Acta Scientiarum

http://periodicos.uem.br/ojs/
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v47i1.72323

Parasitic helminths of wild vertebrates from San Juan province, Argentina

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ABSTRACT. We present a list of parasitic helminths found in wild vertebrates from San Juan Province, Argentina. The list encompasses various helminth species parasitizing fish, amphibians, reptiles, birds, and mammals. The data were sourced from national and international journals up to December 2023. A systematic bibliographic search was conducted across electronic databases such as SciELO (Scientific Electronic Library Online), Dialnet, and Google Scholar, as well as institutional repositories. Congress abstracts were excluded from consideration. The compiled list documents 35 helminth taxa associated with 39 species of wild vertebrates, spanning different taxa of fish, amphibians, reptiles, mammals, and birds. The 35 helminth taxa are distributed across 21 genera, 16 families, 6 orders, and 2 phyla, parasitizing a total of 39 vertebrate hosts: 2 fish species, 6 amphibians, 21 reptiles, 8 mammals, and 2 bird species. Nematodes exhibited the highest number of taxa, while cestodes were the least recorded or studied. Among vertebrates, reptiles represent the most extensively studied group, with the genus *Liolaemus* being the most analyzed, followed by the genus *Phymaturus*. Birds and fish, however, remain the least studied. This taxonomic list of helminths in association with vertebrate hosts is fundamental for understanding ecosystem dynamics. Notably, this represents the first taxonomic list of parasitic helminths in vertebrates from San Juan Province, Argentina, contributing to a deeper understanding of current parasite-host interactions.

Keywords: nematodes; cestodes; San Juan; Argentina.

Received on May 23, 2024
Accepted on November 29 2024

Introduction

Parasites are the most common and successful life form within the animal kingdom (Lucius et al., 2016), with estimates suggesting that over 50% of all living organisms are parasites or exhibit some form of parasitic life (Lucius et al., 2016). Among multicellular parasites, helminths (flatworms, nematodes, nematomorpha and acanthocephalans), are characterized by infecting humans and animals, causing in certain cases serious diseases (Lucius et al., 2016).

In Argentina, different lists of helminths in different vertebrate hosts have been presented over the years (Lunaschi & Drago, 2007, 2010; González & Hamann, 2015; González-Rivas et al., 2019; Castillo et al., 2020a; Fugassa, 2020; Ramallo & Ailán-Choke, 2022). Based on these lists, most of the research work associated with helminths in Argentina is generally biased to south, central and northeast of the country (Castillo et al., 2020a; Ramallo & Ailán-Choke, 2022). This demonstrates that there is a need to know the biodiversity of parasitic helminths and their interaction with vertebrate hosts in central-western Argentina, more precisely in San Juan province.

In terms of vertebrate host biodiversity, San Juan province has considerable richness, with 62 species of reptiles, 16 amphibians, 22 fish, 50 mammals and 270 birds (Acosta et al., 2016a, 2016b; Ortiz et al., 2016; Acosta et al., 2017; Bauni et al., 2021). Despite this considerable richness, research related to parasitic helminths in San Juan is scarce and fragmentary (Castillo et al., 2020a, 2022a; González-Rivas et al., 2023c). However, in recent years there has been increased interest and study of parasitic helminths, mostly in reptiles, mammals and amphibians, and with fewer studies associated with birds and fish (González-Rivas et al., 2023c). Due to the aforementioned, the objective of this work is to present a list based on a bibliographic review of everything known and published about parasitic helminths in vertebrates for the province of San Juan. This will allow us to know the diversity of helminths and their interaction with their hosts, enabling us

to elucidate aspects of the life history of the hosts associated with trophic consumption, behavioral and reproductive strategies, habitat use, among other ecological aspects.

Materials and methods

The bibliographic search covered publications until December 2023, utilizing different search engines: SciELO (Scientific Electronic Library Online), Dialnet, Google Scholar, and WorldWideScience.org. Conference abstracts, as well as doctoral and undergraduate theses, were excluded. Within each search engine, all publications related to helminth parasites of fish, amphibians, reptiles, birds, and mammal host species in the province of San Juan, Argentina (Figure 1), were compiled and subsequently reviewed. The search employed the following keywords: helminths, nematodes, cestodes, digeneans, trematodes, parasitism, parasites, vertebrate hosts, fish, amphibians, reptiles, mammals, birds, San Juan, Argentina.

