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ORIGINAL PAPER

Digenean parasites of Sigmodontinae rodents from Argentina: a list of species, new host, and geographical records

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Abstract

Introduction Among Argentinean rodents, only one species of Muridae and seven of Cricetidae were reported as digenean hosts. Despite the available data, the taxonomic diversity of the Digenea from rodents has been little explored. An update on digeneans of Sigmodontinae rodents (Cricetidae-Muroidea) in Cuenca del Plata is provided. New host and geographical data are recorded and taxonomic and ecological data are summarized.

Methods Rodents were collected from 11 localities in the region Cuenca del Plata, Argentina. Moreover, other unidentified specimens from four localities, deposited in the Colección de Helmintología del Museo de La Plata, were studied. Prevalence, mean intensity, and mean abundance are provided.

Results Eight species of digeneans belonging to four families were identified. Twelve new geographical records for five provinces of Argentina are presented. In addition, six new host–parasite associations are reported. The information is presented in a taxonomic list for each digenean species: site of infection, host records, locality records, and comments.

Conclusions It becomes interesting to explore the diets and habits of each rodent species to understand the dispersal and transmission ability of each group of digeneans. This survey constitutes an update on digeneans of Sigmodontinae rodents in Cuenca del Plata, Argentina.

Keywords Argentina · Cricetidae · Digeneans · Platyhelminthes · Rodentia

Introduction

Digeneans are common parasites of micromammals around the world. Among these, rodents harbor the most diverse fauna of such parasites, including representatives of 30 families that show relatively low host specificity. In addition, the assembly structure of digeneans is known to be strongly affected by feeding habits of their hosts [1, 2].

Rodents of the subfamily Sigmodontinae Wagner are endemic to the American continent and they include about 110 species grouped in 40 genera in Argentina [3–5]. Moreover, these rodents are fundamental components in the structure of Neotropical communities and constitute the most diverse South American group of the family Cricetidae Fischer [6]. Sigmodontinae rodents live in almost all types of habitats within their geographical range, including deserts, wet tropical and temperate forests, scrublands, wetlands, savannas, steppes, high elevation grasslands, and salt flats [6, 7]. Most rodents are herbivores and omnivores, but they will opportunistically consume meat [8]. Specialist animalivorous and insectivores have evolved independently within multiple rodent families, most notably in the Muridae Illiger and Cricetidae [9].

More than 50 surveys on some aspect of digeneans parasitizing wild mammals have been published in Argentina. These host species represent only about 7% of the total number of mammal species recorded in the country. Among rodents, only one Muridae species *Rattus norvegicus* (Berkenhout) and eight of Cricetidae, *Akodon azarae* (Fischer), *Deltamys kempi* Thomas, *Holochilus vulpinus* Brants, *Holochilus chacarius* Thomas, *Oxymycterus rufus* (Fischer), *Oligoryzomys flavescens* (Waterhouse), *O. nigripes* (Olfers), and *Scapteromys aquaticus* Thomas, were reported as hosts

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of Digenea [10–12]. Despite the available data, the Digenea taxonomic diversity on rodents has barely been explored.

In this paper, an update of digeneans of Sigmodontinae rodents (Cricetidae-Muroidea) in the Cuenca del Plata is provided. New hosts and geographical data are recorded and taxonomic and ecological data are summarized.

Materials and methods

Study area and host sampling

Rodents were obtained by several collaborators between 1994 and 2018 (see Acknowledgements). Eleven localities from the Cuenca del Plata region in Argentina were sampled: Las Brusquitas creek, La Balandra, Punta Indio and Cerro de la Gloria, Buenos Aires Province; Villa Elisa, Entre Ríos Province; Estancia de Don Leguizamón, and Selvas de Río de Oro, Chaco Province; Reserva El Bagual and Estación de Animales Silvestres Guaycolec, Formosa Province and Reserva de Vida Silvestre Urugua-í and Parque Provincial Piñalito, Misiones Province (Table 1).

Research was conducted according to Argentinian laws. Sample collection was carried out during fieldwork under official permissions. This study was performed in agreement with recommendations of the Care and Use of Laboratory Animals of the National Institute of Health Guide. Specimens obtained with methods for live capture were studied and humanely killed following the procedures and protocols approved by national laws and the Ethics Committee for Research on laboratory, farm and obtained from nature animals, National Council of Scientific and Technical Research (CONICET).

Host repository

Rodent specimens were deposited in the Mastozoological Collection from Centro Nacional Patagónico (CNP), Puerto Madryn, Chubut, CNP 4942, CNP 4977, CNP 4961, CNP 5067, CNP 4608, CNP 4146. Other hosts with collection number are in process, field numbers: (CNP) CG 78, CG 402, CG 876, CG 877, CG 443; (Mastozoological Collection from Museo de La Plata) LB 222, LB 284, LB 293, RO 16, RR 15, RR 25.

