Chapter

The State of Knowledge on Intestinal Helminths in Free-Roaming Dogs in Southern South America

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Abstract

In South America there are more dogs per person than in developed countries. Many owners allow their dogs to roam freely in public areas, which favours the spread of zoonotic diseases. The objective of this work is to describe, through bibliographic analysis, the occurrence, prevalence, species richness, and distribution of intestinal helminth parasites found in dog faeces from urban and rural areas of southern South America (Argentina-Chile-Uruguay). Using three databases, we performed a systematic review of articles published between 2000 and 2020 in indexed journals. A total of 219 articles was evaluated for eligibility, and of these 67 were included in the final analysis; 48 correspond to Argentina, 17 to Chile, and 2 to Uruguay. The total number of parasite taxa recorded was 22, the most frequently occurring species being *Toxocara canis*, *Ancylostoma* sp., *Trichuris vulpis* and *Echinococcus* sp. Species richness was correlated with sample size and varied between 1 and 10 species. In addition, disease risk is not homogeneously distributed. Due to the high infection levels in dogs, urban and rural dwellers are at risk of infection with zoonotic diseases transmitted by these animals, therefore a One Health approach to public health would be advisable.

Keywords: Argentina, Chile, Uruguay, Helminths, Canine faeces, *Toxocara canis*, *Echinococcus granulosus*, *Ancylostoma caninum*, *Trichuris vulpis*, systematic bibliographic review, zoonotic risk

1. Introduction

1.1 Dog populations

Humans and dogs share a long history and were probably associated with European early-modern humans [1], coexisting indoors and outdoors and colonising new environments, often in cooperation [2]. From ancient times dogs have been used by humans as tools for different purposes, such as hunting, gathering food, caring for livestock, protection, and more recently as detectors of explosives and drugs, as companion animals, or as assistants for people with various types of disease or disability [3–5]. Therefore, their coexistence has been wide-ranging, and has generated numerous opportunities for around 260 zoonotic diseases to emerge between dogs and humans [2, 6].

There are almost one billion dogs worldwide [7], but the relationship between the numbers of people and dogs varies according to the geographic area and socioeconomic conditions of each country or region [8]. In developed countries the human to dog ratio varies from 6 to 10:1 according to the World Health Organisation [9]; in Italy the human:dog ratio is 9:1 [10], and in the United States it is 3.6:1 [11]. The dog population in South America is very large, around 87.6 million. In Brazil in particular there are 44.9 million children aged under 14 years, and an estimated total of 52.2 million dogs, which means there are more dogs than children [12]. In Argentina, a survey carried out for food companies determined that there are approximately 9 million dogs, and that 78% of households have a dog, whose function is mainly exclusively companionship [13]. The situation in Chile is similar, where the dog population is around 3.5 million and 64% of households have at least one [14], while in Uruguay the dog population is 1.75 million and 72% of households own a dog [15].

To encourage responsible ownership of this large number of dogs, it was necessary to enact laws indicating what responsible dog care implies (Argentina: Decree 1088/11; Chile: No. 21.020/17; Uruguay: No. 1189/14). Animal welfare thus imposes obligations on the owner, which include vaccinations, deworming, neutering, adequate food, and keeping pets confined to the household or taking them outside on a lead, thus preventing them from roaming freely. It should be noted that in most localities of these countries these laws are not enforced effectively [16].

1.2 Dog care

Although national laws have been promulgated several years ago, knowledge of them and the care received by dogs is far from adequate [17–20]. The biggest problem in these countries is that dogs are allowed to roam freely in public areas, and this is associated with education, socio-economic level, the idiosyncrasy and customs of each country, the role the dog plays within the family, and the low importance that people give to how their dog can affect other people or animals [21]. In addition, allowing dogs to roam freely is strongly correlated with other aspects of dog care, such as a lack of appropriate vaccination and deworming treatment [21]. The care given to dogs that roam freely is poorer than for dogs which are confined, and they are rarely taken to the vet due to the high cost that this represents [22]. In Chile, the average cost spent per pet for annual veterinary check-ups, diagnoses, vaccines and treatment is US$ 330 [4], while in Argentina this cost is around US$ 100 annually (personal observation). The percentage of vaccinated dogs is low, even when there is a possibility of rabies contagion [14, 23], and the frequency of deworming is in most cases inadequate considering that dogs can roam freely on public roads, becoming reinfected [23–25]. The percentage of animals that are neutered is also insufficient, despite the national or local neutering programs run in the three countries [21, 26, 27]. Neutered animals represent less than half the dog population [21, 23, 28] and the majority are older than 3 years; in many cases dogs are allowed to have at least one litter of offspring [23].

1.3 Dogs, parasites and diseases

One Health is recognised as a valuable paradigm for global health management, and seeks the integration of human and animal health. The risk of transmission of a zoonotic disease from dogs to humans is related to the abundance of infectious forms in the environment, climatic conditions, whether dogs roam freely, and the behaviour of humans that exposes them to infective sources [29, 30]. It has been observed that free-roaming dogs are more exposed and prone to acquiring parasites [24, 31–33]. In Chile, rural dogs are associated with agricultural and livestock activities. They are unsupervised, have freedom to roam and are given limited veterinary care [34]. In Argentina, parasite richness and prevalence are positively associated with free-roaming animals, and only a small proportion of dogs (17%) is subjected to some degree of movement restriction [20]. In the cities of Argentinian Patagonia, another important factor that promotes infection by zoonotic parasites, mainly cystic echinococcosis, is the domestic slaughter of small ruminants for human consumption. This practice occurs frequently in rural areas and the peripheral low-income neighbourhoods of cities, where dogs are fed with the raw offal of sheep and goats [35, 36]. The vast majority of parasites registered in South America are cosmopolitan zoonotic parasites transmitted through dog faeces, such as *Toxocara canis*, *Ancylostoma caninum*,*Toxascaris leonina*, *Echinococcus* spp., and *Dipylidium caninum*, which are common parasites in dogs worldwide [12]. Zoonotic parasitic infections in dogs are a public health issue not only in developing countries but also in developed nations, such as in the USA and European countries [37, 38]. Other parasites like *Trichuris vulpis* are distributed worldwide, but are rarely transmitted to humans [39]. Some human parasites like *Ascaris lumbricoide*s and *Strongyloides stercoralis* are occasionally reported in dogs [40, 41]. Therefore, worldwide, dogs may harbour zoonotic parasites that affect the health and wellbeing of humans, their distribution being linked to poverty, poor knowledge of sanitary practices, insufficient hygiene and problems with unconfined and untreated dogs [42]. Pet diseases may pose risks to human health but are rarely included in surveillance systems. Although pet-borne infections have become increasingly relevant to human health, systematic notification of these infections is not currently conducted, except for rabies and Echinococcosis in some countries [22, 43].

Southern South America is a region with varied geography and climate and marked altitudinal and latitudinal differences; for example, plains (Pampas in Argentina and Uruguay), arid plateaus (Patagonia), forests (Patagonia and northeastern Argentina), and mountains of high altitude between Argentina and Chile (the Andes). The climate ranges from humid tropical in northern Argentina and Uruguay, arid in northern Chile, to humid cold in the south of Argentina and Chile. This climatic variety favours the distribution and occurrence of different parasites. On the other hand, the socio-economic condition of a large part of the population is characterised by poverty and a low-income economy. This scenario is accompanied by a lack of parasitological studies, surveillance and zoonosis control plans on the part of public health organisations [44].

The objective of this work is to describe, through bibliographic analysis, the occurrence, prevalence, species richness, and distribution of intestinal helminth parasites found in dog faeces in urban and rural areas of southern South America (Argentina-Chile-Uruguay).

2. Materials and methods

2.1 Search approach

Three databases (PubMed, Google Scholar and Scopus) were searched for studies published between 2000 and 2020. The search terms were "dog AND parasite AND Argentina"; "dog AND parasite AND Chile"; and "dog AND parasite AND Uruguay".

The Google Scholar search in particular returned a large number of results, of which the first 700 titles were read (and in some cases the abstract); however, it was observed that after the first 200 no results were found that met the search requirements.

2.2 Paper assortment

The studies to be included were identified independently by two reviewers, and were confirmed by a third reviewer following standardised methodology [45]. The studies included met the following criteria: (1) full text articles available online; (2) published between 2000 and 2020; (3) peer-reviewed, original papers published either in English or Spanish; (4) cross-sectional studies that assessed the prevalence of any intestinal helminth parasite of dogs in Argentina, Chile or Uruguay; (5) studies that detected parasite infection in faeces using at least one parasitological, serological and/or molecular method; (6) studies that reported sample sizes, and the prevalence of each parasite species. Reviews and case reports were excluded. The following data were extracted from each article: authors, publication year, country, localities (coordinates), type of locality (rural/urban), sample size, detection method, prevalence of each parasite, number of parasite species.

2.3 Parasite distribution

The distribution maps were constructed using the Free and Open Source Geographic Information System (QGis system). The coordinates for the site locations were taken from the selected works or were completed using Google Earth. The prevalence values shown on the maps were obtained from the studies included in the bibliographic review. The map of South America was obtained from shape files from *Instituto Geográfico Nacional* [46].

2.4 Statistical analysis

Spearman's rank Correlation Tests were performed to analyse the relation between richness, with sample size and latitude. All sites with richness = 1 were excluded, since they searched for only one parasite.