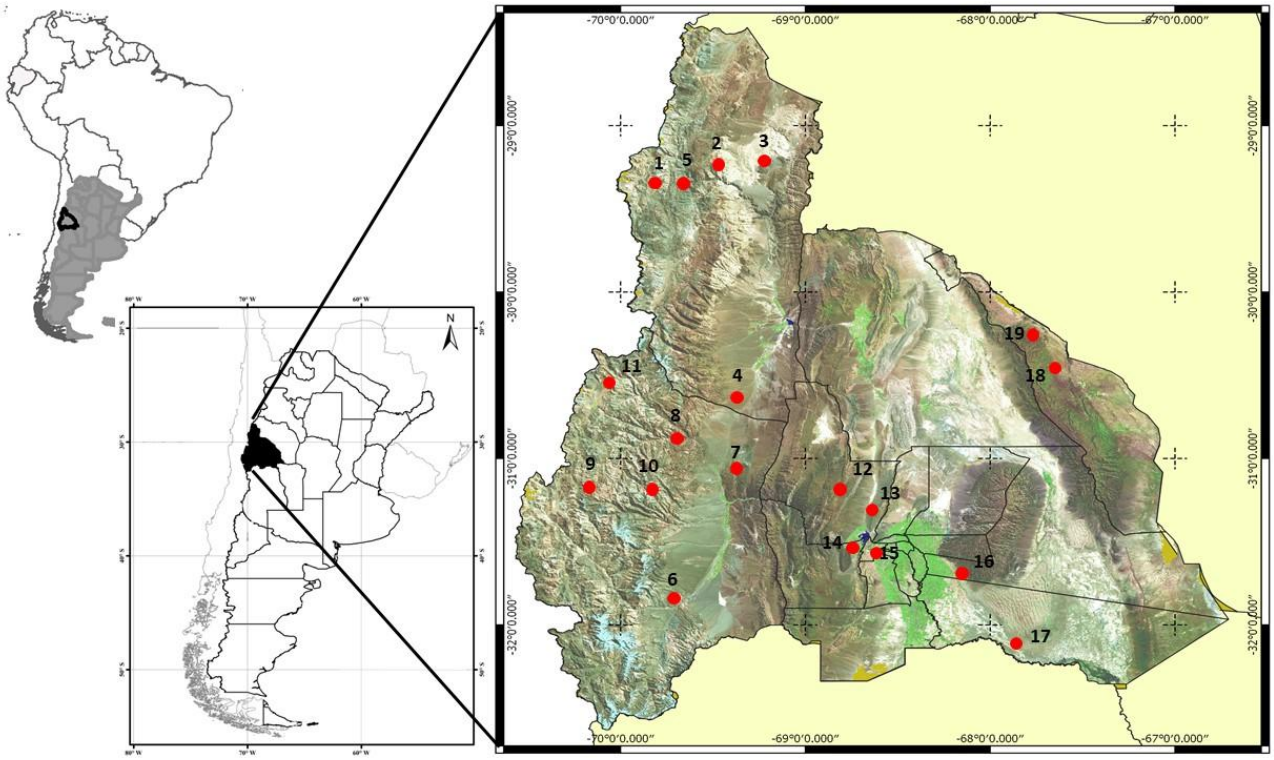

Figure 1. Geographic location in San Juan province, Argentina. Reference points: 1. Las Taguas River and Amarillo Creek, Iglesia Dept.; 2. Agua del Godo, San Guillermo, Iglesia Dept.; 3. San Guillermo National Park, Iglesia Dept.; 4. Tocota, Iglesia Dept.; 5. RPSG, Iglesia Dept.; 6. Blanca Lake, Calingasta Dept.; 7. Castaño River, Calingasta Dept.; 8. Vallecito Ravine, Calingasta Dept.; 9. Los Azules, Calingasta Dept.; 10. La Puerta Ravine, Calingasta Dept.; 11. Portezuelo, Calingasta Dept.; 12. RNDC, Ullum Dpt.; 13. Matagusanos, Ullum Dept.; 14. RPPS, Zonda Dpt.; 15. Rehabilitation center; 16. Las Flores Ravine, Caucete Dept.; 17. El Encón, 25 de Mayo Dept.; 18. Usno, Valle Fértil Dept.; 19. La Majadita, Valle Fértil Dept.

The presented list of parasite-host interactions includes information on the taxonomic level of helminths and vertebrate hosts, the site of infection where the helminth was located, the locality where the host was recorded, the institution where the material is deposited, and references. The taxonomy of nematodes follows the classifications of Anderson et al., (2009), and Hodda (2022).

The acronyms of the collections are: CH-N-FML = Invertebrate Collection, Miguel Lillo Foundation, San Miguel de Tucumán, Tucumán; CECOAL = Center for Applied Ecology of the Litoral, Corrientes; UNSJPar = Parasitological collection of the Department of Biology of the Faculty of Exact, Physical and Natural Sciences, National University of San Juan; MLP-He = Helminthological Collection of the Museum of La Plata, Argentina; United States National Parasite Collection; CRFSJ-P = Parasitological Collection of the Center for Wildlife Rehabilitation, Environmental Education and Responsible Recreation (Fauna).

Ethical approval: All applicable international, national, and/or institutional guidelines for the care and use of animals were strictly followed. All animal sample collection protocols complied with the current laws of Argentina.

Results

In the province of San Juan, 35 helminth taxa were documented, which were associated with 39 wild vertebrate hosts (Figure 2 and 3). These hosts included 2 fish species, 6 amphibians, 21 reptiles, 8 mammals, and 2 bird species. The recorded helminths are distributed across 21 genera, 16 families, 6 orders, and 2 phyla. Table 1 provides a list of hosts in association with their respective helminth parasites.

