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Artículo

NEW HOST RECORDS AND GEOGRAPHIC DISTRIBUTION OF SPECIES OF *Trichuris* (NEMATODA: TRICHURIIDAE) IN RODENTS FROM ARGENTINA WITH AN UPDATED SUMMARY OF RECORDS FROM AMERICA

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ABSTRACT. Species of *Trichuris* have a cosmopolitan distribution and parasitize a broad range of mammalian hosts. Although, the prevalence and intensity of this genus depends on many factors, the life cycles and characteristics of the environment have been the main aspect used to explain their geographical distribution. In this paper, we provide new host and geographical records for the species of *Trichuris* from Sigmodontinae rodents in Argentina. Moreover, we present comprehensive data about previous records of the genus from rodents in North and South America, and mainly in Argentina. A total of 563 specimens including in 25 species of rodents from 12 provinces and 43 localities from Northeast and Southern Argentina were sampled for *Trichuris*. Six species of *Trichuris* including 9 new hosts and 16 new geographical records were found. The prevalence of *Trichuris* in Misiones province is higher than in other geographical areas studied. This tropical-subtropical nematode group is recorded for the first time from the latitude 40º S. Nevertheless, more surveys are necessary to determine whether the scarcity of infections of *Trichuris* in regions of high latitude is due to the absence of sample effort or to environmental effects on the survival of infective stages.

RESUMEN. Nuevos registros hospedatorios y de distribución geográfica de *Trichuris* (Nematoda: Trichuriidae) de roedores de Argentina con un resumen actualizado de los registros en América. Las especies de *Trichuris* presentan una distribución cosmopolita y parasitan un amplio rango de hospedadores mamíferos. Aunque la prevalencia e intensidad parasitaria de estos nematodes dependen de diferentes factores, su ciclo de vida y las características del ambiente han sido los principales aspectos que explican su distribución geográfica. En este trabajo se brindan nuevos hospedadores y registros geográficos para las especies de *Trichuris* de roedores Sigmodontinae para la Argentina. Además, se presentan datos completos y organizados sobre previos registros del género en roedores del continente americano, y principalmente de Argentina. Un total de 563 especímenes incluidos en 25 especies de roedores procedentes de 12 provincias y 43 localidades del noreste y del sur de la Argentina fueron examinados con el fin de hallar especímenes de *Trichuris*. Se presentan seis especies de *Trichuris* incluyendo 9 nuevos hospedadores y 16 nuevos registros geográficos. La prevalencia de *Trichuris* en la provincia de Misiones es más alta que en otras áreas geográficas estudiadas. Este grupo de nematodes tropical-subtropical es registrado por primera vez por sobre los 40º S. De todos modos, son necesarios nuevos estudios para explicar si la escasez de infecciones de *Trichuris* en regiones de altas latitudes es debido a la ausencia de esfuerzo de muestreo o al resultado del efecto del ambiente sobre la supervivencia del estadio infectivo.

Key words: America. Argentina. Nematoda. Rodentia. Sigmodontinae. *Trichuris*.

Palabras clave: América. Argentina. Nematoda. Rodentia. Sigmodontinae. *Trichuris*.

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INTRODUCTION

Species of *Trichuris* Roederer, 1761 (Nematoda: Trichuridae) have a cosmopolitan distribution and parasitize a broad range of mammalian hosts (Cafrune et al., 1999; Anderson, 2000). Among these, the most common species are *Trichuris trichiura* (Linnaeus, 1758) from humans, and *T. muris* (Schrank, 1788), *T. ovis* (Abildgaard, 1795), *T. suis* (Schrank 1788), and *T. vulpis* (Froelich, 1789) from synanthropic and domestic animals (e.g. Knight, 1971; Beer, 1976; Bundy and Cooper, 1989; Callejón et al., 2010). Although, the prevalence and intensity of *Trichuris* in a host population depend on many factors, host immunologic status, behavior, areas with inadequate sanitation (food and fecal deposition areas mixed); the characteristics of its life cycle and environmental limiting factors have been the main aspects used to explain the geographical distribution (Bundy et al., 1988; Bundy and Cooper, 1989; Grencis et al., 1993; Anderson, 2000).