3. Results

From the search in the 3 databases, 29,450 scientific items were found. Of these, 24,517 belong to the period between 2000 and 2020. After analysing the titles and abstracts, 24,298 articles were excluded because they did not comply with the objectives or inclusion criteria, did not include helminths, did not correspond to the countries under study, or were not cross-sectional studies. A total of 219 articles were evaluated for eligibility. After removing the duplicates, 67 were included in the final analysis (**Table 1**), and the full texts of these relevant articles were reviewed in depth. Forty-eight corresponded to Argentina, 17 to Chile, and 2 to Uruguay (**Figure 1**). The data come from analysis of 32,300 dog faeces collected in urban or rural sites of the 3 countries. Sample sizes in the different studies ranged from 4 to 2,417, except for Uruguay where 5,356 faeces were analysed for the National Echinococcosis Control Programs, without considering the presence of other parasites (**Table 1**).

The number of copro-parasitological techniques used in each study varied between 1 and 3, with a total of 15 different methods (**Table 1**). The most

Autor	Año	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris sp.*	*Dibothriocephalus* sp.	*Dipylidium* caninum	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Acosta Jamett et al. [47]	2010	Chile	Tangue	30°20'S, 71°34'W	120		ELISA	1	rural		1							10															
Acosta Jamett et al. [47]	2010	Chile	Guanaqueros	30°11'S, 71°25'W	81		ELISA	1		urban	0																						
Acosta Jamett et al. [47]	2010	Chile	Coquimbo	29°57'S, 71°20'W	128		ELISA	1		urban	1							15															
Acosta Jamett et al. [48]	2014	Chile	Combarbalá	31°10′S, 71°03′W	52		CoproElisa	1		urban	1							27															
Andresiuk et al. [49]	2007	Argentina	Mar del Plata	37°56'S, 57°35'W	400		Willis Flotation	1		urban	3		62.8																13.9	46.75			
Andresiuk et al. [50]	2003	Argentina	Mar del Plata	38°00′S, 57°33′W	125		Flotation, sedimentation of Willis	1		urban	4		62.96	24.07							2.56								22.22	62.96			
Andresiuk et al. [29]	2004	Argentina	Mar del Plata	38°00′S, 57°33′W	288		Flotation, sedimentation of Willis	1		urban	3			65.83															14.17	46.67			
Archelli et al. [51]	2018	Argentina	Ensenada	34°51′S, 57°54′W	217	Formol 10%	Sedimentation of Teleman and Flotation of Sheater	2		urban	1																		23.0				
Arezo et al . [36]	2020	Argentina	Bariloche	41°10'S, 71°18'W	1780		coproElisa Echinococcus	1	rural		1							1															
Arezo et al . [36]	2020	Argentina	El Bolson	41°58′S, 71°32′W			CoproElisa	1	rural																								
Arezo et al. [36]	2020	Argentina	Comallo	41°02′S, 70°16′W			CoproElisa	1	rural		1							1															
Arezo et al. [36]	2020	Argentina	El Cuy	39°56′S, 68°20′W			CoproElisa	1	rural		1							1															
Arezo et al. [36]	2020	Argentina	Ing. Jacobacci	41°18′S, 69°35′W			CoproElisa	1	rural		1							1															
Arezo et al. [36]	2020	Argentina	Maquinchao	41°15′S, 68°42′W			CoproElisa	1	rural																								
Arezo et al. [36]	2020	Argentina	Los Menucos	40°50′S, 68°05′W			CoproElisa	1	rural		1							1															
Arezo et al. [36]	2020	Argentina	Ñorquinco	41°51′S, 70°54′W			CoproElisa	1	rural		1							1															
Arezo et al. [36]	2020	Argentina	Pilcaniyeu	41°07′S, 70°43′W			CoproElisa	1	rural		1							1															

Autor	Año	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris sp.*	*Dibothriocephalus* sp.	*Dipylidium* caninum	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Arezo et al. [36]	2020	Argentina	Ramos Mexia	40°30′S, 67°17′W			CoproElisa	1	rural		1							1															
Arezo et al. [36]	2020	Argentina	Sierra Colorada	40°35′S, 67°45′W			CoproElisa	1	rural		1							1															
Arezo et al. [36]	2020	Argentina	Sierra Grande	41°36′S, 65°21′W			CoproElisa	1	rural																								
Arezo et al . [36]	2020	Argentina	Valcheta	40°42′S, 66°09′W			CoproElisa	1	rural		1							1															
Armstrong et al. [52]	2011	Chile	Temuco	37°24′S, 72°31′W	196		Flotation with zinc	1		urban	4												9.3			4.7			12.4	4.7			
Casas et al. [53]	2013	Argentina	La Quiaca	22°06′S, 65°36′W	89		Copro, Elisa and WB	2		urban	1							2.2															
Castillo et al. [54]	2000	Chile	Santiago de Chile	33°27′S, 70° 40′W	288	Formol salino	Telemann modified, using ethandl acetate	1		urban	4		4.5		0.7														13.5	7.3			
Chiodo et al. [55]	2006	Argentina	General Mansilla	35°04′S, 57°44′W	81		Sedimentation of Teleman modified	1	rural		1																		6.17				
Cociancic et al. [56]	2017	Argentina	La Plata	34°56′S, 57°57′W	78		Sedimentation of Ritchie and Flotation of Willis	2		urban	7		69.2	41.0			1.3				1.3							1.3	21.8	28.2			
Cociancic et al. [32]	2020	Argentina	Ushuaia	54°48′S, 68°18′W	80	Formol 5%	Sedimentation and Flotac	2		urban	7			1.3				2.5											5.0	1.3			
De Costas et al. [57]	2014	Argentina	Tumbaya	23°51′S, 65°28′W	222		Copro, Elisa and WB	2			1							11.7															
De Costas et al. [57]	2014	Argentina	Humahuaca	23°12′S, 65°21′W	18		Copro, Elisa and WB	2			1							27.7															
De Costas et al. [57]	2014	Argentina	Tilcara	23°34′S, 65°23′W	64		Copro, Elisa and WB	2			1							14.0															
De Costas et al. [57]	2014	Argentina	Cochinoca	22°44′S, 65°53′W	94		Copro, Elisa and WB	2			1							9.5															
De Costas et al. [57]	2014	Argentina	Susques	23°24′S, 66°22′W	50		Copro, Elisa and WB	2			1							2.0															
De Costas et al. [57]	2014	Argentina	Santa Catalina	21°56′S, 66°03′W	28		Copro, Elisa and WB	2			1							10.7															
De Costas et al. [57]	2014	Argentina	Yavi	22°07′S, 65°27′W	47		Copro, Elisa and WB	2			1							14.8															

Autor	Año	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris sp.*	*Dibothriocephalus* sp.	*Dipylidium* caninum	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Dopchiz et al. [58]	2013	Argentina	Lobos, Bs As	35°10′S, 59°05′W	42	Formol 10%, freezado	Sedimetation of Ritchie, Flotation of Sheater and CoproElisa	3	rural		6		11.9	14.29				19.05	26.19											26.19			
Enriquez et al. [59]	2019	Argentina	Pampa del Indio, Chaco	26°02′S, 59°55′W	85	SAF solution	Flotation with NaCl and Sedimentation	2		urban	8		68.2				2.4				1.2			5.9	5.9				14.1	3.5	15.3		
Flores et al. [35]	2017	Argentina	Bariloche	41°10′S, 71°18′W	118		Sheater Flotation	1		urban	9		47.0			16.9	0.8	9.3			5.1		2.5					11.9	12.7	39.0			
Fontanarosa et al. [60]	2006	Argentina	Lanus	34°22′S, 58°22′W	262		Sheater Flotation	1		urban	5		9.1															0.05	12.6	11			
Fontanarosa et al. [60]	2006	Argentina	Avellaneda	34°39′S, 58°22′W	547		Sheater Flotation	1		urban	5		8.9				0.8												14.2	5.4			
Fontanarosa et al. [60]	2006	Argentina	Alte Brown	34°50′S, 58°23′W	458		Sheater Flotation	1		urban	5		19																8.9	14.1			
Fontanarosa et al. [60]	2006	Argentina	E.Echeverria	34°52′S, 58°28′W	134		Sheater Flotation	1		urban	5		21.6																6.7	17.9			
Fontanarosa et al. [60]	2006	Argentina	Lomas de Zamora	34°45′S, 58°25′W	499		Sheater Flotation	1		urban	5		13																9.8	10.2			
Fontanarosa et al. [60]	2006	Argentina	Quilmes	34°15′S, 58°15′W	293		Sheater Flotation	1		urban	5		13.6																10.2	7.5			
Gamboa et al. [61]	2011	Argentina	La Plata	34°56′S, 57°53′W	12	Formol 10%	Sedimentation of Ritchie and Flotation of Willis	2		urban	4		16		16														16	8			
Gamboa et al. [62]	2009	Argentina	La Plata Norte	34°56′S, 57°57′W	5		Sedimentation of Ritchie and Carles Barthelemand, and Flotation of Fülleborn	3		urban	4		16.7		16.7														16.7	8.3			
Gamboa et al. [62]	2009	Argentina	La Plata Sur	34°56′S, 57°57′W	4		Sedimentation of Ritchie and Carles Barthelemand, and Flotation of Fülleborn	3		urban	2		33.3																8.3				
Gamboa et al. [62]	2009	Argentina	Aristóbulo del Valle	27°05′S, 54°53′W	11		Sedimentation of Ritchie and Carles Barthelemand, and Flotation of Fülleborn	3		urban	4		90.9		9.1														27.3	9.1			
Gonzalez Acuña et al. [63]	2008	Chile	Archipiélago de Juan Fernández	33°38′S, 78°50′w	40	SAF solution	Teuscher Methods or Flotation of Willis	2	rural		3	30.0						3.9					15										
Gorman et al. [31]	2006	Chile	Santiago de Chile	33°27′S, 70° 40′W	582		Flotation zinc sulfate and Sedimentation of Teleman modified	2		urban	5	5.3					2.1											2.4	9.1	8.6			
Irabedra et al. [64]	2016	Uruguay					5356		CoproElisa	1							3.6																