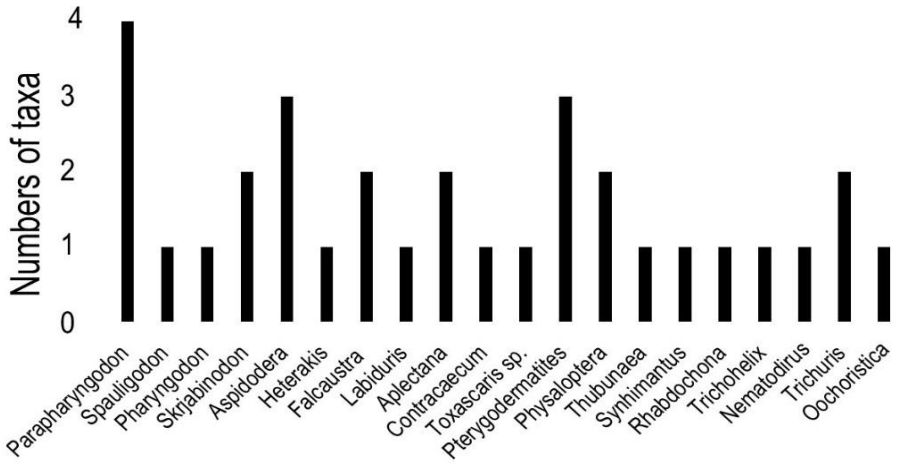

Figure 2. Nematode parasitizing wild vertebrates in San Juan.

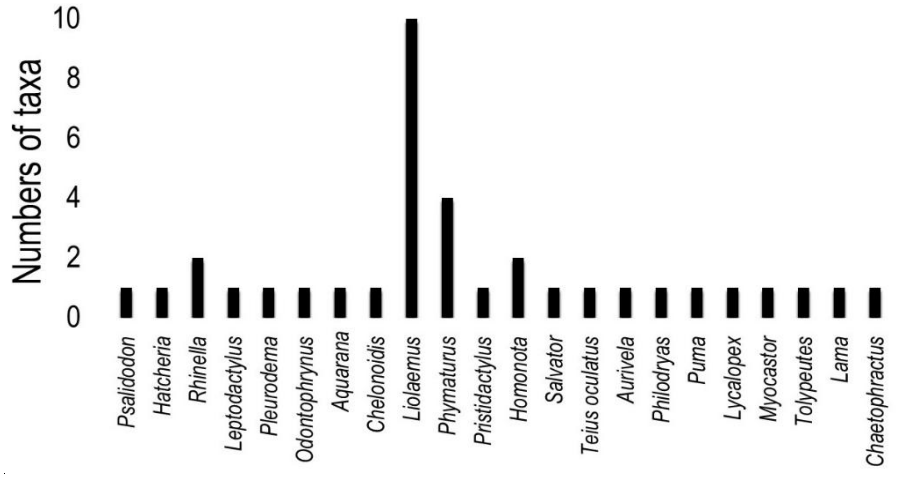

Figure 3. Wild vertebrate parasitized by helminths in San Juan.

Table 1. Helminth species interacting with vertebrate hosts recorded for the province of San Juan, Argentina. Acronyms: RPPS = Sarmiento Park Provincial Reserve; Rehabilitation center = Center for Wildlife Rehabilitation, Environmental Education and Responsible Recreation (Faunístico); RPSG = San Guillermo Provincial Reserve; RNDC = Don Carmelo Natural Reserve. S/N = without number.

Vertebrates	Order	Family	Host	Parasites	Helminths	Deposit	Infection site	Location	References
FISH	Characiformes	Characidae	*P. eigenmanniorum*	*Contracaecum* sp.	Nematode	CI-FML#6397	Free or encapsulated in abdominal cavity	Castaño River, Calingasta Dept.	Ramallo & Cancino (2021); Ramallo & Ailán-Choke (2022)
	Siluriformes	Trichomycteridae	*H. macraei*	*R. acuminata*	Nematode	CI-FML#6396	Intestine	Castaño River, Calingasta Dept.	Ramallo & Ailán-Choke (2022)
AMPHIBIANS	Anura	Bufonidae	*R. arenarum*	*A. hylambatis*	Nematode	CECOAL 11072601	Small and large intestine	RPPS, Zonda Dpt.	González, et al. (2013b)
			R. spinulosa	*A. hylambatis*	Nematode	UNSJPar_288	Large intestine	Vallecito Ravine, Calingasta Dept.	Castillo et al. (2023b)