Whipworm eggs are deposited from host feces to the soil where infective larvae develop within the egg. Development of this larval stage has been shown to be influenced by temperature. Following ingestion of infective eggs by the host, all subsequent larval development to the adult stage occurs in the mucosa of the caecum and colon (Beer, 1973; Bundy and Cooper, 1988, 1989). Infections by trichuriasis are more prevalent in warm and moist tropical regions than in other parts of the world, and occur mainly in North and South America (Bundy and Cooper, 1988, 1989). However, most records are from medical and veterinary surveys (e.g. Bundy and Cooper, 1988; Traub et al., 2004; Gamboa et al., 2005), and comparatively few studies have been carried out on natural infections of *Trichuris* from wild hosts. In addition, many geographical areas have not been surveyed for *Trichuris*. Current distribution of the genus might reflect the absence of sample effort rather than the absence of infection (Bundy and Cooper, 1989).

Argentina is the second largest country in South America by land area, after Brazil, and exhibits a wide variety of soil types and climatic conditions (Bertonatti and Corcuera, 2000). The generally temperate climate ranges from subtropical in the north to subpolar in the far south and these environments include different eco-regions. Under natural conditions the rate of development of *Trichuris* species in this country may differ significantly from the optima, depending on the geographical distribution.

In this country, 8 species of *Trichuris* have been described and recorded from rodents (Morini et al., 1955; Boero and Boehringer, 1967; Suriano and Navone, 1994; Robles et al., 2006; Robles, 2011; Robles et al., 2012b). The only two records of this genus from wild hosts in other orders are *Trichuris tenuis* Chandler, 1930 from *Lama glama* and *Vicugna vicugna* (Artiodactyla; Cafrune et al., 1999) and *T. campanula* Linstow, 1889 from *Oncifelis geoffroyi* (Carnivora; Beldomenico et al., 2005). In general, the information available from many mammalian hosts is poor, hidden and scattered, making it difficult to evaluate the distribution and geographical gaps of the species of *Trichuris*.

Several parasitological studies on Sigmodontinae rodents (Cricetidae) have been carried out in Argentina in recent years (e.g. Robles and Navone, 2010; Notarnicola and Navone, 2011; Digiani et al., 2012; Robles et al., 2012a, 2012c; Digiani et al., 2013) and among these, three dealt with the taxonomy of *Trichuris* (Robles and Navone, 2006; Robles et al., 2006; Robles, 2011). However, these are only partial records, because several host species and *Trichuris* species are still under study.

In this paper, we provide new host and geographical records for *Trichuris* species from sigmodontine rodents of Argentina. Moreover, we present comprehensive data on previous records of the genus from rodents in North and South America, mainly in Argentina.

MATERIALS AND METHODS

Studied area

This includes the Northeast of Argentina, approximately between 26° and 35° S, politically covering the eastern Formosa, Chaco and Santa Fe provinces, the northern Buenos Aires province and Misiones, Corrientes and Entre Rios provinces. Also, the studied

area includes the south of Argentina (Patagonia), approximately between 38º and 54º S, embracing Chubut, Neuquén, Río Negro, Santa Cruz and Tierra del Fuego provinces (see **supplementary material** for additional details on localities).

Hosts

Sigmodontine rodents were trapped during different field works between 2007 and 2010 (see collectors and support in acknowledgements). Many specimens are still being studied, but partial results were analyzed. Species of hosts with a very low representation (< 5) have not been considered in this paper (except *Chelemys macronyx* with n = 3). A total of 563 specimens were examined for *Trichuris*. From the northeast area, 493 specimens belonging to 17 species from 29 localities and 7 provinces were examined as following: *Akodon azarae* (n = 118) [*A. azarae bibianae* (n = 12), *A. azarae hunteri* (n = 106)], *Akodon philipmyersi* (n = 14), *Bruceppatersonius* sp. (n = 6), *Calomys* sp. (n = 13), *Euryoryzomys russatus* (n = 8), *Holochilus brasiliensis* (n = 5), *H. chacarius* (n = 13), *Necromys lasiurus* (n = 109), *Necromys obscurus* (n = 11), *Nectomys squamipes* (n = 5), *Oligoryzomys flavescens* (n = 37), *O. fornesi* (n = 10), *O. nigripes* (n = 71), *Oxymycterus rufus* (n = 45), *Scapteromys aquaticus* (n = 5), *Sooretamys angouya* (n = 8), *Thaptomys nigrita* (n = 15). From Patagonia we examined 70 specimens belonging to 8 species from 14 localities and 5 provinces as following: *Abrothrix hirta* (n = 12), *A. olivacea* (n = 19), *Akodon dolores* (n = 5), *Chelemys macronyx* (n = 3), *Eligmodontia morgani* (n = 6), *Euneomys* sp. (n = 6), *Oligoryzomys longicaudatus* (n = 10), *Phyllotis xanthopygus* (n = 9) (see **supplementary material**).