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Irabedra et al. [64]	2016	Uruguay					1496		CoproElisa		1							7.35															
La Sala et al. [65]	2015a	Argentina	Bahía Blanca	38°44′S, 62°16′W	475	Formol 10%	Sedimentation of Ritchie	1		urban	5		21.1												0.6				2.3	18.1			
La Sala et al. [66]	2015b	Argentina	Bahia Blanca	38°43′S, 62°16′W	475		Direct observation	1		urban	5		22.3												0.6				2.3	18.1			
Lamberti et al . [67]	2014	Argentina	Gra. Pico	35°39′S, 63°45′W	785		Flotation with ClNa	1		urban	3		45.4		7.1															25.8			
Lamberti et al. [68]	2015	Argentina	Gral Pico	35°40′S, 63°44′W	1229		Flotation with ClNa and ZnSO4	2		urban	3		45.4		6.4															21.9			
Larrieu et al. [69]	2014	Argentina	El Bolsón	41°58′S, 71°32′W	68		Copro, Elisa and WB	2	rural		1							11.8															
Larrieu et al. [69]	2014	Argentina	El Cuy	39°56′S, 68°20′W	81		Copro, Elisa and WB	2	rural		1							6.1															
Larrieu et al. [69]	2014	Argentina	Ñorquinco	41°51′S, 70°54′W	47		Copro, Elisa and WB	2	rural		1							6.4															
Larrieu et al. [69]	2014	Argentina	Pilcaniyeu	41°07′S, 70°43′W	19		Copro, Elisa and WB	2	rural		1							5.3															
Larrieu et al. [69]	2014	Argentina	Comallo	41°02′S, 70°16′W	12		Copro, Elisa and WB	2	rural		1							8.3															
Larrieu et al. [69]	2014	Argentina	Ingeniero Jacobacci	41°18′S, 69°35′W	108		Copro, Elisa and WB	2	rural		1							7.4															
Larrieu et al. [69]	2014	Argentina	Maquinchao	41°15′S, 68°42′W	16		Copro, Elisa and WB	2	rural		1							12.5															
Larrieu et al. [69]	2014	Argentina	Los Menucos	40°50′S, 68°05′W	37		Copro, Elisa and WB	2	rural		1							5.4															
Larrieu et al. [69]	2014	Argentina	Sierra Colorada	40°35′S, 67°45′W	42		Copro, Elisa and WB	2	rural		1							2.4															
Larrieu et al. [69]	2014	Argentina	Valcheta	40°42′S, 66°09′W	106		Copro, Elisa and WB	2	rural		1							4.7															
Larrieu et al. [69]	2014	Argentina	Sierra Grande	41°36′S, 65°21′W	14		Copro, Elisa and WB	2	rural		1							7.2															
Lavallén et al. [70]	2011	Argentina	Gral Pueyrredon	38°00′S, 57°33′W	46	Formol 10%	Sediemtation of Ritchie and Flotation of Sheater and coproELISA	3		urban	6		71.74	41.3				8.6	17.36										63.04	45.65			

Autor	Año	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris sp.*	*Dibothriocephalus* sp.	*Dipylidium* caninum	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Lopez et al. [71]	2006	Chile	Santiago de Chile	33°27′S, 70° 40′W	972	PAF fenol, alcohol and formaldehído	Burrows Technique	1		urban	7	1.8					2.2									0.4		1.4	11.1	8.9			1.2
Luzio et al. [72]	2013	Chile	Tomé	36°37′S, 72°57′W	223	PAF fenol, alcohol and formaldehído	Burrows Technique	1		urban	9		8.1	0.9			9.9				2.7		3.1			1.8		6.3	22.9	8.1			
Luzio et al. [73]	2015	Chile	Santa de los Angeles	37°28′S, 72°21′W	452	PAF fenol, alcohol and formaldehído	Burrows Technique	2		urban	7		4.2	0.44			2.6						0.44			1.6		1.3	9.3				
Luzio et al. [74]	2017	Chile	Concepcion	36°49′S, 73°03′W	64	PAF fenol, alcohol and formaldehído	Burrows Technique	1		urban	5		8.5					29					4.5			6.3			29.7				
Madrid et al. [75]	2008	Argentina	Mar del Plata	38°00′S, 57°33′W	358		Flotation with NaCl	1		urban	7		18.9	11.5							1.1							0.6	5.9	13.4			
Marder et al. [76]	2004	Argentina	Ciudad de Corrientes	27°25′S, 58°52′W	900		Flotation of Willis, Sheater and Faust	3		urban	3		64.5																7.6	3.1			
Martin et al. [77]	2008	Argentina	Paraná	31°44′S, 60°31′W	61	Solución salina 5%	Concentration methods	1		urban	2		67.0																7.0				
Martin et al. [77]	2008	Argentina	Santa Fé	31°38′S, 60°42′W	200	Solución salina 5%	Concentration methods	1		urban	3		14.0																62.0	12.0			
Martin et al. [77]	2008	Argentina	Avellaneda (Santa Fé)	29°07′S, 59°39′W	15	Solución salina 5%	Concentration methods	1		urban	3		5.0																6.0	1.0			
Martin et al. [77]	2008	Argentina	Reconquista (Santa Fé)	29°09′S, 59°39′W	10	Solución salina 5%	Concentration methods	1		urban	2		5.0																5.0				
Martin et al. [77]	2008	Argentina	Calchaquí (Santa Fé)	29°53′S, 60°16′W	17	Solución salina 5%	Concentration methods	1		urban	3		2.0																5.0	1.0			
Martin et al. [77]	2008	Argentina	Hersilia (Santa Fé)	30°00′S, 61°51′W	12	Solución salina 5%	Concentration methods	1		urban	3		4.0																5.0	1.0			
Martin et al. [77]	2008	Argentina	San Carlos Centro (Santa Fé)	31°44′S, 61°06′W	24	Solución salina 5%	Concentration methods	1		urban	3		8.0																6.0	3.0			
Martin et al. [77]	2008	Argentina	Santo Tomé (Santa Fé)	31°40′S, 60° 46′W	54	Solución salina 5%	Concentration methods	1		urban	3		9.0																5.0	2.0			
Mercado et al. [78]	2004	Chile	Arica	18°28′S, 70°19′W	50		Sedimentation and Harada, Mori	2		urban	2		2																4				
Mercado et al. [78]	2004	Chile	Antofagasta	23°38′S, 70°23′W	50		Sedimentation and Harada, Mori	2		urban	2																		2				

Autor	Ano	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris* sp.	*Dibothriocephalus* sp.	*Dipylidium caninum*	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Mercado et al. [78]	2004	Chile	Illapel	31°37'S, 71°10'W	50		Sedimentation and Harada, Mori	2		urban	2		7.2																10				
Mercado et al. [78]	2004	Chile	Viña del Mar	33°01'S, 71°33'W	27		Sedimentation and Harada, Mori	2		urban	2																						
Mercado et al. [78]	2004	Chile	Valparaiso	33°02'S, 71°37'W	40		Sedimentation and Harada, Mori	2		urban	2		10																12.5				
Mercado et al. [78]	2004	Chile	San Felipe	32°45'S, 70°43'W	44		Sedimentation and Harada, Mori	2		urban	2																		6.8				
Mercado et al. [78]	2004	Chile	Santiago de Chile	33°27'S, 70° 40'W	54		Sedimentation and Harada, Mori	2		urban	2																		1.9				
Mercado et al. [78]	2004	Chile	Rancagua	34°09'S, 70°44'W	27		Sedimentation and Harada, Mori	2		urban	2																		7.4				
Mercado et al. [78]	2004	Chile	San Fernando	34°35'S, 70°59'W	50		Sedimentation and Harada, Mori	2		urban	2		24																8				
Mercado et al. [78]	2004	Chile	Concepcion	36°49'S, 73°03'W	49		Sedimentation and Harada, Mori	2		urban	2		8.2																6.1				
Mercado et al. [78]	2004	Chile	Temuco	38°44'S, 72°35'W	50		Sedimentation and Harada, Mori	2		urban	2		40																4				
Mercado et al. [78]	2004	Chile	Valdivia	39°48'S, 73°14'W	50		Sedimentation and Harada, Mori	2		urban	2		20																4				
Mercado et al. [78]	2004	Chile	Punta Arenas	53°09'S, 70°54'W	54		Sedimentation and Harada, Mori	2		urban	2																		1.9				
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25'S, 58°52'W	61	Formol 10%	Sedimentation and flotation of Willis	2		urban	4		32.8				1.6												26.3	3.3			
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25'S, 58°52'W	40	Formol 10%	Sedimentation and flotation of Willis	2		urban	4		35.0			2.5													17.5	2.5			
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25'S, 58°52'W	40	Formol 10%	Sedimentation and flotation of Willis	2		urban	4		35.0			12.5													12.5	10.0			
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25'S, 58°52'W	32	Formol 10%	Sedimentation and flotation of Willis	2		urban	3		50.0																15.6	9.4			
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25'S, 58°52'W	40	Formol 10%	Sedimentation and flotation of Willis	2		urban	4		45.0			2.5													20.0	2.5			
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25'S, 58°52'W	33	Formol 10%	Sedimentation and flotation of Willis	2		urban	3		48.2																6.0	3.0			