		Leptodactylidae	*L. luctator* (= *L. latrans*)	*F. sanjuanensis*	Nematode	CH-N-FML 07582, 07583	Large intestine	La Majadita, Valle Fértil Dept.	Ramallo et al. (2016b)
			P. nebulosum	*A. nebulosa*	Nematode	Holotype: MLP-He 7156; Allotype: MLP-He 7157; UNSJPar 265 Paratypes: MLP-He 7158; CECOAL 16062601	Small and large intestine	Matagusanos, Ullum Dept.; RPPS, Zonda Dpt.	Piñeiro-Gómez et al. (2017); Castillo et al. (2021); Castillo et al. (2023a)
				C. cf. *americana*	Cestode	UNSJPar282	Stomach	RPPS, Zonda Dpt.	Castillo et al. (2023c)
		Odontophrynidae	*O. occidentalis*	*F. sanjuanensis*	Nematode	CECOAL 17021402	Large intestine	Las Flores Ravine, Caucete Dept.	Piñeiro et al. (2023); González et al. (2013a)
				A. hylambatis	Nematode	CECOAL 17021401	Large intestine	Las Flores Ravine, Caucete Dept.	Piñeiro et al. (2023)
		Ranidae	*Aquarana catesbeianus* (=*L. catesbeianus*)	*Contracaecum* sp.	Nematode	CECOAL 13111101	Stomach	Castaño River, Calingasta Dept.	González et al. (2014)
				F. sanjuanensis	Nematode	MLP-He 6705; CECOAL 13111102	Large intestine	Castaño River, Calingasta Dept.	González et al. (2014)
REPTILES	Testudines	Testudinidae	*C. chilensis*	*Falcaustra* sp.	Nematode	UNSJPar 255 256	Large intestine	Rehabilitation center	González-Rivas and Castillo (2019)
				Labiduris argentinensis	Nematode	UNSJPar 255	Large intestine	Rehabilitation center	González-Rivas and Castillo, (2019); González-Rivas et al. (2024)
	Lepidosauria	Liolaemidae	*L. ruibali*	*Parapharyngodon* sp.	Nematode	UNSJPar 260	Stomach	RNDC, Ullum Dpt	Castillo and Acosta (2019); Castillo et al. (2020a)
				P. riojensis	Nematode	CH-N-FML 7733,7734	Large intestine	Vallecito Ravine, Calingasta Dept.	Castillo et al. (2017)
			L. parvus	*Parapharyngodon* sp.	Nematode	UNSJPar 261	Stomach	RNDC, Ullum Dpt.	Castillo et al. (2019b); Castillo and Acosta (2019)
				P. riojensis	Nematode	UNSJPar 251	Stomach	Vallecito Ravine, Calingasta Dept.	Castillo et al. (2022b)
				Spauligodon sp.	Nematode	S/N	Large intestine	La Puerta Ravine, Calingasta Dept.	Castillo et al. (2022b)
				P. sceleratus	Nematode	S/N	Large intestine	La Puerta Ravine, Calingasta Dept.	Castillo et al. (2022b)
			L. fitzgeraldi	*Parapharyngodon* sp.	Nematode	UNSJPar253	Large intestine	Los Azules, Calingasta Dept.	Castillo et al. (2019a); Castillo et al. (2020b)
			L. eleodori	*T. eleodori*	Nematode	CH-N-FML (S/N)	Stomach light	San Guillermo National Park, Iglesia Dept.	Ramallo et al. (2017b)
			L. olongasta	*Physaloptera* sp.	Nematode	UNSJPar254	Stomach	Matagusanos, Ullum Dept.	Castillo et al. (2019c)