Parasites

Nematodes were collected from the large intestine and caecum and preserved in 70% ethanol. For identification, the worms were prepared and identified following Robles et al. (2006), Robles and Navone (2006) and Robles (2011). Voucher specimens were deposited in the Colección de Helmintología from Museo de La Plata, Argentina (CHMLP).

Data analysis

Quantitative parameters of prevalence (P = specimens parasitized/specimens examined *100), intensity (I = number of parasites in a single infected host), mean intensity (MI = number of parasites/specimens parasitized) and mean abundance (MA = number of parasites/specimens examined) were calculated according to Bush et al. (1997) for each host species and locality (**Table 1**). Prevalence, MI, I and MA for host species and studied area were given in the text. Prevalence differences were compared by the χ^2 test, and the data were analyzed by use of the Chi squared test employing the correction of Yates or by use of Fisher's exact test (positive cases <5), considering significant at $p < 0.05$. Statistical analysis was performed with EpiInfo™ 7.

RESULTS

Ten species of sigmodontine rodents from Argentina were parasitized with species of *Trichuris*. Three species of *Trichuris* were identified to the specific level, and at least 3 others were studied in detail, although these could not be identified to the species level (**Table 1**).

Published and new records for *Trichuris* in Argentina are shown in **Fig. 1** (also see **Tables 1** and **2** for species references). Records of *Trichuris* from the literature were summarized for Argentina in **Table 2** and those for North and South America in **Table 3**.

Akodon azarae bibianae, *A. azarae hunteri* and *N. lasiurus* were parasitized with *Trichuris laevitestis* Suriano and Navone, 1994. *A. azarae bibianae* and *N. lasiurus* are new host records, and 11 localities are new geographical records (**Table 1**). The total P, MI and MA of *T. laevitestis* in all host species were 11.9%, 4.03 and 0.48, respectively; and in each host species: *A. azarae* 16.9%, 3.85 and 0.65 and *N. lasiurus* 6.42%, 4.57 and 0.29, respectively. *T. nigrita* were parasitized with a species of *Trichuris*. This host and Refugio Moconá represent new records for this nematode (**Table 1**). General features of these specimens suggest that they belong to *Trichuris navonae* Robles, 2011. However, some diagnostic measurements (in millimeters) such as spicule length (1.9-2.3), distal cloacal tube length (1.7-2.1), proximal cloacal tube lengths (1.2-1.7), present ranges higher than those prevously recorded for *T. navonae* from *A. montensis* (1.3-2.1, 1-1.9, 0.75-1.5; respectively), verified through their ratios with the posterior portion of body and total body lengths. For this reason, these specimens are listed provisionally as *Trichuris* cf. *T. navonae* until more detailed morphometric analyses and molecular comparative studies determine whether they are cryptic species. The P, MI and

Table 1

New hosts and geographical records for species of *Trichuris* in Argentina with data of Prevalence (P), Intensity (I), Mean Intensity (MI) and Mean Abundance (MA) by locality and host species; numbers and symbols refer to **Fig. 1**.