Parasite study

The body cavity, stomach, small and large intestines, and cecum (unfixed and fixed in 10% formalin) of hosts were examined for parasites. Digeneans were killed in glacial acetic acid and preserved in 70% ethanol or were fixed inside the viscera in 10% formalin and preserved in 70% alcohol. Moreover, eight unidentified specimens from four localities were deposited in the Helminthological Collection of the of Museo de La Plata (MLP-He), La Plata, Argentina, were analyzed (MLP-He 1740-2, 2220-3, 4693, 4678, 1751-2, 4674-2, 1753-2, 2228-3). Specimens were stained with hydrochloric carmine, dehydrated through an alcohol series, cleared in eugenol, and studied by light microscopy (Leica MZ6 and Olympus SZ). Drawings were made with the aid of a drawing tube. Specimens were identified following the keys of Bray et al. [13], Gibson et al. [14], Jones et al. [15], and Yamaguti [16]. Voucher specimens were deposited in the MLP-He 7528-7540, La Plata, Buenos Aires, Argentina.

Data analysis

Prevalence (P), mean intensity (MI), and mean abundance (MA) were calculated for each host population following Bush et al. [17]. Previous records of digenean species on Sigmodontinae (Cricetidae) rodents were compiled from the available literature: scientific papers and book sections. When necessary, scientific names of mammal hosts were updated following Wilson et al. [18].

Results

A total of 876 Sigmodontinae rodents were examined. Digeneans were found in 21 specimens of six rodent species: *Akodon azarae*, *Akodon montensis* Thomas, *Holochilus chacarius* Thomas, *Necromys lasiurus* (Lund), *O. rufus,* and *S. aquaticus* from 11 localities belonging to different ecoregions of the Cuenca del Plata from Argentina. In addition, unidentified digeneans deposited in the CHMLP parasitizing *S. aquaticus* and *O. rufus* from another four localities were studied (Table 1).

Eight taxa of digeneans belonging to the families Echinostomatidae Looss 1899, Dicrocoeliidae Looss 1899, Cladorchiidae Looss 1899, and Zygocotylidae Ward 1917 were identified. The information is presented in a taxonomic list for each digenean species, which contains the site of infection, host records, locality records, and comments. Moreover, the ecological data of each parasite species by locality are shown in Table 1. Previous and new host and geographical records of digeneans on Sigmodontinae rodents (Cricetidae) from Argentina are summarized in Tables 1, 2 and Fig. 1.

An annotated list of the digenean species registered in this work is provided as below:

Phylum Platyhelminthes
Class Trematoda Rudolphi 1808
Subclass Digenea Carus 1863
Superfamily Echinostomatoidea Looss 1899
Family Echinostomatidae Poche 1926

Table 1 New hosts and geographical records of digenean species in Argentina with data of prevalence (P), mean intensity (MI) and mean abundance (MA) by locality and host species; numbers, refer Fig. 1

	Digenean species (collection number)	Host	Localities	Coord S	Coord W	Province	P (%)	MI	MA
1	*Canaania obesa* (MLP-He 7535)	*A. azarae**	La Balandra**	34°56′00″	57°42′00″	Buenos Aires	3.1 (1/32)	130 (130/1)	4.1 (130/32)
	(MLP-He 7536)	*A. montensis*	Parque Provincial Piñalito**	26°30′00″	53°50′00″	Misiones	25 (1/4)	6 (6/1)	1.5 (6/4)
			Total				5.6 (2/36)	4 (136/34)	3.8 (136/36)
2	*Echinoparyphium scapteromae* (MLP-He 7529)	*A. azarae*	Punta Indio**	35°16′00″	57°15′00″	Buenos Aires	33.3 (1/3)	6 (6/1)	2 (6/3)
	(MLP-He 1740-2)	*S. aquaticus*	Isla Talavera, Canal Irigoyen, Campana** (λ)	34°00′00″	58°59′20″	Buenos Aires	–	–	–
	(MLP-He 2220-3)		Berisso, Bagliardi beach (λ)	34°52′00″	57°05′00″	Buenos Aires	–	–	–
	(MLP-He 4693)		Isla Talavera, Establecimiento Savitar Rio Carabelas, Campana (λ)	34°10′00″	58°43′00″	Buenos Aires	–	–	–
	(MLP-He 4678)	*O. rufus*	Isla Talavera, Campana** (λ)	34°00′00″	58°59′20″	Buenos Aires	–	–	–
3	*Echinoparyphium* sp. (MLP-He 7528)	*N. lasiurus**	Reserva El Bagual**	26°18′12″	58°48′51″	Formosa	50 (1/2)	1 (1/1)	0.5 (1/2)
4	*Echinostoma platensis* (MLP-He 7531)	*S. aquaticus*	Reserva El Bagual**	26°18′12″	58°48′51″	Formosa	(1/1)	2 (1/1)	2 (1/1)
	(MLP-He 7532)		Estación de Animales Silvestres Guaycolec**	25°58′54″	58°09′58″	Formosa	50 (2/4)	6.5 (13/2)	3.2 (13/4)
	(MLP-He 7533)		Estancia de Don Leguizamón (7 km S Puerto Las Palmas)**	27°09′40″	58°40′27″	Chaco	(1/1)	8 (8/1)	8 (8/1)
	(MLP-He 7534)		La Balandra	34°56′00″	57°42′00″	Buenos Aires	13.3 (4/30)	7 (28/4)	0.9 (28/30)
			Total				22.2 (8/36)	6.25 (50/8)	1.4 (50/36)
	(MPL-He 1751-2)	*S. aquaticus*	Ruta 12 km 100, Campana** (λ)	34°05′00″	58°58′00″	Buenos Aires	–	–	–
5	*Echinostoma* sp. (MLP-He 7530)	*H. chacarius**	Selvas de Rio de Oro**	26°46′51″	58°57′55″	Chaco	33.3 (1/3)	1 (1/1)	0.3 (1/3)
6	*Skrjabinus oxymycterae* (MLP-He 7539)	*A. azarae*	Cerro de la Gloria**	36°06′00″	57°46′00″	Buenos Aires	2.6 (1/38)	2 (2/1)	0.05 (2/38)
	(MLP-He 7538)	*O. rufus*	Las Brusquitas creeck	38°13′59″	57°46′44″	Buenos Aires	15 (3/20)	5.3 (16/3)	0.8 (16/20)
			Total				6.9 (4/58)	4.5 (18/4)	0.3 (18/58)
	(MLP-He 4674-2)	*O. rufus*	Isla Talavera, Campana** (λ)	34°00′00″	58°59′20″	Buenos Aires	–	–	–
	(MPL-He 1753-2)	*O. rufus*	Ruta 12 km 100, Campana** (λ)	34°05′00″	58°58′00″	Buenos Aires	–	–	–
7	*Skrjabinus* sp. (MLP-He 7537)	*A. montensis**	Reserva de Vida Silvestre Urugua-í**	25°58′32″	54°07′00″	Misiones	4.17 (1/24)	1 (1/1)	0.04 (1/24)
	(MLP-He 2228-3)	*S. aquaticus**	Berisso, Blagiardi beach** (λ)	34°52′00″	57°05′00″	Buenos Aires	–	–	–