Autor	Año	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris sp.*	*Dibothriocephalus* sp.	*Dipylidium* caninum	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25′S, 58°52′W	34	Formol 10%	Sedimentation and flotation of Willis	2		urban	3		38.2																17.6	5.9			
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25′S, 58°52′W	44	Formol 10%	Sedimentation and flotation of Willis	2		urban	4		43.2			4.5													6.8				
Milano et al. [79]	2005	Argentina	Ciudad de Corrientes	27°25′S, 58°52′W	38	Formol 10%	Sedimentation and flotation of Willis	2		urban	4		50.0			2.6													15.8	7.9			
Motta et al . [80]	2019	Argentina	Rio Cuarto	33°07′S, 64°20′W	493	Formol 10%	Flotation of Willis, and Sheather, and Sedimentation	3		urban	5		30.83				0.61			1.42									6.9	9.94			
Natalini et al . [81]	2020	Argentina	Parque Nac Mburucuya	27°58′S, 57°59′W	28	Formol 10%	Flotation Sheater and sedimentation of Ritchie	2	rural		6			4	4		4		7						14				4	4			
Natalini et al . [81]	2020	Argentina	San Nicolás NP	27°59′S, 57°35′W	23	Formol 10%	Flotation Sheater and Sedimentation of Ritchie	2	rural		3		52						9				9										
Oku et al. [82]	2004	Uruguay	Tacuarembo	31°42′S, 55°58′W	79		Necropsy	1		urban	4						38	23				1				8							
Oku et al. [82]	2004	Uruguay		31°45′S, 55°58′W	- 31.75		Necropsy	1	rural		6					1	30	3.49				4				23	3						
Olivares et al. [83]	2014	Chile	Temuco	37°24′S, 72°36′W	102		Flotation and Sedimentation of Teuscher	1		urban	4										21.5		12.7						21.5	35.2			
Opazo et al. [84]	2019	Chile	Valparaiso	33°02′S, 71°37′W	30	PAF fenol, alcohol and formaldehído	Burrows Technique	1	rural		6	7		13			17						17						40	3			
Oyarzun et al. [85]	2019	Chile	Contulmo	38°00′S, 73°14′W	270	Alcohol	Sedimentation and Flotation of Teuscher	1	rural		5			25.5				4					53.9			30.5				15.6			
Parra et al. [86]	2017	Argentina	Ancajuli	26°35′S, 65°33′W	43		CoproElisa	1	rural		1							13															
Parra et al. [86]	2017	Argentina	Anfama	26°45′S, 65°34′W	22		CoproElisa	1	rural		1							7															
Parra et al. [86]	2017	Argentina	Chaquivil	26°41′S, 65°36′W	7		CoproElisa	1	rural		1							4															
Parra et al. [86]	2017	Argentina	La Hoyada	26°41′S, 65°31′W	5		CoproElisa	1	rural		1							3															
Parra et al. [86]	2017	Argentina	Mala Mala	26°47′S, 65°33′W	9		CoproElisa	1	rural		1							6															
Parra et al. [86]	2017	Argentina	San José de Chasquivil	26°41′S, 65°36′W	17		CoproElisa	1	rural		1							8															

Autor	Año	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris sp.*	*Dibothriocephalus* sp.	*Dipylidium* caninum	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Perez et al. [87]	2006	Argentina	Rio Negro	40°48′S, 63° 00′W	416		Copro, Elisa and WB	2			2							4.6							14.9								
Quilodrán-González et al. [88]	2018	Chile	Cabrero	37°2'S, 72°24'W	83		Flotation of Sheater	1		urban	1	41														4.8			4.8	13.3			
Quilodrán-González et al. [88]	2018	Chile	Cabrero	37°2'S, 72°24'W	10		Flotation of Sheater	1	rural		2	60																		10			
Radman et al. [89]	2006	Argentina	Capital Federal	34°34S, 58°31W	125		Flotation of Fülleborn	1		urban	1																		51.2				
Rivero et al. [90]	2015	Argentina	Puerto Iguazú y alrededres	25°35′S, 54°34′W	405	Formol 10%	Flotation of Sheater and Sedimentation of Telemann	2	rural		1					0.49																	
Rivero et al. [91]	2017	Argentina	Puerto Iguazú y alrededres	25°35′S, 54°34′W	530	Formol 10%	Direct with lugol, Flotation of Sheater and Sedimentation of Teleman	3		urban	8				0.9	0.9	1.3						55.6		0.4			3.9	13.4	12.1			
Rodriguez et al. [92]	2005	Argentina	Mar del Plata	38°00′S, 57°33′W	171		Flotation and Sedimentation	2		urban	6		67.8	42.4			1.5				5.6								6.8	52.2			
Roth et al. [93]	2018	Argentina	Bariloche	41°08′S, 71°27′W	118	Freezado	Flotation of Sheater and Sedimentation of Telemann	2		urban	1					16.9																	
Rubel et al. [94]	2003	Argentina	Capital Federal	34°34S, 58°31W	31	Formol 5%	Sedimentation of Teleman	1		urban	1																		14.0				
Rubel et al. [95]	2005	Argentina	Capital Federal	34°34S, 58°31'W	2417	Formol 5%	Sedimentation of Teleman	1		urban	4		33.5				0.7												13.0	32.0			
Rubel et al. [96]	2010	Argentina	Capital Federal	34°34'S, 58°31'W	421	Formol 5%	Flotation of Willis	1		urban	7		26.0				0.6						0.9		0.6			0.2	1.7	4.0			
Rubel et al. [97]	2019	Argentina	Buenos Aires	34°37′S, 58°25′W	112		Centrifugation and Flotation of Sheater	2		urban	4		20.5												0.9				1.8	3.6			
Sánchez et al. [98]	2003	Argentina	Comodoro Rivadavia y Rada Tilly	45°S, 68° W	481	Formol 5%	Sedimentation de Teleman and Flotation de Willis	2		urban	6			1.0			0.2				0.2			2.6	3.6				17.9				
Sánchez Thevenet et al. [99]	2003	Argentina	Comodoro Rivadavia	45°S, 68° W	163	Formol 5%	Sedimentation of Teleman and Flotation of Willis	2		urban	6			0.8			0.3							1.6	1.4				8.8				
Semenas et al. [100]	2014	Argentina	Bariloche	41°10′S, 71°18′W	54		Sedimentation of Teleman and Flotation of Sheater	2		urban	10		1.8	3.7		12.8		3.6			1.8		12.8		7.3			1.8	11.0	29.3			
Soriano et al. [101]	2010	Argentina	Neuquen rural	38°14′S, 69°46′W	1298	Formol 5%	Flotation and Sedimentation	2	rural		8		0.15			0.15	0.15								17.87			0.84	16.4	1.3		0.3	

Autor	Año	Country	Name Study Locality	Coordinates	Sample size	Fixing method	of tection Methods	No. Of detection methods	RURAL	URBAN	Richness	Ancylostomids	*Ancylostoma* sp.	*Uncinaria* sp.	*Ascaris sp.*	*Dibothriocephalus* sp.	*Dipylidium* caninum	*Echinococcus* sp.	*Eucoleus aerophila*	*Eucoleus boehmi*	Capillaria sp.	*Taenia multiceps* sp.	*Strongyloides* eggs	*Spirocerca*	*Taenidae*	*Taenia hydatigena*	*Taenia ovis*	*Toxascaris* sp.	*Toxocara* sp.	*Trichuris* sp.	Trematodes	*Oncicola canis*	*Physalopetra* sp.
Soriano et al. [101]	2010	Argentina	Neuquén urbano (neuquen y chos malal	37°23′S, 70°17′W	646	Formol 5%	Flotation and Sedimentation	2		urban	6		0.93								0.31				2.17				16.1	15.63			
Souto et al. [102]	2016	Argentina	El Chalía (Chubut)	45°41′S, 70°59′W	22	Formol 10%	Sedimentation of Teleman, Flotation of Willis and copro, Elisa	3	rural		2							13.6							9.1								
Taranto et al. [103]	2000	Argentina	Fortín Dragones y Misión Chaqueña	23°15′S, 63°20′W	106		Directo, Flotation of Willis and centrifugation	3		urban	4		69.8												1.9				17.2	7.5			
Torres et al. [104]	2004	Chile	Panguipulli	39°38′S, 72°20′W	109	PAF fenol, alcohol y formaldehído	Sedimentation	1		urban	1					1.8																	
Torres et al. [104]	2004	Chile	Choshuenco	39°50′S, 72°04′W	22	PAF fenol, alcohol y formaldehído	Sedimentation	1		urban	1					4.5																	
Vargas et al. [105]	2016	Chile	Niebla	39°48′S, 73°14′W	78	Formol salino	Sedimentation of Telemann modified, Flotation Sulphate Zinc, método cuantitativo	3			1																		15.4				
Vargas et al. [105]	2016	Chile	Valdivia	39°48′S, 73°14′W	77	Formol salino	Sedimentation of Telemann modified, Flotation Sulphate Zinc, método cuantitativo	3		urban	1																		15.6				
Winter et al. [106]	2018	Argentina	Viedma	40°48′S, 62°59′W	531		Flotation de Sheater	1		urban	6		33.8							2.2					0.7			2.9	22.8	40.4			
Zonta et al [107]	2019	Argentina	Clorinda (Formosa)	25°17′S, 57°43′W	16	Formol	Sedimentation of Ritchie and Flotation of Willis	2		urban	4		62.5	37.5																			
Zunino et al. [108]	2000	Argentina	Comodoro Rivadavia	45°S, 68° W	31	Formol 5%	Flotation of Willis	1		urban	2												9.7						3.3				
Zunino et al. [108]	2000	Argentina	Trelew	43°15′S, 65°18′W	30	Formol 5%	Flotation of Willis	1		urban	3			3.3									3.3						33.3				
Zunino et al. [108]	2000	Argentina	Puerto Madryn	42°46′S, 65°02′W	29	Formol 5%	Flotation of Willis	1		urban	1																		10.3				
Zunino et al. [108]	2000	Argentina	Sarmiento	45°36′S, 69°05′	29	Formol 5%	Flotation of Willis	1		urban	3			6.9									6.9						24.1				
Zunino et al. [108]	2000	Argentina	Esquel	42°54′S, 71°19′W	29	Formol 5%	Flotation of Willis	1		urban	3			6.9									3.4						13.8				
Zunino et al. [108]	2000	Argentina	Lago Puelo	42°09′S, 71°38′W	30	Formol 5%	Flotation of Willis	1		urban	3			16.7									6.9						20.0				

Table 1.
Data extracted from the 67 articles selected for analysis.