	Trichuris species	Host species	Locality*	Prevalence	Intensity or Mean intesity	Mean abundance
1	*T. laevitesitis*	*A. azarae bibianae***	7 km S Puerto Las Palmas, Chaco**	25% (1/4)	2+	0.5 (2/4)
			INTA-IPAF NEA, Formosa**	33.3% (1/3)	4+	1.33 (4/3)
		A. azarae hunteri[a]	Arroyo de las Brusquitas, Buenos Aires**	37% (10/27)	1.9 (19/10)	0.7 (19/27)
			Punta Indio, Buenos Aires**	9.1% (1/11)	2+	0.2 (2/11)
			Zárate, Buenos Aires**	18.2% (2/11)	1 (2/2)	0.2 (2/11)
			Arroyo Caraballo, Entre Ríos**	25% (1/4)	35+	8.8 (35/4)
			Colonia Villa Elisa, Entre Ríos**	12.5% (3/24)	2 (6/3)	0.3 (6/24)
			Oliveros, Santa Fe**	(1/1)	7+	7 (7/1)
		*N. lasiurus***	Finca La Adelita, Laguna Paiva, Corrientes**	14.3% (2/14)	1.5 (3/2)	0.2 (3/14)
			Pergamino, Buenos Aires**	12.5% (2/16)	3 (6/2)	0.4 (6/16)
			Uranga, Santa Fe**	16.6% (3/18)	7.6 (23/3)	1.3 (23/18)
2	*T.* cf. *navonae*	*T. nigrita***	Refugio Moconá, Misiones**	75% (3/4)	2 (6/3)	1.5 (6/4)
			Desembocadura Arroyo Paranay-Guazú, Misiones[c]	33% (1/3)	6+	2 (6/3)
			Balneario Municipal de Aristóbulo del Valle, Misiones[c]	85.7% (6/7)	1.16 (7/6)	1 (7/7)
3	*T.* cf. *T. pardinasi*	*P. xanthopygus xanthopygus***	Cerro Corona, Meseta de Sumuncurá, Río Negro**	(2/2)	10 (20/2)	10 (20/2)
4	*Trichuris* sp. 1	*H. chacarius***	INTA-IPAF NEA, Formosa[#]	23.1% (3/13)	18.6 (56/3)	4.3 (56/13)
5	*Trichuris* sp. 2	*S. angouya***	Refugio Moconá, Misiones[#]	50% (2/4)	7 (14/2)	3.5 (14/4)
			Reserva de Usos Múltiples Guaraní, Misiones**	(2/2)	1 (2/2)	1 (2/2)
6	*Trichuris* sp. 3	*C. macronyx***	Cañadón de la Madera, Sierra de Tepuel, Chubut**	33.3% (1/3)	10+	3.3 (10/3)
7	*Trichuris* sp. 4	*N. obscurus***	Arroyo de las Brusquitas, Buenos Aires[#]	36.4% (4/11)	1.5 (6/4)	0.5 (6/11)
‡	*Trichuris* sp.	*E. russatus***	Arroyo Paraíso, Misiones[c]	(1/1)	1+	1 (1/1)
‡	*Trichuris* sp.	*S. aquaticus*[b]	Estancia San Nicolás, Corrientes**	20% (1/5)	1+	0.2 (1/5)

* See complete data in supplementary material; ** denotes a new host and/or a new locality records.
[a] Robles and Navone, 2006; [b] Suriano and Navone, 1994; [c] Robles, 2011. [#] shared record; + intensity.

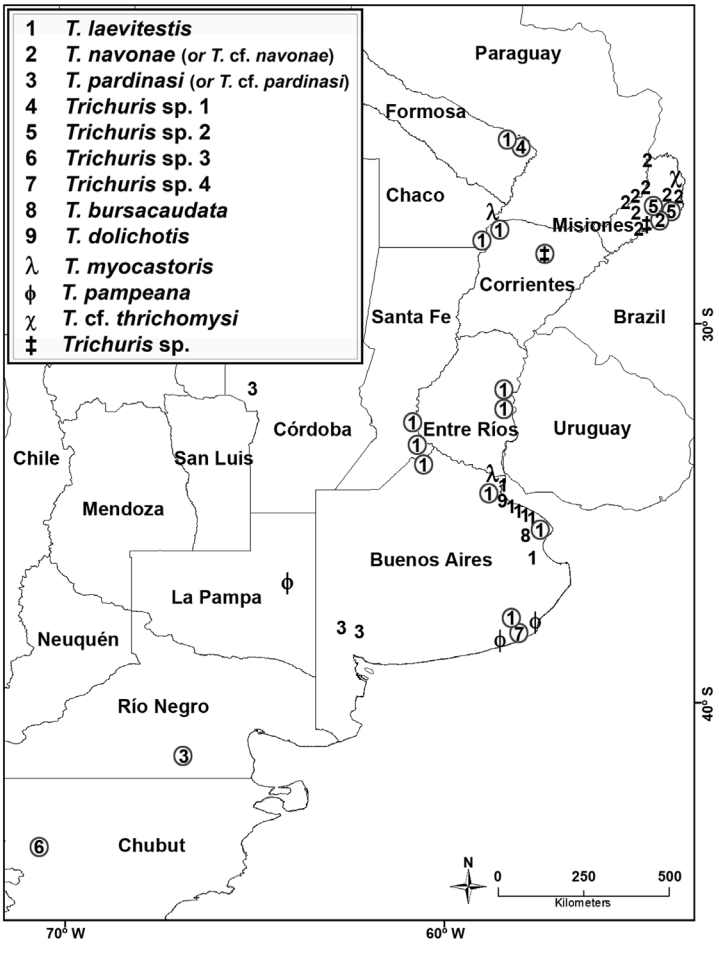

Fig. 1. Previous and new records for the species of *Trichuris* in Argentina. Localities are detailed in Tables 1 and 2. New records are marked with a circle.

MA of *T.* cf. *T. navonae* in the population of *T. nigrita* were 66.6%, 1.9 and 1.26, respectively.