			L. gracielae	*S. castillensis*	Nematode	UNSJPar 288	Large intestine	Road to the RPSG, Iglesia Dept.	Castillo et al. (2023d)
			L. darwinii	*P. retusa*	Nematode	UNSJPar: 260	Stomach	El Encón, 25 de Mayo Dept.	Castillo et al. (2020b); Castillo et al. (2022a)
				Physaloptera sp.	Nematode	UNSJPar 261	Stomach	El Encón, 25 de Mayo Dept.	Castillo et al. (2020b)
			L. riojanus	*Physaloptera* sp.	Nematode	UNSJPar 262	Large intestine	El Encón, 25 de Mayo Dept.	Castillo et al. (2020b)
			L. vallecurensis	*Oo. travasossi*	Cestode	United States National Parasite Collection 92481	Small intestine	Las Taguas river and arroyo Amarillo, Iglesia Dept.	Goldberg et al. (2004)
			P. extrilidus	*P. riojensis*	Nematode	UNSJPar250; CH-N-FML 07746	Large intestine	RNDC, Dpto. Ullum	Castillo et al. (2018)
				P. sanjuanensis	Nematode	FML# 07666, 07667; CH–FML # 07779	Large intestine	RNDC, Dpto. Ullum	Ramallo et al. (2020)
			P. punae	*P. sanjuanensis*	Nematode	CH-N-FML: #07545, 07546, 07547.	Large intestine	Agua del Godo, San Guillermo, Iglesia Dept.	Ramallo et al. (2016a)
			P. williamsi	*P. sanjuanensis*	Nematode	CH-FML # 07542; 07543; 07544	Large intestine	La Puerta Ravine, Calingasta Dept.	Ramallo et al. (2016a)
			P. cf. *palluma*	*P. sanjuanensis*	Nematode	UNSJPar 285	Large intestine	Laguna Blanca, Calingasta Dept.	Castillo and Acosta (2022)
		Leiosauridae	*P. scapulatus*	*P. retusa*	Nematode	UNSJPar 271	Stomach	Portezuelo, Calingasta Dept.	Castillo et al. (2023e)
				Physaloptera sp.	Nematode	CH-N-FML #07754	Stomach	Tocota, Iglesia Dept.	Castillo et al. (2019e)
				Skrjabinodon sp. (adult female)	Nematode	UNSJPar 272)	Stomach	Portezuelo, Calingasta Dept.	Castillo et al. (2023e)
		Phyllodactylidae	*H. underwoodi*	*Physaloptera* sp.	Nematode	UNSJPar 258	Stomach	El Encón, 25 de Mayo Dept.	Castillo et al. (2019d)
			H. horrida	*S. castillensis*	Nematode	UNSJPar280; 281	Large intestine	El Encón, 25 de Mayo Dept.	Gonzalez-Rivas et al. (2022a)
		Teiidae	*S. rufescens*	*P. retusa*	Nematode	UNSJPar 257; CRFSJ-P 23 y 24	Stomach	El Encón, 25 de Mayo Dept.; Rehabilitation center	Castillo et al. (2019d); González-Rivas et al. (2022b)
			T. oculatus (*T. teyou*)	*P. travasossi*	Nematode	UNSJPar 259	Large intestine	El Encón, 25 de Mayo Dept.	Castillo et al. (2019d); Castillo et al. (2022c)
			A. longicauda	*P. retusa*	Nematode	UNSJPar260	Stomach	El Encón, 25 de Mayo Dept.	Castillo et al. (2020b)
				P. riojensis	Nematode	UNSJPar 264	Large intestine	El Encón, 25 de Mayo Dept.	Castillo et al. (2020b)
		Colubridae	*Philodryas trilineata*	*Physaloptera* sp.	Nematode	UNSJPar 263	Stomach	Urban site, Rivadavia Dept.	Castillo et al. (2020b)
MAMMALS	Carnivora	Felidae	*P. concolor*	*Toxascaris* sp.	Nematode	CRFSJ_P_36	Stomach	Rehabilitation center	González-Rivas et al. (2023c)
		Canidae	*L. gymnocercus*	*P. clausa*	Nematode	CRFSJ_P_26	Stomach	Rehabilitation center	González-Rivas et al. (2023c)

	Rodentia	Echimydae	*M. coypus*	*T. myocastoris*	Nematode	CRFSJ_P_36	Large intestine and cecum	Rehabilitation center	González-Rivas et al. (2023c)
		Caviidae	*D. patagonum*	*T. dolichotis*	Nematode	CRFSJ_P_51	Intestine	Rehabilitation center	González-Rivas et al. (2023b)
	Cingulata	Chlamyphoridae	*T. matacus*	*Aspidodera* sp.	Nematode	S/N	-	Rehabilitation center	González-Rivas et al. (2023c)
	Artiodactyla	Camelidae	*L. guanicoe*	*Nematodirus* sp.	Nematode	S/N	Fecal material (fresh feces)	RNDC, Ullum Dpt; RPSG	González-Rivas et al. (2019)
				Trichuris sp.	Nematode	S/N	Fecal material (fresh feces)	RNDC, Ullum Dpt	González-Rivas et al. (2019)
	Cingulata	Chlamyphoridae	*C. vellerosus*	*P.* (P) *argentinensis*	Nematode	S/N	Small intestine	Usno, Valle Fértil Dept.	Ezquiaga and Navone (2013); Ezquiaga et al. (2017)
				P. (P) *chaetophracti*	Nematode	S/N	Small intestine	Usno, Valle Fértil Dept.	Ezquiaga and Navone (2013); Ezquiaga et al. (2017)
				T. tuberculata	Nematode	S/N	Small intestine	Usno, Valle Fértil Dept.	Ezquiaga and Navone (2013); Ezquiaga et al. (2017)
				A. fasciata	Nematode	S/N	Large intestine and cecum	Usno, Valle Fértil Dept.	Ezquiaga and Navone (2013); Ezquiaga et al. (2017)
				A. scoleciformis	Nematode	S/N	Large intestine and cecum	Usno, Valle Fértil Dept.	Ezquiaga and Navone (2013); Ezquiaga et al. (2017)
	Rodentia	Cricetidae	*P. xanthopygus*	*P.* (P) *kozeki*	Nematode	MLP-He 7359	Stomach	La Puerta Ravine, Calingasta Dept.	Castillo et al. (2016)
BIRDS	Rheiiformes	Rheidae	*R. tarapacensis*	*Heterakis*	Nematode	S/N	Fecal material (fresh feces)	RNDC, Ullum Dpt	Gonzalez-Rivas et al. (2018)
	Piciformes	Picidae	*C. melanochloros*	*S.* (*Dispharynx*) *nasuta*	Nematode	CRFSJ-04A	Gizzard	Rehabilitation center	Gonzalez-Rivas et al. (2023a)

