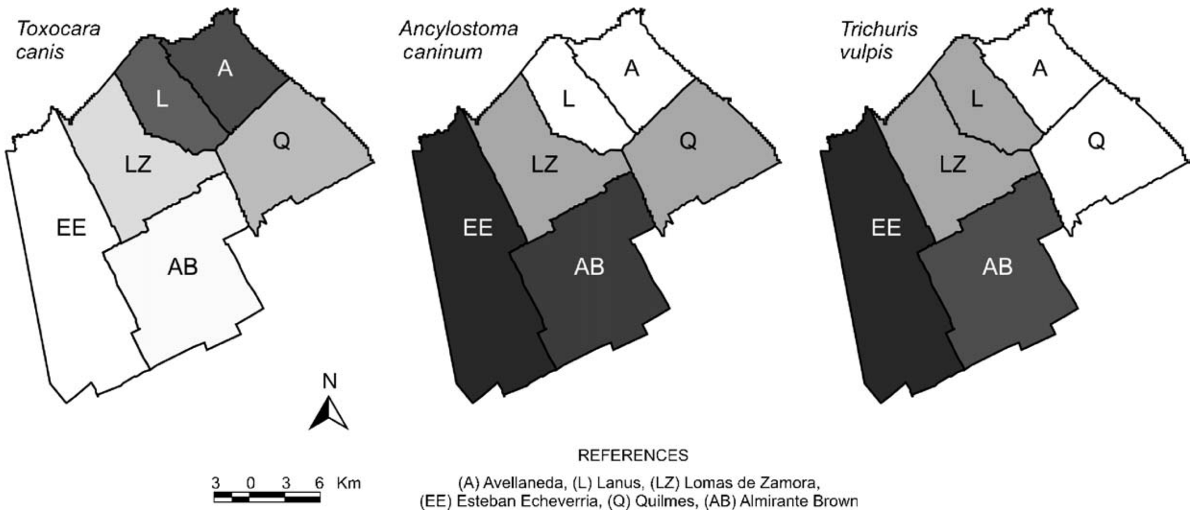

Fig. 2. Spatial patterns of the prevalences of *Toxocara canis*, *Ancylostoma caninum*, and *Trichuris vulpis* in Southern Greater Buenos Aires, Argentina. Period 2003–2004. Dark and light gray represent high and low prevalences, respectively.

($p < 0.05$). The specific prevalences of *T. canis* showed an increasing trend from Southwest to Northeast, whereas an increasing gradient in the opposite direction was observed for *A. caninum* and *T. vulpis* (Fig. 2).

A clear seasonal pattern was only found for *Sarcocystis* sp. and *G. duodenalis* (Table 4). The former had a maximum peak in February–March (end of summer) with 24.5% of cases registered within this period, and 3-month (January–March) and 4-month (January–April) peaks. By contrast, *G. duodenalis* had a maximum peak in August–September (end of winter) with 27.6% of cases registered within this period, and 3-month (July–September) and 5-month (May–September) peaks.

Single and mixed infections occurred in 781 (35.6%) and 368 (16.8%) of the samples, respectively, and up to six parasite species were detected per fecal sample. The frequency distribution of the number of species per fecal sample was described by a Poisson distribution with mean of 0.737 ($\chi^2_{(4)} = 4.856$, $p = 0.302$) (Fig. 3). Therefore, the distribution of the number of species per dog cannot be assumed to be significantly different from a random distribution.

All species occurred concurrently in mixed infections, except for the less frequent parasites (*D. caninum*, *Cryptosporidium* sp., and *T. leonina*). Significant associations were found for eight pairwise combinations (Table 5). *I. ohioensis* complex was more frequently observed with *I. canis*, *Hammondia–Neospora* complex, and *T. canis* than expected at random. A similar pattern was observed for *T. canis* with *G. duodenalis*, and *T. vulpis* with *A. caninum*. Negative pairwise associations (i.e., less frequent than expected at random) were found between *T. vulpis* and the *I. ohioensis* complex, and between *A. caninum* and *G. duodenalis* or the *I. ohioensis* complex.