Table 1 (continued)

	Digenean species (collection number)	Host	Localities	Coord S	Coord W	Province	P (%)	MI	MA
8	*Zygocotyle lunatum* (MLP-He 7540)	*S. aquaticus**	Villa Elisa**	32°08′00″	58°24′00″	Entre Ríos	33.3 (2/6)	2 (4/2)	0.67 (4/6)

*New host; **new locality records; (λ) the coordinate obtained from this location is very near the sampling site

Genus *Echinoparyphium* Dietz 1909

Echinoparyphium sp. (Fig. 2a, b)

Site of infection: small intestine

Host species: *Necromys lasiurus*

Locality: Reserva El Bagual, Formosa Province

Comments: this specimen was classified under the genus *Echinoparyphium*, according Jones et al. [15] based on its morphological features, i.e. head-collar armed with 29–45 spines collar in double row; testes in tandem, intercecal; cirrus sac situated dorsally to acetabulum; ovary pre-testicular; eggs not numerous; vitelline fields extending from ovarian region to posterior end of body and not confluent posteriorly to testes.

Two genera of Echinostomatidae have currently been recorded from Cricetidae rodents in South America (i.e., *Echinoparyphium* Dietz 1909 and *Echinostoma* Rudolphi 1809) [19].

Among *Echinoparyphium*, *E. scapteromae* (Sutton 1983) Sutton and Lunaschi 1994, was reported in five species of Sigmodontinae rodents from Argentina: *A. azarae*, *O. flavescens*, *O. nigripes*, *O. rufus,* and *S. aquaticus* [19].

This is the first record of genus *Echinoparyphium* in *N. lasiurus* from the Formosa Province, Argentina.

Echinoparyphium scapteromae (Sutton 1983) Sutton and Lunaschi 1994 (Fig. 2c, d)

Site of infection: small intestine

Host species: *Akodon azarae, Oxymycterus rufus, Scapteromys aquaticus*

Localities: Punta Indio and Isla Talavera, Campana, Buenos Aires Province

Comments: morphological features observed in these specimens agree with the original description that provided by Sutton and Lunaschi [20], i.e., tegument armed with small spines that decrease toward posterior end; head-collar armed with 44 spines arranged alternately and present between 4 and 5 angular spines; fore<body long (20–40%); pharynx muscular; small, spherical, pre-testicular ovary; testes in tandem, intercecal in mid-hindbody; cirrus sac situated dorsally to acetabulum; cirrus unspined; vitelline fields extending from posterior edge of acetabulum to posterior end of body; eggs not numerous.

This species can be separated from the species described above *Echinoparyphium* sp. by having both a different acetabulum and egg size, and a higher number of head-collar spines.

Echinoparyphium scapteromae was referred to as *Isthmiphora scapteromae* by Sutton [21], reporting its presence in the small intestine of *S. aquaticus* from Campana, Buenos Aires Province. This species was later found to be parasitizing *S. aquaticus* and *R. norvegicus* from Berisso [20], and *O. rufus*, *O. flavescens*, *O. nigripes*, *A. azarae*, and *S. aquaticus* in the Río de La Plata wetlands, Buenos Aires Province [11]. This finding adds a new locality (Punta Indio) in Buenos Aires Province for *E. scapteromae*.

Echinostoma Rudolphi 1809

Echinostoma sp. (Fig. 2e)

Site of infection: small intestine

Host species: *Holochilus chacarius*

Locality: Selvas de Río de Oro, Chaco Province

Comments: this specimen was classified under the genus *Echinostoma* according Jones et al. [15] based on its morphological features, i.e., presence of a head-collar armed with 31–55 spines; testes in tandem, intercecal; cirrus sac between intestinal bifurcation; spherical, median, pre-testicular ovary; eggs abundant; vitelline fields laterally extending from posterior edge of acetabulum to posterior end of body and not confluent posteriorly to testes.