Phyllotis xanthopygus xanthopygus were parasitized with another species of *Trichuris*. This host subspecies represents a new host record for this nematode. In addition, these results add a new locality and province, Cerro Corona and Río Negro, respectively (**Table 1**). General features of these specimens suggest that they belong to *Trichuris pardinasi* Robles, Navone and Notarnicola, 2006. However, some morphometrical discrepancies (in millimeters) such as spicule lengths were observed (2.5-3.3 in *P. x. xanthopygus* vs. 3.6-5.2 in *P. bonariensis* and *P. x. vaccarum*). For this reason, these specimens are listed provisionally as *Trichuris* cf. *T. pardinasi*. It would be useful to obtain new samples and data from other sources (i.e. genetic data). The P, MI and MA of *T.* cf. *T. pardinasi* in *P. x. xanthopygus* were 28.6%, 10 and 2.86, respectively.

Sooretamys angouya, *N. obscurus*, *H. chacarius*, and *C. macronyx* were parasitized, each one with 1 species of *Trichuris*. These findings contitute 4 new host records and 4 new locality records (**Table 1**). *Trichuris* specimens from the first 3 host species listed above are mainly characterized by the absence of a spicular tube, a spinose spicular sheath (spines very small, densely arranged), and a slightly protusive or nonprotusive vulva. The *Trichuris* specimens from *C. macronyx* are characterized by the presence of a spicular tube, a spinose spicular sheath (spines very small, densely arranged), and a protusive vulva; along with morphometric characters. Morphologically these specimens correspond to 4 different species of *Trichuris*, suggesting the presence of 2 new species, one from *S. angouya* and one from *H. chacarius*; and 2 preliminary unidentified species, one from *N. obscurus* and one *C. macronyx*. Until new samples are obtained and molecular comparative studies are concluded these species are listed here as *Trichuris* sp. The P, MI and MA of the species of *Trichuris* were in *S. angouya*, 50%, 4 and 2, respectively; in *N. obscurus*, 36.4%, 1.5 and 0.54, respectively; in *H. chacarius*, 16.6%, 18.6 and 3.11, respectively; and in *C. macronyx* 33%, 10 and 3.33, respectively.

Table 2

Host and geographical data for the species of *Trichuris* previously recorded from rodents in Argentina; numbers and symbols refer to **Fig. 1**.

	Trichuris species	Host species	Locality	Coord S	Coord W	Province	References
1	*T. laevitestis*	*Akodon azarae hunteri*	Punta Lara	34°47'30"	58°0'5"	Buenos Aires	Suriano and Navone, 1994
			La Balandra	34°55'51"	57°43'0.6"	Buenos Aires	Robles and Navone, 2006
			Reserva Otamendi	34°09'	58°57'	Buenos Aires	Robles and Navone, 2006
			Cerro de la Gloria	36°06'	57°46'	Buenos Aires	Robles and Navone, 2006
		Scapteromys aquaticus	Punta Lara	34°47'30"	58°0'5"	Buenos Aires	Suriano and Navone, 1994
			La Balandra	34°55'51"	57°43'0.6"	Buenos Aires	Robles and Navone, 2006
			Los Talas	34°52'05"	57°49'20"	Buenos Aires	Robles and Navone, 2006
			Palo Blanco	34°52'24"	57°48'47"	Buenos Aires	Robles and Navone, 2006
2	*T. navonae*	*Akodon montensis*	Balneario Municipal de Aristóbulo del Valle	27°05´17"	54°57'9"	Misiones	Robles, 2011
			Club Pesca Paranay-Guazú	26°40'32"	54°48'51"	Misiones	Robles, 2011
			Desembocadura arroyo Paranay-Guazú	26°40'39"	54°50'8"	Misiones	Robles, 2011
			Arroyo Salamanca	26°36'53"	54°46'51"	Misiones	Robles, 2011
			Salto El Paraíso, arroyo Paraíso	27°13'49"	54°02'24"	Misiones	Robles, 2011
			Arroyo Oveja Negra - Ruta 21	27°8'20"	53°55'31"	Misiones	Robles, 2011
			Parque Provincial Cruce Caballero	26°30'50"	53°59'54"	Misiones	Robles, 2011
			Parque Provincial Moconá**	27°9'23"	53°54'10"	Misiones	Robles, 2011
			Puerto Península	25°40´	54°38´	Misiones	Robles, 2011
3	*T. pardinasi*	*Phyllotis bonariensis*	Cerro Destierro, Sierra de la Ventana	38°1'25"	62°54'39"	Buenos Aires	Robles et al., 2006
			Abra de la Ventana, Sierra de la Ventana	38°4'3"	62°1'17"	Buenos Aires	Robles et al., 2006
3	*T. pardinasi*	*Phyllotis xanthopygus vaccarum*	Pampa de Achala	31°37'19"	64°54'39"	Córdoba	Robles et al., 2006