Of the total number of fish species (n = 22) recorded in the province of San Juan, only 2 species have been studied recording helminths (Figure 4A). With respect to amphibians, out of n = 14 anuran species recorded in the province, only 6 species were recorded with parasitic helminths (Figure 4B). In reptiles, out of n = 62 species present in San Juan, 21 have been mentioned with some type of helminth (Figure 4C). Regarding mammals, n = 50 species are represented in San Juan, of which only 7 have been reported with helminths (Figure 4D). Finally, in birds, we reported the highest biodiversity with n = 270 species, of which only 2 species were recorded with parasitic helminths (Figure 4E).

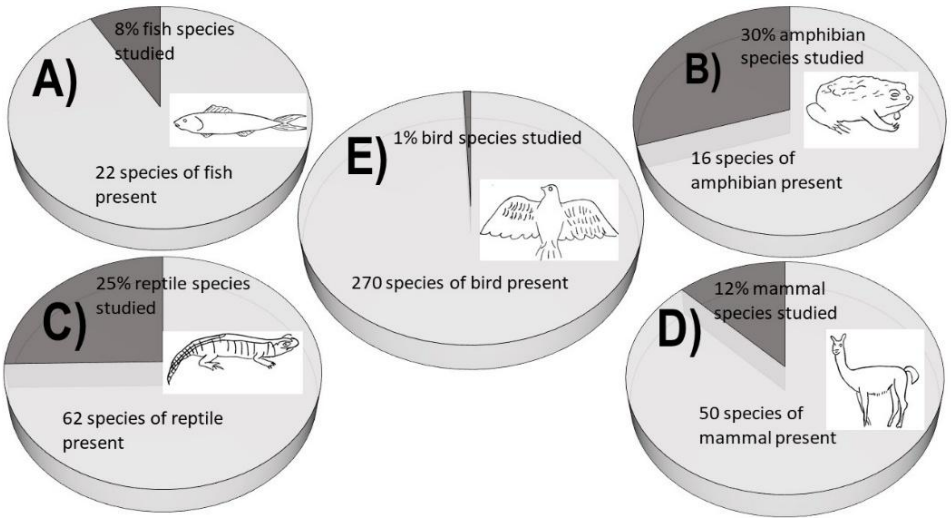

Figure 4. Percentages of parasitized vertebrate species in San Juan. A) Fish; B) Amphibian; C) Reptile; D) Mammal and E) Bird.

Taxonomic List of Helminths Parasitizing Vertebrates in San Juan Province, Argentina

Phylum Platyhelminthes Gegenbaur, 1959
Class Cestoda Rudolphi, 1808
Order Cyclophillidea Braun, 1900
Family Taeniidae
Cylindrotaenia cf. *americana* Jewel, 1916
Family Anoplocephalidae Cholodkovsky, 1902
Oochoristica travasossi Rêgo & Ibáñez, 1965

Phylum Nematoda Rudolphi, 1808
Subclass Secernentea Chitwood, 1950
Order Ascaridida Skrjabin & Schulz, 1940
Family Anisakidae Railliet & Henry, 1912
Contracaecum Railliet & Henry, 1912
Family Cosmocercidae Railiet, 1916 Travassos, 1925
Aplectana hylambatis Baylis, 1927
Aplectana nebulosa Piñeiro et al., 2017.
Family Kathlaniidae Lane, 1914 (Travassos, 1918)
Falcaustra sp. Lane, 1915
Falcaustra sanjuanensis González et al., 2013a
Family Atractidae Railiet, 1917 Travassos, 1920
Labiduris argentinensis González-Rivas, Castillo & Simoncelli 2024
Family Ascarididae Baird, 1853
Toxascaris sp. Leiper, 1907
Family Aspidoderidae Skryabin & Schikhobalova, 1947 Freitas, 1956
Aspidodera sp. Railliet & Henry, 1912
Aspidodera fasciata Schneider, 1866
Aspidodera scoleciformis Diesing, 1851
Family Heterakidae Railliet & Henry, 1912
Heterakis sp. Dujardin, 1845

Order Rhabditida Chitwood, 1933
Family Molineidae Durette-Desset & Chabaud, 1977
Trichohelix tuberculata Parona & Stossich, 1901
Nematodirus sp. Ransom, 1907

Order Spirurida Chitwood, 1933
Family Rhabdochonidae Travassos, Artigas & Pereira, 1928
Rhabdochona acuminata Molin, 1860
Family Physalopteridae
Physaloptera sp. Rudolphi 1819
Physaloptera clausa Rudolphi, 1819
Physaloptera retusa Rudolphi 1819
Thubunaea eleodori Ramallo et al., 2017b
Family Rictulariidae Hall, 1916 (Railliet, 1916)
Pterygodermatites (P) *argentinensis* Ezquiaga et al., 2017
Pterygodermatites (P) *chaetophracti* Navone & Lombrdero,1980
Pterygodermatites (P) *kozeki* (Chabaud y Bain, 1981)
Family Acuariidae Railliet, Henry & Sisoff, 1912
Synhimantus (Dispharynx) *nasuta* Rudolphi 1819