Echinostoma platensis was previously reported in *S. aquaticus* from Buenos Aires Province. This is the first record of *Echinostoma* species in *H. chacarius* from Chaco Province, Argentina.

Echinostoma platensis Sutton and Lunaschi 1994 (Fig. 2f, g)

Site of infection: small intestine

Host species: *Scapteromys aquaticus*

Localities: Ruta 12 km 100, Campana, Buenos Aires Province; Estación de Animales Silvestres Guaycolec and Reserva El Bagual, Formosa Province; Estancia de Don Leguizamón, Chaco Province

Comments: the morphological features observed in these specimens agree with the original description provided by Sutton and Lunaschi [20], i.e. tegument armed with numerous spines with a large base and contiguous throughout the pre-acetabular body, on dorsal and ventral surfaces, density diminishes from acetabulum being relegated to lateral fields; head-spine armed with 39–40 spines; forebody

Table 2 Host and geographical data of previously recorded digenean species of Sigmodontinae rodents in Argentina; numbers and letters, refer Fig. 1

	Digenean species	Host species	Locality	Coord S	Coord W	Province	References
2	*Echinoparyphium scaptteromae* (Sutton 1983) Sutton and Lunaschi 1994	*A. azarae*	Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
		O. flavescens	Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
		O. nigripes	Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
		O. rufus	Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
		S. aquaticus	Estación Experimental INTA, Campana (λ)	34°17′00″	58°52′00″	Buenos Aires	Sutton [22]
			Bagliardi beach, Berisso	34°52′00″	57°05′00″	Buenos Aires	Sutton and Lunaschi [21]
4	*Echinostoma platensis* Sutton and Lunaschi, 1994	*S. aquaticus*	Bagliardi beach, Berisso	34°52′00″	57°05′00″	Buenos Aires	Sutton and Lunaschi [21]
			Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
6	*Skrjabinus oxymycterae* Sutton 1983	*A. azarae*	Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
		O. rufus	Estación Experimental INTA, Campana (λ)	34°17′00″	58°52′00″	Buenos Aires	Sutton [22]
			Las Brusquitas creeck	38°13′59″	57°46′44″	Buenos Aires	Sutton and Damborenea [26]
			Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
9	*Cladorchis pyriformis* (Diesing. 1838) Fischoeder 1901	*H. vulpinus*	Estación Experimental INTA, Campana (λ)	34°17′00″	58°52′00″	Buenos Aires	Sutton and Lunaschi [35]
			Estancia San Juan Poriahú	27°42′00″	57°12′01″	Corrientes	Guerreiro Martins et al. [13]
			Villa Elisa	32°08′00″	58°24′00″	Entre Ríos	Guerreiro Martins et al. [13]
		H. chacarius	Estación de Animales Silvestres Guaycolec	25°58′54″	58°09′58″	Formosa	Guerreiro Martins et al. [13]
A	*Levinseniella (Monarrhenos) cruzi* Travassos 1920	*D. kempi*	Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
		O. rufus	Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
		S. aquaticus	Bagliardi beach, Berisso	34°52′00″	57°05′00″	Buenos Aires	Sutton and Lunaschi [21]
			Hudson	34°45′00″	58°06′00″	Buenos Aires	Navone et al. [12]
			La Balandra	34°56′00″	57°42′00″	Buenos Aires	Navone et al. [12]
B	*Platynosomoides* sp.	*A. montensis*	Reserva de Vida Silvestre Urugua-í	25°58′00′	54°07′00″	Misiones	Panisse et al. (2017)
			Parque Provincial Urugua-í	25°58′00″	54°06′00″	Misiones	Panisse et al. (2017)
C	*Urotrema scabridum* Braun, 1900	*H. vulpinus*	Estación Experimental INTA, Campana (λ)	34°17′00″	58°52′00″	Buenos Aires	Sutton and Lunaschi [35]

Table 2 (continued)

	Digenean species	Host species	Locality	Coord S	Coord W	Province	References
D	*Conspicuum minor* Mañé-Garzón and Holcmann-Spector 1975	*S. aquaticus*	Isla Talavera, Campana (λ)	34°00′00″	58°59′20″	Buenos Aires	Sutton and Damborenea [26]