8	*T. bursacaudata*	*Ctenomys talarum*	Punta de Indio	35°16'27"	57°15'38"	Buenos Aires	Suriano and Navone, 1994
9	*T. dolichotis*	*Dolichotis patagonum*	Jardín zoológico, Ciudad de Buenos Aires*	34°34'44"	58°24'55"	Buenos Aires	Morini et al., 1955
λ	*T. myocastoris*	*Myocastor coypus*	Región del Delta*	34°21'32"	58°40'53"	Buenos Aires	Boero and Boehringer, 1967
			Región Chaqueña*	27°20'27"	58°47'9"	Chaco	Boero and Boehringer, 1967
φ	*T. pampaeana*	*Ctenomys azarae*	Santa Rosa	36°36'33"	64°19'2"	La Pampa	Suriano and Navone, 1994
		Ctenomys australis	Necochea	38°33'	58°45'	Buenos Aires	Rossin et al., 2010
		Ctenomys talarum	Necochea	38°33'	58°45'	Buenos Aires	Rossin and Malizia, 2005
			Mar de Cobo, Pdo. Mar Chiquita	37°58'	57°34'	Buenos Aires	Rossin and Malizia, 2005
χ	*T. cf. thrichomysi*	*Euryzygomatomys spinosus*	Cuartel Río Victoria, Ruta 14 km 273, INTA	26°46'	54°18'	Misiones	Robles et al., 2012

* Area not detailed; ** This locality is very near to Refugio Moconá (see **Table 1**)

Euryoryzomys russatus and *S. aquaticus* from Ea. San Nicolás were each parasitized with a *Trichuris* sp., constituting a new host and a new geographical record, respectively (**Table 1**). In both cases, species identification was not possible due to the absence of males. The P, MI and MA of the species of *Trichuris* in each host species were 12.5%, 1, 0.13 and 20%, 1, 0.2, respectively.

Specimens of *Trichuris* were not distributed homogeneously among the host species and study areas. The prevalence between species pairs: *A. azarae* with *N. lasiurus*, *T. nigrita* and *S. angouya*; *N. lasiurus* with *N. obscurus*, *T. nigrita* and *S. angouya*; *T. nigrita* with *E. russatus* and *H. chacarius* were significantly different ($p < 0.05$). On the other hand, the prevalence between other host species pairs studied did not differ significantly. Moreover, the prevalence between the two studied areas, Northeast (P 9.53%) and South (P 4.41%) of Argentina, were not significantly different ($p = 0.25$).

In summary, we recorded 9 new hosts (7 species and 2 subspecies) and 16 new geographical records for *Trichuris*, enlarging significantly their distributional range (**Table 1**).

A total of 8 species of *Trichuris* from 11 rodent species have been recorded in Argentina since 1955 (Morini et al., 1955; Boero and Boehringer, 1967; Suriano and Navone, 1994; Rossin and Malizia, 2005; Robles and Navone, 2006; Rossin et al., 2010; Robles et al., 2006; Robles, 2011; Robles et al., 2012b). These species are distributed approximately from 25° 12´S to 43° 51´S and from 70° 43´W to 53° 54´W (Tables 1 and 2). A total of 24 species of *Trichuris* from 33 rodent species have been recorded in the Americas since 1955. These species are distributed from Manitoba (N) (Canada) to Texas (S) and from California (W) to Maryland (E) (USA); and in South America from Trinidad (N) (Republic of Trinidad and Tobago) to La Pampa (S) (Argentina) and from Minas Gerais (W) (Brazil) to La Hauyca (E) (Chile) (**Table 3**) (Lent and Freitas, 1936; Chandler, 1945; Tiner, 1950; Cameron and Reesal, 1951; Morini, et al. 1955; Read, 1956; Boero and Boehringer, 1967; Kenneth and Lepp, 1972; Barus et al., 1975; Babero et al.,

Table 3

Host and geographical data previously recorded for species of *Trichuris* from rodents in America excluding Argentinean records.