Order Oxyurida Railliet, 1916
Family Pharyngodonidae Travassos, 1920
Parapharyngodon sp. Chatterji, 1933
Parapharyngodon riojensis Ramallo, Bursey, Goldberg, 2002
Parapharyngodon sanjuanensis Ramallo et al., 2016a
Parapharyngodon sceleratus Freitas, 1957
Pharyngodon travasossi Pereira, 1935
Spauligodon sp. Skrjabin, Schikhobalova, Lagodovskaja, 1960
Skrjabinodon sp. Inglis, 1968
Skrjabinodon castillensis González-Rivas et al., 2022a
Subclass Adenophorea Chitwood, 1950

Order Enoplida Filipjev, 1929
Family Trichuridae (Ransom, 1911) Railliet, 1915
Trichuris myocastoris Enigk, 1933
Trichuris dolichotis Morini, Boero & Rodriguez, 1955
Trichuris sp. (Linnaeus, 1771)

Taxonomic list of vertebrate hosts parasitized by helminths in San Juan province, Argentina

Order Characiformes Goodrich, 1909
Family Characidae Latreille, 1825
Psalidodon eigenmanniorum (=*Astyanax eigenmanniorum*) Cope,1894

Order Siluriformes Hay, 1929
Family Trichomycteridae Bleeker 1858
Hatcheria macraei Girard, 1855

Order Anura Merrem, 1820
Family Bufonidae Gray, 1825
Rhinella arenarum Hensel, 1867
Rhinella spinulosa Wiegmann, 1834
Family Leptodactylidae Werner, 1896
Leptodactylus luctator (= *L. latrans*) Hudson, 1892
Pleurodema nebulosum Burmeister, 1861
Family Odontophrynidae
Odontophrynus occidentalis Cei, Ruiz y Beçak, 1982
Family Ranidae
Aquarana catesbeiana Shaw,1802 (=*Lithobates catesbeianus*)

Order Testudines Linnaeus, 1758
Family Testudinidae Batsch 1788
Chelonoidis chilensis Gray 1870

Order Lepidosauria Haeckel, 1866
Family *Liolaemidae* Frost & Etheridge, 1989
Liolaemus ruibali Donoso-Barros, 1961
Liolaemus parvus Quinteros, Abdala, Gómez & Scrocchi 2008
Liolaemus fitzgeraldi Boulenger, 1899
Liolaemus eleodori Cei, Etheridge y Videla 1985
Liolaemus olongasta Etheridge, 1993
Liolaemus gracielae Abdala, Acosta, Cabrera, Villavicencio & Marinero, 2009
Liolaemus darwinii Bell, 1843
Liolaemus riojanus Cei 1979
Liolaemus vallecurensis Pereyra 1992
Phymaturus extrilidus Lobo, Espinoza, Sanabria & Quiroga, 2012
Phymaturus punae Cei, Etheridge & Videla, 1985
Phymaturus williamsi Lobo, Laspiur, Acosta 2013
Phymaturus cf. *palluma* Bell, 1843
Family Leiosauridae Frost, Etheridge, Janies & Titus, 2001
Pristidactylus scapulatus Burmeister, 1861
Family Phyllodactylidae Gamble, Bauer, Greenbaum & Jackman, 2008
Homonota underwoodi Kluge, 1964
Homonota horrida Burmeister, 1861
Family Teiidae Gray 1827
Salvator rufescens Günther, 1871
Teius oculatus = (*Teius teyou*) Daudin, 1802
Aurivela longicauda Bell, 1843
Family Colubridae Oppel, 1811
Philodryas trilineata Burmeister, 1861

Order Carnivora Bowdich, 1821
Family Felidae Fischer, 1817
Puma concolor Linnaeus, 1771
Family Canidae Fischer, 1817
Lycalopex gymnocercus Fischer, 1814

Order Rodentia Bowdich, 1821
Family Echimydae Gray, 1825
Myocastor coypus Molina, 1782
Family Cricetidae Fischer, 1817
Phyllotis xanthopygus Waterhouse 1837
Family Caviidae Fischer, 1817
Dolichotis patagonum Zimmermann, 1780

Order Cingulata Illiger, 1811
Family Chlamyphoridae Pocock, 1924
Tolypeutes matacus Desmarest, 1804
Chaetophractus vellerosus Gray, 1865

Order Artiodactyla Owen, 1848
Family Camelidae Gray, 1821
Lama guanicoe Müller, 1776

Order Rheiiformes Forbes, 1884
Family Rheidae Bonaparte 1849
Rhea tarapacensis Chubb, 1913