(λ) The coordinate obtained from this location is very near the sampling site

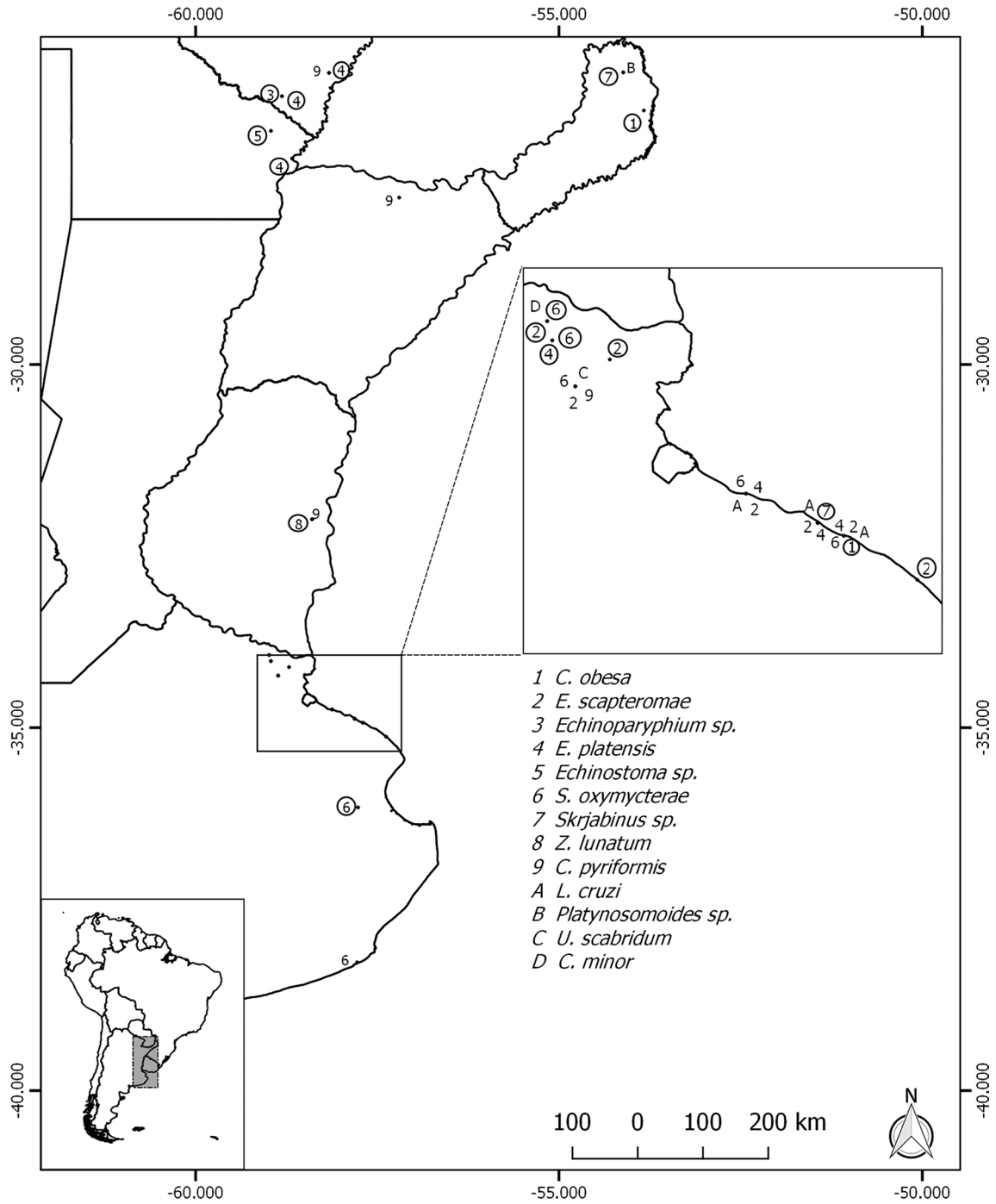

Fig. 1 Previous (number/letters without circles) and new records (number with circles) for species of Digenea in the Cuenca del Plata region in Argentina. See data of localities in Tables 1 and 2