4. Discussion

The large number of parasite species registered in our survey (11) was within the range of 6–12 species documented worldwide (Causapé et al., 1996; Anene et al., 1996; Fok et al., 2001; Oliveira-Sequeira et al., 2002; Minnaar et al., 2002; Asano et al., 2004; Ramírez-Barrios et al., 2004; Eguía-Aguilar et al., 2005). The overall prevalence estimated in this work was high (52.4%), considering that only owned dogs with access to a veterinary clinic were analyzed. This value was also included within the wide range reported previously; e.g., 28.7% in Australia (Bugg et al., 1999), 35.5% in Venezuela (Ramírez-Barrios et al., 2004), 34.8–42% in United States (Kirkpatrick, 1988; Coggins, 1998), 18–42% in Japan (Asano et al., 2004), 53% in Hungary (Fok et al., 2001), 68% in Nigeria

Table 4
Specific prevalences (in percentage) by month, and results of tests for seasonality

	Month												Tests for seasonality					
	January (183)	February (172)	March (173)	April (161)	May (189)	June (176)	July (177)	August (215)	September (180)	October (190)	November (187)	December (187)	Freedman's V(N); P	Ratchet circular scan		Hewitt's rank-sum		
														2-m peak	3-m peak	4-m peak	5-m peak	6-m peak
T. canis	13.7	10.5	11.6	11.8	11.1	8.0	17.5	7.9	10.0	13.7	7.5	9.1	0.047; >0.1	>0.1	>0.1	>0.05	>0.05	>0.05
A. caninum	11.5	14.5	12.1	16.8	14.3	12.5	13.6	13.0	10.6	17.4	13.4	11.8	0.030; >0.1	>0.1	>0.1	>0.05	>0.05	>0.05
T. vulpis	12.0	9.3	8.7	7.5	8.5	10.8	9.6	13.5	11.7	9.5	10.7	8.6	0.066; >0.1	>0.1	>0.1	>0.05	>0.05	>0.05
I. canis	3.8	1.7	4.6	3.1	2.6	3.4	3.4	3.3	6.1	2.1	3.7	4.3	0.068; >0.1	>0.1	>0.1	>0.05	>0.05	>0.05
I. ohioensis complex	15.3	9.9	16.2	13.7	12.2	9.1	11.3	9.3	10.6	10.5	9.6	16.6	0.070; >0.1	>0.1	>0.1	>0.05	>0.05	>0.05
Hammondia–Neospora complex	2.2	4.1	5.2	3.1	3.2	1.7	4.0	0.9	3.9	4.2	0.5	3.7	0.080; >0.1	>0.1	>0.1	>0.05	>0.05	>0.05
Sarcosystis sp.	12.6	15.7	15.0	13.0	6.9	9.1	11.3	5.6	12.2	7.4	5.3	6.4	0.120; <0.01	February–March <0.01	January–March <0.05	January–April >0.05	>0.05	<0.005
G. duodenalis	1.6	5.2	5.8	6.8	11.6	12.5	9.0	13.5	13.9	8.4	8.6	9.1	0.163; <0.01	August-Sepember <0.05	July-September <0.01	>0.05	May–September <0.01	>0.05

Southern Greater Buenos Aires, 2003–2004 period. Values from 2003 and 2004 were combined under the assumption of no long-term trend. Number of fecal samples within brackets.

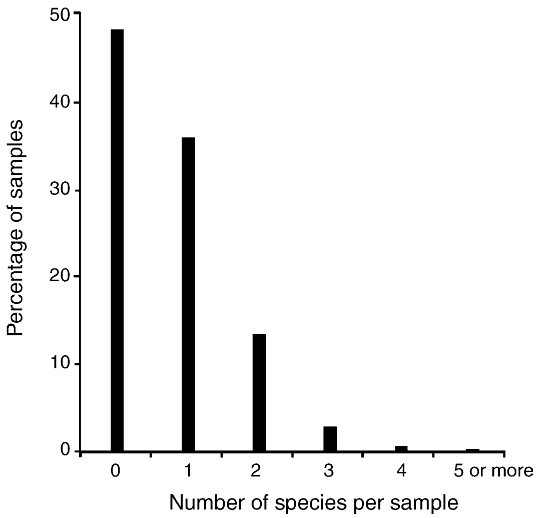

Fig. 3. Percentage of fecal samples with different number of parasite species. Southern Greater Buenos Aires, Argentina. Period 2003–2004.

(Anene et al., 1996), and 85% in Mexico (Eguía-Aguilar et al., 2005).