Order Piciformes Meyer & Wolf, 1810
Family Picidae Vigors, 1825
Colaptes melanochloros Gmelin, 1788

Discussion

In San Juan, the registered vertebrates exceed 418 species. To date, 39 vertebrate species have been documented in the San Juan province in association with 35 species of helminth parasites, mainly nematodes. The number of helminth species recorded is relatively low given the high diversity of fish, amphibians, reptiles, mammals and birds present in the province. The most studied vertebrates were reptiles, followed by mammals, then amphibians and finally birds and fish. Our analysis indicates that birds and fish are the most abundant vertebrates in the San Juan province, however, they are the least studied. The low diversity of helminths found in birds and fish is due to the limited amount of sampling carried out for parasitological purposes. In contrast, a greater amount of parasitological research has been carried out on birds in eastern and southern Argentina (Lunaschi & Drago, 2009; Drago & Lunaschi, 2015; Ramallo & Ailán-Choque, 2022). As for fish, southern Argentina stands out for having the largest records of nematodes and sampling in these populations (Ramallo & Ailán-Choque, 2022).

Within the group of reptiles (the most studied vertebrates), lizards of the genus *Liolaemus* spp. and *Phymaturus* spp. belonging to the family Liolaemidae were the most analyzed, presenting the highest number of records, diversity and parasitic richness. Nevertheess, in northeastern Brazil, Lacerda et al. (2023) recorded that lizards of the genus *Tropidurus* Wied-Neuwied, 1824 of the family Tropiduridae were the most studied. For San Juan, nematodes exhibit the highest species richness with 37 taxa, followed by cestodes with 2 taxa. The high number of nematode species found in vertebrates from San Juan coincides with observations in mammals, reptiles and amphibians from other geographic areas, confirming that nematodes are the most common endoparasitic (Rodríguez-Ortíz et al., 2004; Muniz-Pereira et al., 2009; Fugassa, 2015; Castillo et al., 2020a; Ramallo & Ailán-Choke, 2022; Chero et al., 2023, Lacerda et al., 2023). The most frequent nematodes recorded in reptiles from San Juan province were the genera *Parapharyngodon* and *Physaloptera*. Our results are similar to the parasite genera reported by Lacerda et al. (2023) for northeastern Brazil. In mammals, the most frequently recorded were species of the genus *Aspidodera* and *Pterygodermatites*.

In our review, most of the nematodes analyzed and recorded were adult stages; these results are similar to other lists such as that of Rodríguez-Ortíz et al. (2004) where they recorded adult parasitic forms as well. However, we also recorded larval stages, mainly of the genus *Physaloptera* sp. on reptile hosts. This is not accidental, because many lizard species could act as paratenic hosts (Widmer, 1970). Some studies have mentioned that *L. darwinii* could have a role as a paratenic host in the life cycle of *Physaloptera* (Castillo et al., 2019d, 2020a). Anyway, more studies are needed to corroborate this premise. All nematodes and cestodes were found in the gastrointestinal tract, either stomachs or intestines.

Our annotated list reports nematode species of both monoxenic and heteroxenic cycles. For instance, nematodes of the family Rictulariidae, such as the genus *Pterygodermatites* require an intermediate host in the life cycle (Castillo et al., 2016). Nematodes of the order Oxyurida, all with monoxen cycle, were recorded in San Juan only in reptiles, although they are not exclusive to them, being also present in amphibians (Araujo Filho et al., 2015; Santos et al., 2022). In birds, we recorded *Synhimantus* (Dispharynx) *nasuta*, family Acuariidae, with a heteroxenous cycle, where its intermediate host is an isopod (González-Rivas et al., 2022c). In the terrestrial turtle *C. chilensis* we recorded the genus *Labiduris* sp. belonging to the family Atractidae. This genus is found parasitizing the gut of its host (Inglis & Díaz-Ungría, 1963; Tracchia, 2018), with a single-host cycle (Inglis & Díaz-Ungría, 1963). Females are monodelphic and viviparous (larviparous), where hatching occurs inside the uterus (adult females can be observed with larval stages in the uterus) (personal obs.). The larvae are expelled at an advanced stage of development (endogenous development). Infestations probably occur by performing coprophagy of fecal matter (Tracchia, 2018).

Conclusion

This list represents the first study on endoparasites in vertebrates carried out in San Juan province, Argentina. It has been observed that the parasitic fauna of the province is mostly made up of nematodes, with reptiles being the most investigated group. This phenomenon is possibly due to the extensive collection of samples and ease of capture of these animals, as well as the great diversity and abundance of species present in the various phytogeographic regions of San Juan. Over the past 12 years, there has been a growing interest in the province of San Juan to investigate the relationship between parasites and wildlife. More detailed studies focused on less explored groups are essential. The annotated list of endoparasites in vertebrates presented here provides the most recent information on the presence of nematodes and cestodes in the fauna of San Juan. Finally, this work reports observations of 35 helminth taxa in association with 39 species of wild vertebrates including different taxa of fish, amphibians, reptiles, mammals and birds.

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