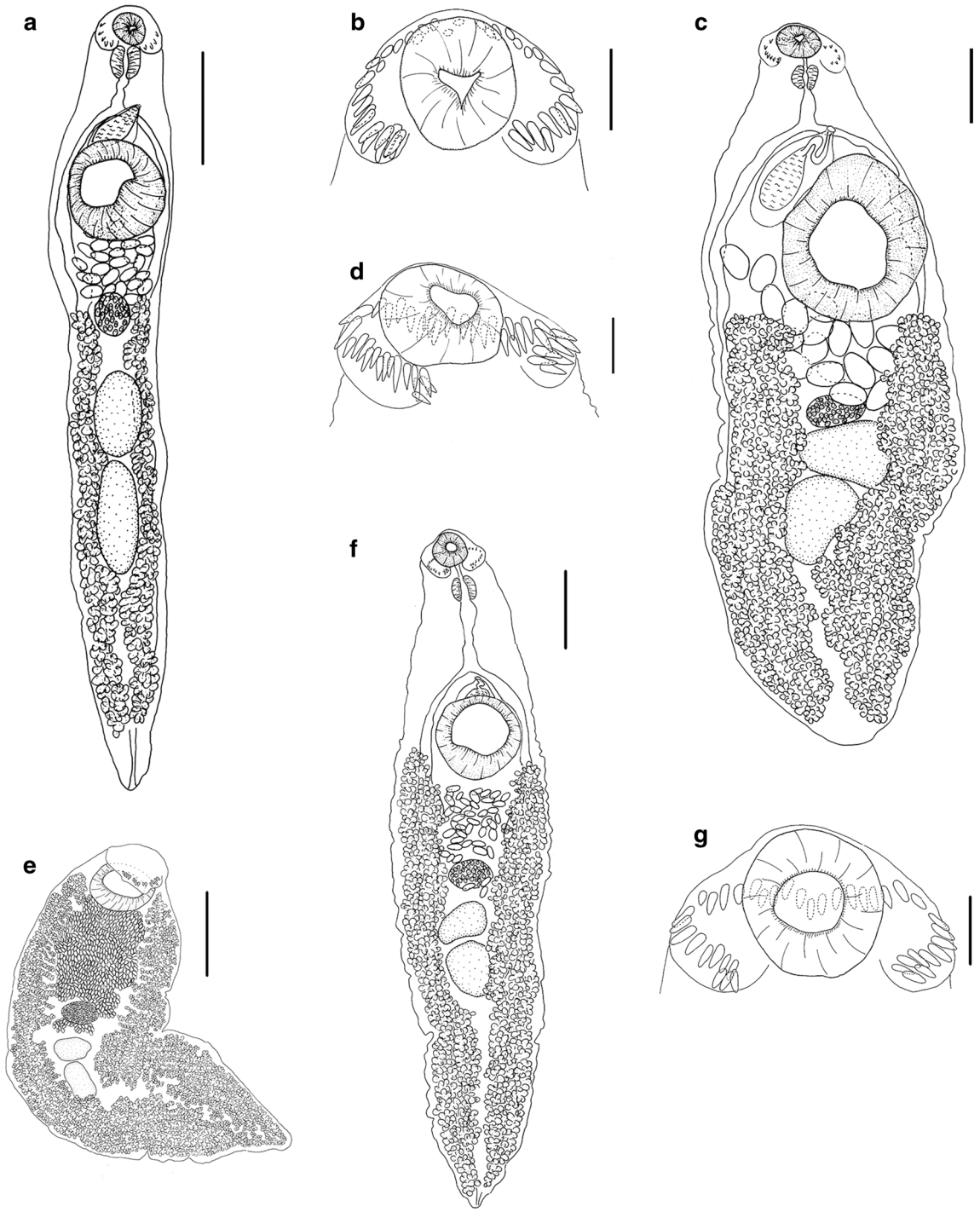

Fig. 2 *Echinoparyphium* sp. **a** entire ventral view, scale bar 500 µm. **b** Head-collar, scale bar 100 µm; *Echinoparyphium scapteromae*, **c** entire ventral view, scale bar 200 µm; **d** head-collar, scale bar 50 µm; *Echinostoma* sp. **e** entire ventral view, sale bar 500 µm; *Echinostoma platensis*, **f** entire ventral view, scale bar 500 µm; **g** head-collar, scale bar 100 µm

short (10–20%); pre-pharynx long; pharynx well-developed; esophagus long; genital pore postbifurcal; testes in tandem, intercecal in mid-hindbody; cirrus sac between intestinal bifurcation and posterior margin of acetabulum dorsally; spherical, median, pre-testicular ovary; cirrus sac oval, between intestinal bifurcation and acetabulum; cirrus unspined; vitelline fields extending from posterior edge of acetabulum to posterior end of body.

Echinostoma platensis was previously reported in *S. aquaticus* from the Balneario Bagliardi and other localities

in the Río de La Plata wetlands [11, 20]. In this study, this species is reported for the first time in Formosa and Chaco Provinces extending its geographical distribution. This finding adds a new locality in Buenos Aires Province for *E. platensis.*

Superfamily Gorgoderoidea Looss 1899
Family Dicrocoeliidae Looss 1899
Genus *Canaania* Travassos 1944
Canaania obesa Travassos 1944 (Fig. 3a)
Site of infection: liver, bile ducts, and small intestine
Host species: *Akodon azarae*, *Akodon montensis*
Localities: La Balandra, Buenos Aires Province; Parque Provincial Piñalito, Misiones Province.

Comments: morphological features observed in these specimens agree with the description of *C. obesa* [22], i.e., rounded body with conical extremities and maximum width at level of acetabulum; oral sucker subterminal; acetabulum in mid region of body, much larger than oral sucker; long caeca, not reaching end of body; testes in mid region of body, posterior to acetabulum; cirrus sac postero-dorsal to acetabulum; ovary laterally and posterior to testes; vitelline follicles distributed from pre-acetabular region up to 2/3 of body length, not overlapping end of caeca.

This species was originally described from the bile duct of *Akodon cursor* from Brazil [23] and was later recorded from *A. cursor*, *A. montensis*, *N. squamipes,* and *O. nigripes* from Brazil [22].

This is the first record of *C. obesa* in *A. azarae* and *A. montensis* from Argentina, enlarging the host and geographical range of the species.

Skrjabinus Bhalerao 1936
Skrjabinus sp. (Fig. 3b)
Site of infection: liver, bile ducts, and small intestine
Host species: *Akodon montensis*, *Scapteromys aquaticus*
Localities: Reserva de Vida Silvestre Urugua-í, Fundación Vida Silvestre, Misiones Province; Bagliardi Beach, Berisso, Buenos Aires Province

Comments: this specimen was classified under the genus *Skrjabinus* [24] based on its morphological features, i.e., tegument unspined; both suckers in anterior third of body; intercecal and post-acetabular testes; cirrus sac extending beyond intestinal bifurcation; ovary post-testicular; vitelline fields extending from anterior area of testicles to near posterior end of body.

The genus *Skrjabinus* has a cosmopolitan distribution with species that parasitize birds and mammals.

This is the first record of the genus in *A. montensis* and *S. aquaticus* from Argentina.