Trichuris species	Host species	Host family	Locality	Country
T. leporis (Froelich, 1789)	*Spermophilus richardsonii*[§]	Sciuridae	Manitoba	Canada
T. gracilis (Rudolphi, 1819)	*Dasyprocta leporina*[*], *D. fuliginosa*	Dasyproctidae	State of Amazonas	Trinidad Brazil
T. opaca Barker et Noyes, 1915	*Ondatra zibethicus*, *Microtus pennsylvanicus*	Cricetidae	Nebraska, Wisconsin, Ohio, Wyoming, Maryland	USA
T. fossor Hall, 1916	*Thomomys talpoides*[†], *T. bottae*	Geomyidae	California, Wyoming	USA
T. myocastoris Enigk, 1933	*Myocastor coypus*	Myocastoridae	San Pablo	Brazil
T. citelli Chandler, 1945	*Spermophilus beecheyi*[‡]	Sciuridae	California	USA
T. perognathi Chandler, 1945	*Perognathus californicus californicus, P. pennicillata*	Heteromyidae	California	USA
T. neotomae Chandler, 1945	*Neotoma fuscipes*	Cricetidae	California	USA
T. peromysci Chandler, 1946	*Peromyscus californicus*	Cricetidae	California	USA
T. madisonensis Tiner, 1950	*Tamias striatus*	Sciuridae	Wisconsin	USA
T. dipodomys (Read, 1956)	*Dipodomys ordii*, *D. phillipsi*,	Heteromyidae	New Mexico, Utah	USA
T. bradleyi Babero, Cattan and Cabello, 1975	*Octodondegus*	Octodontidae	Santiago	Chile
T. chilensis Babero, Cattan and Cabello, 1976	*Abrothrix longipilis*[α]	Cricetidae	Santiago	Chile
T. fulvi Babero et Murua, 1987	*Ctenomys fulvus phillipiensis*	Ctenomyidae	San Pedro de Atacama	Chile
T. elatoris Pfaffnberger and Best, 1989	*Dipodomys elator*, *D. merriami, D. ordii*	Heteromyidae	Texas	Mexico
T. robusti Babero and Murua, 1990	*Ctenomys robustus*	Ctenomyidae	La Hauyca	Chile
T. travassosi Correa Gomes, Lanfredi, Pinto and Souza, 1992	*Oligoryzomys nigripes*[#]	Cricetidae	Rio Grande do Sul	Brazil

(Table 3 cont.)

Trichuris species	Host species	Host family	Locality	Country
T. thrichomysi Lopes Torres et al., 2011	*Thrichomys apereoides*, *Euryzygomatomys spinosus*	Echimyidae	Minas Gerais	Brazil

§ Cited as *Citellus richardsoni* by Tiner, 1950; * Cited as *Cavia agouti* by Rudolphi, 1819; † Cited as *Thomomys fossor* by Hall, 1916; ‡ Cited as *Citellus beecheyi* by Chandler, 1945; α Cited as *Akodon longipilis* by Babero, Cattan and Cabello, 1976; # Cited as *Oryzomys nigripes* by Correa Gomes et al., 1992. Families of Argentinean records, Caviidae: *T. dolichotis;* Cricetidae*: T. laevitestis, T. pardinasi* and *T. navonae;* Ctenomyidae*: T. bursacaudata* and *T. pampeana*.

1975, 1976; Babero and Murua, 1987; 1990; Pfaffnberger and Bests, 1989; Correa Gomes et al., 1992; Suriano and Navone, 1994; Gonçalves et al., 2002; Rossin and Malizia, 2005; Robles and Navone, 2006; Robles et al., 2006; Rossin et al., 2010; Robles, 2011; Robles et al., 2012b).

DISCUSSION

Each species of *Trichuris* geographically located in Argentina can be distinguished by diagnostic features. In several cases (e.g., *Trichuris* specimens obtained from *C. macronyx*, *E. russatus*, *N. obscurus*, and *S. aquaticus*), observed differences in morphological and metric traits prevent us a confident specific assignation. Two possible new species were found from *S. angouya* and *H. chacarius* each one. However, new and more detailed studies and material are necessary to clarify the alpha taxonomy of *Trichuris* in Argentina.

To date, a total of 24 species of *Trichuris* have been described from 10 families of rodents in America, Caviidae (1 species), Cricetidae (8), Ctenomyidae (4), Dasyproctidae (1), Echymyidae (1), Geomyidae (1), Heteromyidae (3), Myocastoridae (1), Octodontidae (1), and Sciuridae (3). Of these, 8 species have been reported from Argentina, including *Trichuris dolichotis* Morini, Boero and Rodriguez, 1955, *T. myocastoris* Enigk, 1933, *T. laevitestis T. bursacaudata* Suriano and Navone, 1994, *T. pampeana* Suriano and Navone, 1994, *T. pardinasi*, *T. navonae*, *T.* cf. *T. thrichomysi* Lopes Torres et al., 2012 (Morini et al., 1955; Boero and Boehringer, 1967; Suriano and Navone, 1994; Robles et al., 2006; Robles, 2011; Robles et al., 2012b) and 4 additional species, not identified to specific level, mentioned in this paper (**Tables 1**, **2** and **3**).