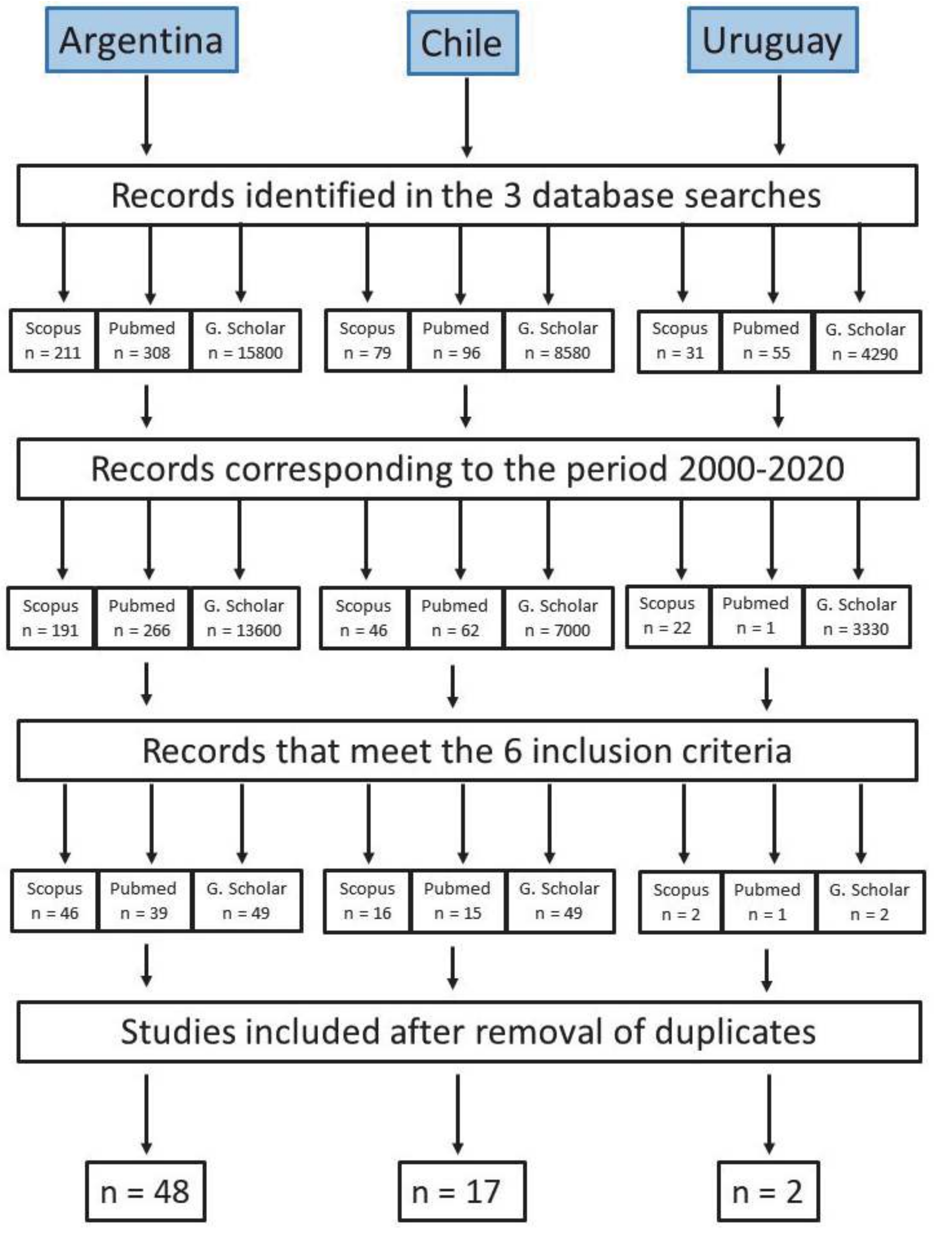

Figure 1.
Flow diagram of epidemiologic studies on dog parasites for the systematic review.

commonly used techniques were Willis flotation (20 reports), Sheater flotation (15 reports) and Telemann sedimentation (14 reports). In Uruguay only two methods were used: necropsy of stray dogs and coproELISA for *Echinococcus* sp., whereas in Argentina and Chile the techniques in common were Faust, Sheater, Telemann, Willis, and coproELISA for *Echinococcus* sp. Chilean researchers also used a modification of Faust (Teuscher), Burrows, and Harada-Mori for larvae. Other methods used only in Argentina were Füllerborn, Mini Flotac; Ritchie, Carles Barthelemy, direct observation with lugol; and Western Blot and PCR molecular techniques for *E. granulosus*.

More than 140 sites were analysed in Chile and Argentina (**Figure 2**, **Table 1**); however, the number of sites analysed in Uruguay could not be determined as this information is not given in the 2 selected studies. In Argentina and Chile, a total of 104 urban sites and 43 rural areas were considered (**Table 2**).

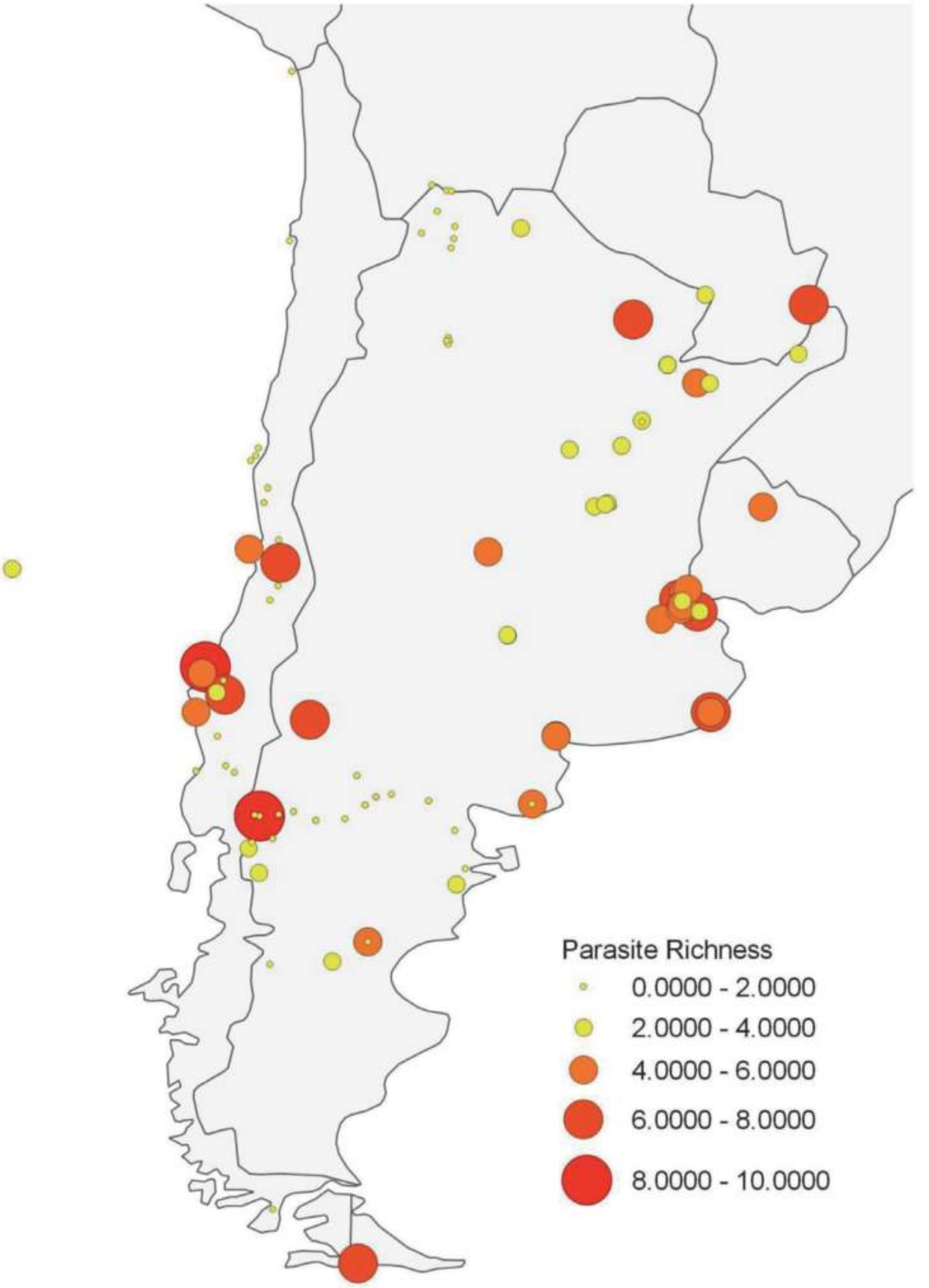

Figure 2.
Distribution of collection sites and species richness in each site.