Skrjabinus oxymycterae (Sutton 1983) (Fig. 3c)
Site of infection: liver, bile ducts, and small intestine

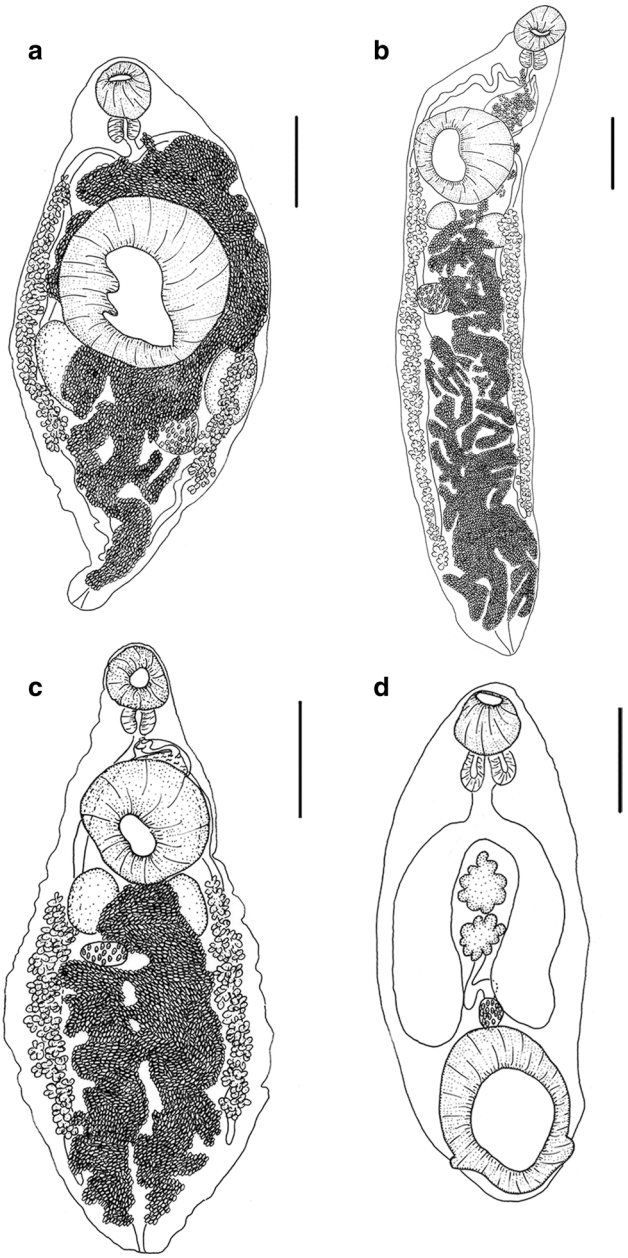

Fig. 3 Entire ventral view **a** *Canaania obesa*, scale bar 500 µm; **b** *Skrjabinus* sp., scale bar 500 µm; **c** *Skrjabinus oxymycterae*, scale bar 500 µm; **d** *Zygocotyle lunata,* scale bar 200 µm

Host species: *Akodon azarae*, *Oxymycterus rufus*
Localities: Cerro de la Gloria, Isla Talavera and Ruta 12 km 100, Buenos Aires Province

Comments: the morphological features observed in these specimens agree with the original description provided by Sutton [21], i.e. tegument unspined; oral sucker subterminal; large, muscular acetabulum close to oral sucker; testes intercecal and post-acetabular; cirrus sac extending beyond intestinal bifurcation; ovary post-testicular; vitelline fields

extending from anterior region of testes to near posterior end of body.

This species was originally referred as *Zonorchis oxymycterae* and recorded in *O. rufus* from Campana, Las Brusquitas creek and Río de La Plata wetlands, Buenos Aires [11, 21, 25], and in *A. azarae* from Río de La Plata wetlands, Buenos Aires Province [11]. This is the only species of the genus described for American rodents. *Skrjabinus oxymycterae* differs from the *Skrjabinus* sp. by the proportions of both the body and internal organs (Fig. 3b, c).

This finding adds new localities in the Buenos Aires Province for *S. oxymycterae*.

Family Zygocotylidae Ward 1917
Zygocotyle Stunkard 1917
Zygocotyle lunata (Diesing 1836) Stunkard 1917 (Fig. 3d)
Site of infection: cecum
Host species: *Scapteromys aquaticus*
Locality: Villa Elisa, Entre Ríos Province

Comments: morphological features observed in these specimens agree with the original description provided by Stunkard [26], i.e. acetabulum ventroterminal, prolonged anteriorly, with paired posterolateral muscular projections; pharynx with anterior sphincter and small extramural sac; esophageal bulb present; ceca thick-walled, extending almost to acetabulum; testes in tandem, in mid region of body; genital pore postbifurcal; ovary intercecal, in mid region of body; vitelline fields in extracecal lateral fields extending from level of pharyngeal sacs to near mid-level of acetabulum.

This species was referred as *Amphistoma lunatum* by Diesing [27] from the ducks *Anas melanotus* and *A. epecutiri*, and the South American deer *Blastocerus* (= *Cervus*) *dichotomus* from Brazil. Stunkard [26] erected the genus *Zygocotyle* describing a new species, *Z. ceratosa*, based on the shape and size of some internal organs. Price [28] discussed the taxonomy of the genus and concluded that *A. lunatum* and *Z. ceratosa* were synonymous. This species was also reported from the cow *Bos taurus* from Panama, providing further evidence that this species occurs in mammals as well as birds [28–32, 41, 42].

This is the first record of *Z. lunata* in rodents naturally infected from Argentina, enlarging the range of mammals parasitized.