In regard to species composition, we found five helminths (four nematodes and one cestode) and six protozoa (five coccidia and one flagellate). *A. caninum*, *T. canis*, *T. vulpis*, *I. ohioensis* complex, *Sarcocystis* sp., and *G. duodenalis* were the most frequent parasites and registered similar prevalences. A summary of their prevalences in different countries from different regions over the world is given in Table 6. It can be observed that: (a) specific prevalences registered in Buenos Aires were higher (*T. vulpis* and *Sarcocystis* sp.), lower (*T. leonina* and *D. caninum*), or within the range (*T. canis* and *Ancylostoma* sp.) than those in other reports; (b) none of the eleven parasites found herein registered similar prevalences throughout the world; (c) the most frequent species vary according to the survey; e.g., *Ancylostoma* spp. in Brazil, *D. caninum* in South Africa, and *Giardia* spp. in Australia. In conclusion, the great variability in species composition, specific prevalences and most frequent species, points out the necessity of being cautious in extrapolating data from one location to another.

However, some general assumptions can be made regarding host gender over different world regions, including our study area. The overall and specific prevalences between males and females are almost alike, except for *Ancylostoma* spp. (Visco et al., 1977; Venturini and Radman, 1988; Anene et al., 1996; Coggins, 1998), and *T. canis* (Visco et al., 1977; Rubel et al., 2003; Ramírez-Barrios et al., 2004). The only statistical difference found in our study was a significantly higher prevalence of *A. caninum* among males, in agreement with the study by Venturini and Radman (1988) conducted in La Plata City, close to the study area.

Pure- and mixed-breed dogs did not show differences in their overall prevalences, but three protozoan species were more frequent in pure-breed dogs and two nematode species in mixed-breed dogs. In São Paulo, Oliveira-Sequeira et al. (2002) found higher prevalences of *T. canis* and *Isospora* spp. in mixed-breed dogs than in pure-breed dogs, but most of the latter had owners and received better veterinary care. We consider that variables ‘‘with or without owner’’ and ‘‘pure or mixed-breed’’ are highly associated with each other and therefore they should not be examined independently. In our survey, differences between pure- and mixed-breed dogs cannot be attributed to health care access or owner’s social status because all samples were taken from owned dogs attending at a veterinary clinic.

Although researchers have grouped the age of the host into dissimilar categories, there is general consensus that the prevalence of intestinal parasites is higher in pups than in adults. In our study, the prevalences of *T. canis*, *I. canis*, *I. ohioensis* complex, *Hammondia–Neospora* complex, *Sarcocystis* sp., and *G. duodenalis* showed a decreasing trend with age, whereas those of *A. caninum* and *T. vulpis* showed an increasing trend. Similar results were previously reported for *T. canis*, *Isospora* spp., *A. caninum*, *T. vulpis*, and *Giardia* sp. (Visco et al., 1977; Venturini and Radman, 1988; Anene et al., 1996; Coggins, 1998; Fok et al., 2001; Ramírez-Barrios et al., 2004; Eguía-Aguilar et al., 2005). Pups are at higher risk of infection due to transplacental and transmammary transmission (Schantz, 1999), and parasite-specific immunity is usually acquired with age, probably as a consequence of single or repeated exposures (Ramírez-Barrios et al., 2004). Higher infection rates in older hosts could be caused by parasite species that are not transmitted to dogs at early age or by parasites that do not elicit an immune response.

Table 5
Comparisons between observed and expected (at random) prevalences of mixed infections

	Mixed infection observed	Mixed infection expected	$\chi^2_{(1)}$
T. canis–A. caninum	45	32	2.23
T. canis–T. vulpis	24	24	0.00
T. canis–I. canis	13	8	1.20
T. canis–I. ohioensis complex	50	29	5.68*
T. canis–Hammondia–Neospora complex	9	7	0.25
T. canis–Sarcosystis sp.	19	24	0.59
T. canis–G. duodenalis	37	21	4.47*
A. caninum–T. vulpis	77	30	21.16***
A. caninum–I. canis	7	10	0.53
A. caninum–I. ohioensis complex	20	35	4.14*
A. caninum–Hammondia–Neospora complex	10	9	0.05
A. caninum–Sarcosystis sp.	25	29	0.30
A. caninum–G. duodenalis	10	26	7.17**
T. vulpis–I. canis	6	8	0.29
T. vulpis–I. ohioensis complex	8	26	9.60**
T. vulpis–Hammondia–Neospora complex	6	7	0.08
T. vulpis–Sarcosystis sp.	19	22	0.22
T. vulpis–G. duodenalis	10	20	3.36
I. canis–I. ohioensis complex	26	9	8.32**
I. canis–Hammondia–Neospora complex	2	2	0.00
I. canis–Sarcosystis sp.	8	8	0.00
I. canis–G. duodenalis	13	7	1.81
I. ohioensis complex–*Hamondia-N.* complex	21	8	5.87*
I. ohioensis complex–*Sarcosystis* sp.	40	26	3.02
I. ohioensis complex–*G. duodenalis*	36	23	2.90
Hammondia–Neospora complex–*Sarcosystis* sp.	9	7	0.25
Hammondia–Neospora complex–*G. duodenalis*	13	6	2.59
Sarcosystis sp.–*G. duodenalis*	15	19	0.47