Furthermore, a total of 9 species of *Trichuris* have been recorded from 14 sigmodontines (*A. azarae*, *A. montensis*, *A. hirta*, *C. macronyx*, *E. russatus*, *H. chacarius*, *O. nigripes*, *P. bonariensis*, *P. xanthopygus*, *N. lasiurus*, *N. obscurus*, *T. nigrita*, *S. aquaticus*, and *S. angouya*; **Tables 1**, **2** and **3**). Sigmodontine rodents are distributed predominantly in South America, with a few species having a Central and North American distribution, and this subfamily includes approximately 400 species (Patton et al., in press). Despite the large number of potential host species, only about 3.5% of sigmodontine rodent species have been recorded as hosts for species of *Trichuris*. Among these hosts, 86% of infections were recorded in Argentina (Morini et al., 1955; Boero and Boehringer, 1967; Suriano and Navone, 1994; Robles and Navone, 2006; Robles et al., 2006; Robles, 2011; Robles et al., 2012b). This number may represent only a small fraction of the species of *Trichuris* that occurs in sigmodontine rodents, and additional surveys of this group should yield both new species and records.

The distribution of *Trichuris* species among the species of sigmodontine rodents in the surveyed localities showed a range of prevalence between 9.1-85.7% (samples of 2 or < specimens were not considered). Although the prevalence values given for some localities may be questionable because of the low number of specimens examined, these data give a new overview of the regional distribution of *Trichuris*. *Trichuris* cf. *T. navonae*

and *Trichuris* sp. from 3 localities in Misiones showed the highest prevalence (85.7%, 75% and 50%) (**Table 1**). However, *T. laevitestis* from *A. a. hunteri* of Arroyo Caraballo (I = 35, MA = 8.8) and *Trichuris* sp. from *H. chacarius* of INTA-IPAF NEA (MI = 18.6, MA = 4.3) showed the highest intensities.

The significant differences observed in the prevalences of the species of *Trichuris* among host species probably relate to a combination of factors, including host immunologic status, behavior of the host species and characteristics of environment where the eggs were deposited. However, the prevalences between the two studied areas, northeast and south of Argentina, were not significantly different ($p > 0.05$). Since this is a limited study, these results are not conclusive and surely new data on the soil and microenvironment characters, home range and behavior of host species, and experimental studies will lead to clearer hypotheses about the limiting factors of *Trichuris* present in wild mammals and extreme geographical areas.

Because of this, a previous hypothesis about the global geographical distribution (tropical and subtropical areas) of genus *Trichuris* should be revisited. To date, different studies have demonstrated that the embryonation period varies between 9-37 days and 25-35 ºC for *T. trichiura*, *T. muris* and *T. vulpis* (Beer, 1971, 1976). A field survey in southern England found that egg development in *T. suis* was greatly retarded at ground temperatures of 4-20º C, with an embryonation period of 434-630 days (Burden and Hammet, 1979). Moreover, species of *Trichuris* have been infrequently recorded in high latitudes (Tiner, 1950; Burden and Hammet, 1979; Sardella and Fugassa, 2009). These examples may explain why trichuriasis in humans is presently almost unknown in cold regions; and in the same way, in rodents.

Patagonia presents unique environment characteristics, comprising a series of plateaus and high plains, a vegetation in open patches, and a temperate climate, which ranges from subtropical in the north to subpolar in the far south and at higher elevations (e.g. Soriano, 1956; León et al., 1998). To date, in the subpolar areas there have been no previous records of *Trichuris* in Patagonia, except in archaeological samples (Sardella and Fugassa, 2009). However, in this survey, a population of this tropical-subtropical nematode is recorded for the first time from 40º S (*T.* cf. *T. pardinasi* and *Trichuris* sp., see **Table 1**).

In the context of the hypothesis above referred to the absence of *Trichuris* in the north, west and south of Argentina is consistent with a lower degree of sampling effort with respect to other areas in the country (**Fig. 1**). Parasitological studies have been carried out in the northeast area of Argentina for a long time, while these studies in Patagonian area have begun recently. It is likely that future studies will reveal the presence of more species and a more accurate host and geographical distribution, mainly in the southern portion of the country.

Consequently, more surveys on different host groups are necessary to determine whether the scarcity of infections of the genus *Trichuris* in regions of high latitude is due to the absence of sample effort or to environmental effects on the survival of infective stages.

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