A total of 22 parasite taxa was recorded (**Table 3**): 1 trematode (Trematoda sp.), 7 cestodes (*Dibothriocephalus* sp., *Dipylidium caninum*, *Echinococcus* sp., Taenidae, *Taenia multiceps*,*Taenia hydatigena*,*Taenia ovis*), 13 nematodes (*Trichuris vulpis, Eucoleus aerophila*, *Eucoleus boehmi*, *Capillaria* sp., *Strongyloides* sp., Ancylostomatidae sp., *Ancylostoma* sp., *Uncinaria* sp., *Ascaris* sp.,*Toxascaris leonina*, *Toxocara canis, Spirocerca* sp., and *Physaloptera* sp.), and 1 acanthocephalan species (*Oncicola canis*). In Argentina the presence of *Ancylostoma* was recorded up to genus level, whereas in Chile they were recorded only as Ancylostomatidae sp., so while it is likely that there are some shared species, this cannot be established from the records analysed. The distribution of the species is presented in **Figures 3–5**, which show that most of the parasitic records are located in the central zone of Chile, while

Country	Number of studies analysed	Number of sites analysed	Rural Sites	Urban Sites	Total collected faeces (range)	Richness (Range)	Number of Techniques used
Argentina	48	110	38	76	18,812 (4–2417)	17 (1–10)	13
Chile	19	33	5	28	4,574 (10–972),	14 (1–9)	11
Uruguay	2	not reported	not reported	not reported	7,134 (79–5356)	6 (1–6)	2

Table 2.
Summary of studies: Total number of reports analysed for the three countries, number of rural and urban sites, collected samples, techniques used, and species richness.

Parasite species	Total Number of Sites	Mean prevalence (SD)	Number of positive urban sites	Mean prevalence in urban sites (SD)	Number of positive rural sites	Mean prevalence in rural sites (SD)
***Dibothriocephalus* sp.**	14	5.7 ± 6.2	10	7.8 ± 6.3	4	0.6 ± 0.4
Dipylidium caninum	21	5.6 ± 10.3	16	4.1 ± 9.3	5	10.5 ± 12.8
Echinococcus granulosus	52	7.9 ± 7.1	14	12.9 ± 9.9	38	6 ± 4.7
Taenidae	16	5.1 ± 5.9	12	3.4 ± 4.2	4	10.3 ± 7.5
Taenia hydatigena	9	9 ± 10.5	7	3.9 ± 2.7	2	26.8 ± 5.3
Taenia multiceps	2	2.5 ± 2.1	1	1	1	4
Taenia ovis	1	3			1	3
Trichuris vulpis	60	14.7 ± 14.7	53	15.3 ± 15.3	7	10.3 ± 8.7
Eucoleus aerophila	4	14.9 ± 8.8	1	17.4	3	14.1 ± 10.5
Eucoleus boehmi	2	1.8 ± 0.6	2	1.8 ± 0.6		
***Capillaria* sp.**	11	3.9 ± 6.1	11	3.9 ± 6.1		
***Strongyloides* sp.**	19	12 ± 16.1	14	5.6 ± 4.2	5	30.1 ± 22.7
Ancylostomatidae	6	24.2 ± 23.5	3	16 ± 21.7	3	32.3 ± 26.6
***Ancylostoma* sp.**	66	29 ± 23.4	62	29.7 ± 23.3	3	21.4 ± 27.2
***Uncinaria* sp.**	21	17.3 ± 18.5	17	18 ± 20.2	4	14.2 ± 8.8
***Ascaris* sp.**	8	7.6 ± 6.2	6	9.3 ± 6.1	2	2.5 ± 2.2
Toxascaris leonina	13	2.7 ± 3.2	11	2.7 ± 3.5	2	2.4 ± 2.2
Toxocara canis	86	13.6 ± 11.6	80	13.4 ± 11.5	6	15.9 ± 12.8
***Spirocerca* sp.**	3	3.4 ± 2.3	3	3.4 ± 2.3		
***Physalopetra* sp.**	1	1.2	1	1.2		
Oncicola canis	1	0.3			1	0.3

Table 3.
Species recorded in the studies analysed, their distribution (urban versus rural) and mean intensity.

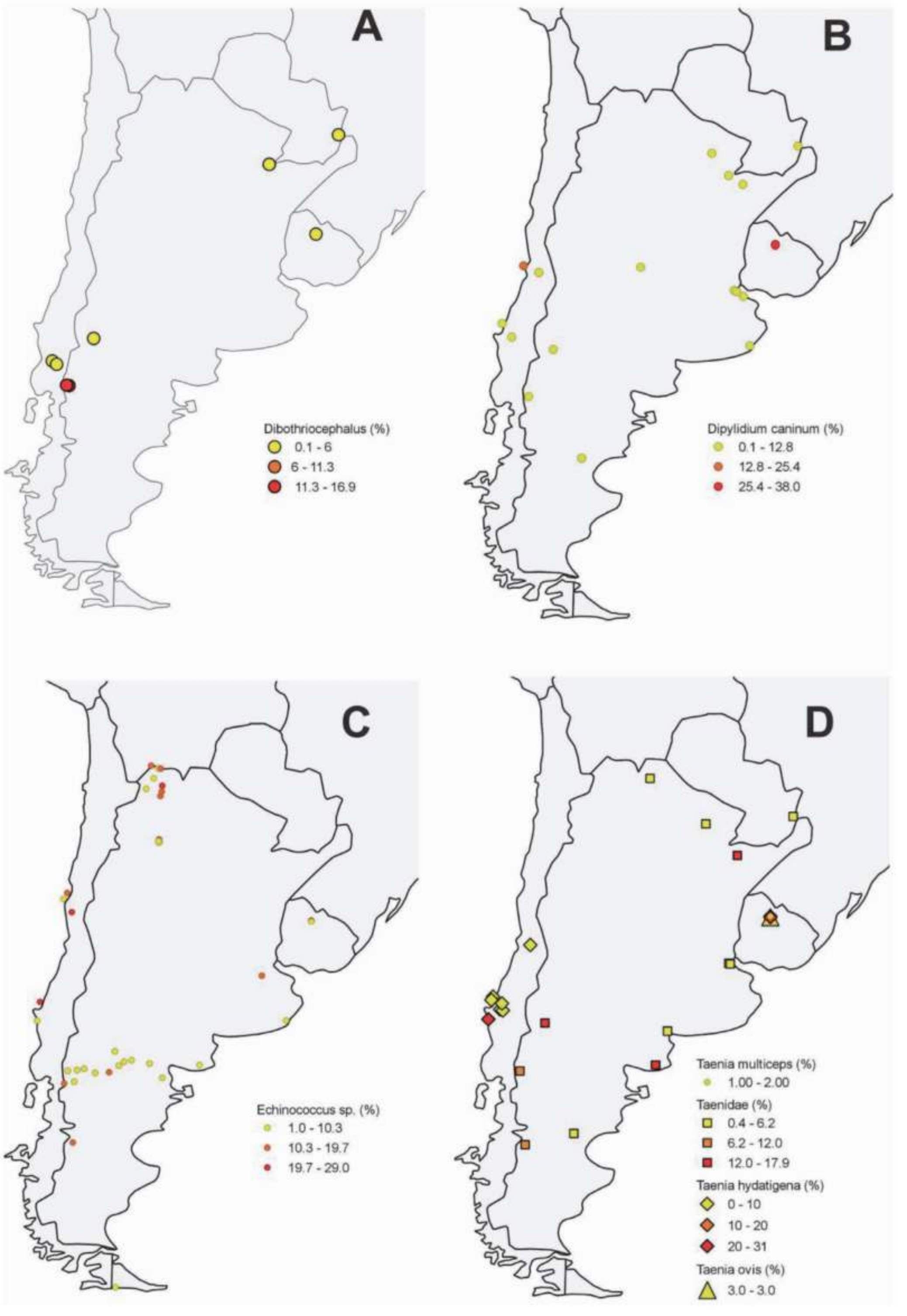

Figure 3.
Distribution of Cestoda collected in Argentina, Chile and Uruguay. A.: Dibothriocephalus *sp.; B.:* Dipilidium caninum*; C.:* Echinococcus *sp.; D.: Taenids.*

in Argentina there are records at all latitudes, except in an arid zone in the north-west, close to the Andes mountains. Species richness was correlated only with sample size ($R = 0.44809$, $p < 0.05$) and varied between sites, from 1 to 10 species (Argentina 1 to 10; Chile 1 to 9; Uruguay 1 to 6) (**Figure 2**).