Southern Greater Buenos Aires, 2003–2004 period.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

The spatial distribution of the prevalences of intestinal parasites of dogs has been rarely treated in the veterinary literature. The homogeneity or heterogeneity of the spatial distribution of a disease may indicate if data can be extrapolated to neighboring areas. For example, the fact that Northern and Southern areas of Mexico City share nine helminth species and that *A. caninum* is the dominant species at both sites (Eguía-Aguilar et al., 2005), may suggest a similar outcome in other parts of the city. In Southern Greater Buenos Aires, the prevalence of protozoan species showed a homogeneous distribution, and that of nematodes *T. canis*, *A. caninum*, and *T. vulpis*, a marked Southwest–Northeast trend. These spatial heterogeneities are probably related to habitat differences among municipalities, which can affect the free-living stages of nematodes. However, we cannot discard that the spatial trends observed for these nematodes were related to differences in the proportion of fecal samples of puppies among municipalities. Factors influencing spatial differences will be matter of a future investigation.

Seasonal variation in the prevalences of *Ancylostoma* spp. with a peak of abundance at different times of the year was found in different cities; e.g., summer–autumn period in São Paulo (Oliveira-Sequeira et al., 2002), dry season in Maracaibo (Ramírez-Barrios et al., 2004), summer in Brisbane (McCarthy and Moore, 2000), and spring–summer in Pennsylvania (Kirkpatrick, 1988). In our survey, monthly preva-

Table 6
Prevalences (in percentage) of canine intestinal parasites from countries of different regions of the world

	Argentina[a] (%)	Brazil[b] (%)	Venezuela[c] (%)	Mexico[d] (%)	Japan[e] (%)	Nigeria[f] (%)	South Africa[g] (%)	Spain[h] (%)	Australia[i] (%)
T. canis	10.9	5.5	11.4	13.3	5.7	31.5	19	3.7	1.7
Ancylostoma spp.	13.4	23.6	24.5	62.5	5.6	37.6	25	6.2	1.9
T. vulpis	10.1	4.8	2.9	–	4.4	3.6	–	3.7	–
T. leonina	0.05	–	–	4.2	–	–	31.7	2.5	–
D. caninum	0.8	0.74	2.3	60	2	11.2	44.4	2.5	0.2
Giardia spp.	8.9	12.8	–	–	1.2	–	–	4.9	22.1
I. canis	3.5	–	8.1 (*Isospora* spp.)	–	–	–	–	9.9 (*Isospora* spp.)	6.9
I. ohioensis complex	11.9	–		–	–		–		4.5
Hammondia–Neospora complex	3	2.6	–	–	–	18.3 (Coccidia)	–	–	1.7
Sarcosystis sp.	9.8	2.2	–	–	–		–	1.2	6.2
Cryptosporidium sp.	0.23	–	–	–	0.4		–	7.4	–
Other species (number)	–	2	3	5	2	1	2	1	1

[a] Present study, Southern Greater Buenos Aires.
[b] Oliveira-Sequeira et al. (2002).
[c] Ramírez-Barrios et al. (2004).
[d] Eguía-Aguilar et al. (2005).
[e] Asano et al. (2004); only the last year (2002) was used in our study. *D. caninum* was not differentiated from *Taenia taeniaeformis*.
[f] Anene et al. (1996).
[g] Minnaar et al. (2002).
[h] Causapé et al. (1996).
[i] Bugg et al. (1999).

lences of *A. caninum* were similar throughout the year. Only *G. duodenalis* and *Sarcocystis* sp. showed a seasonal pattern of prevalence with peaks at the end of winter and summer, respectively. In Italy, Bianciardi et al. (2004) reported that *Giardia* infection in dogs was higher in winter, probably because summer conditions are not favorable for cyst survival. Similarly, in Pennsylvania, Kirkpatrick (1988) found that infection of dogs with *Giardia* was higher in autumn and winter, but no seasonality was observed by Nolan and Smith (1995) in the same area.