Discussion

Prior to our study, seven species of digeneans were reported from Cricetidae in Argentina, namely *Echinoparyphium scapteromae*, *Skrjabinus oxymycterae*, *Levinsiniella cruzi*, *Cladorchis pyriformis*, *Urotrema scabridum*, *Conspicuum minor,* and *Echinostoma platensis* [11, 20, 21, 34, 35]. In this work, eight digenean taxa from 16 localities are reported with 12 of them being new geographical records for Buenos Aires, Chaco, Entre Ríos, Misiones, and Formosa Provinces. In addition, six new host–parasite associations are identified and one species is reported for the first time in rodents (Table 1).

Digenean–host associations occur in a complex system of biotic and abiotic factors. Rodents have varied diets and behavioral habits [18]. Digenean species found in this study are known to be acquired by definitive hosts through different food items. Therefore, it becomes interesting to explore habits of each rodent species to understand the dispersal and transmission abilities of each group of digeneans.

Among the studied hosts, different feeding preferences are observed, e.g. *S. aquaticus* and *O. rufus* are mainly animalivorous, *Akodon* spp. and *Oligoryzomys* spp. are omnivores, whereas *Holochilus* spp. are herbivorous. Among those hosts with an omnivorous diet, *Akodon* spp. eat mainly green vegetation, leaves, fruit and seeds, whereas *Oligoryzomys* spp. vary their diet according to the season [7, 18, 36]. The present study and the previous records in Argentina indicate that *S. aquaticus* is parasitized by six digenean species, whereas *O. rufus*, *A. azarae*, and *A. montensis* by only three species. Consequently, the richness of digenean species could be associated to the variety of food items. *Holochilus vulpinus* and *H. chacarius* noticeably harbor two digenean species suggesting an accidental ingestion of some kind of invertebrate as an intermediate host. This led us to conclude that the encysted cercariae might be in the vegetation that are part of the rodent diet.

In addition, some invertebrates were found into the stomach contents of *Akodon* spp. and *S. aquaticus* revealing that mollusks might act as intermediate hosts as well [7, 18, 37]. Among Echinostomatidae, the genus *Echinoparyphium* and *Echinostoma* use birds or mammals as definitive hosts [16]. Metacercariae of the genera mentioned above have been reported in multiple species of gastropods, amphibian larvae, and bivalves (e.g. *Lymnaea* spp., *Physa* spp., *Biomphalaria* spp., *Corbicula* spp.) [38]. In contrast, most common intermediate hosts of *Canaania* spp. are gastropods and ants of the genus *Formica* [39]. There is little information about other genera of mollusks or invertebrate intermediate hosts, which are involved in the life cycle of the referred species.

Cercarial encystment may take place on aquatic vegetation, water surface, or even on snail shells for the family Cladorchiidae. Therefore, it becomes interesting to explore the way in which the parasite species such as *C. pyriformis* disperse into herbivorous hosts.

Biomphalaria peregrina and *B. tenagophila* were reported as natural intermediate hosts of *Z. lunata* [33, 40]. In Argentina, this species was found naturally parasitizing both *Anas sibilatrix* and *Cygnus melancorypha* [41, 42]. Its presence in *S. aquaticus* as definitive host may be influenced

by environmental conditions that affect the distribution of the intermediate hosts [33].

From the 876 specimens reviewed only 21 harbored digeneans with a total prevalence of 2.4% indicating that the occurrence of this parasitic group in Sigmodontinae rodents is low. Likewise, the ecological data observed for each host population also indicated a low presence and intensity (Table 1).

Some differences with respect to previous studies considering the ecological data of each digenean species on each host species were noticed. *Canaania obesa* in *A. azarae* from La Balandra showed the highest value of MI (130) and P (3.1%). This digenean species was previously recorded in *Akodon* spp., *O. nigripes,* and *N. squamipes* in three localities of Rio de Janeiro, Brazil, indicating lower prevalences ($P = 23.3\%$, 0.47%, and 1.58% for each species) [22]. Comparing previous and new records, *Echinoparyphium scapteromae* showed the widest range of host and geographical distribution. This species showed higher values of P and MA in *A. azarae* than those ones reported by Navone et al. [11] from five localities of La Plata ($P = 33.3\%$ vs. 4.3%, and MA = 2 vs. 0.1, respectively). *Echinostoma platensis* in *S. aquaticus* from four localities showed higher values of P and MA than those ones reported by Navone et al. [11] from five localities of La Plata ($P = 22.2\%$ vs. 13.1%, and MA = 1.4 vs. 0.3, respectively). *Skrjabinus oxymycterae* was present in two Akodontini rodents showing both different P and MA from those ones recorded by Navone et al. [11] ($P = 2.6\%$ vs. 4.3%, and MA = 0.05 vs. 0.3 in *A. azarae,* and $P = 15\%$ vs. 8.6%, and MA = 0.8 vs. 1.6 in *O. rufus*). Mentioned values allow exploring the parasite species distribution within the host and geographical ranges between this study and other previous works.

Finally, *Z. lunata* showed high values of *P* (33.3%) regarding other species examined herein. Since this species has been previously reported to naturally parasitize birds in Argentina [41, 42] and experimentally infect mice [40], it seems that it has extended its range to other natural hosts in this work. This suggests the possibility of re-studying the specimens from these two distant host groups, adding molecular analyses.

To conclude, it would be interesting to analyze the contrast between host and geographical range and prevalences and intensities of digenean species as an intrinsic characteristic of each species [43].

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Compliance ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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