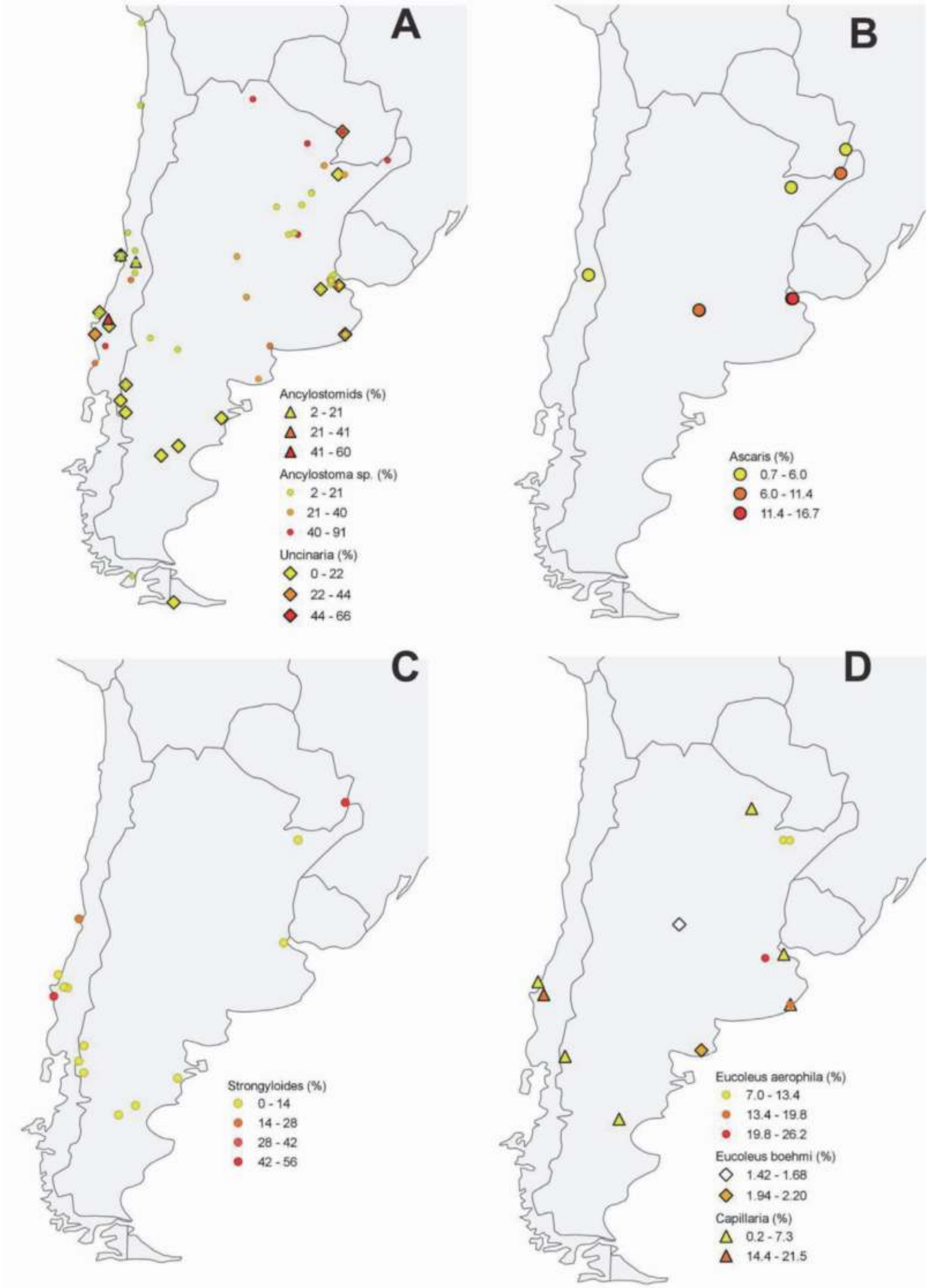

Figure 4.
Distribution of Nematoda (part 1) in Argentina, Chile and Uruguay. A.: Ancylostomatidae.; B.: Ascaris sp.; *C.:* Strongyloides*; D.:* Eucocleus *spp. and* Capillaria *sp.*

The most frequently recorded species was *T. canis* (86 sites), followed by *Ancylostoma* sp. (66); *Trichuris vulpis* (60 sites), and *Echinococcus* sp. (52) (**Table 3**; **Figure 4A, 5B, 3E**, respectively); others were recorded only once, e.g.: Trematoda sp. and *O. canis* in Argentina, and *Physaloptera* sp. in Chile. The species detected in Uruguay, except for *Echinococcus* sp., correspond to different taeniid cestodes. Argentina and Chile shared 10 helminth species: *Dibothriocephalus* sp., *D. caninum*

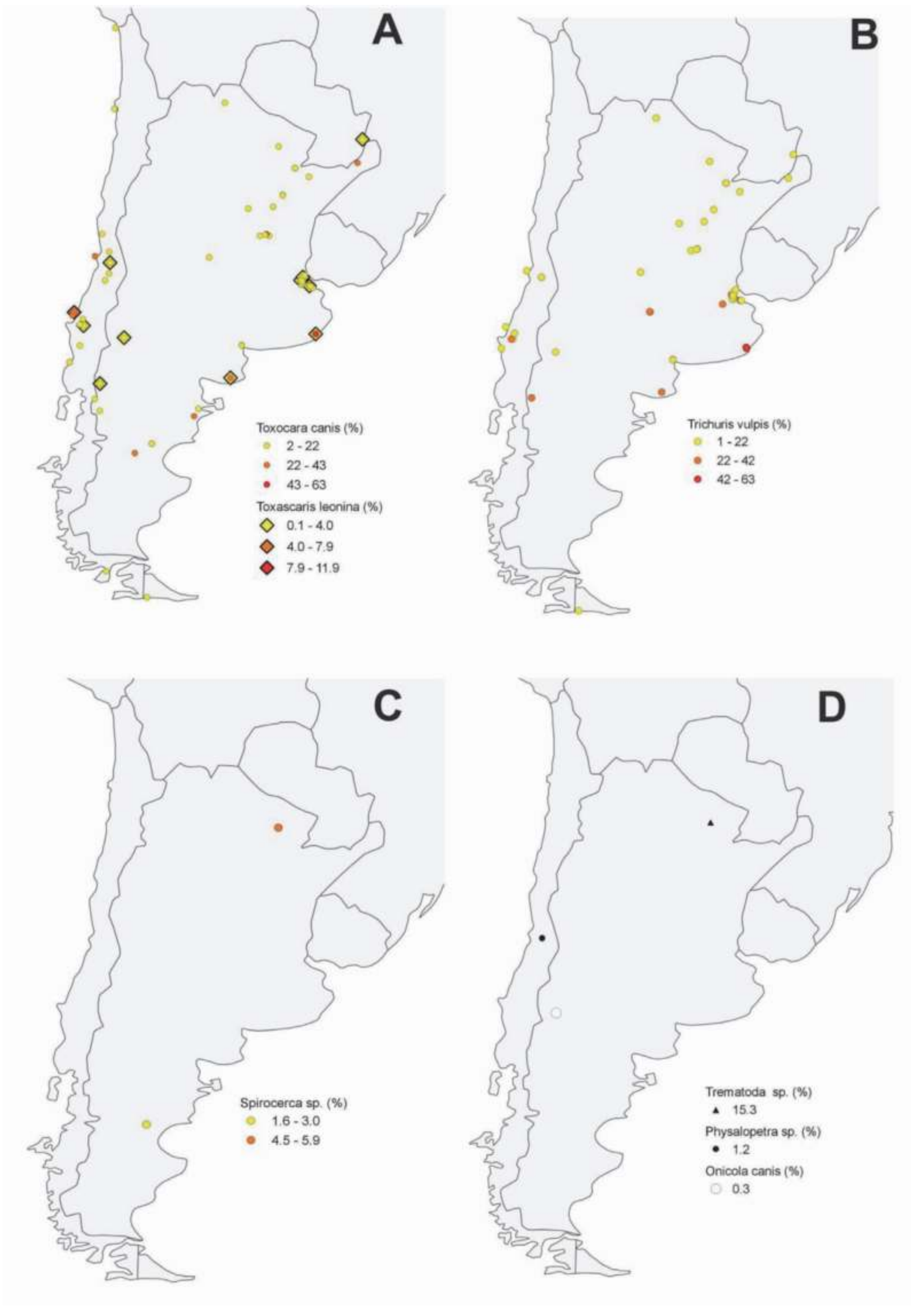

Figure 5.
Distribution of Nematoda (part 2) in Argentina, Chile and Uruguay. A.: Toxocara canis *and* Toxascaris leonina*.; B.:* Trichuris vulpis*; C.:* Spirocerca*; D.:* Physalopetra*, Trematoda* sp. *and* Oncicola canis.

sp., *Echinococcus* sp., *Ascaris* sp., *Capillaria* sp., *Strongyloides* sp., *T. leonina*, *T. canis*, *T. vulpis*, and *Uncinaria* sp.

The species richness in urban areas (20 species) was slightly higher than in rural areas (17 species) (**Table 3**). In addition, a higher number of zoonotic species was recorded in urban areas, species such as *Uncinaria s*p.*,* *Ancylostoma* sp. and *Echinococcus* sp. being widespread and prevalent in the cities (**Table 3**). Many parasite

Country	Urban			Rural			
	Richness (Range)	*Mean richness*	*Most widespread species*	*Richness (Range)*	*Mean richness*	*Most widespread species*	*Similarity*
Argentina	16 (1–10)	3.8	*Toxocara canis*, *Ancylostoma* sp. *Trichuris vulpis*	10 (1–8)	1.7	*Echinococcus* sp.	7/17
Chile	14 (1–9)	2.8	*Toxocara canis*, *Ancylostoma* sp. *Trichuris vulpis*	8 (1–6)	3	*Echinococcus* sp.	7/14

Table 4.
Characterisation of urban and rural areas in terms of richness and most widespread species, present in Argentina and Chile.

species showed greater prevalence in urban areas than in rural ones. The only exception to this was *T. canis* which had higher values in the rural areas (**Table 3**). In Chile 8 species were registered in rural areas and 14 in urban locations, whereas in Argentina the species richness was 10 and 16, respectively (**Table 4**).