Mixed infections may play an important role in the epidemiology of parasitic diseases because they reveal the proportion of dogs requiring combined drug treatment; this is the case for about one out of five dogs in Buenos Aires. The distribution of the number of species per dog followed a randomly distributed pattern, i.e., the presence of any particular parasite species in a dog was not enhanced or diminished by the presence of the others. This result is as expected, since interaction among species (e.g., competence) would depend on parasite burden rather than on the mere presence of other species. We found five positive and three negative associations, but data of parasite burden are needed for a better understanding of these findings. However, the strongest species association observed (*Ancylostoma* and *Trichuris*) was previously reported in North America (Visco et al., 1977; Nolan and Smith, 1995).

In Argentina, the main source of information on canine intestinal parasites is provided by surveys involving soil or fecal samples from public places such as squares and parks (Minvielle et al., 1993; Sommerfelt et al., 1994; Castro et al., 1997; Fonrouge et al., 2000; Zunino et al., 2000; Alonso et al., 2001; Milano and Oscherov, 2001; Córdoba et al., 2002; Andresiuk et al., 2003; Sánchez Thevenet et al., 2003). Although these studies contribute with valuable information on the diversity, geographical distribution and relative abundances of parasite species, data do not allow to estimate the actual prevalence of parasites in dog populations. Previous works conducted in Buenos Aires City, reported *Toxocara* sp., *Ancylostoma* sp., and coccidia as the most frequent species (Sommerfelt et al., 1994; Castro et al., 1997). In a study similar to ours carried out in the neighboring city of La Plata, Venturini and Radman (1988), found an overall prevalence of 45%, with prevalence of *A. caninum* higher than that of *T. canis*. In addition, their results regarding gender and age were comparable to the ones obtained in this study. Parasite species found in the Northern Provinces of Corrientes, Chaco, and Misiones, were the same as in Buenos Aires but with higher overall prevalences ranging between 60% and 100% (Lombardero and Santa Cruz, 1986; Maubecin and Mentzel, 1995; Taranto et al., 2000; Milano and Oscherov, 2001), probably due to more favorable climatic conditions. On the contrary, overall prevalences ranged between 13% and 47% in the Southern Patagonian Province of Chubut (Zunino et al., 2000; Sánchez Thevenet et al., 2003).

The diversity of results obtained from different regions of the world, and even from studies conducted in nearby locations, highlights the importance of promoting research at local scale for planning control strategies. However, the low number of samples collected in some of the surveys may also account for differences in the results. In our survey, the size of the dog population is expected to be large enough to draw reliable conclusions. On the other hand, our study only included owned dogs and the role of stray dogs in the ecoepidemiology of parasitic diseases is still a pending subject. Another factor affecting the comparison and interpretation of results is the sensitivity of the diagnostic techniques. We probably underestimated the prevalence of *D. caninum* because the centrifugation–flotation method is unsuitable for the detection of cestodes (Robertson et al., 2000). In addition, higher prevalences of *Cryptosporidium* could be detected using a specific stain method as the modified Ziehl–Neelsen.

Among the parasites found in our survey, *Toxocara*, *Giardia* and *Cryptosporidium* are responsible for important zoonoses. In Argentina, human toxocarosis has recently been documented by several researchers, with 20–38% of the children population and 10–39% of the general population seropositive to *Toxocara* (Alonso et al., 2000; Minvielle et al., 2000; Radman et al., 2000; Taranto et al., 2000). The high prevalence of *Giardia* (9%) registered in the dog population from Buenos Aires highlights a potential risk to human health. Regard to *Cryptosporidium*, its zoonotic role is well known but we detected only a few canine cases. The relevance of the remaining parasites as zoonotic agents has not been reported yet in the country, although some cases of cutaneous larva migrans caused by *Ancylostoma* sp. were recorded in the North (Alonso et al., 2001).

Veterinarians should play an important role in increasing the level of awareness of canine zoonotic parasites, thus helping to prevent or minimize zoonotic transmission (Bugg et al., 1999; Robertson et al., 2000; Irwin, 2002). However, communication among veterinarians, physicians, and dogs' owners or human patients seems to be insufficient (McCarthy and Moore, 2000). In Argentina, veterinary practitioners acting as information sources about canine zoonoses are also required, but there are basic priorities that should be considered first. So far, data are mainly limited to few urban areas and no information is available for large territories of the country with more suitable socio-economic and environmental conditions for parasite transmission. Multidisciplinary approaches will lead to a more complete understanding of the actual epidemiological situation in the country.

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