Of the total taxa recorded, 14 (63.6%) have been registered in humans: *Dibothriocephalus* sp., *D. caninum*, *Echinococcus* (*sensu lato*), Taenidae, *T. multiceps*, *T. hydatigena*, Ancylostomatidae sp., *Ancylostoma* sp., *Uncinaria* sp., *Ascaris* sp., *E. aerophila*, *E. boehmi*, *T. leonina,* and *T. canis.* Some of these species are only occasionally recorded infecting humans, such as *D. caninum, Taenia multiceps, E. aerophila*, *E. boehmi* and *T. leonina.*

4. Discussion

4.1 State of knowledge and distribution

Although three databases were used, this work could have some bias due to the exclusion of grey literature, like technical reports, congress abstracts or thesis manuscripts, so some sites or negative data may be excluded in the analysis [109]. The systematic bibliographic review carried out shows that the published and available knowledge of the occurrence and distribution of helminths in dogs is scarce in southern South America; in countries such as Uruguay there are no records other than those obtained within the Echinococcosis National Programmes. Furthermore, in Argentina there are arid regions near the Andes, such as the northwest of the country, where there are no records of parasites in dogs. The same was observed for Chile south to 40°s, except for one record in Punta Arenas, the southernmost city in Chile. Most of the records are associated with large cities and their surroundings, such as Buenos Aires and La Plata in Argentina, and in the area of Santiago de Chile, Concepción, and Temuco in Chile.

Although sample size is the only factor that significantly affected richness, other factors to consider could be the analytical methods used and whether the sample was fixed or not. Sample size affects the results, generating deviations in the number of species and in their prevalence, especially in places where the sample size was too low. On the other hand, a lack of methodological specifications can be observed in the techniques used. This could imply potential biases in the reporting and/or interpretation of data. In order to obtain data of higher quality, a general consensus should be reached on the techniques to be applied. It is also desirable to apply molecular techniques that allow parasite identification to species level, thus solving records identified to family level, such as "Ancylostomatidae" or "Strongylids", or the recording of species outside their natural range of distribution, like *Dibothriocephalus* in the northeast of Argentina.

The presence of a greater number of species, most of which have zoonotic potential, in urban areas than rural ones is probably due to the fact that dogs can roam freely. Dogs spread the parasite eggs, thereby these areas will function as contagion points for both other dogs and humans. A further problem is that deworming in these countries is insufficient [21]. A similar situation has been detected in parks in the United States, where it has been suggested that dogs are at risk of infection with parasites at these sites, and it has been recommended that preventive strategies be considered [30, 110]. Some parasitic infections could become increasingly urbanised, and an estimation for 2050 indicates that up to two-thirds of the global population will live in megacities. The slums of these megacities would concentrate high levels of intestinal helminth. Toxocariasis and other urban soil-transmitted helminths are important, yet little studied, health issues in the cities of the Americas [111].

The zoonotic broad tapeworm, *Dibothriocephalus* sp., is found in dogs from the endemic zone of the disease, the Andean Patagonia of Argentina and Chile [93, 104]. The records from the northeastern region of Argentina require revision, as there are no molecular studies confirming the identity of these parasites, and there are no records of fish infected by plerocercoids in this zone. Although *Dibothriocephalus* sp., is not transmitted to humans by dogs, they can act as disseminators of the disease and are often used as sentinel species for the spread of the disease in some areas. *Ascaris* sp. in dogs is distributed mainly in subtropical regions of Argentina, where this parasite is most prevalent in humans [107]. Some parasites are distributed throughout all the latitudes regardless of the type of climate, like *T. canis*.,*T. vulpis*, and Ancylostomatids, as observed in other parts of the world [112–114]. *Echinococcus* sp. is distributed across almost all rural areas of the three countries, although has recently also been registered in cities [35, 47, 64, 115].

4.2 Zoonoses and human cases reported

The high percentage of parasites with zoonotic potential reinforces the need to establish effective prevention measures, not only with regard to parasitosis in animals but also to transmission to humans. This situation highlights the need for better integration between specialists in animal and human health [74]. A few diseases transmitted by dogs have surveillance mechanisms in humans, but there are many other important zoonoses worldwide, with numerous human cases, which are not kept watch on. Some of these have been recorded in Argentina and Chile, such as those caused by *T. canis*, *Ancylostoma* sp*., A. caninum*, *Uncinaria* sp., and *Strongyloides* sp. [30]. Of the main zoonoses recorded in dogs in the three countries, cystic echinococcosis is the only one which has to be reported to the health authorities, since it is of major sanitary importance [115]. The others, like toxocariasis, hookworm and strongyloidiasis are not reported, and records of human cases in these countries are scarce. The status of these zoonoses in humans from southern South America is analysed below.

4.2.1 Cystic echinococcosis

Cystic echinococcosis or hydatidosis, produced by *Echinococcus granulosus sensu lato*, is a highly endemic parasitic zoonosis in South American countries, especially in Argentina, Chile, Uruguay and Brazil. It is associated with rural areas dedicated mainly to goat and sheep breeding, and causes significant economic losses [47, 69, 116–118].

From 2009 to 2014, a total of 29,559 new human cases of cystic echinococcosis were registered in these countries. The average fatality rate across the three countries was 2.9%, suggesting that the disease causes approximately 880 deaths annually. The most affected are children <15 years of age, which is indicative of a persistent environmental risk leading to new cases [69, 115]. In the countries analysed, Government Control Programmes have been addressed, and surveillance of the disease from a holistic perspective based on Primary Health Care has been implemented [64, 69, 115, 117]. The number of human cases has a heterogeneous geographical distribution in Chile and Argentina, showing an increase towards the south [116, 118].

4.2.2 Toxocariasis

Toxocariasis is an infection that has a worldwide distribution and is a very important zoonosis due to its frequent occurrence in humans [119]. The estimate of the overall worldwide prevalence of *T. canis* in dogs of 11.1% represents 100 million dogs, which should alert Public Health experts and policy makers to the need for effective intervention programs [114, 120]. This parasite species has high biotic potential since its eggs contaminate water, soil, grass, and pet fur [51]. The results presented here regarding *T. canis* in dogs of southern South America show higher prevalence values (around 13%) than the overall prevalence registered worldwide. Also, the risk of infection is similar in urban and rural areas, as suggested in Chile [105]. In Argentina, numerous studies that analysed the seroprevalence of toxocariasis in both children and adults from urban and rural areas reported results varying between 28% and 80% [51, 121, 122]. In Chile, the seroprevalence of this parasitosis varies between 1.3% and 25.4% [105]. Although in Uruguay there are no published records of seroprevalence in humans [123], a recently published work reported that from 2014 to 2018, 20 children had been treated in the public health system for ocular and visceral *larva migrans* syndrome [123].

4.2.3 Ancylostomiasis

Dog hookworms are *Ancylostoma caninum*, *Ancylostoma braziliense*, and *Uncinaria stenocephala,* and their eggs can be found in faeces. The larvae of these parasites can cause cutaneous *larva migrans* in humans [124]. The main causal agent of *larva migrans* worldwide is *A. braziliense*; however, the causative agents vary among geographical areas, even within a single country. This disease is mainly endemic to tropical and subtropical developing countries with high average annual temperatures and humid climates, predominating in America from the southern United States, through Mexico, Central, and reaching South America. It is especially prevalent in areas where dogs roam freely, and on sandy, wet soils, such as beaches and playgrounds [124]. In Argentina, records of human cutaneous *larva migrans* correspond to the *Wichi* aboriginal communities in the subtropics of the northwest of the country [103], or to people who had travelled to Brazil [125]. In Chile, there are also few reports of this disease, and they correspond to a 3-year-old patient who acquired the disease in an urban area [126], and to an adult who had been infected on a trip to Brazil [127].

4.2.4 Strongyloidiasis

Strongyloidiasis is prevalent in remote socioeconomically disadvantaged communities around the world, and dogs can act as reservoirs of human strongyloidiasis [128]. This parasitosis is registered in the north of Argentina, with similar infection values in both rural and urban populations and an overall seroprevalence of 19.6%

[129, 130]. In Chile, the seroprevalence is much lower (0.25%) in blood donors from Arica and La Union. Human infections by *S. stercoralis* in this country are therefore endemic, with very low frequency in apparently healthy individuals [131].

5. General conclusions

This review shows that knowledge of canine helminths in southern South America is scarce. The studies published on dog parasites are not equally distributed across the three countries, with Uruguay presenting the least amount of available information. Data on dog parasites in southern South America is still too incipient for identification of a clear distribution pattern. Homogenisation of criteria would be beneficial, since the methods used are diverse and heterogeneous, some studies using only flotation or sedimentation techniques. Numerous parasitic species were recorded, many of which are zoonotic and widely distributed throughout both urban and rural areas of these countries. The risk of dogs becoming infected is high given the number of parasites present and the style of pet ownership in the communities of these countries, where dogs are allowed to roam freely, and veterinary care is scarce. The high percentage of zoonotic helminths reinforces the need to establish effective prevention measures, not only for parasitosis in animals but also for transmission to humans. Considering that people in both urban and rural areas are at risk of being infected with zoonoses transmitted by dogs, given the high levels of infection they present in their faeces, a One Health approach to public health would be desirable, such that humans and dogs should be treated concomitantly to control the parasites. Furthermore, it would be desirable to implement measures such as control of the canine population, mass treatment of dogs with anthelmintics, education programmes and healthcare alert systems.

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